Umpqua Basin Watershed Council

Calapooya Creek Temperature Study 1999

Procedure, results and preliminary analysis

January 2000

Prepared by InSight Consultants
PO Box 10, Yoncalla, OR 97499
insight@rosenet.net

Acknowledgements:

This project was sponsored by the Umpqua Basin Watershed Council (UBWC). The project was partially funded by grants from:

- Governors Watershed Enhancement Board
- EPA Section 319 of the Clean Water Act for nonpoint sources.

Grateful appreciation is extended to the following individuals and organizations for their contribution to this project.

- All the landowners who granted permission for the monitoring project

- Mikeal Jones – Umpqua National Forest
- Josh Peters – Calapooya & Sutherlin Creeks Watershed Project
- Janice Green – Umpqua Fisherman Association
- Paul Heberling and Bobbi Lindberg – Roseburg DEQ
- Lenny Schussel – Schussel & Associates
- Russ Lawrence – Stream Fix
- Lowell Duell – Roseburg BLM
- Debra Gray – Umpqua National Forest
- UBWC Technical Advisory Committee members

******

The writer takes full responsibility for all errors and omissions.

Kent Smith
Consultant, InSight Consultants

Disclaimer

The Roseburg BLM requested that the following disclaimer be included in the final document:

> “No warranty is made by the Bureau of Land Management as to the accuracy, reliability or completeness of these data for individual use or aggregate use with other data." In addition these data are provisional and subject to revision.”

Calapooya Creek Temperature Study
Summer of 1999

Executive Summary

Temperature data from 29 continuously sampling sensors was obtained from monitoring sites in the Calapooya Creek watershed during the summer of 1999. The seasonal maximums from the various sites ranged between 82.5 and 57.5 °F with an average of 72.0 °F. The 7-day maximums lagged the seasonal maximums by an average of 1.9 degrees with a maximum difference of 3.3 °F. The maximum ΔT (difference between daily maximum and minimum values) value ranged from 2.5 to 14.2 °F with an average of 9.7 °F.

Analysis of the data with respect to the location in the watershed indicated that the tributary streams tended to be in the order of 10 °F cooler than the mainstem Calapooya. Charting the data with respect to the distance from the ridge of each stream indicated that the maximum temperature of the coldest streams tended to increase about 1.25°F per downstream mile. The data cluster above this line suggests that many of the similarly sized tributary streams have the potential to be at cooler temperatures.

Objective and scope of the study:

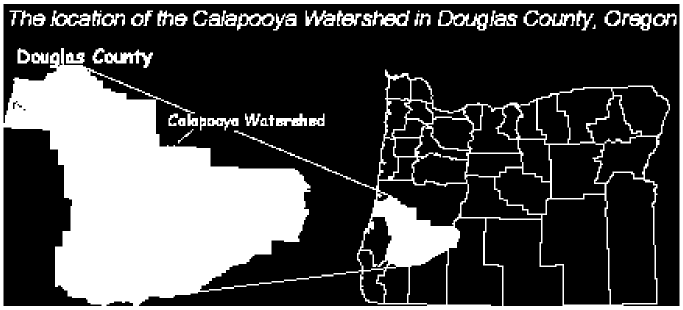
This study was sponsored by the Umpqua Basin Watershed Council (UBWC) in partnership with the Umpqua National Forest, Roseburg BLM, and Roseburg DEQ. The study is part of an ongoing project to characterize the summer stream temperature regime in the interior watersheds of the Umpqua Basin with an emphasis on the seasonal maximum temperatures. This particular study is directed at stream temperatures within the Calapooya watershed. A synoptic approach was taken by distributing 28 data sensors in streams throughout the watershed in the summer of 1999 with the intent of eliminating the between-year variability in the data. An additional sensor was deployed to measure air temperature at site Cal 10 which is located on the north side of Oakland. The Roseburg BLM provided data from two additional sites and Roseburg DEQ provided data from one site which is also included in the report. Companion temperature characterization projects include the 1998 Elk Creek Study and the 1999 South Umpqua Study.

A preliminary analysis using statistics from the data was completed to examine the spatial distribution of the temperature patterns. It is expected that this data and analysis will provide a basis for addressing site specific temperature related issues, aquatic habitat evaluation, and a Temperature Management Plan for the watershed.

Study Area:

Geographical Characteristics

The Calapooya Creek Watershed is located in north central Douglas County and is about 564 square miles in size. The elevation at the mouth is 340 feet and the elevation of the defining ridges ranges from 800 feet to over 4000 feet at the Calapooya Divide located at the east end of the watershed.



Map 1 State scale location map

Description of the study:

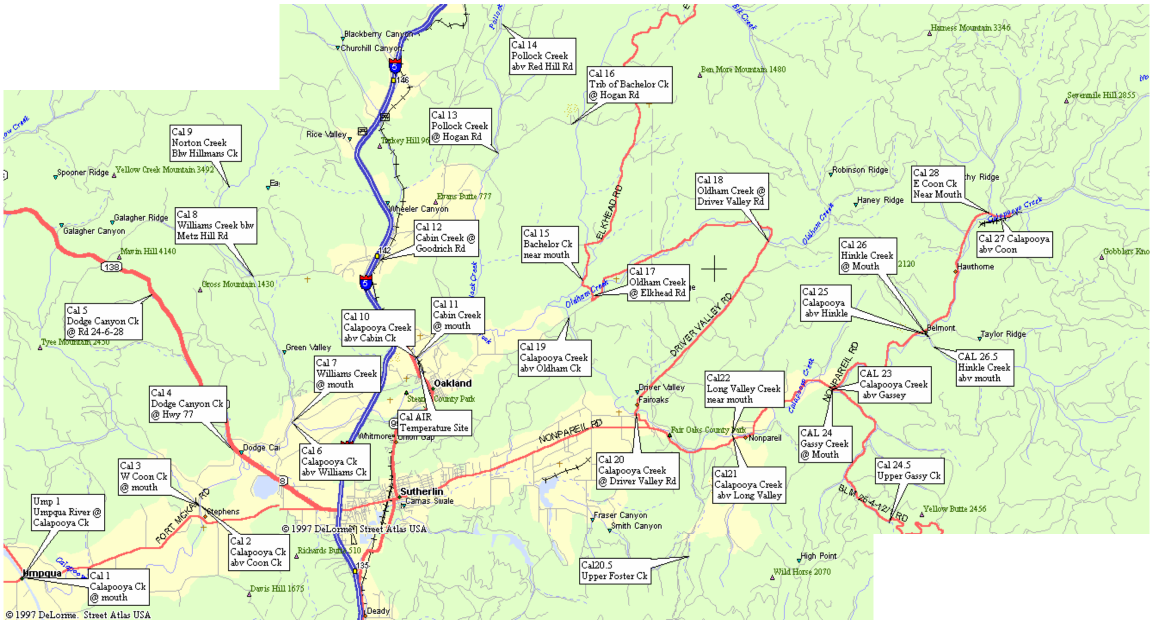
Site Selection:

Twenty-eight site locations were chosen to obtain a representative sample of the various types of streams throughout the watershed. Data were also obtained from one DEQ and two BLM monitoring stations for a total of 31 stations within the watershed. No sites were monitored in the upper main stem of the Calapooya above East Coon Creek because permission to monitor was not granted by the landowner.

Sites were selected to provide a broad representative sample of streams in the watershed. An emphasis was placed on monitoring the smaller streams to better understand their temperature characteristics and how they affect the larger streams. Sites on the mainstem of the Calapooya were typically paired with a site at the mouth of a tributary.

At site Cal 10 which is in the center of the watershed near Oakland, an additional sensor was deployed to measure air temperature. The unit was placed in a shaded location about 10 feet above the water. It is recommended that the Cal 10 be used in the future as a temperature baseline station for the watershed.

The locations of the monitoring sites are shown on Map 2. Site numbers with decimal extensions represent sites monitored by other agencies. Detailed information for each site is included on Site Data Sheets in Appendix A. Digital picture computer files are also available for each site that show the upstream and downstream views as well as the logger site location.



Map 2 Temperature Monitoring Sites in the Calapooya Watershed

Chart 1 shows the relative elevation of the sites and the stream miles to the mouth of the Calapooya. Note the discontinuity between site 20 and site 21.

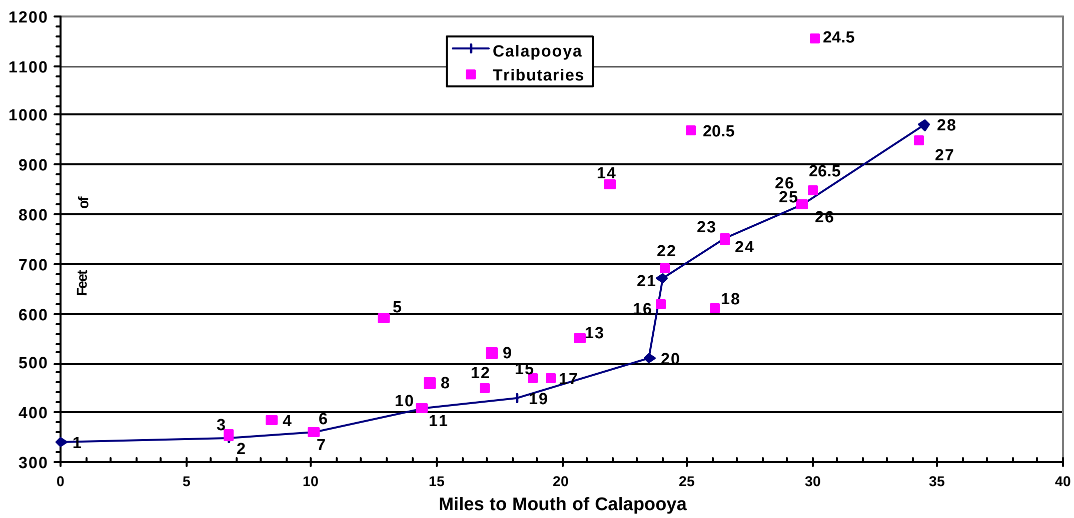


Chart 1 Site Elevation Vs Stream Distance From Mouth of Calapooya Ck

Deployment and Collection:

The 28 UBWC "StowAway® Tidbit®" data logger units were deployed in the Calapooya watershed between June 11 and June 15 and collected between September 8 and September 10. The exact date of deployment and collection for the BLM and DEQ units is not available but the dates of the data record are shown on the Site Data Sheets in appendix A.

The units were set to record the temperature at 30-minute intervals. Typically, over 4,000 temperature measurements were taken at each site. Permission was obtained from landowners to access sites located on private property. An attempt was made to place the temperature logger device to assure it was measuring a representative sample of theactive steam at the site. However, on large streams it was often difficult to secure a unit directly in the central portion of the channel at a point where it would remain submerged as the flow recedes. In the small streams the challenge was to select sites with good circulation and enough water volume to keep the unit submerged. In spite of best efforts, several logger units were exposed by receding flows and some units ended up measuring the temperature of an isolated pool. The sites that experienced this condition are identified in the report.

Field Documentation:

A camcorder was used to document the exact sensor location and general characteristics of each UBWC deployment site. Digital picture files for each site were produced that show the downstream and upstream views as well as the sensor location. Copies of these files are available through the watershed council.

A VHS recording entitled "Calapooya Creek Temperature 1999– Field Notes" is also available for viewing or copying. The emphasis of this video was to document the location of each sensor unit. However, it also provides information about the general characteristics of each site.

Data sheets for each UBWC site were also developed that describe some of the site characteristics. Elevation data and the distances to mouth and ridge were obtained from mapping software. Local distance measurements at the site were estimated visually. Depth of unit at removal was measured with a tape measure to provide an indication of the final state of the unit. In some cases flow estimates were made using the streamflow nomograph in Appendix C. A temperature graph is also included on each sheet that charts all of the temperature data used to produce the summary statistics.

Accuracy Checks:

To assure that the logger units were operating properly an accuracy check was made on all of the UBWC instruments before deployment and after retrieval. A Traceable© reference thermometer was used to check each sensor at two different temperatures. Several readings were taken over a period of time to trace the response of the unit to an abrupt change in temperature. Chart 2 shows the results from a typical accuracy test. Note that the temperature time response of the units in stirred water is about six minutes. Tables 1 and 2 in Appendix B (Data Accuracy Information) shows the results of these tests. All of the units were within +0.3° and –0.1°C of the reference thermometer after thermal equilibrium was reached.

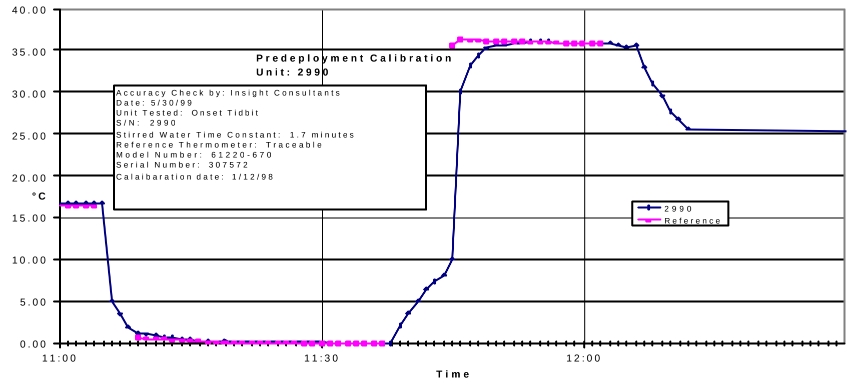


Chart2 Typical accuracy check for a Tidbit® unit.

A field audit was also conducted on all of the UBWC sites using a Traceable reference thermometer to measure the water temperature at the site. The recorded value was later compared with the corresponding data logger value. This method is not as accurate as the direct calibration method since the water temperature was, in some cases, changing rapidly and the logger units do not respond to the changes as rapidly as the reference thermometer. Nevertheless, the field audit temperatures matched the Logger temperatures within +/ 1ºF. (See Table 3 Appendix B). Since the accuracy of the sensors under controlled conditions was consistently better than +/- 0.2 °F, both before and after the field deployment, it is reasonable to assume that the larger deviations in the field audit data were the result of the procedure and should not be attributed to the data loggers.

Data Logger Results:

Each logger unit produced over 4000 readings that were loaded into an Excel® file. As mentioned previously, some of the data was affected by receding streamflow that caused the logger units to either become exposed to air or to end up in an isolated pool with no direct surface flow. All air-exposure data was trimmed from each file and discarded. The water temperature data from the isolated pool sites was retained because the pool temperature information has value when evaluating aquatic habitat. Table 1 provides a summary of the status of the end-of-season condition for each site.

- **Condition A**: Unit remained submerged in a flowing stream for entire period between 7/9 and 8/30. Seasonal statistics represent active flow conditions.
- **Condition B**: The stream flow receded to an isolated pool condition. Seasonal statistics were developed for the entire period that include both flow and pool conditions.
- **Condition C**: The unit was exposed to air temperatures by receding stream flow.

The data trim date is noted and seasonal statistics were not developed (except for Cal 1 which had sufficient record).

Site #	Site Name	Condition Category
Cal 1	Calapooya @ mouth	C 9/5
Cal 2	Calapooya Ck abv W Coon Ck	A
Cal 3	W Coon Ck @ mouth	A
Cal 4	Dodge Canyon @ Hy 77	B
Cal 5	Dodge Canyon @ Rd 24-6-28	C 7/13
Cal 6	Calapooya abv Williams Ck	A
Cal 7	Williams Ck @ mouth	B
Cal 8	Williams Ck @ Metz Hill Rd	A
Cal 9	Norton Ck blw Hillman trib	B
Cal10	Calapooya Ck abv Cabin Ck	A
Cal 11	Cabin Ck @ mouth	C 8/16
Cal 12	Cabin Ck @ Goodrich Rd	B
Cal 13	Pollock Ck @ Hogan Rd	A
Cal 14	Pollock Ck Abv Red Hill Rd	A
Cal 15	Bachelor Ck near mouth	A
Cal 16	Bachelor Ck @ Hogan Rd	A
Cal 17	Oldham Ck @ Elkhead Rd	A
Cal 18	Oldham Ck @ Driver Valley Rd	A
Cal 19	Calapooya abv Oldham Ck	A
Cal 20	Calapooya @ Driver Valley Rd	A
Cal 21	Calapooya Ck abv Long Valley Ck	A
Cal 22	Long Valley Ck near mouth	C 8/9
Cal 23	Calapooya abv Gassy	A
Cal 24	Gassey Ck @ mouth	B
Cal 24.5	Upper Gassy Ck	A
Cal 25	Calapooya abv Hinkle Ck	A
Cal 26	Hinkle Ck @ mouth	A
Cal 26.5	Upper Hinkle	A
Cal 27	Calapooya abv E Coon	A
Cal 28	E Coon Ck near mouth	A
UMP 1	Umpqua abv Calapooya	A
Cal AIR	Air Temperature @ Cal 10 site	A

Table 1 Site Data Record Condition

Preliminary Analysis

Seasonal Patterns

Each year the summer weather patterns cause a unique characteristic pattern that is generally apparent in all of the stream data within a river basin. Chart 3 compares the 1998 and 1999 results at a site in the Elk Creek watershed. Notice that the maximum values for this site were over 5 degrees warmer in 1998 and that 1999 had a relatively flat temperature profile. The flat shape of the 1999 pattern resulted in more variability in the dates of the seasonal maximum temperatures for the various sites.

The difference in the seasonal maximums that is apparent in Chart 3 demonstrates the value of same-year synoptic studies. Any direct comparison of data from different years would need to account for this between-year variability.

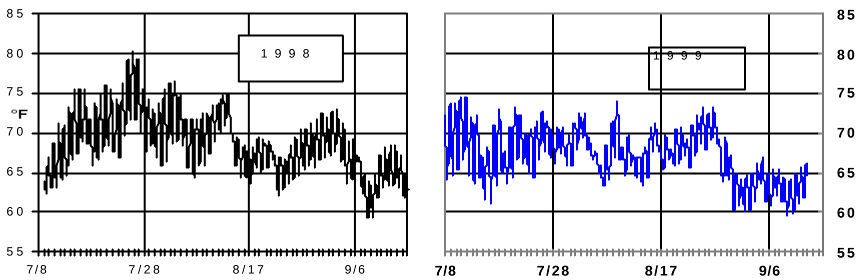


Chart 3 Comparison of 1998 and 1999 seasonal patterns (Data from Pass Creek @ mouth /Elk Creek

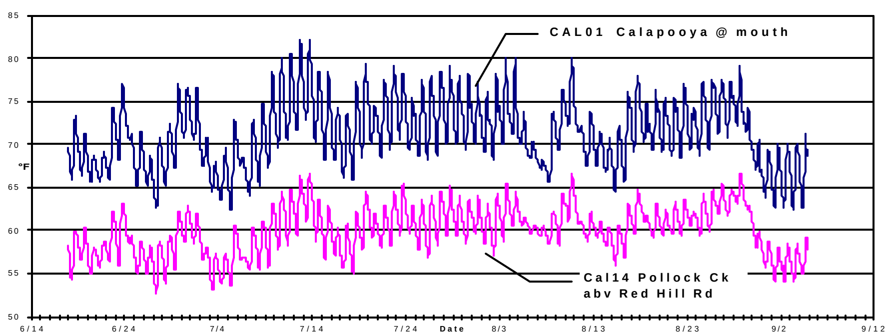


Chart 4 Typical pattern for the 1999 season.

Chart 4 shows typical patterns for the 1999 maximum temperature season for two sites in the Calapooya watershed. Notice the similarity of the data with the 1999 data in Chart 3 from the Elk Creek watershed. Since the elevated temperature period remained relatively uniform during the hot period between 7/10 and 8/30 there was not a common date for the maximum temperature at all of the sites. It appears that the streams in the lower part of the watershed showed a seasonal maximum around 7/13 while sites at higher elevations had a seasonal maximum near the end of August.

Site Temperature Statistics

Table 2 lists statistics generated by the DEQ Temperature Analysis Macro Version 1.1 when applied to the files with complete data records as identified in Table 1.

Deleted: <sp>

Site Name	Start	Stop	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
	Date	Date	Date	Value	Date	Value	Date	Value	Date	Max	Min	ΔT
Cal01 Calapooya @ mouth	06/18/99	09/04/99	07/13/99	82.0	09/03/99	62.4	07/18/99	11.4	07/12/99	80.0	70.1	9.9
Cal02 Calapooya abv W Coon	06/18/99	09/07/99	07/13/99	80.1	06/27/99	62.4	07/09/99	10.5	07/12/99	78.2	70.3	7.9
Cal03 W Coon @ mouth	06/18/99	09/07/99	07/13/99	74.2	07/05/99	54.9	07/19/99	12.3	07/12/99	71.7	60.8	10.9
Cal04 Dodge Canyon Ck @ Hwy 77	06/18/99	09/07/99	06/23/99	65.3	09/03/99	55.1	06/23/99	4.0	08/27/99	63.0	61.9	1.1
Cal05 Dodge Canyon @ rd 24-6-28	06/18/99	07/11/99										
Cal06 Calapooya abv Williams Ck	06/18/99	09/07/99	08/03/99	82.5	06/27/99	61.1	07/05/99	12.7	07/25/99	80.6	71.7	8.9
Cal07 Williams Ck @ mouth	06/18/99	09/07/99	07/13/99	73.3	09/03/99	55.3	07/26/99	11.7	07/26/99	72.0	62.4	9.6
Cal08 Williams Ck @ Metz Hill Rd	06/18/99	09/07/99	08/28/99	69.9	06/27/99	54.2	06/23/99	7.8	08/26/99	68.1	64.9	3.2
Cal09 Norton Ck blw Hillman's	06/18/99	09/07/99	08/28/99	66.5	09/02/99	52.9	08/31/99	5.0	08/27/99	63.8	61.0	2.8
Cal10 Calapooya abv Cabin	06/18/99	09/07/99	08/28/99	80.8	06/27/99	58.2	06/23/99	13.1	07/31/99	78.9	71.1	7.7
Cal11 Cabin Ck @ mouth	06/18/99	08/12/99										
Cal12 Cabin Ck @ Goodrich Rd	06/18/99	09/07/99	07/13/99	75.3	09/03/99	54.9	07/19/99	10.6	07/12/99	72.6	64.4	8.3
Cal13 Pollock Ck @ Hogan Rd	06/18/99	09/07/99	08/10/99	71.2	09/03/99	54.1	07/09/99	9.6	08/26/99	69.2	63.4	5.8
Cal14 Pollock Ck abv Red Hill Rd	06/18/99	09/07/99	08/28/99	66.6	06/27/99	52.7	07/09/99	7.4	08/26/99	64.7	61.1	3.6
Cal15 Bachelor Ck near mouth	06/18/99	09/07/99	08/28/99	75.8	09/03/99	57.1	08/27/99	9.2	07/28/99	72.8	65.2	7.6
Cal16 Bachelor Ck Trib @ Hogan R	06/18/99	09/07/99	08/28/99	63.9	06/18/99	54.8	06/18/99	3.6	08/27/99	62.7	60.9	1.8
Cal17 Oldham Ck @ Elkhead Rd	06/18/99	09/07/99	08/03/99	81.1	06/27/99	57.6	08/02/99	14.2	07/31/99	79.4	67.1	12.2
Cal18 Oldham Ck @ Driver Valley R	06/18/99	09/07/99	07/13/99	75.4	06/27/99	54.2	07/05/99	13.4	07/12/99	73.7	63.4	10.3
Cal19 Calapooya abv Oldham	06/18/99	09/07/99	08/10/99	79.5	06/27/99	56.0	06/29/99	13.1	07/25/99	76.7	66.2	10.5
Cal20 Calapooya @ Driver Valley R	06/18/99	09/07/99	08/10/99	74.7	06/27/99	55.8	08/16/99	9.6	07/12/99	72.6	64.6	8.1
CAL20.5 Upper Foster Creek	07/08/99	10/07/99	08/29/99	57.5	09/28/99	46.4	09/26/99	3.6	08/27/99	57.0	56.0	1.0
Cal21 Calapooya Ck abv Long Valle	06/18/99	09/07/99	08/28/99	75.1	06/27/99	54.5	06/22/99	8.9	08/26/99	72.9	67.7	5.1
Cal22 Long Valley Ck near mouth	06/18/99	08/09/99										
Cal23 Calapooya abv Gassy	06/18/99	09/07/99	08/28/99	75.5	06/27/99	51.6	07/05/99	14.2	07/31/99	73.5	61.8	11.7
Cal24 Gassy Ck @ mouth	06/18/99	09/07/99	08/28/99	70.4	09/07/99	50.2	08/25/99	9.2	08/26/99	67.1	60.0	7.0
CAL24.5 Upper Gassy Creek	07/07/99	10/07/99	08/29/99	57.8	09/28/99	49.7	07/18/99	2.5	08/27/99	57.4	56.6	0.9
Cal25 Calapooya abv Hinkle	06/18/99	09/07/99	08/28/99	71.5	06/27/99	50.0	07/05/99	13.0	07/31/99	69.4	60.2	9.2
Cal26 Hinkle Ck @ mouth	06/18/99	09/07/99	08/28/99	66.6	07/05/99	50.2	07/05/99	8.9	08/26/99	65.0	60.5	4.5
Cal26.5 Upper Hinkle	07/17/99	11/14/99	08/28/99	66.6	11/02/99	42.4	07/18/99	8.6	08/26/99	64.9	60.4	4.5
Cal27 Calapooya abv E. Coon	06/18/99	09/07/99	08/28/99	70.6	07/05/99	49.2	07/26/99	14.0	07/31/99	69.5	57.5	12.1
Cal28 E Coon near mouth	06/18/99	09/07/99	08/28/99	67.4	07/05/99	50.3	07/05/99	8.7	08/26/99	65.4	60.1	5.3
CalAIR Temp Calapooya Ck	06/18/99	09/07/99	07/09/99	100.4	09/03/99	41.8	07/05/99	57.1	07/10/99	96.4	53.7	42.7
Ump01 Umpqua abv Calapooya	06/18/99	09/07/99	08/26/99	73.3	06/22/99	59.5	07/08/99	4.1	08/26/99	72.2	70.5	1.7

Site Name	Lat	Long	Days > 55 F	Days > 64 F	Days > 70 F	Hours > 55 F	Hours > 64 F	Hours > 70 F	Warmest day of 7-day ma			Agency
									Date	Max	Min	
Cal01 Calapooya @ mouth	43 22 0.33	123 28 6.42	79	79	69	1895.5	1851.0	1113.5	07/12/99	82.0	71.8	UBWC
Cal02 Calapooya abv W Coon	43 23 13.48	123 23 36.7	82	82	65	1967.5	1937.0	1147.0	07/13/99	80.1	73.6	UBWC
Cal03 W Coon @ mouth	43 23 12.43	123 23 37.3	82	64	15	1966.0	860.0	59.0	07/13/99	74.2	63.6	UBWC
Cal04 Dodge Canyon Ck @ Hwy 77	43 24 11.35	123 22 44.9	82	3	0	1967.5	10.0	0.0	08/28/99	64.2	63.0	UBWC
Cal05 Dodge Canyon @ rd 24-6-28	43 26 57.45	123 24 49.11										UBWC
Cal06 Calapooya abv Williams Ck	43 24 42.98	123 21 22.8	82	82	75	1967.5	1923.0	1372.5	07/28/99	82.5	73.1	UBWC
Cal07 Williams Ck @ mouth	43 24 43.22	123 21 25.1	82	68	22	1967.5	1129.0	104.0	07/23/99	73.0	63.8	UBWC
Cal08 Williams Ck @ Metz Hill Rd	43 27 14.96	123 22 17.7	82	53	0	1958.5	740.0	0.0	08/28/99	69.9	66.7	UBWC
Cal09 Norton Ck blw Hillman's	43 28 51.13	123 22 49.3	82	2	0	1901.5	16.5	0.0	08/28/99	66.5	63.3	UBWC
Cal10 Calapooya abv Cabin	43 25 51.62	123 18 11.54	82	82	72	1967.5	1819.5	1204.5	08/03/99	80.8	71.9	UBWC
Cal11 Cabin Ck @ mouth	43 25 53.11	123 18 20.02										UBWC
Cal12 Cabin Ck @ Goodrich Rd	43 27 37.83	123 19 10.6	82	72	28	1966.0	1135.5	157.0	07/13/99	75.3	67.2	UBWC
Cal13 Pollock Ck @ Hogan Rd	43 29 29.12	123 16 12.0	82	55	4	1938.0	701.5	18.0	08/28/99	70.9	65.9	UBWC
Cal14 Pollock Ck abv Red Hill Rd	43 31 43.57	123 16 8.6	82	21	0	1886.0	110.5	0.0	08/28/99	66.6	63.1	UBWC
Cal15 Bachelor Ck near mouth	43 27 10.67	123 14 5.55	82	76	40	1967.5	1479.5	301.5	07/28/99	74.0	66.0	UBWC
Cal16 Bachelor Ck Trib @ Hogan R	43 30 7.44	123 14 49.6	82	0	0	1966.0	0.0	0.0	08/28/99	63.9	62.2	UBWC
Cal17 Oldham Ck @ Elkhead Rd	43 27 1.5	123 13 36.3	82	82	60	1967.5	1612.0	615.5	08/03/99	81.1	67.1	UBWC
Cal18 Oldham Ck @ Driver Valley R	43 27 54.75	123 9 26.34	82	76	42	1963.0	1253.5	313.5	07/13/99	75.4	65.9	UBWC
Cal19 Calapooya abv Oldham	43 26 36.43	123 14 28.7	82	81	56	1967.5	1526.5	560.0	07/23/99	77.9	67.1	UBWC
Cal20 Calapooya @ Driver Valley R	43 24 53.29	123 12 47.5	82	68	21	1967.5	1332.5	109.5	07/12/99	74.1	65.5	UBWC
CAL20.5 Upper Foster Creek	43.3737	123.1898	38	0	0	620.0	0.0	0.0	08/28/99	57.5	57.0	BLM
Cal21 Calapooya Ck abv Long Valle	43 24 32.84	123 10 18.4	82	73	28	1964.0	1344.0	284.0	08/28/99	75.1	69.9	UBWC
Cal22 Long Valley Ck near mouth	43 24 38.29	123 10 16.43										UBWC
Cal23 Calapooya abv Gassy	43 25 19.86	123 7 51.05	82	70	37	1901.5	844.0	235.5	07/28/99	75.2	62.5	UBWC
Cal24 Gassy Ck @ mouth	43 25 19.05	123 7 51.65	82	33	1	1890.0	241.5	1.5	08/28/99	70.4	63.4	UBWC
CAL24.5 Upper Gassy Creek	43.3834	123.1023	49	0	0	784.5	0.0	0.0	08/28/99	57.8	57.5	BLM
Cal25 Calapooya abv Hinkle	43 26 18.11	123 5 30.4	82	53	4	1815.0	526.5	10.0	07/28/99	70.3	60.7	UBWC
Cal26 Hinkle Ck @ mouth	43 26 17.18	123 5 31.25	81	20	0	1660.5	93.5	0.0	08/28/99	66.6	62.5	UBWC
Cal26.5 Upper Hinkle	43 26 1.57	123 05 14.9	72	16	0	1572.5	83.5	0.0	08/28/99	66.6	62.4	DEQ
Cal27 Calapooya abv E. Coon	43 28 20.97	123 3 34.88	82	47	3	1641.0	324.5	6.5	07/28/99	70.6	57.6	UBWC
Cal28 E Coon near mouth	43 28 26.66	123 3 52.01	82	21	0	1702.5	100.0	0.0	08/28/99	67.4	62.1	UBWC
CalAIR Temp Calapooya Ck	43 25 51.62	123 18 11.54	82	80	75	1648.5	887.0	554.0	07/09/99	100.4	48.5	UBWC
Ump01 Umpqua abv Calapooya	43 21 55.87	123 28 3.37	82	68	29	1967.5	1565.0	436.5	08/26/99	73.3	71.5	UBWC

Table 2 Statistical Summary Table

Chart 5 provides a visual comparison of the seasonal maximum, 7-day maximum and ΔT statistics

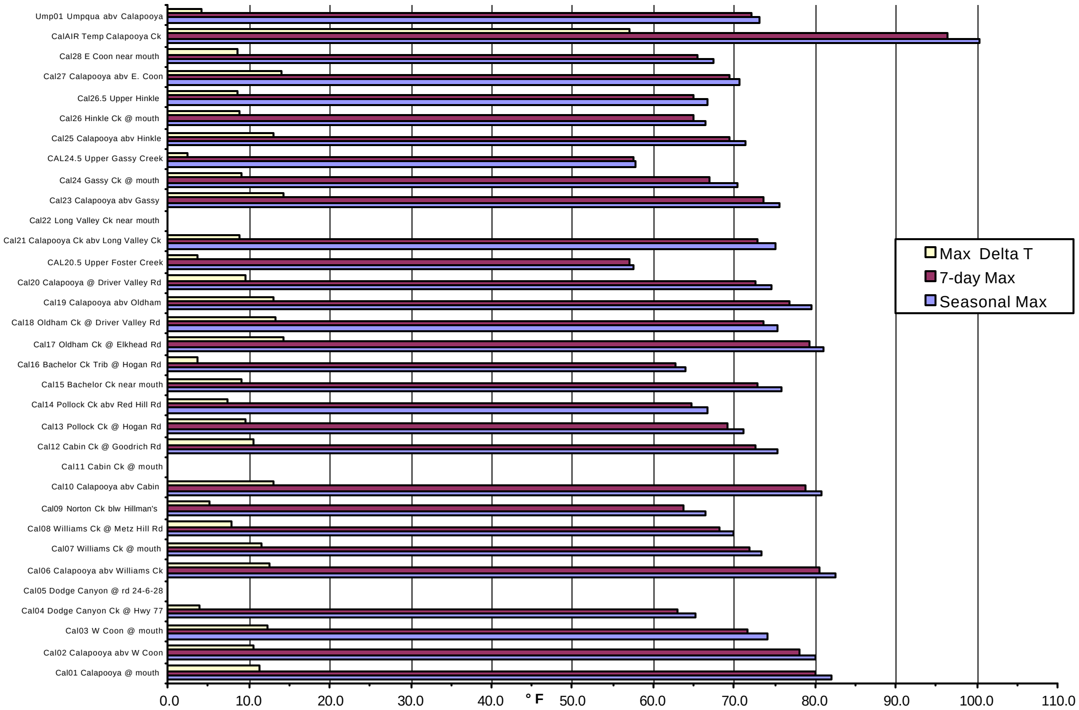


Chart 5 Summary of key seasonal statistics

Notes to Table 2 and Chart 5:

- The seasonal maximum value is the highest daily temperature measured at the site.
- The maximum ΔT (Delta T) represents the largest difference between the daily maximum and minimum for the site.
- The 7-day maximum is the seasonal maximum of the 7-day running average of the daily maximum values. This statistic blends a time duration factor with the maximum value and is part of the state criteria for stream temperatures.
- The “Cal Air” entry is air temperature measured at site Cal 10.
- The Umpqua River is cooler than the Calapooya in the vicinity of the mouth. Typically the tributaries are cooler than the larger stream or river.
- The Seasonal maximums from the various sites ranged between 82.5 and 57.5 with an average of 72.0 °F.
- The 7-day maximums lagged the seasonal maximums by an average of 1.9 °F with a maximum difference of 3.31 °F.
- The maximum ΔT value ranged from 14.2 to 2.5 with an average of 9.7 °F.

Spatial analysis of the data

Distance from the mouth

A basic objective of this project is to better understand the distribution pattern of the stream temperatures within the watershed. To accomplish this on a two dimensional chart, it is helpful to plot the site data as a function of the distance from the mouth of the watershed being studied. This approach emphasizes the distance "up-the- river" from the mouth to a particular site and it provides the opportunity to compare the temperature of the mainstem stream with the temperature of a contributing tributary.

To provide a synoptic or "snapshot" view of the data it was necessary to select an appropriate date for the analysis. The seasonal statistics were not used since the seasonal maximum did not occur on the same day at all of the sites. Data from August 28 was used because the majority of sites experienced their seasonal maximum on this date. The interested reader can do a similar analysis for other dates using data gleaned from the appendix.

Chart 6 shows how the maximum, minimum and ΔT temperatures that were measured on 8/28/99 varied when displayed as a function of their distance from the mouth of the Calapooya. The points connected by the dark line represent the sites that were on the main stem of Calapooya Creek and the box shaped points indicate data from the tributaries. The sites joined by the dotted arrows indicate paired sites where the main stem temperature was measured directly upstream from the mouth of a measured tributary.

Chart Use Example: To fully understand the chart, it is helpful to look at an example. Site 6 in on the Calapooya above Williams Creek and is located about 10 miles upstream from the mouth of the river. Site 7 in on the mouth of Williams Creek in the same vicinity. A fish in this area would experience cooler temperatures in the mouth of Williams than in the Calapooya. Site 8 is in Williams Creek at Metz Hill Road which is about 4 miles further up Williams Creek.

General Observations: Note that the maximum temperature of the tributaries is generally about 10°F cooler than the main stem temperatures on the lower end. An important implication is that the tributaries can provide a cooler refuge for fish when there is sufficient habitat and cover. It is also interesting to note that Site 2 and Site 20 are significantly cooler than other points on the mainstem. Site 20 is associated with a canyon while site 2 is associated with a large, slow moving body of water. Topographic shading and/or higher groundwater may be contributing factors. It is interesting to note that the Elk Creek study showed a similar effect in Elk Creek in the canyon area below the Hwy 38 tunnel. Also, note in Chart 1 that there is a major change in channel gradient above Site 20. It is possible that this change may be causing a higher groundwater contribution to the stream.

Some of the tributaries had two or more sites along them and a temperature – distance profile can be developed. For example, Sites 9, 8, and 7 are located along Williams Creek. Site 9 is near the source and is relatively cool. The water appears to heat fairly rapidly to site 8 and then recover to a lower level at site 7. Even though, as a general rule, there is a trend for stream temperatures to increase in the downstream direction, it is also apparent that local conditions can occasionally cause a deviation from the trend.

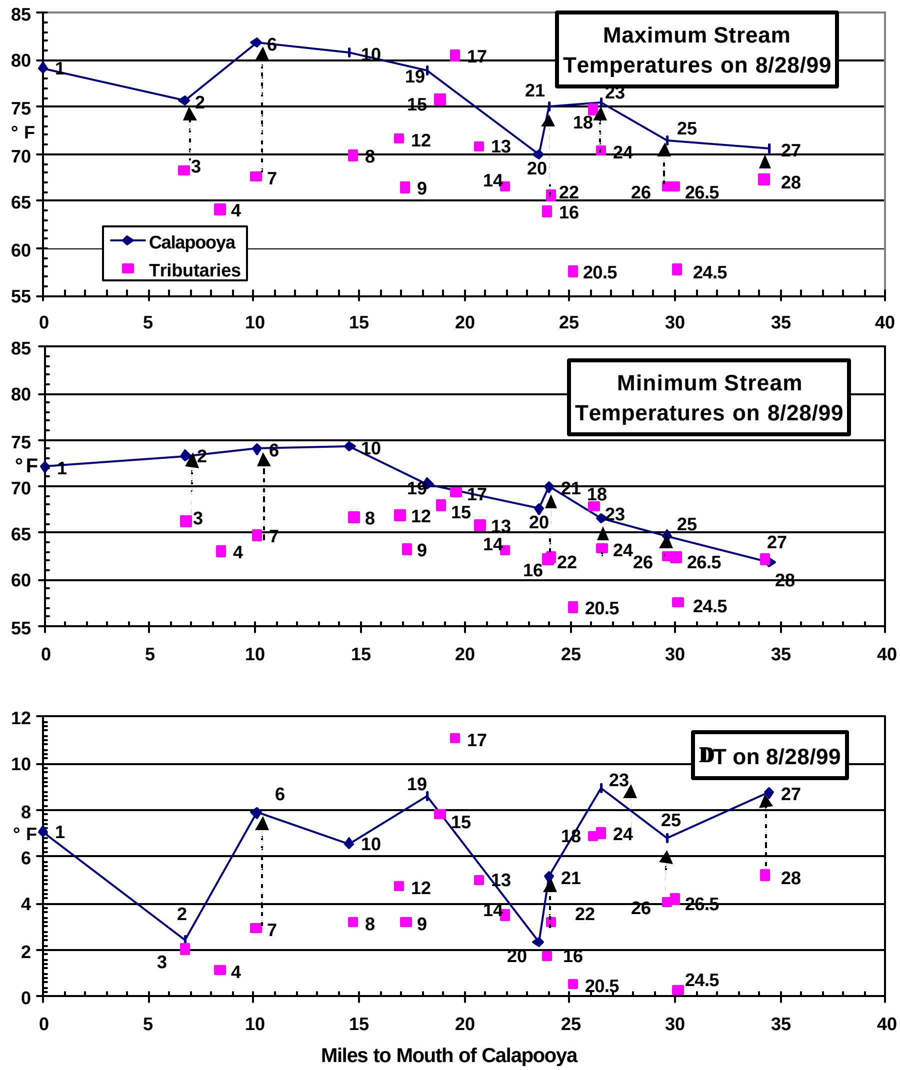


Chart 6 Calapooya Watershed Maximum, Minimum and DT Temperatures for August 28, 1999 Vs Distance to the Mouth of the Calapooya

The ΔT value represents the range of temperatures experienced at a site for a 24-hr period. Since the solar radiation is the only variable that changes regularly on a daily basis, most of the variability in the ΔT values between the sites is associated with changes in the amount of solar energy received by the stream. Vegetative shade, topographic shade, cloud cover, and solar path influence the amount of solar energy received on any give day. Sites with high ΔT are apparently receiving a higher level of solar energy per unit volume throughout the day. Large streams and rivers may experience a low ΔT due to the large volume of water that is being heated.

An example of this effect is shown in Chart 7 which plots the temperature pattern for the Umpqua River at a site above the mouth of Calapooya Creek. Since the river is wide and the riparian shading is minimal, the water surface is receiving the full amount of solar radiation. However, the mass of the water is so great that the solar energy does not raise the water temperature very rapidly.

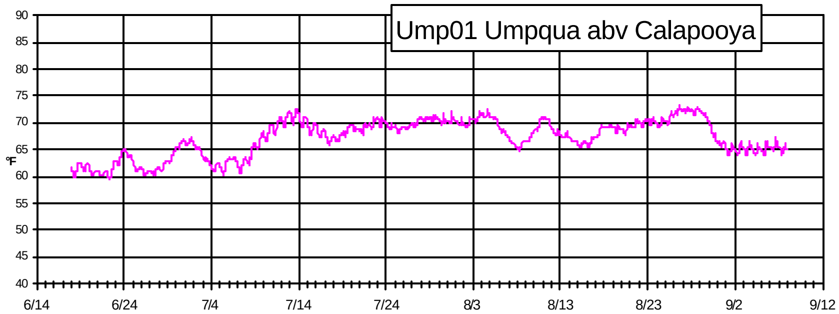


Chart 7 Stream Temperature - Umpqua River above Calapooya

An example of the effect of a low mass situation as shown in Chart 8 which is the temperature graph from the air temperature site near Cal 10. The low mass and heat capacity of the air results in high temperatures even in a well shaded micro environment. Air convection is also a factor that can bring heated air from the surrounding area.

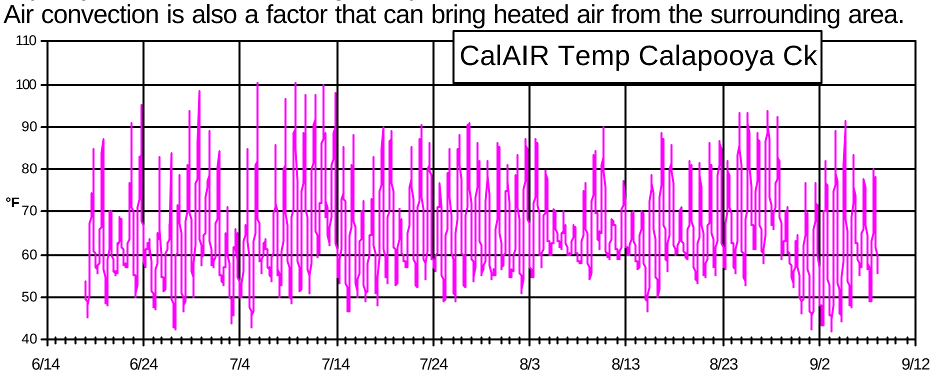


Chart 8 Air Temperature at site Cal 10 near Oakland

Very small streams also have small mass but can still have a small ΔT as shown in Chart 9. Shade is probably the dominant factor keeping the water cool but groundwater inflow and evaporation may also be significant. The flow at removal was estimated to be less than 0.01 cfs when the data logger was removed at the end of the season. Heat reaching such a small quantity of water would tend to cause a large temperature increase. Apparently, the effects of shade, evaporation and groundwater contribution outweigh the effect of any solar energy reaching the water.

An interesting conclusion from the above discussion is that ΔT values may be minimal for both large and small streams with a maximum for intermediate streams. The August 28 ΔT value for the Umpqua River above Calapooya was 1.5°F. The distance to the ridge for the Umpqua is about 120 miles. Applying this information to the ΔT chart on chart 6 suggests that ΔT values peak between 5 and 15 miles and then may decline slowly at the average rate of about 0.08 °F/mile to points further downstream.

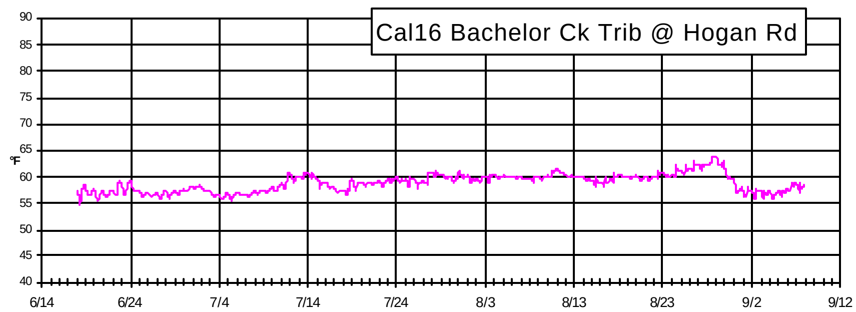


Chart 9 Temperature graph of tributary of Bachelor Creek

Distance to the source ridge

There is a strong association between the size of a stream and its temperature. It is well known that streams generally get larger as they accumulate more water while moving down through the watershed. With increased flow, they generally get wider, deeper and flow faster. Also, the channel bank and bed characteristics change as well as the type and extent of riparian vegetation. Likewise, the proportional contribution of groundwater inflow also generally decreases. All of these effects can influence the stream temperature and generally contribute to higher stream temperatures in the down stream direction.

Likewise the quality of the fish habitat tends to be related to the size of the stream. The very small streams may be the coldest but they may not have a sufficient volume of water for adequate rearing during the summer months. The large streams have sufficient water but may get too warm. If temperature is limiting the fish, there may be an optimum stream size range that has the right mix of water and temperature. If this proves to be the case, these areas should be identified and receive management emphasis.

Plotting the sites as a function of the distance to their respective ridgelines is a way to roughly sort the streams by size. In general, sites that are the same distance to their respective ridge will be more similar than other sites. For example, points 5 miles from the ridge of each stream will tend to have similar flows and channel characteristics. Of course, this relationship breaks down if the streams are in different geographic area or have different watershed geometry. For that reason, this type of comparison should be made only in the same geographic area. It should be noted that this sorting does not account for elevation but it does account, to some extent, for vertical drop from the source ridge.

Chart 10 shows how the maximum, minimum and T temperatures on 7/28 varied as a function of the distance of the site to the stream's respective source ridgeline. For example, site 20 (Calapooya @ Driver Valley) is about 19.5 miles downstream from its source ridge on the east end of the watershed while the source ridge for Site 7 (Williams Ck @ mouth) is about 10 miles up Williams Creek on the northwest edge of the watershed.

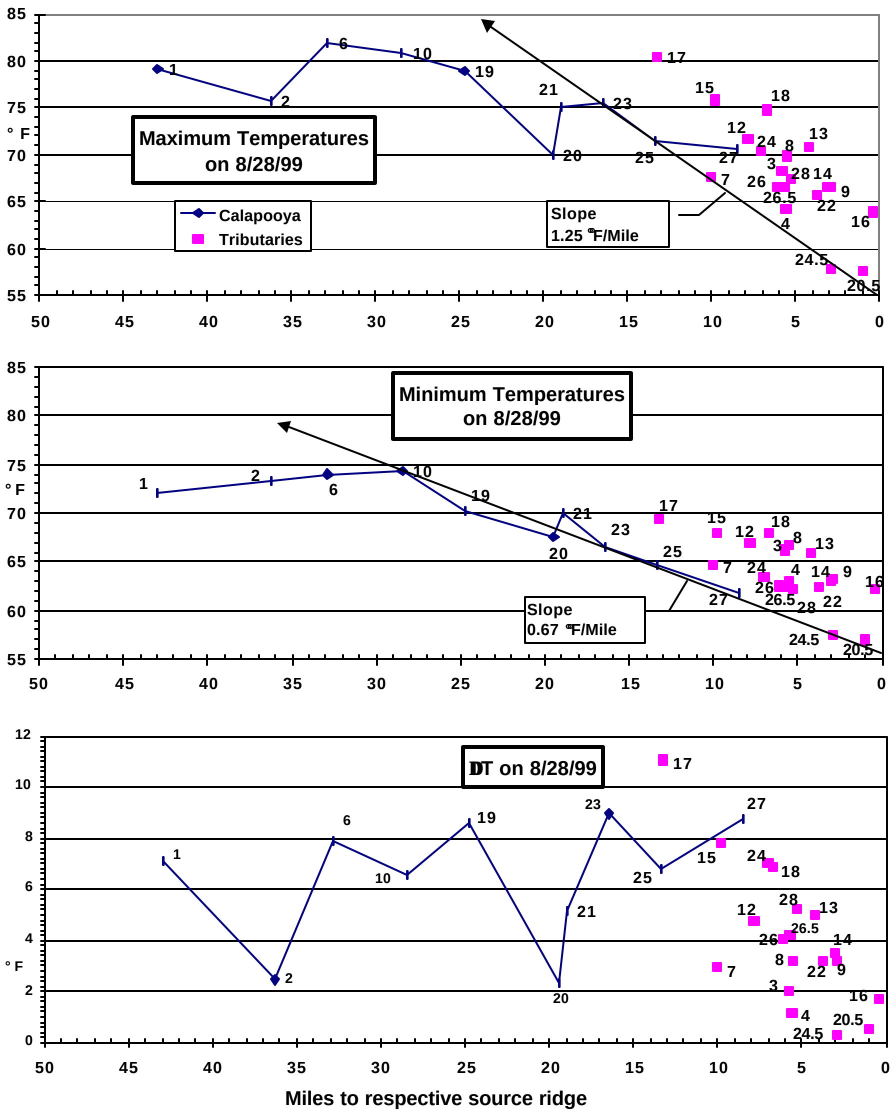


Chart 10 Calapooya Watershed Maximum, Minimum and ΔT Temperatures for August 28, 1999 Vs Distance to the respective source ridge.

Since the streams associated with a particular river-mile will tend to have similar size and flow characteristics, one would expect they would have similar temperature if they had similar shade characteristics. It is readily apparent from chart 10 that there is considerable temperature variability between sites at any given ridge distance. To the extent that these sites have similar size, shape and flow, the remaining variability can be associated with differences in shade. Consequently, the chart provides a "first cut" of sites that may benefit from improved shade. However, it should be emphasized that there may be other factors that cause a site to have elevated temperatures and a local field assessment would be required before a site-specific management plan is developed.

These charts can help show how streams gain heat as they move downstream from their source point. A typical temperature for emergent groundwater at a headwater source is about 52°F and the stream temperature generally tends to increase in the downward direction as the channel get wider, exposure increases and the percent of local groundwater contribution to total flow decreases.

The sites along the lower edge of the cluster are of interest because they represent the best temperatures in the watershed under current conditions. The important implication is that shade management on the other sites may bring the maximum temperatures down to at least this level. The question remains open whether these sites represent the best possible conditions and the lowest possible temperatures. Further analysis and modeling is needed to determine the expected temperatures under "ideal" watershed conditions. Nevertheless, it is apparent that there are many streams in the 4 to 12 mile range with potentially good habitat that could be cooled as much as 10°F. Cold-water fish that are trying to survive in these areas would certainly benefit from this reduction.

Conclusions

When the results of the Calapooya study are combined with the Elk Creek study several important points can be inferred.

Key Observations:

- All observed streams that were more than three miles from the ridge source area significantly and frequently exceed 64 °F during the summer season.
- Based on the rate of heating for maximum temperatures shown in chart 10, streams less than 7 miles from the ridge could potentially be at or below 64 °F.
- There is a general tendency for streams in the 0-20 mile range to heat in the downstream direction. However, downstream temperatures for individual streams can be colder than points upstream if conditions are significantly different. (Example: Williams Creek)
- The low temperature areas on the main stem (sites 2 and 20) may have an association with canyon-like topography and/or increased groundwater inflow.
- The warmer sites appear to have a strong association with exposure to direct solar radiation (absence of shade).
- The low flow period represents an extreme condition in the stream channels. Surface flow velocities can tend toward zero as the streams go dry. The resulting isolated pools apparently can remain relatively cool. Hyporheic (groundwater flow)

circulation may be a contributing factor. The data from these pools provides an opportunity to test the calibration of the stream temperature models under zero surface flow conditions.

- Maximum ΔT values may occur between 5 and 15 miles of the ridgeline.

Management Implications:

The small tributaries may be providing important thermal refuge areas for the cold-water fish species and other aquatic life. Since the watershed does support a population of cold-water fish, they would likely benefit from any temperature reductions at any point in the watershed. Increasing stream shade may be the most direct way to obtain these reductions. A long-term management objective could be to achieve a full shade condition for all perennial streams in the watershed. However, it should be noted that a significant benefit could be realized by improving the effectiveness of the existing riparian shade. Assigning implementation priority to improving existing buffers would have the advantage of (1) faster results since vegetation is already established and (2) not requiring a land use change.

Recommended additional work:

- Inventory the stream shade in the watershed and use models to determine potential stream temperatures under various shade and flow conditions.
- Take additional field temperature measurements at the low temperature sites to determine the nature and extent of these areas.
- Correlate fish presence data with the temperature data to identify the optimum habitat zones if they exist.
- Develop a temperature management plan for the watershed.
- Monitor the stream temperature at site Cal 10 each year to provide a link between current conditions and the 1999 data.
- Conduct similar characterization studies in other watersheds in the Umpqua Basin.
- Manage the watershed for increased/ optimum shade to reduce the maximum summer heating.

Other Information

About the Data used for the analysis

The following provides source and accuracy information for the data used in the analysis:

Tidbit data loggers

Appendix B contains the specifications for the logger as well as results from the pre and post deployment accuracy checks and the field audit. The procedure was discussed in the "Accuracy Check" section of this report.

Stream Distance

Stream mile distance between major streams was obtained from the ODFW stream database. The distance to the source ridge was measured using Terrain Navigator® mapping software from Maptech. The error between any two stations is estimated as +/- 0.2 miles.

Position

The longitude and latitude were measured using Terrain Navigator® mapping software from Maptech. Maximum error is estimated at +/- .1 minute.

Elevation

Elevation data for the monitoring sites were estimated from USGS 1:24000 quad maps with 40-foot contours. Error in elevation data is estimated at +/- 10 feet.

Field Materials and equipment

The following materials were used to conduct this study:

- 30 temperature data loggers
- camcorder
- Traceable thermometer
- rebar wire
- surgical tubing
- hip waders
- brush clippers

Further Information

For information on obtaining the following:

1. VHS Video "Field Notes" approximately 1 hr. Shows details of each sensor location and some general site characteristics – includes written narrative.
2. .jpg picture files of each site.
3. Raw data files from each site.

Contact:

Umpqua Basin Watershed Council, 1758 N.E. Airport Road, Roseburg OR 97470.
InSight Consultants. PO Box 10, Yoncalla OR 97499.

k