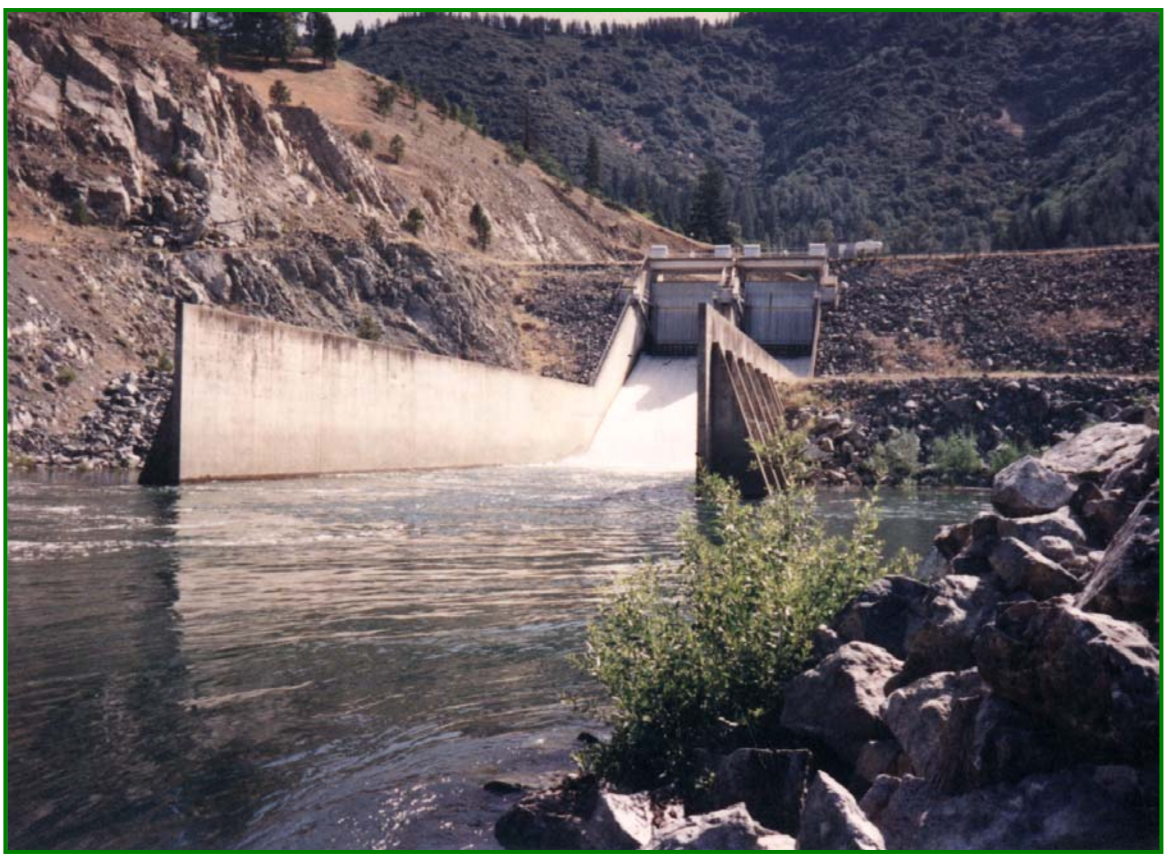
U.S. Fish and Wildlife Service

Lewiston Dam Releases and Their Influence on Water Temperatures of the Trinity River, California

WY 2002



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Lewiston Dam Releases and Their Influence On Water Temperatures of the Trinity River, CA WY 2002

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A Report to the
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SUMMARY OF FINDINGS

- Spring-time flows from Lewiston Dam in 2002 had a large influence on flow at all mainstem gages. The effect was greatest at the Lewiston gage during the peak dam-release of 6,000 cfs in early May. Flow accretions from tributaries lessened the effect at lower river gages.

- During the peak dam release of 6,000 cfs, the mean daily water temperature of the Trinity River at Lewiston (RK 178.2) was reduced from approximately 10 to 8 degrees Celsius (°C). This reduction in water temperature was attributed to a more rapid transit time of larger hypolimnetic releases from Trinity Dam and short hydraulic residence time, which limit heating of water in Lewiston Reservoir before being released to the Trinity River.

- Water temperatures of the entire mainstem Trinity River below Lewiston were notably affected by the peak dam release and moderated during the receding portion of the hydrograph. Sites closest to the dam were affected the most.

- Comparison of average daily temperatures calculated from hourly data collected from two independent thermisters at Lewiston, Douglas and Pear Tree Gulch gage locations indicated they were generally within 0.2 ºC of each other.

- Water temperature objectives of the North Coast Regional Water Quality Control Board were always met from July 1 through October 16 when dam release flow was 450 cfs, and from October 16 to December 31 when dam release flow was 300 cfs.

- Spring-time water temperature objectives at Weitchpec, as prescribed in the Record of Decision of the Trinity River Environmental Impact Statement for a Dry water year were met, although the hydrologic conditions of the basin were Normal. Optimally suitable smolt water temperatures were maintained in the Trinity River through late May and thereafter only marginally suitable smolt water temperatures were maintained.

- From April to mid-July, the average daily water temperatures of the South Fork Trinity River were up to 6 ºC warmer than other major tributaries. For this same time period, Rush Creek, Canyon Creek, Big French Creek, and the North Fork Trinity River were generally within 3 ºC of each other. Big French Creek and Rush Creek exhibited the least amount of seasonal variation and overall colder thermal regimes.

- Prior to the peak release from Lewiston Dam in early May, average daily water temperatures of the Klamath River at Weitchpec (RK 70) were about 1 ºC colder than the Trinity River. Shortly after the peak release, average daily water temperatures of the Trinity River became about 1 ºC colder than the Klamath River. By mid-June, water temperatures of the Trinity and Klamath Rivers were similar.

- It is recommended that the temperature monitoring network that was used in 2002 be maintained. Only by collection of this information can important “cause and effect” relationships of TRD water operations be empirically described.

INTRODUCTION

Flow and water temperatures of the Trinity River mainstem changed appreciably when the Trinity River Division (TRD) of the Central Valley Project was completed and the Trinity River was dammed in 1963 (U.S. Fish and Wildlife and Hoopa Valley Tribe 1999). Prior to the dams, the water temperatures of the river were largely dependent on flow quantity. Today, the Trinity River below Lewiston dam receives water from a large impoundment that acts to moderate extremes in water temperatures throughout the year. During the fall and winter months water temperatures in the vicinity of Lewiston Dam have become warmer and from early summer to early fall the water temperatures have become cooler when compared to pre-dam conditions.

Areas further downstream have also been affected, most notably during the spring and early summer months (U.S. Fish and Wildlife and Hoopa Valley Tribe 1999). Prior to the TRD, the spring-time snowmelt portion of the hydrograph provided abundant snowmelt runoff throughout the Trinity River. Since the TRD, lower river flow has resulted in the Trinity River becoming warmer during the spring and early summer.

Past water management decisions are indicative of the importance of the need to improve or maintain cold water thermal regimes throughout the river to restore the salmonid populations of the river system. In 1991, the North Coast Regional Water Quality Control Board (NCRWQCB) formally adopted temperature objectives for the first 64 kilometers of river below Lewiston Dam. These objectives were intended to assure that adequate areas of suitable temperatures were available for the protection of adult spring-run salmon that migrate and hold in the upper basin in the early summer and spawn in the fall (Table 1).

The signing of the Record of Decision for the Trinity River Environmental Impact Statement (TREIS) by the Secretary of the Interior in 1999 further solidified the need to maintain the NCRWQCB objectives as well as improving the thermal regime of the river during the spring and early summer (hereafter referred to as the spring-time objectives). Unlike the NCRWQCB objectives, which target an area immediately below Lewiston Dam and remain similar between all water year types, the spring-time objectives are intended to improve the thermal regime along the entire Trinity River from Lewiston Dam to Weitchpec and vary with water year type designation (Table 1). In June 2000, the Hoopa Valley Tribe formally adopted the spring-time temperature criteria in their Water Quality Control Plan (Hoopa Valley Tribe 2000).

The recommended thermal regimes differ between Normal, Wet, and Extremely Wet water years and Dry and Critically Dry water years (Table 1). In Normal, Wet, and Extremely Wet years colder temperature objectives are sought through flow augmentation from Lewiston Dam. In addition to larger peak flows and a gradual recession, the flow schedules of these water year types include a minimum dam release of 2,000 cfs through July 9 to maintain optimal water temperatures in the mainstem Trinity River. In contrast, peak flows are reduced and only marginally suitable water temperatures are managed for until mid-June in Dry and Critically Dry years (U.S. Fish and Wildlife and Hoopa Valley Tribe 1999).

As a result of pending litigation on the TREIS, 470 thousand acre-feet (TAF) of water was allocated to the Trinity River in water year 2002. This allocation represented approximately a 100 TAF increase over the 2001 allocation to the Trinity River and approximately 17 TAF greater than a Dry water year type allocation. In retrospect, the 90 percent exceedence forecast for the Trinity River basin on April 1, 2002 suggested that the water year type would have been designated a Normal water year (T. Patton pers. com.). Had a Normal water year been designated, the volume of water dedicated to the Trinity River would have been approximately 647 TAF.

Water temperature is perhaps the most important variable affecting the distribution and survival of aquatic organisms. Because of its importance, there is a need to ensure availability of complete records of water temperatures for key locations within the Trinity River basin. This data is valuable for establishing a database from which to evaluate land and water management decisions currently under the direction of the Trinity River Restoration Program.

The objectives of this report were to: 1) describe the thermal regime of the Trinity River and select major tributaries during 2002; and 2) evaluate the resulting thermal regime in the context of meeting various temperature objectives in the Trinity River.

METHODS

The U.S. Fish and Wildlife Service (Service) obtained flow and water temperature data collected by U.S. Geological Survey, the U.S. Bureau of Reclamation, and the California Department of

Table 1. Water temperature objectives of the Trinity River.

Objective	Target Area	Dates	Criteria[a]
NCRWQCB	• Lewiston to Douglas City	July 1 to Sept 15	≤ 15.5
	• Lewiston to Douglas City	Sept 15 to Sept 30	≤ 13.3
	• Lewiston to North Fork Trinity River Confluence	Oct 1 to Dec 31	≤ 13.3
Spring-Time Objectives[b]	• Lewiston to Weitchpec	Normal and Wetter Water Years:	
		• May 22	≤ 13.0
		• Jun 4	≤ 15.0
		• Jul 9	≤ 17.0
		Dry and Critically Dry Water Years:	
		• May 22	≤ 15.0
		• Jun 4	≤ 17.0
		• Jun 15	≤ 20.0

‘a = Average daily criteria in degrees Celsius
‘b = Criteria adopted in the Trinity River EIS Record of Decision of December 2000, and the Hoopa Valley Tribe Water Quality Control Plan in 2000

Water Resources using the internet website for the California Data Exchange Center (CDEC). Additionally, the Service deployed temperature probes at several of these CDEC sites and they included: Lewiston, Douglas City, and Pear Tree Gulch. Past review of historical records by Service staff found periodic breaks in the data collected by CDEC stations that prompted the need to collect information at these same sites and assure the availability of accurate data.

The Service used StowAway Tidbit [tm] temperature probes manufactured by Onset Computer Corporation to collect water temperature data. Prior to and after deployment, each probe was subjected to a performance test to verify it was recording to within the manufacturer’s accuracy specification of ± 0.2 ˚C. Probes were programmed to record every hour from mid-April to mid-October at several locations in the mainstem Trinity River and in select tributaries (Table 2). An additional probe was placed in the Klamath River immediately above the confluence of the Trinity River.

Table 2. Water Temperature Monitoring Locations, 2002.

Water Temperature Monitoring Locations			
Mainstem Locations	**River Kilometer**	**Tributary Locations**	**River Kilometer[a]**
Lewiston Gage	178.2	TR Rush Creek	173.0 + 1.5
Above Rush Creek	173.0	Canyon Creek	127.3 + 0.1
Steelbridge Temp Site (LKN)	158.7	North Fork Trinity River	116.7 + 0.1
Douglas City Gage	148.5	Big French Creek	94.1 + 0.1
Above Canyon Creek	127.4	South Fork Trinity River	50.5 + 0.1
Pear Tree Gulch Gage	117.6		
Above Big French Creek	94.2		
Burnt Ranch Transfer Station	76.4		
Above South Fork Trinity R.	50.6		
Trinity River at Weitchpec	0.1		
Klamath River at Weitchpec[b]	70.0		

‘a = River kilometer of mainstem Trinity River + the distance up the tributary
‘b = This site is located immediately above the confluence of the Trinity River and refers to the distance from the Klamath River mouth.

RESULTS

River Flow

Flow of the Trinity River at Lewiston, Burnt Ranch, and Hoopa is presented in Figure 1. The Lewiston hydrograph was based upon the 470 thousand acre-feet (TAF) allocation of 2002. River flow at Burnt Ranch and Hoopa represent flow from Lewiston Dam in addition to accretion from many large tributaries including Canyon Creek, the North Fork Trinity River, New River, and the South Fork Trinity River to name a few. Accurate gage information for the Douglas City site was not available by the time of report completion.

Lewiston Dam releases had a large influence on the hydrology of the Trinity River (Figure 1). The peak dam release of 6,000 cfs that occurred in early May contributed much of the flow at the Burnt Ranch and Hoopa. Following the peak, releases from Lewiston Dam and flow at Burnt Ranch and Hoopa steadily decreased. Lewiston Dam releases reached base summer flow of 450 cfs on June 25 and remained there until mid –October. From October 16 to March 31, 2003, Lewiston Dam releases were maintained at 300 cfs.

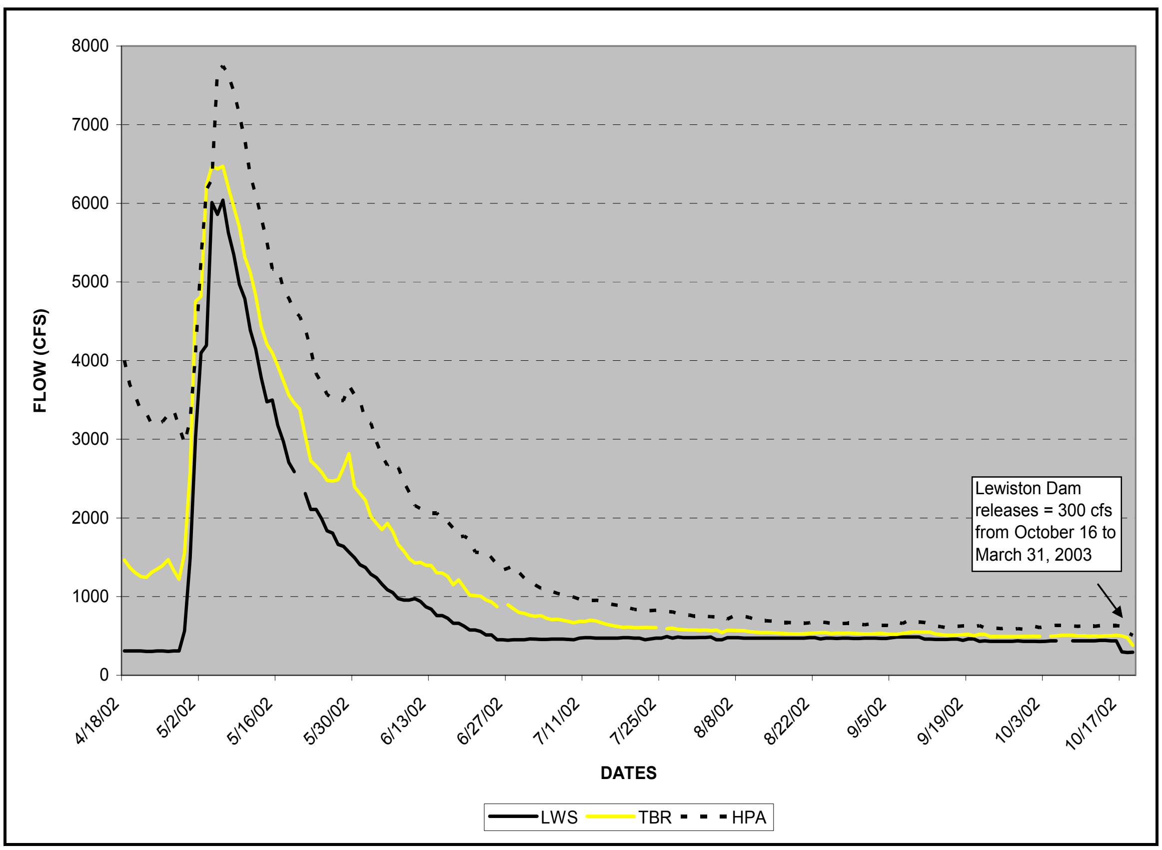

Figure 1. Flow of the Trinity River at Lewiston gage (LWS), Burnt Ranch gage (TBR) and Hoopa Gage (HPA), 2002.

Thermal Regime of the Mainstem Trinity River

Lewiston Gage (RK 178.2)

During the peak spring flow, the water temperatures at this location were reduced (Figure 2). Before the peak flow, water temperatures at the Lewiston gage approached 10 ˚C. During the peak release, water temperatures decreased to 8 to 8.5 ˚C. Following the peak flow and gradual recession, water temperatures slowly increased. In August and September water temperatures remained below 10 ˚C. In late September water temperature rose to 10.9 ˚C before decreasing to below 9 ˚C. Large temperature reductions at the Lewiston gage during the spring and summer months are generally associated with rapid transit time of Trinity Reservoir water through Lewiston Reservoir. Rapid transit times through Lewiston Reservoir are generally achieved through high volume releases in the Trinity River or in combination with large diversions to the Sacramento River basin through the Carr Tunnel (Zedonis 1997).

Comparison of the thermister used in the CDEC station and the probe deployed by the Service showed comparable results (Figure 2). The largest difference observed between average daily values was 0.2 ˚C, and generally the U.S. Fish and Wildlife Service probe (Service) was reading lower than the CDEC thermister.

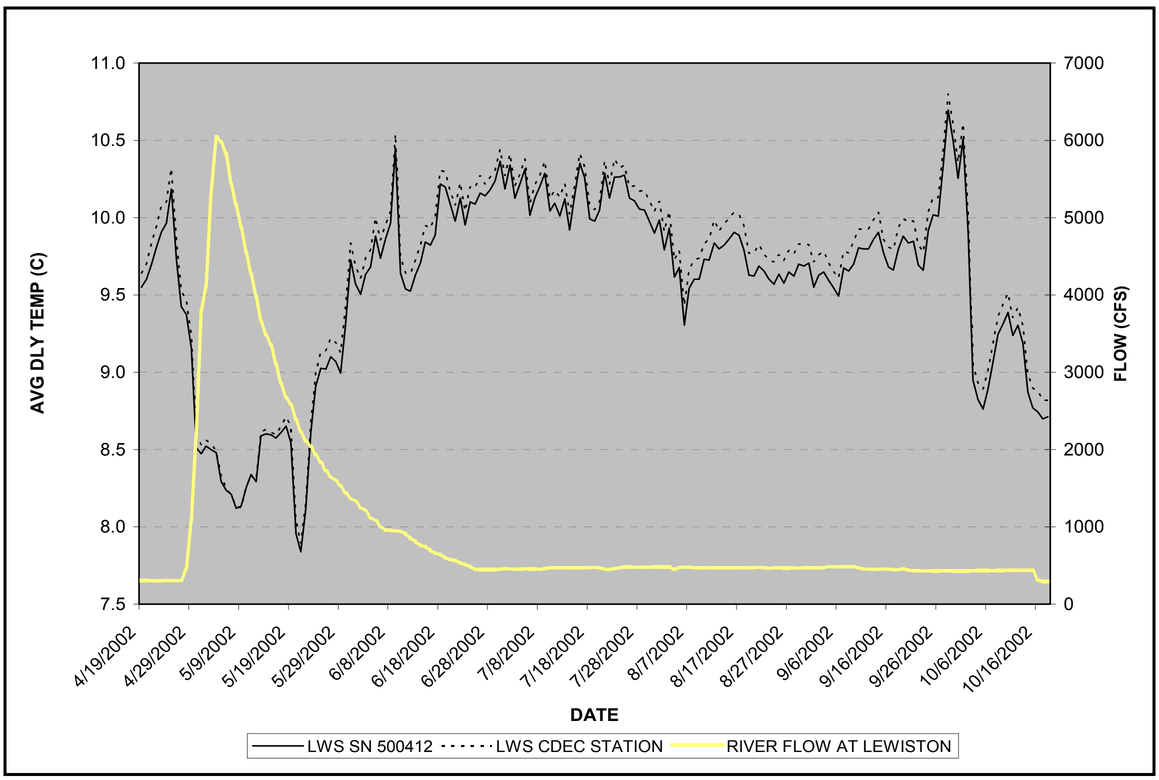

Figure 2. Average daily water temperature and flow of the Trinity River at Lewiston gage in 2002. Comparisons of water temperature data from the CDEC station and the Service probe (SN 500412).

Douglas City Gage (RK 148.5)

Prior to the peak flow that occurred in early May, water temperatures at the Douglas City gage approached 13.0 ˚C (Figure 3). During the peak release, water temperatures decreased to less than 9.0 ˚C. Following the peak flow, water temperatures slowly increased and peaked in late June. From July through September, average daily temperatures generally declined and the water temperature objectives of the North Coast Regional Water Quality Control Board were met.

Comparison of the thermister used in the CDEC station and the probe deployed by the Service showed comparable water temperature regimes (Figure 3). The largest difference observed between average daily values was 0.3 ˚C, and this occurred infrequently.

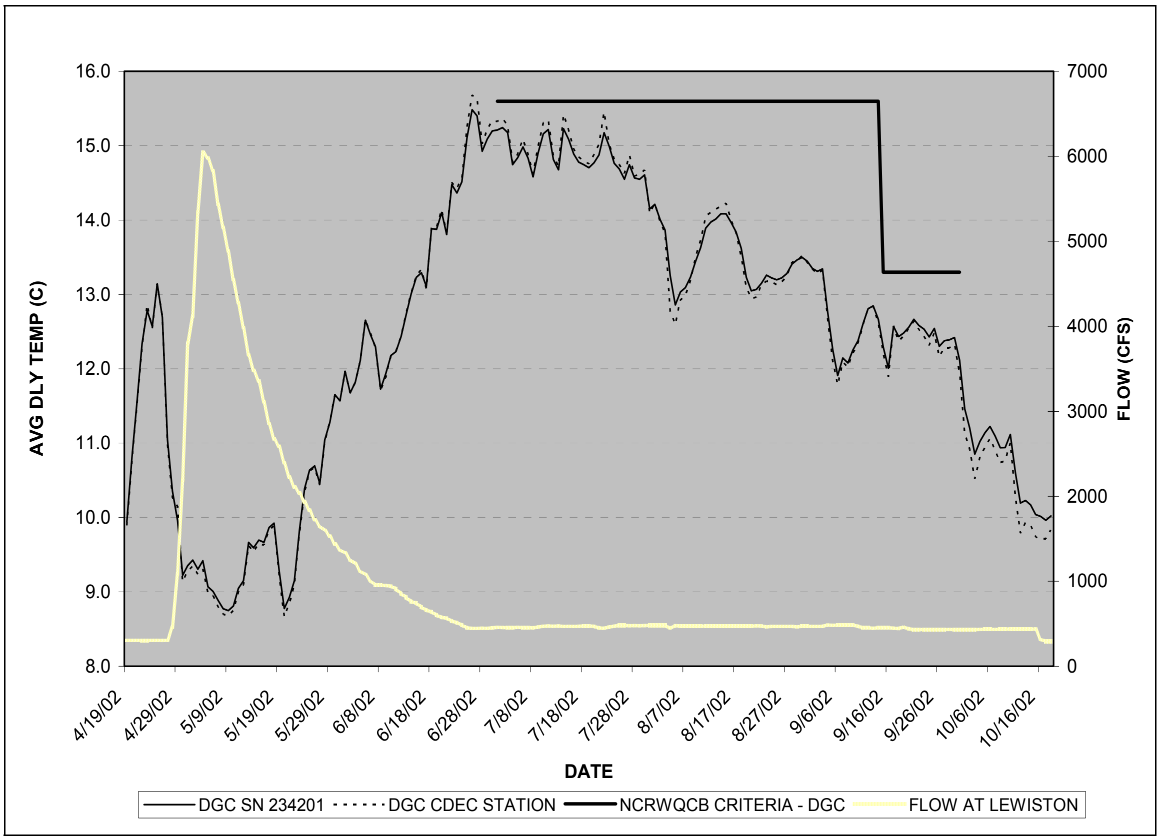

Figure 3. Average daily water temperatures of the Trinity River at the Douglas City gage in 2002. Comparisons of water temperature data from the CDEC station and Service probe (SN 234201) and the North Coast Regional Water Quality Control Board water temperature objectives.

Pear Tree Gulch (RK 117.6)

Prior to the peak flow that occurred in early May, water temperatures at the Pear Tree Gulch gage also approached 13.0 ˚C (Figure 4). During the peak release, water temperatures decreased to about 9 ˚C. Following the peak flow and gradual decrease in flow, water temperatures slowly increased and reached their summer peak in mid-July. From mid-July on, the water temperature at this location continued to decrease. From October 1 on, the average daily water temperatures were below the 13.3 ˚C threshold of the North Coast Regional Water Quality Control Board (Figure 4). Although not presented here, average daily water temperatures continued to meet the objective through December 31.

Comparison of the thermister used in the CDEC station and the probe deployed by the Service showed comparable results for the time periods in which comparable data exist (Figure 4). During July and early August, the CDEC thermister was not recording. The largest difference between average daily values was approximately 0.2 ˚C.

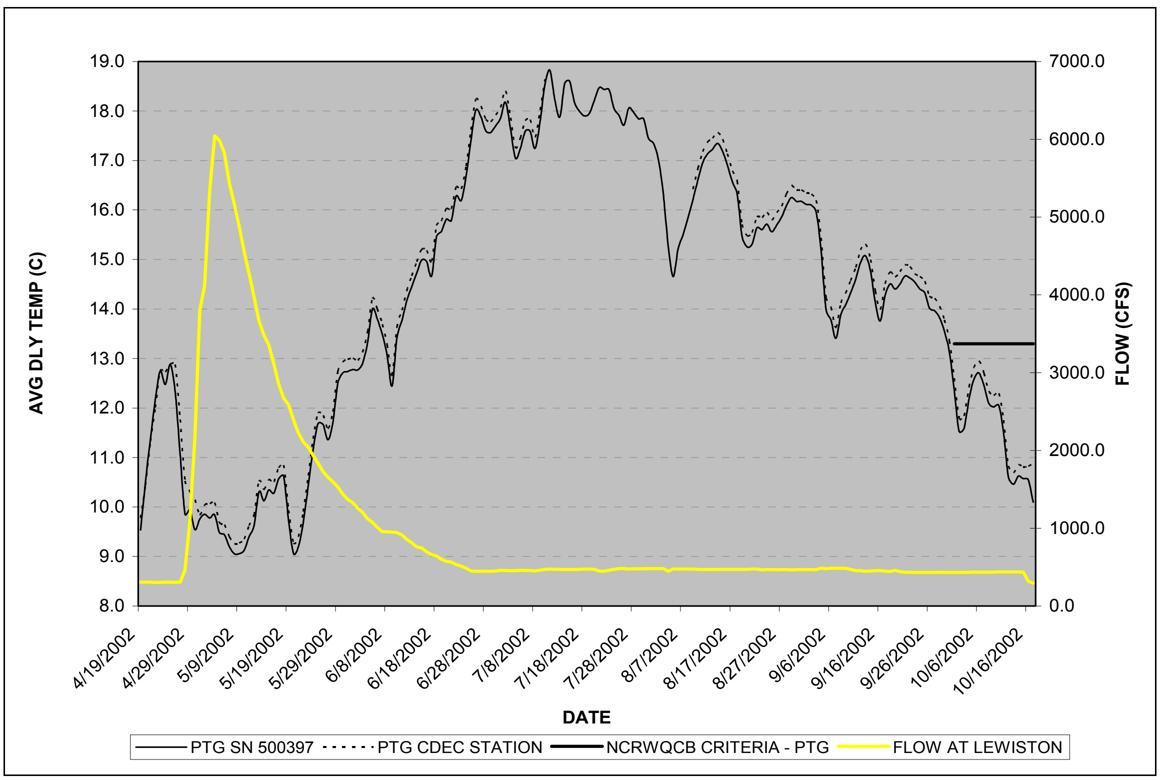

Figure 4. Average daily water temperatures of the Trinity River at the Pear Tree Gulch gage in 2002. Comparison of water temperature data of the CDEC Station and the Service probe (SN 500397) and the North Coast Regional Water Quality Control Board temperature objectives

Average Daily Water Temperatures - RK 178.2 to 117.6

Water temperatures of the Trinity River from Lewiston (RK 178.2) to Pear Tree Gulch (RK 117.6) are represented by data collected by six different probes (Figure 5). The pulse flow that occurred in early May had a significant affect on water temperatures in this region of the river.

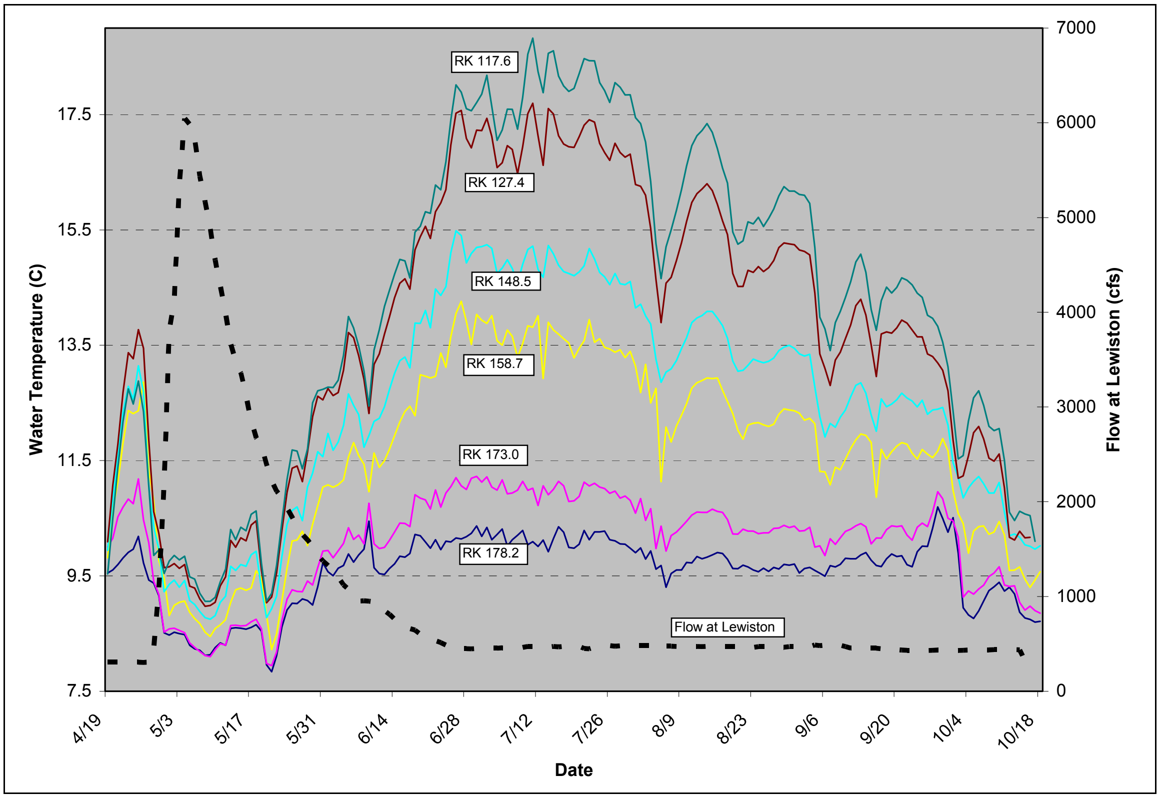

Figure 5. Average daily water temperatures of the Trinity River from Lewiston gage (RK 178.2) to Pear Tree Gulch gage (RK 117.6), USFWS data, 2002.

Average Daily Water Temperatures - RK 117.6 to 0.1

Water temperatures of the Trinity River between Pear Tree Gulch gage (RK 117.6) and Weitchpec (RK 0.1) are represented by data collected by five different probes (Figure 6). Similar to the upper region of the river, the peak flow had an effect on water temperatures of this region of river, although to a lesser extent.

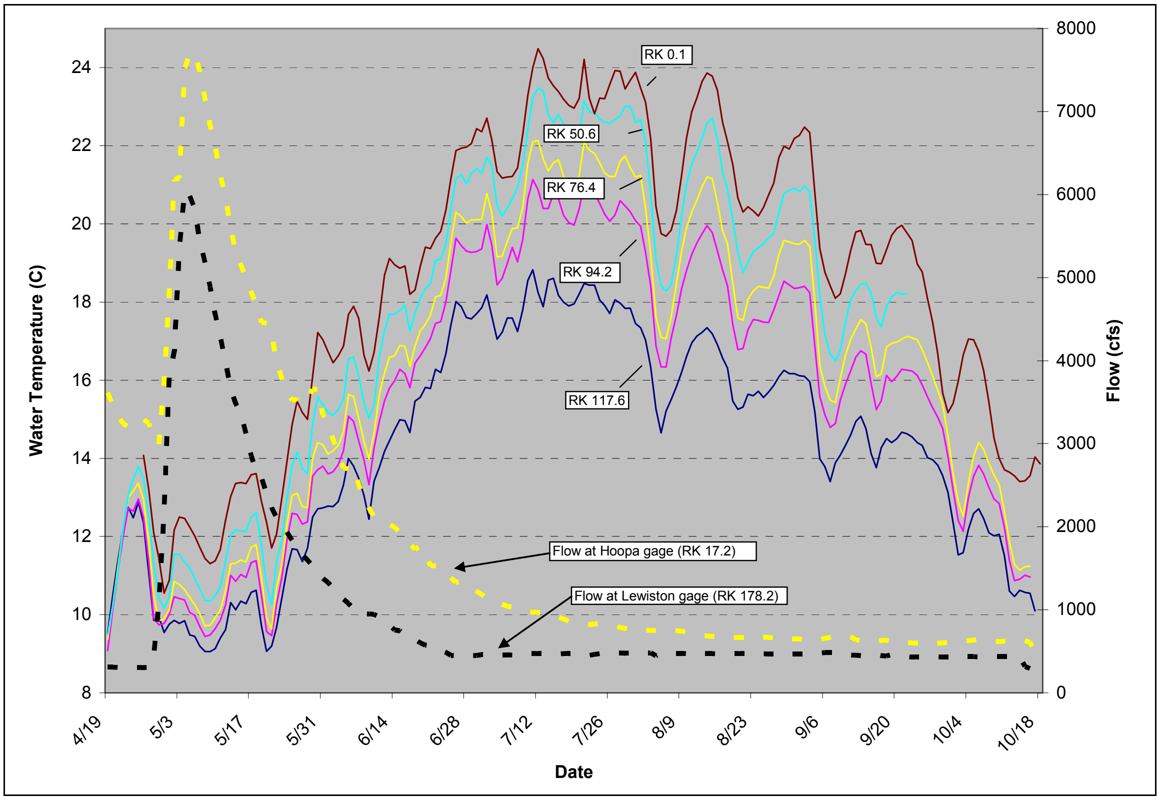

Figure 6. Average daily water temperatures of the Trinity River from Pear Tree Gulch gage (RK 117.6) to Weitchpec (RK 0.1), USFWS data, 2002.

Spring-time Objectives of the Lower Trinity River

One of the purposes of the recommended spring hydrographs is to provide temperature control in the entire mainstem Trinity River (USFWS and Hoopa Valley Tribe 1999). Preview of average daily water temperature data suggest that this was accomplished in WY 2002, especially during the peak release (Figure 7). The peak flow and protracted descending limb of the hydrograph allowed for gradual warming of water temperatures but maintained a thermal regime recommended for Dry and Critically Dry water year types. In comparison, the cooler temperature targets of Normal, Wet and Extremely Wet years would have only been met in May and a few days in June. Minimum dam releases of 2000 cfs that occur until July 9 in Normal and wetter years are intended to moderate temperatures for a longer period of time than drier water years.

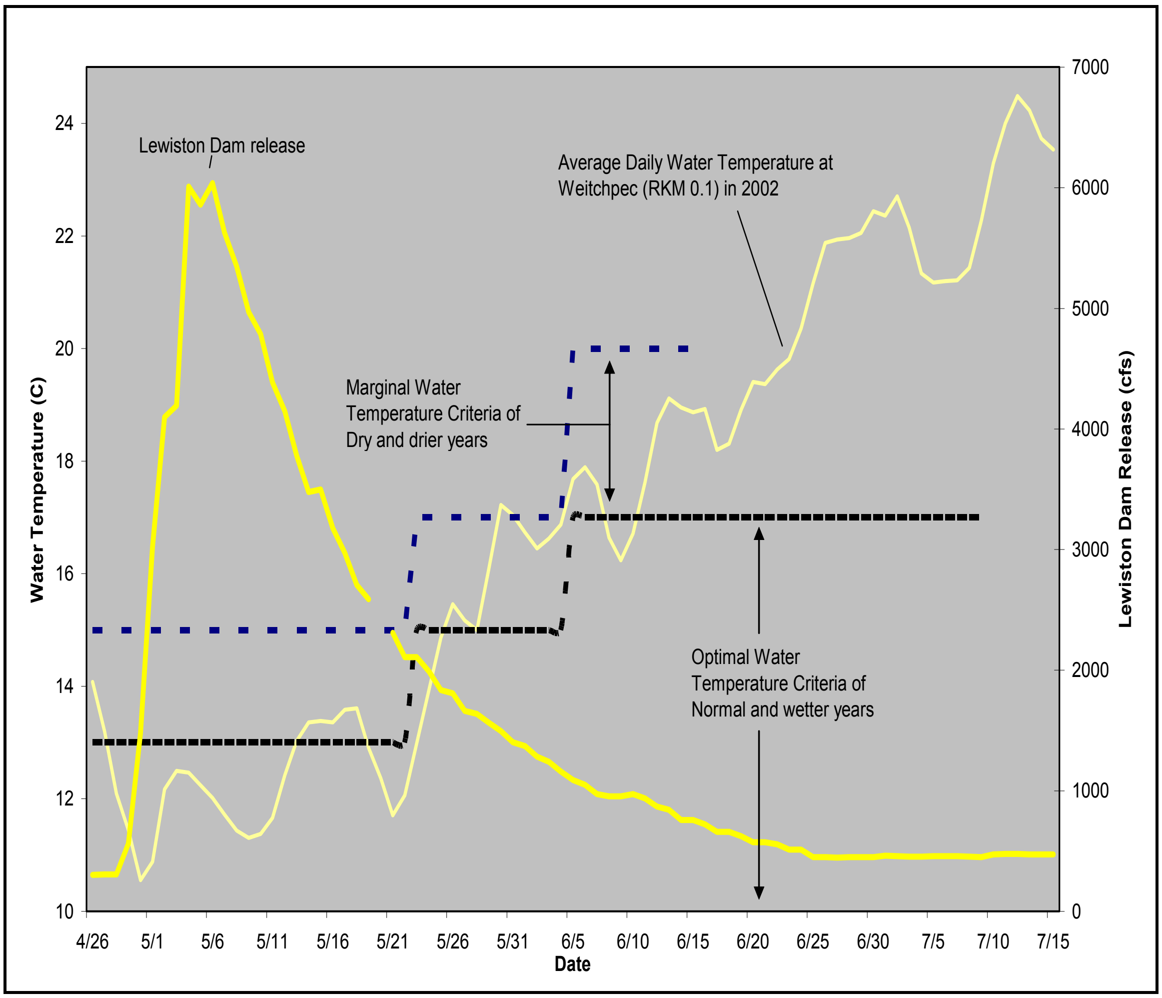

Figure 7. Comparison of Water Temperatures of the Trinity River at Weitchpec (RM 0.1) in 2002 and the spring-time temperature criteria at Weitchpec.

Thermal Regime of Tributaries

Water temperatures of monitored tributaries were quite variable (Figure 8). The South Fork Trinity River was one of the warmest tributaries and presumably contributed the largest amount of water to the mainstem Trinity River. From April to mid July, average daily water temperatures of the South Fork Trinity River were up to 6 ˚C warmer than all other tributaries. During this same time period, the other tributaries were generally within 2 to 3 ˚C of each other. However, from July to October the thermal regimes of these tributaries were increasingly dissimilar. It is suspected that decreasing flow as well as the different levels of topographic and riparian shading resulted in the different thermal regimes between streams. Big French Creek and Rush Creek, which are smaller in size and smaller than Canyon Creek, the North Fork Trinity River, and South Fork Trinity River, exhibited the most stable thermal regime through the monitoring period. These two streams also exhibited the coolest water temperatures during the late summer and early fall.

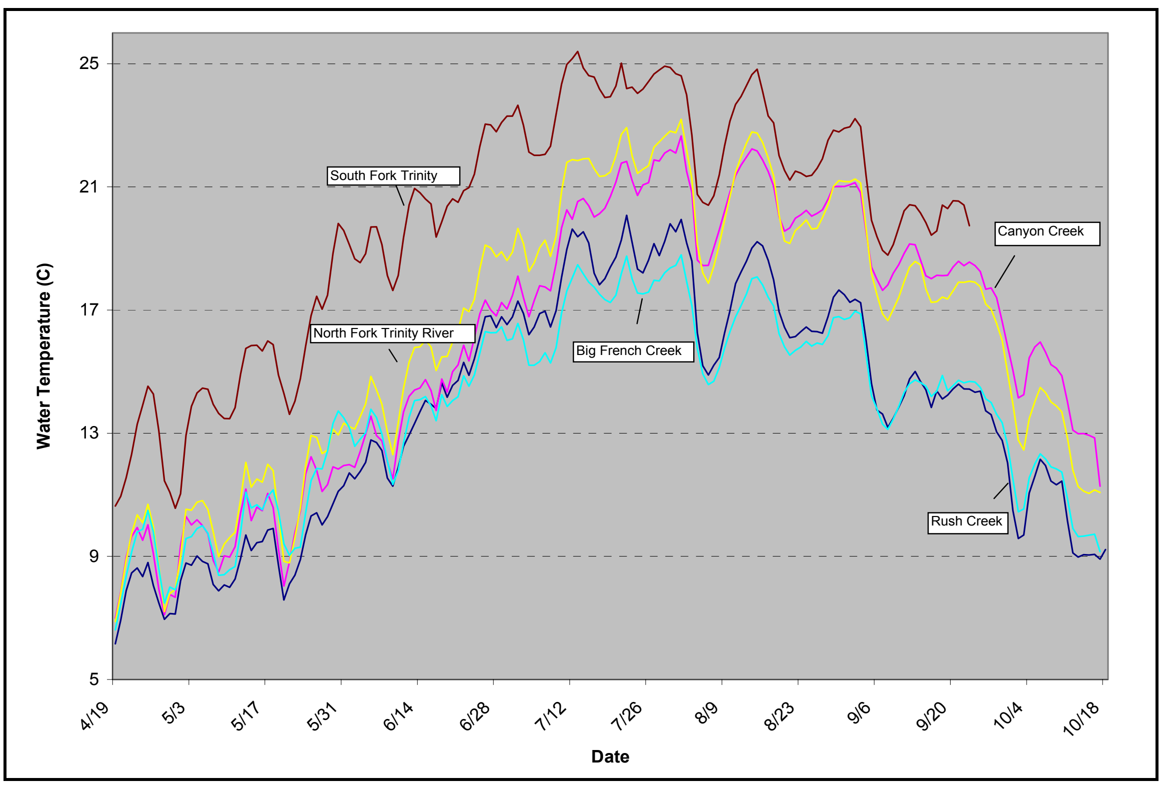

Figure 8. Average daily water temperatures of five tributaries of the Trinity River, USFWS data, 2002.

Water Temperatures of the Trinity River and Klamath River at Weitchpec during the Spring and Early Summer

In addition to collection of water temperature data at the mouth of the Trinity River, water temperature data were collected in the Klamath River immediately above the confluence of the Trinity River. Collection of this data provided an opportunity to evaluate how different the thermal regimes of the Trinity River and Klamath Rivers were as a result of implementing the flow schedule. A premise of the variable year type schedules, and a hypothesis of the Adaptive Management Program, is that these schedules would not result in large thermal differences at the confluence region that could negatively affect salmonid fish departing or entering the Trinity River system (See USFWS and Hoopa Valley Tribe 1999, Chapter 5.5 and Appendix L for more details)

In 2002, the differences in water temperature of the Trinity River and the Klamath River depended on the time of year (Figure 9). In late April, and prior to increased releases from Lewiston Dam, the average daily water temperatures of the Klamath River were about 1.0 ˚C colder than the Trinity River. During the time of the peak releases from Lewiston the water temperature differential changed and the Trinity River became about 1.0 ˚C colder than the Klamath River. Following the peak flow, average daily water temperatures of the Trinity River remained about 0.5 ˚C colder than the Klamath River. Had a Normal water year type schedule been implemented as prescribed in the Trinity River Record of Decision, it is likely the temperature differentials at the confluence would have been larger.

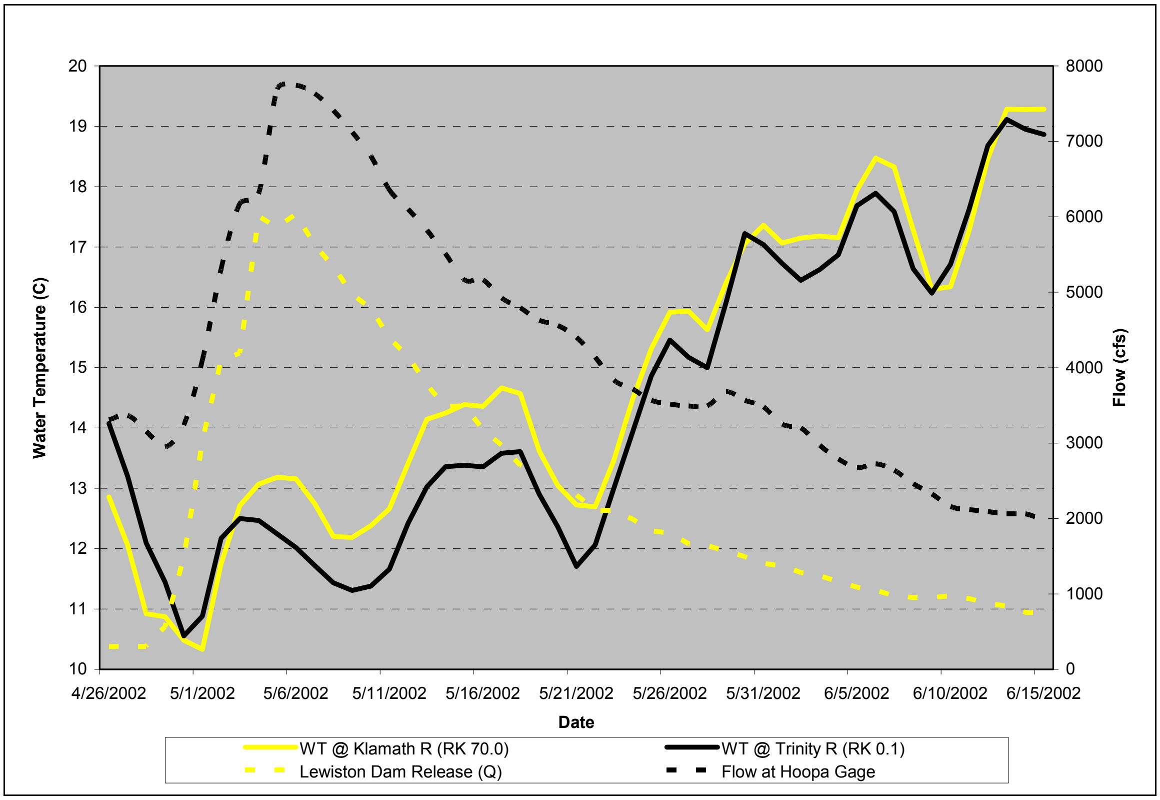

Figure 9. Comparison of water temperatures (WT) and river flow of the Trinity River and the Klamath River at their confluence, USFWS data, 2002.

RECOMMENDATIONS

The water temperature data that was collected provided a fairly complete picture of the effect of the spring hydrograph on the thermal regime of the Trinity River and at its confluence with the Klamath River. It is recommended that a temperature-monitoring network similar to the one used in 2002 be maintained in the future. Only by collection of this information can important "cause and effect" relationships of TRD water operations be empirically described.

Water temperature modeling of the Trinity River system continues to be an important tool for evaluating water management options. In the past, the model served as an important tool to assist in development of dam-release schedules and will likely continue to serve an important role in the Trinity River Restoration Program. Continued collection of complete and accurate water temperature data records will be essential for empirical evaluations of dam releases as well as accurate modeling.

Funding through the Restoration Program has provided an opportunity to update the SNTEMP model of the Trinity River. As part of the update, the Service will incorporate the water temperature data collected in 2002 into the SNTEMP. The Service expects this model update to occur in the near future. After this time, the model will be recalibrated with more recent years and can be used to evaluate various alternative dam-release schedules for these years. For example, one may wish to evaluate a dam-release schedule associated with a Normal water year type in 2002 or a modified Dry year schedule to see what influences a different schedule may have had on the thermal regime of the Trinity River.

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PERSONAL COMMUNICATIONS

Patton, Tom. U.S. Bureau of Reclamation, Central Valley Operations, March 31, 2003

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