Umpqua Basin Watershed Council

Lower Umpqua Watershed Temperature Study 2000

Procedure, results and preliminary analysis

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Bill Arsenault – data contributor
The Temperature Analysis Macro Version 1.1 developed by Medford DEQ was used to develop the seasonal statistics.

Kent Smith
Consultant, InSight Consultants
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Note:
The units of measurement chosen for this report are degrees Fahrenheit and miles to facilitate use by non-technical readers. A unit conversion chart is available on the last page of this document.

Lower Umpqua Watershed Temperature Study - Summer of 2000

Summary

Temperature data from 48 continuously sampling data loggers was obtained from monitoring sites throughout the Lower Umpqua Watershed during the summer of 2000. The seasonal maximums from the various sites ranged between 82.4 and 60.9 °F with an average of 70.5 °F. The 7-day maximums lagged the seasonal maximums by an average of 1.1 degrees with a maximum difference of 4.1 °F. The maximum ΔT (difference between daily maximum and minimum values) value ranged from 1.8 to 15.7°F with an average of 8.3 °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 Lower Umpqua River with smaller streams typically cooler than larger streams. Charting the data with respect to the distance from the source ridge of each stream indicated that the maximum temperature of the coldest streams tended to increase on a logarithmic scale at the rate of 10 degrees for every multiple of ten miles. 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:

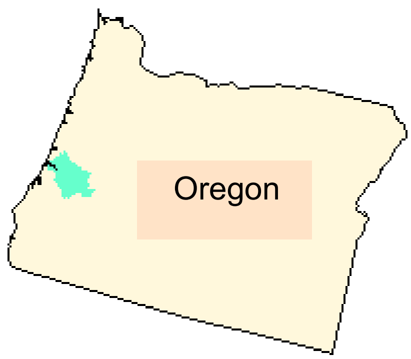
This study was sponsored by the Umpqua Basin Watershed Council (UBWC) and is part of an ongoing project to characterize the summer stream temperature regime in the interior watersheds of the Umpqua River Basin with an emphasis on the seasonal maximum temperatures. This particular study is directed at stream temperatures within the Lower Umpqua Watershed located between Mill Creek, near Reedsport, and Yellow Creek near Kellogg. 48 monitoring sites were established that collected stream temperature data simultaneously at 30-minute intervals.

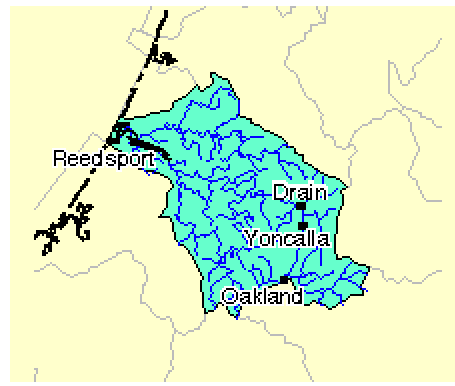
A preliminary analysis using statistics from the data was completed to examine the range of seasonal and daily variability in the data as well as the spatial distribution of the temperature patterns and the effect of stream size on stream temperature. It is expected that this data and analysis will provide a basis for addressing site specific temperature related issues, aquatic habitat evaluation, a Temperature Management Plan for the watershed and further study.

Study Area:

Geographical Characteristics

The Lower Umpqua River Watershed is the portion of the Umpqua River system located below the confluence of the North and South forks of the Umpqua River and continues to the Pacific Ocean near the City of Reedsport. The watershed area is about 1518 square miles with elevation ranging from sea level to about 4000 feet at the eastern edge. Most of the watershed is in the Mid-Coastal Sedimentary ecoregion with portions in Umpqua Interior Foothills and Coastal Uplands.





Description of the study:

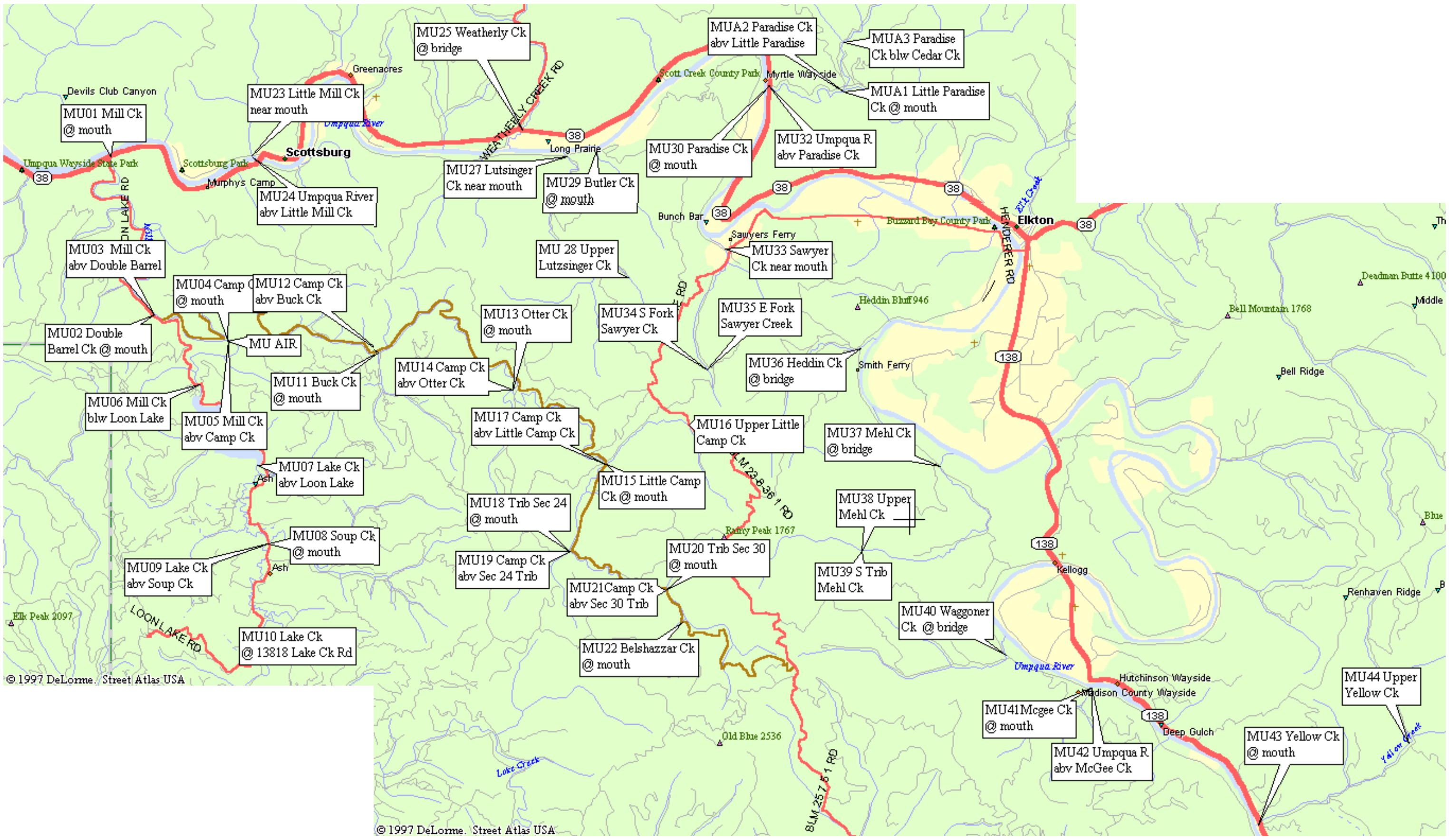
Site Selection:

Forty-five UBWC site locations were selected to obtain a representative sample of the various types of streams throughout the watershed. Data were also obtained from three sites from a private landowner for a total of forty-eight stream temperature sites. Air and stream temperature was also measured at Mill, Pass, Calapooya, North Myrtle, and Windy Creeks to provide a reference sample of the entire central basin.

Emphasis was on placing sites in the lower portion of the Lower Umpqua watershed since the temperature characteristics for the Elk Creek and Calapooya Creek subwatersheds had been previously determined in 1998 and 1999 respectively. No sites were monitored in the upper portion of Lake Creek because permission to access for deployment was not granted by the property owner.

The UBWC sites were selected to provide a broad, representative sample of all types of streams in the watershed. An emphasis was made to include the smaller streams to better understand their temperature characteristics and how they affect the larger streams. Sites on the main streams were often paired with a site at the mouth of a contributing tributary.

The locations of the monitoring sites are shown on Map 1. Site Data Sheets containing temperature data and other site related information are included in Appendix A. Digital picture computer files are also available for each site that show the upstream and downstream riparian condition as well as the data logger site location.



Map 1 Temperature Monitoring Sites in the Western Portion of the Lower Umpqua River Watershed

Elevation and the associated channel gradients are important parameters that affect the energy of the stream as well as the local climatic regime. To help provide a three-dimensional perspective, Chart 1 shows the relative elevation of the sites plotted against the stream miles measured from the mouth of the Umpqua River. The point labels denote the monitoring site number.

The chart shows that all of the sites in this study were less than 1000 feet in elevation with the highest sites located in the upper Camp Creek area. The channel gradient for Paradise, Camp and Mill Creek appeared to follow similar patterns. The upper portion of the Mill/ Lake curve represents Lake Creek located above Loon Lake with a significantly lower channel gradient. This break indicates a geological change from coastal mountains to a plateau area. The gradient of the larger Umpqua River is also low as expected for a river of this size.

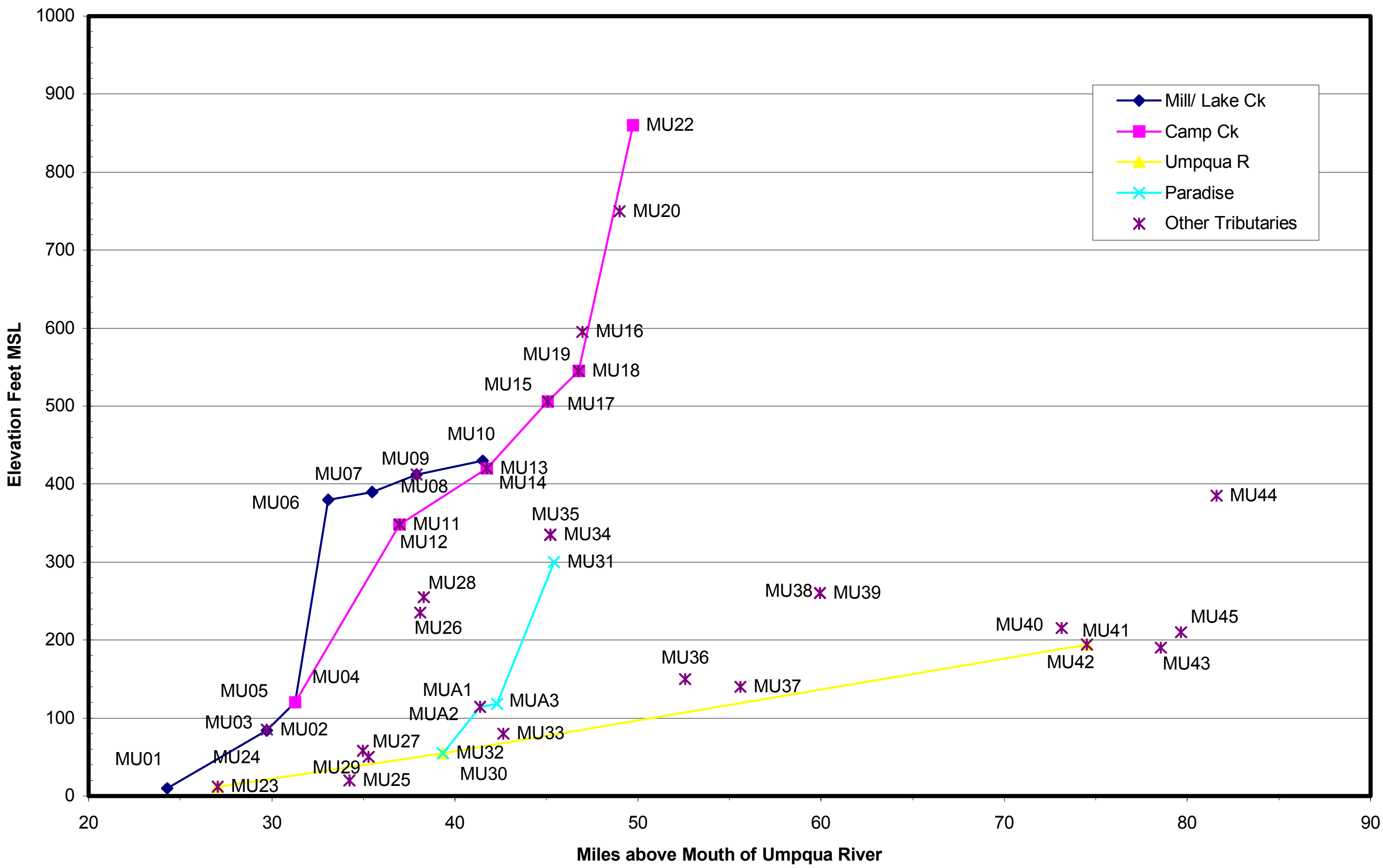


Chart 1 Site elevation with respect to river mile.

Deployment and Collection:

The 45 UBWC "StowAway® Tidbit®" data logger units were deployed in the Lower Umpqua Watershed between June 21 and June 29 and collected between September 20 and September 26, 2000. A field audit was conducted between August 4 and August 8 to obtain a temperature check and to assure that each data logger was properly submerged.

The units were set to record the temperature at 30-minute intervals and typically about 4,000 temperature measurements were collected 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 that it was measuring a representative sample of the active steam at the site. However, on the main river it was more difficult to place a unit directly in active flow 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, some of the logger units were exposed by receding flows and do not have a complete seasonal record. These sites are clearly identified in the data record.

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 also produced that show the downstream and upstream views as well as the sensor location. Copies of these files are available through the Umpqua Basin Watershed Council.

A VHS recording entitled “Lower Umpqua River Temperature 2000– Field Notes” is also available for viewing or copying. The emphasis of this video was to document the location of each sensor unit and the general site characteristics. However, some segments contain other observations including fish presence.

A data sheet was developed for each UBWC site that describes some of the site characteristics and is located in Appendix A. Stream distances to the mouth and source ridge were obtained from digitized streams on mapping software. Elevation data was determined by interpolation of 40-ft contours on computerized USGS quad maps. These maps also verified the site coordinates location data that was measured in the field with GPS equipment. Local distance measurements at the site were estimated visually. Several shade related observations were recorded: Vegetation altitude and density as well as the topographic altitude were taken for the riparian zones on each side of the stream. Wetted stream width, bank-full width, average depth, and bank-full depth were also recorded. Depth of unit at time of audit and time of removal was measured with a tape measure to provide an indication of the submerged state of the unit. Angle measurements for topographic and vegetation altitude were measured with a hand-held clinometer. The water circulation in the vicinity of the data logger was noted to provide an indication of thermal mixing. The circulation was rated “good” if there was obvious, visible flow around the logger unit. A “fair” rating meant that the unit was in a pool with obvious infow and outflow but without easily discernable circulation in the vicinity of the unit. A “poor” circulation rating meant that there was no discernable flow through the pool or around the submerged unit.

The site data sheets also chart the temperature data, which show graphically all of the recorded stream temperature data as well as the seven-day-average-of the daily maximum and the daily mean. The seven-day moving average value is plotted in the center of the seven-day interval and the daily mean is plotted each day at noon. A horizontal line is also plotted to depict the 64 °F temperature standard. The data at the end of the record was trimmed off to assure that no out-of-water temperature information was included. In a few cases, the units were exposed prematurely to air temperatures by receding stream flow. In these cases the data record was trimmed to assure that only water temperature data was included.

Accuracy Checks:

To assure that the logger units were operating properly, accuracy checks were made on all of the UBWC instruments before deployment and after retrieval. A NIST calibrated 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

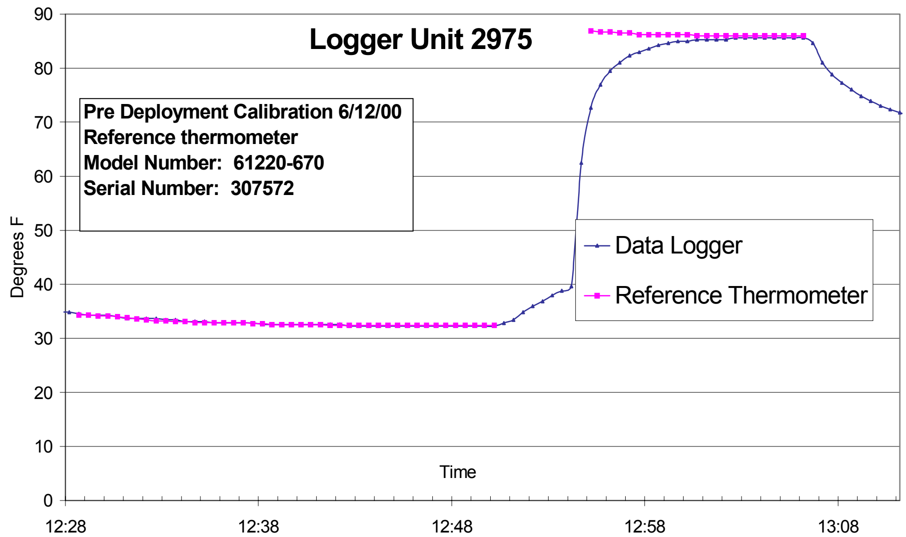


Chart 2 Typical accuracy check for a Tidbit® unit.

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 +0.1° and –0.4°C of the reference thermometer after thermal equilibrium was reached.

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 near the data logger. 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, most of the field audit temperatures matched the Logger temperatures within +/ 5°F. (See Table 3 Appendix B). Since the accuracy of the sensors under controlled conditions was consistently better than +/- 0.5 °F, both before and after the field deployment, it is reasonable to assume that the larger deviations in the field audit data were the caused by other factors and should not be attributed to the data loggers.

Preliminary Analysis

There are many factors that influence stream temperature and understanding the conditions and processes that cause variability over time and distance is essential for a sound temperature management program. The following analysis examines the variability in the data from several perspectives with the objective of introducing the reader to some basic concepts and methods for extracting useful information from the data.

Between Season Variability

Each year the summer weather patterns cause a unique characteristic temperature pattern that is generally apparent in all of the stream temperature data within a river basin. Chart 3 compares the 1998, 1999, and 2000 results at a site in the Elk Creek watershed located in the north central portion of the county. Notice that the maximum values for this site were over 5 degrees warmer in 1998. In 1998 there was a distinctive peak and most of the sites

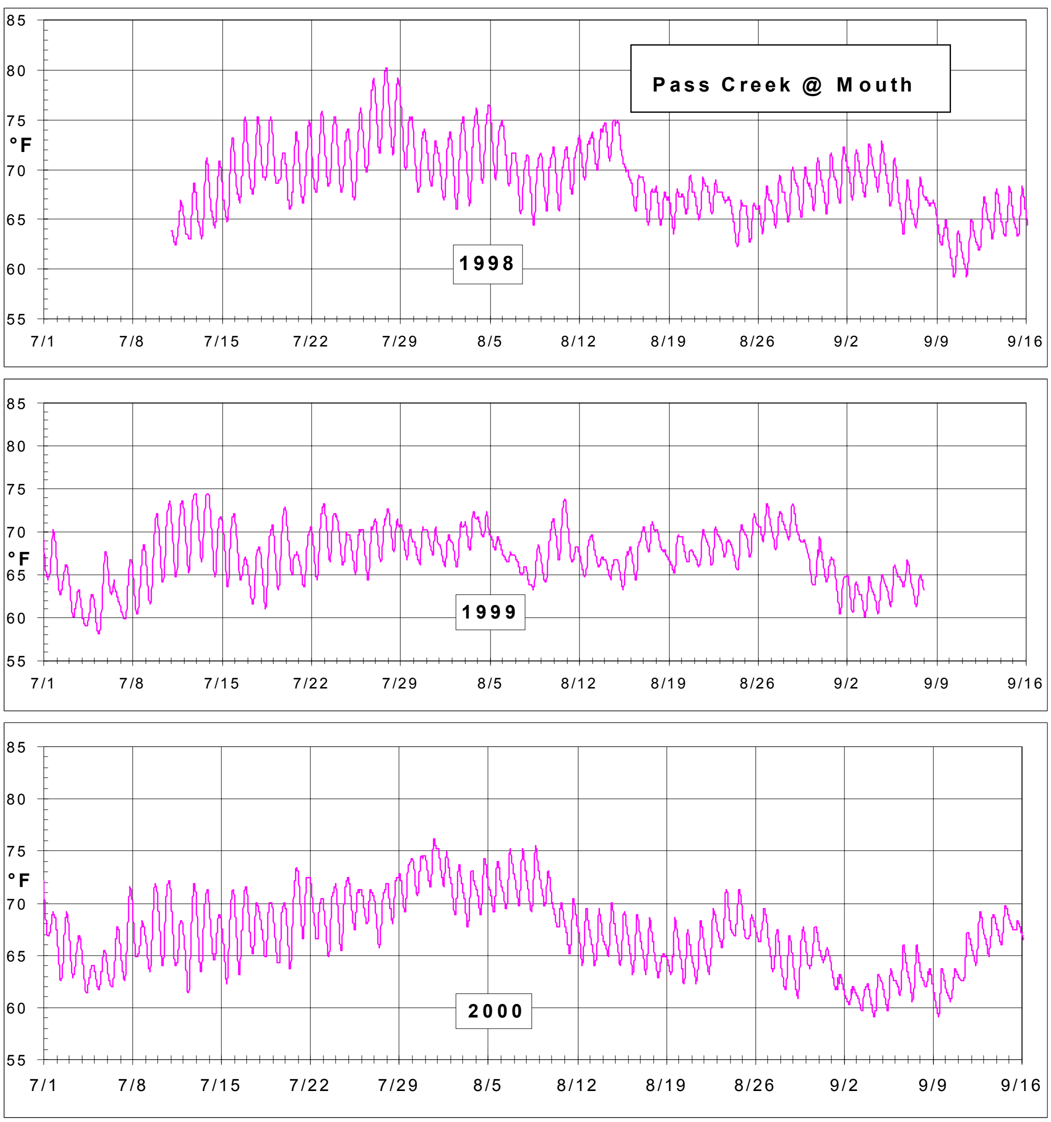


Chart 3 Comparison of 1998 –2000 seasonal stream temperature patterns ` for central Douglas County. (Data from Pass Creek @ mouth /Elk Creek

monitored had a seasonal maximum on 7/27. In 1999 and 2000 there wasn't a distinctive peak and there was more variability in the date of the seasonal maximum. In 2000 most of the sites experienced a seasonal maximum between 7/31 and 8/8.

Within Season Variability

The differences in the temperature patterns between sites during the same time period is due to the variability of the local weather conditions and local site factors such as stream orientation, streamflow depth and velocity, groundwater temperature and flow, and shade conditions.

Since maximum temperatures are a central issue for this analysis, the variability of the air temperature during the warmest part of the season is of interest. Chart 4 shows the

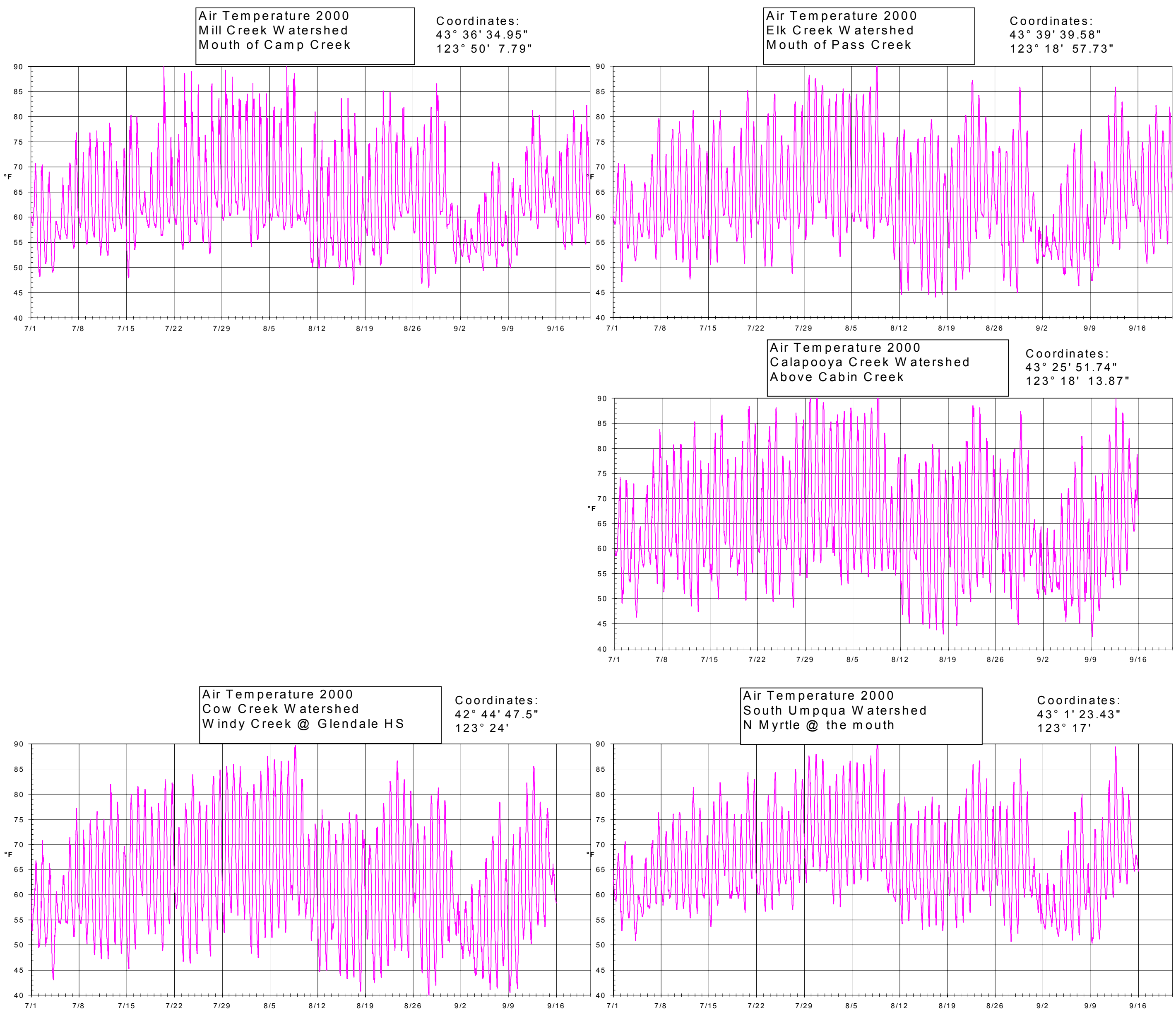


Chart 4 Shaded Riparian Air Temperature at 5 Sites in the Umpqua Basin in summer of 2000

summer air temperatures measured along shaded reaches of streams at five different locations in the Umpqua Basin. A comparison of the data shows that the seasonal maximum air temperatures at these locations were very similar. On the warm days the sky was probably uniformly clear across the basin and it appears that each shaded riparian environment responded to the solar input in a similar manner. There appears to be more variability on some of the cooler days, which suggests that a non-uniform cloud distribution may have been a factor.

This result suggests that most of the stream temperature variability between the sites during the maximum heating period for the summer 2000 season is due to variations in local site conditions other than air temperature. Analysis of the similarities and differences of these data and site characteristics can provide some insight to the processes and conditions that are influencing the variability in stream temperature.

Typical Temperature Patterns

Chart 5 shows typical patterns for the year 2000 summer season for two sites in the Lower Umpqua River watershed. Buck Creek is a small stream in the Mill Creek watershed. Even though the Umpqua River site was more exposed to direct solar radiation, the daily fluctuation was larger for Buck Creek because a much smaller volume of water was being heated per-unit-area of exposed water surface. Notice that, throughout the summer, the Umpqua River is consistently warmer than the smaller stream. This effect is typical with stream temperatures tending to be higher in the larger streams. Note also the similarity of the seasonal data pattern with the year 2000 data in Chart 3 from the Elk Creek watershed and the air temperatures in Chart 4. .

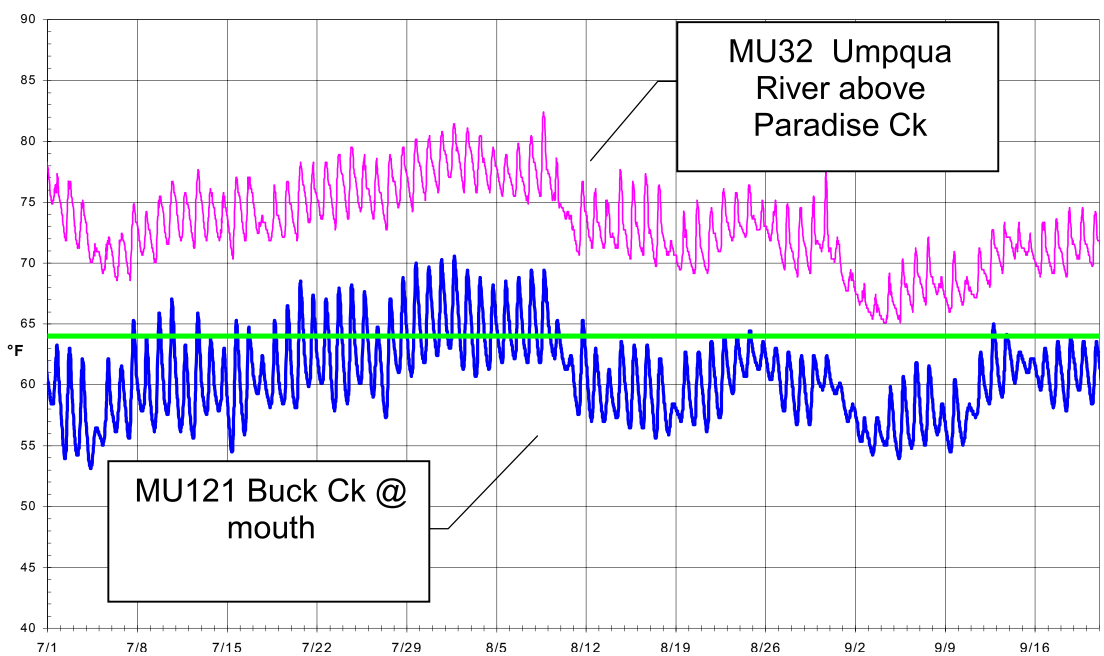


Chart 5 Typical temperature patterns in the Lower Umpqua Watershed

Atypical patterns

It is helpful to look at some atypical temperature patterns from the study and examine the differences in site conditions that affected the pattern.

Chart 6 shows data from the mouth of Mill Creek that experiences a significant tidal influence. Twice a day the tide creates a reverse flow of cooler water for a relatively short period of time causing downward spikes in the stream temperature.

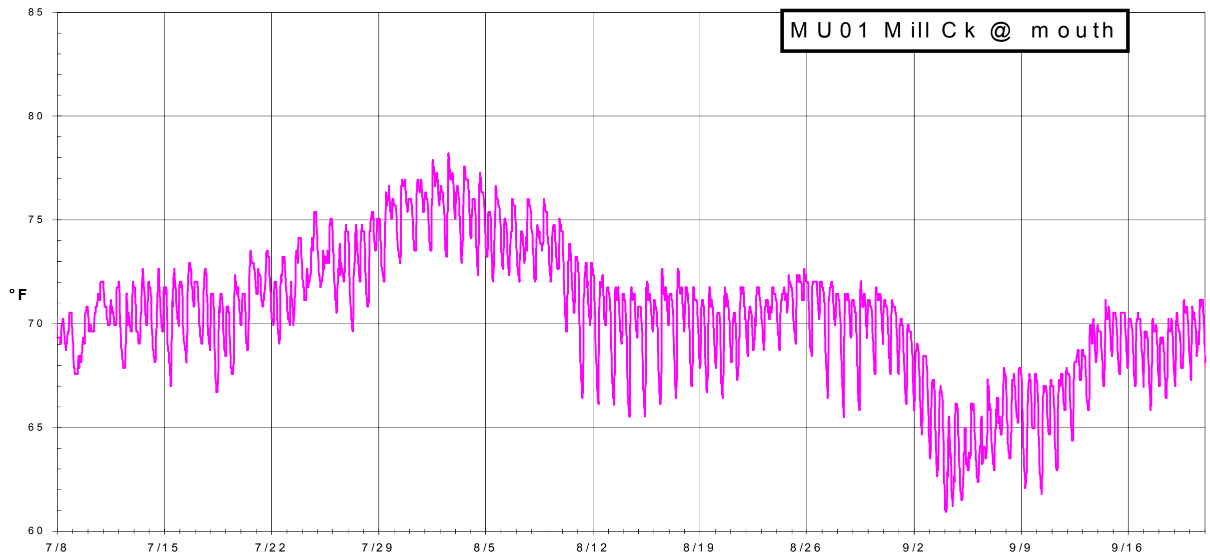


Chart 6 Stream Temperature from Mill Creek showing tidal influences.

Chart 7 shows data from the Umpqua River at Scottsburg. Here the tide initially caused the data logger unit to be exposed to air temperatures twice a day. The low spikes occurred

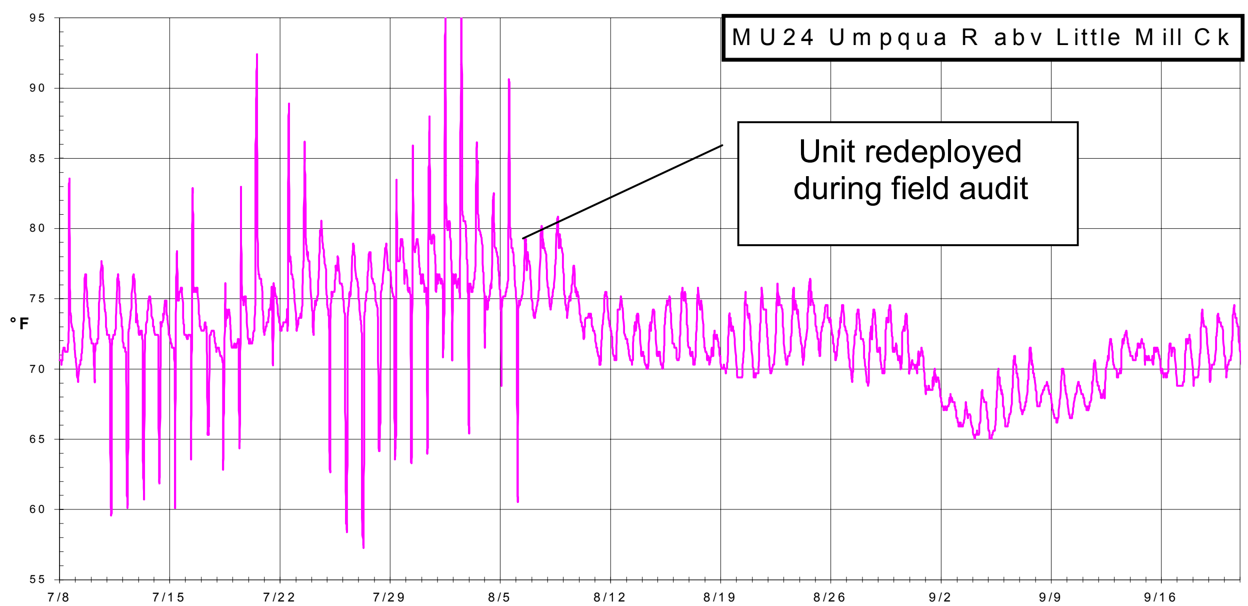


Chart 7 Unit exposed to air twice daily by tide at Scottsburg.

during night exposure and the high spikes occurred during the day. The unit was redeployed at a deeper point during the field audit on 8/6/00. The absence of additional fluctuations indicates that this site is not affected by tidal water flowing upstream to the site. Apparently the change in water depth is a result of downstream flow backing up against the tide. The data recorded prior to the audit was not used for the statistical analysis of the seasonal data.

Chart 8 shows data from Site MU22 Belshazzar Creek located in the headwaters of Camp Creek. The reduced seasonal variability and low temperatures suggest a well-shaded small stream with high groundwater influence. The daily spikes suggest a brief daily exposure to sunlight.

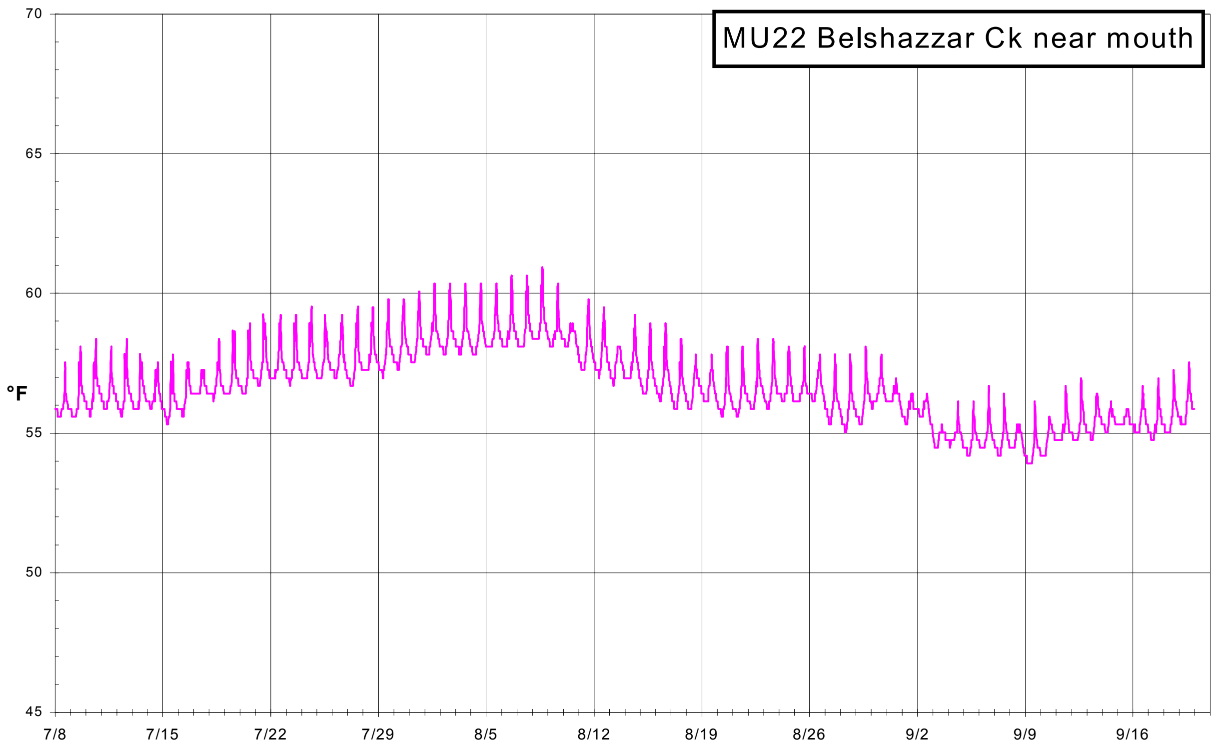


Chart 8 Temperature Pattern From a Small, Well-Shaded Stream

Site Temperature Statistics

Statistics provides the means to reduce the data to more manageable form. Two sets of statistics were generated from the data:

(1) The seasonal statistics show the extreme values and averages for the season. In particular, they show when and where the highest temperatures occurred within the period of record for the site.

(2) Statistics for a given day were also created to show how the various sites responded to similar solar input under prevailing streamflow conditions. Results from August 8, 2000 were used for the spatial distribution analysis.

Table 1(A) Seasonal Statistical Summary

Site Name	Start	Stop	Seasonal Max		Seasonal Min		Seasonal Max ΔT		7-Day averages			
	Date	Date	Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
MU Air Mill Ck Air Temperature	06/24/00	09/22/00	07/20/00	91.0	08/28/00	46.0	08/29/00	37.4	07/30/00	85.9	58.6	27.3
MU01 Mill Ck @ mouth	06/24/00	09/24/00	08/02/00	78.2	09/24/00	60.4	07/02/00	8.1	08/02/00	77.4	72.9	4.4
MU02 Double Barrel Ck @ mouth	08/05/00	09/21/00	08/29/00	66.4	08/28/00	50.8	08/29/00	15.3	08/27/00	62.7	52.4	10.3
MU03 MillCk abv Double Barrel	06/24/00	09/21/00	08/01/00	75.8	09/04/00	59.1	08/15/00	6.4	07/31/00	74.9	70.5	4.4
MU04 Camp Ck @ mouth	06/24/00	09/21/00	08/01/00	73.1	08/28/00	56.3	08/29/00	8.3	07/31/00	72.0	64.9	7.1
MU05 Mill Ck abv Camp Ck	06/25/00	09/21/00	06/28/00	78.2	09/03/00	60.6	06/27/00	10.0	06/28/00	76.0	67.4	8.6
MU06 Mill Ck blw Loon Lake	08/05/00	09/21/00	08/08/00	73.9	09/09/00	65.3	09/12/00	1.8	08/08/00	73.4	72.1	1.3
MU07 Lake Ck abv lake	06/30/00	09/21/00	08/04/00	78.6	09/04/00	65.3	09/12/00	4.8	08/03/00	78.1	75.5	2.6
MU08 Soup Ck @ mouth	06/30/00	09/21/00	08/01/00	62.1	08/17/00	52.0	07/27/00	3.7	07/31/00	61.5	58.7	2.8
MU09 Lake Ck abv Soup Ck	06/30/00	09/21/00	08/08/00	71.5	09/05/00	58.4	06/30/00	4.4	08/05/00	71.2	67.9	3.3
MU10 Lake Ck @ 13818	06/30/00	09/21/00	07/31/00	75.6	09/04/00	57.1	07/27/00	8.5	08/01/00	74.9	68.0	6.8
MU11 Buck Ck @ mouth	06/24/00	09/21/00	08/01/00	70.6	07/04/00	53.1	06/25/00	11.6	07/31/00	69.7	61.6	8.1
MU12 Camp Ck abv Buck Ck	06/24/00	09/21/00	06/27/00	72.7	09/04/00	57.0	06/25/00	9.3	06/27/00	70.9	63.3	7.6
MU13 Otter Ck @ mouth	06/30/00	09/21/00	08/01/00	67.6	08/17/00	50.8	07/27/00	9.9	07/31/00	66.8	58.8	8.0
MU14 Camp Ck abv Otter Ck	06/30/00	09/21/00	08/01/00	72.1	09/05/00	55.3	07/20/00	8.1	08/01/00	71.2	64.7	6.5
MU15 Little Camp Ck @ mouth	06/30/00	09/19/00	08/08/00	65.9	09/09/00	52.0	08/29/00	6.7	08/01/00	64.9	60.1	4.8
MU16 Upper Little Camp Ck	06/30/00	09/19/00	08/08/00	68.8	07/04/00	52.6	08/08/00	9.2	07/31/00	66.6	59.0	7.7
MU17 Camp Ck abv Little Camp Ck	06/30/00	09/19/00	07/31/00	69.7	09/09/00	54.0	08/21/00	6.2	08/01/00	68.7	63.2	5.5
MU18 Small trib @ mouth	06/30/00	09/19/00	08/01/00	68.5	09/09/00	51.5	07/07/00	11.1	08/03/00	67.6	59.7	7.9
MU19 Camp Ck abv trib	06/30/00	09/19/00	08/08/00	64.5	09/05/00	52.0	07/12/00	5.1	08/01/00	63.8	60.0	3.7
MU20 Trib @ mouth	06/30/00	09/19/00	08/01/00	64.8	09/09/00	50.2	07/27/00	7.9	08/03/00	64.1	57.5	6.7
MU22 Belshazzar Ck near mouth	06/30/00	09/19/00	08/08/00	60.9	09/09/00	53.9	07/07/00	3.1	08/06/00	60.5	58.1	2.5
MU23 Little Mill Ck near mouth	06/30/00	09/21/00	08/01/00	62.4	07/04/00	52.6	07/20/00	4.8	08/01/00	61.8	58.2	3.6
MU24 Umpqua R abv Little Mill Ck	08/07/00	09/24/00	08/08/00	80.8	09/24/00	63.9	08/08/00	6.6	08/10/00	76.8	72.1	4.7
MU25 Weatherly Ck @ bridge	06/30/00	09/21/00	08/01/00	75.9	07/04/00	54.8	08/29/00	14.1	08/01/00	74.9	64.0	10.8
MU26 Upper Weatherly	06/30/00	09/21/00	08/08/00	64.5	07/04/00	53.0	07/20/00	4.8	08/01/00	63.9	60.1	3.8
MU27 Lutzsinger Ck near mouth	06/30/00	09/21/00	07/31/00	68.8	08/28/00	54.0	07/15/00	7.3	07/31/00	67.7	61.9	5.8
MU28 Upper Lutzsinger Ck	06/30/00	09/21/00	08/01/00	64.8	08/29/00	52.6	07/15/00	6.2	07/31/00	63.9	59.5	4.4
MU29 Butler Ck @ mouth	06/30/00	09/21/00	08/08/00	65.3	08/28/00	52.6	07/15/00	7.0	08/01/00	64.4	59.0	5.4
MU30 Paradise Ck @ mouth	06/30/00	09/21/00	07/31/00	74.0	08/28/00	55.7	07/15/00	11.2	07/31/00	73.1	64.9	8.2
MU31 Upper Paradise	06/30/00	09/21/00	07/31/00	65.4	09/09/00	52.4	08/29/00	6.2	08/03/00	64.4	59.4	5.0
MU32 Umpqua River abv Paradise Ck	06/30/00	09/21/00	08/08/00	82.4	09/05/00	65.1	08/08/00	6.9	08/01/00	80.6	75.7	4.9
MU33 Sawyer Ck near mouth	06/30/00	09/21/00	07/31/00	74.7	07/04/00	55.3	07/15/00	12.6	07/30/00	73.2	63.9	9.3
MU34 S Fork Sawyer Ck @ mouth	06/30/00	09/19/00	07/31/00	67.3	07/04/00	51.7	07/24/00	9.4	08/01/00	66.3	58.0	8.3
MU35 E Fork Sawyer @ mouth	06/30/00	09/19/00	08/08/00	67.3	08/28/00	51.5	07/27/00	10.2	08/03/00	66.8	58.1	8.7
MU36 Heddin Ck @ bridge	06/30/00	09/19/00	08/08/00	67.8	08/29/00	53.4	08/29/00	6.7	08/01/00	66.0	62.0	4.1
MU37 Melh Ck @ bridge	06/30/00	09/19/00	07/31/00	67.1	08/29/00	53.2	06/30/00	6.3	07/31/00	66.4	61.4	5.0
MU38 Upper Melh	06/30/00	09/19/00	07/31/00	70.1	07/04/00	52.1	07/12/00	12.5	07/31/00	69.1	60.4	8.7
MU39 S Trib Upper Melh	06/30/00	09/19/00	08/08/00	65.0	07/04/00	52.3	06/30/00	7.6	08/03/00	64.3	58.4	5.9
MU40 Waggoner Ck @ bridge	06/30/00	09/19/00	07/31/00	75.4	09/05/00	54.7	07/24/00	12.9	08/01/00	74.0	63.4	10.7
MU41 McGee Ck @ mouth	06/30/00	09/19/00	08/08/00	66.5	08/29/00	51.5	08/29/00	7.8	07/31/00	65.2	60.1	5.1
MU42 Umpqua River abv McGee Ck	06/30/00	09/19/00	07/31/00	80.3	09/05/00	63.2	08/12/00	10.5	08/01/00	79.5	75.1	4.5
MU43 Yellow Ck @ mouth	06/30/00	09/19/00	08/08/00	74.1	09/09/00	54.8	08/29/00	9.7	08/01/00	73.0	64.9	8.1
MU44 Upper Yellow Ck blw Bear Ck	06/30/00	09/19/00	07/31/00	69.4	09/09/00	52.3	07/29/00	8.1	08/01/00	67.9	60.7	7.2
MU45 Little Canyon Ck @ mouth	06/30/00	09/18/00	08/08/00	68.4	08/29/00	53.6	08/29/00	7.9	08/01/00	67.4	61.3	6.1
MUA1 Little Paradise @ mouth	07/16/00	09/13/00	07/31/00	68.3	08/28/00	52.1	07/20/00	8.6	08/01/00	67.2	60.4	6.7
MUA2 Paradise Ck abv Little Paradise	07/16/00	09/13/00	07/31/00	77.9	09/05/00	55.1	07/27/00	15.7	08/01/00	76.7	62.8	13.8
MUA3 Paradise Ck blw Cedar	07/16/00	09/13/00	08/08/00	71.1	08/28/00	53.1	08/29/00	10.4	08/01/00	69.6	61.7	8.0
Summary Statistics *Air Temperature Data Not Included												
Maximum:				82.4		65.3		15.7		80.6	75.7	13.8
Minimum:				60.9		50.2		1.8		60.5	52.4	1.3
Difference:				21.5		15.2		14.0		20.0	23.2	12.6
Average:				70.5		55.0		8.3		69.4	63.1	6.3

Seasonal Statistics:

Table 1(A&B) lists some seasonal statistics for the season of record for each site. Note that some sites had a truncated record as indicated by the “start” and “stop” dates. This statistical information is generally used to determine the range of values of all of the sites for the entire season. Of particular interest is the seasonal maximum of the seven-day running average of the daily maximum temperature because this value determines compliance with the Oregon State stream temperature standard. Chart 9 provides a visual comparison of the seasonal maximum, 7-day maximum and ΔT values. The dates of each record interval are indicated for each site on the chart.

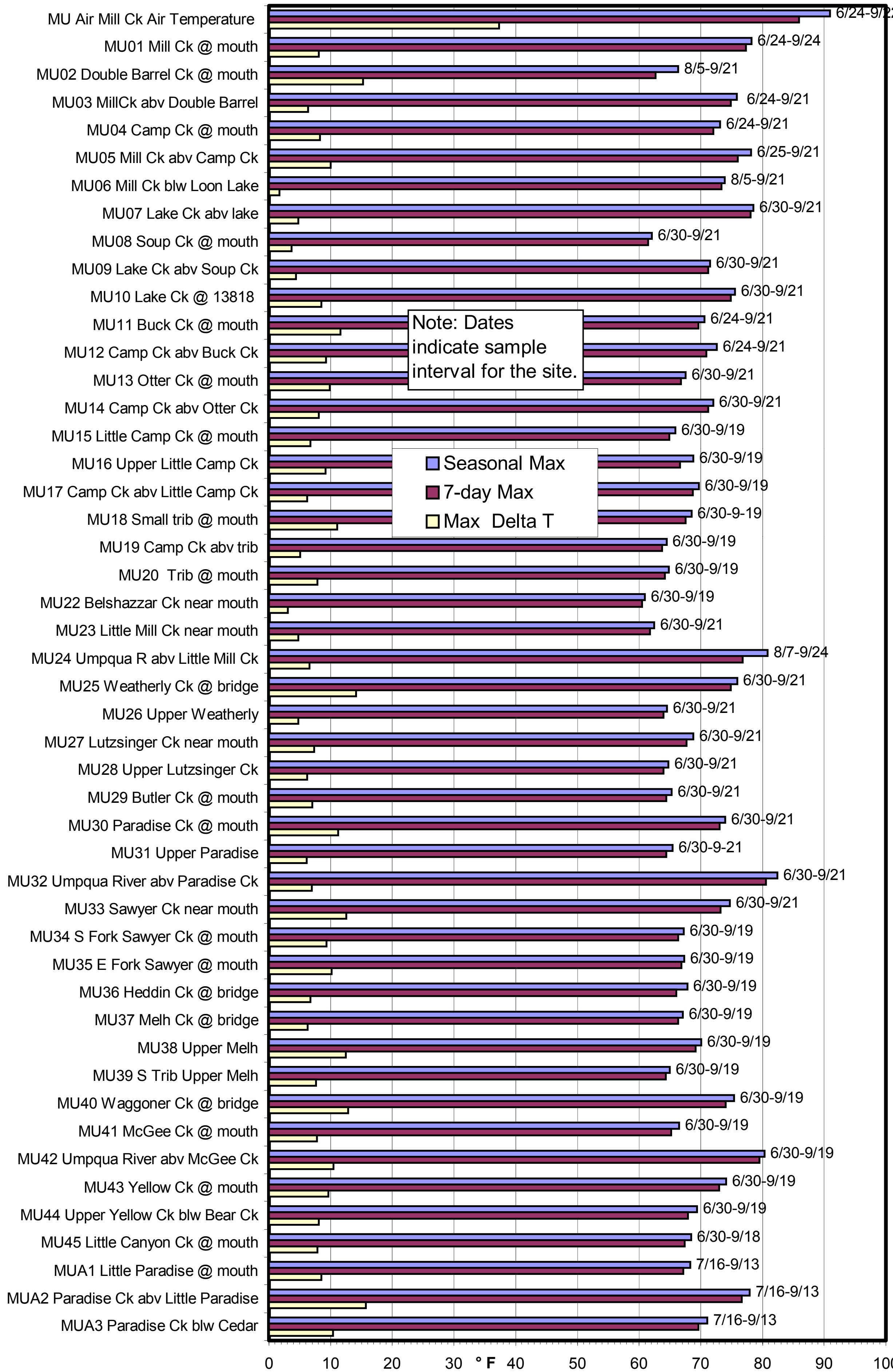
Table 1(B) Continuation of Seasonal Statistical Summary

Site Name	Latitude	Longitude	Days > 55 F	Days > 64 F	Days > 70 F	Hours > 55 F	Hours > 64 F	Hours > 70 F	Warmest day of 7-day max Date	Maximum	Minimum	Agency
MU Air Mill Ck Air Temperature	43° 36' 34.95	123° 50' 7.79	91	84	74	1811.5	816.5	476.5	07/29/00	89.2	59.4	UBWC
MU01 Mill Ck @ mouth	43° 39' 16.06	23° 52' 27.21	93	93	77	2231.5	2147.5	1256.0	08/02/00	78.2	73.2	UBWC
MU02 Double Barrel Ck @ mouth	43° 36' 58.51	23° 51' 35.96	45	2	0	305.5	2.5	0.0	08/29/00	66.4	51.1	UBWC
MU03 MillCk abv Double Barrel	43° 36' 59.44	23° 51' 35.03	90	80	34	2159.5	1737.0	444.5	08/01/00	75.8	71.3	UBWC
MU04 Camp Ck @ mouth	43° 36' 36.08	123° 50' 6.23	90	72	16	2159.5	877.5	88.0	08/01/00	73.1	66.0	UBWC
MU05 Mill Ck abv Camp Ck	43° 36' 35.71	123° 50' 5.12	89	86	46	2135.5	1945.0	584.0	06/28/00	78.2	69.0	UBWC
MU06 Mill Ck blw Loon Lake	43° 35' 54.86	23° 50' 39.93	48	48	12	1151.5	1151.5	217.0	08/05/00	73.9	72.4	UBWC
MU07 Lake Ck abv lake	43° 34' 39.82	23° 49' 27.79	84	84	73	2015.5	2015.5	1442.5	08/04/00	78.6	75.4	UBWC
MU08 Soup Ck @ mouth	43° 33' 36.79	23° 49' 15.73	74	0	0	1527.5	0.0	0.0	08/01/00	62.1	59.3	UBWC
MU09 Lake Ck abv Soup Ck	43° 33' 36.27	23° 49' 16.65	84	64	11	2015.5	1040.0	87.5	08/06/00	71.5	68.2	UBWC
MU10 Lake Ck @ 13818	43° 32' 17.67	23° 49' 25.49	84	71	21	2015.5	1353.0	263.5	07/31/00	75.6	68.3	UBWC
MU11 Buck Ck @ mouth	43° 36' 26.17	123° 46' 56.3	90	40	2	2101.0	322.5	2.5	08/01/00	70.6	63.0	UBWC
MU12 Camp Ck abv Buck Ck	43° 36' 26.61	23° 46' 55.11	90	64	10	2159.5	1038.0	49.0	06/27/00	72.7	64.1	UBWC
MU13 Otter Ck @ mouth	43° 35' 41.93	23° 44' 19.82	84	18	0	1699.5	108.5	0.0	07/31/00	67.6	60.1	UBWC
MU14 Camp Ck abv Otter Ck	43° 35' 42.8"	23° 44' 19.23	84	62	10	2015.5	739.5	46.0	08/01/00	72.1	66.2	UBWC
MU15 Little Camp Ck @ mouth	43° 34' 44.7"	23° 42' 23.58	82	11	0	1712.0	61.5	0.0	08/01/00	65.9	61.3	UBWC
MU16 Upper Little Camp Ck	43° 35' 17.53	23° 40' 39.36	82	14	0	1778.5	45.0	0.0	07/31/00	68.2	59.6	UBWC
MU17 Camp Ck abv Little Camp Ck	43° 34' 44.21	123° 42' 24.6	82	27	0	1919.0	287.5	0.0	07/31/00	69.7	64.2	UBWC
MU18 Small trib @ mouth	43° 33' 34.18	123° 43' 7.77	82	31	0	1712.5	212.0	0.0	08/01/00	68.5	60.7	UBWC
MU19 Camp Ck abv trib	43° 33' 34.49	123° 43' 6.77	79	3	0	1678.0	18.5	0.0	07/31/00	64.5	61.0	UBWC
MU20 Trib @ mouth	43° 32' 56.95	23° 41' 10.78	75	5	0	1362.5	8.5	0.0	08/01/00	64.8	58.2	UBWC
MU22 Belshazzar Ck near mouth	43° 32' 27.5"	23° 40' 51.72	82	0	0	1775.5	0.0	0.0	08/08/00	60.9	58.4	UBWC
MU23 Little Mill Ck near mouth	43° 39' 20.02	23° 49' 33.93	83	0	0	1737.5	0.0	0.0	07/31/00	62.4	58.7	UBWC
MU24 Umpqua R abv Little Mill Ck	43° 39' 18.1"	23° 49' 32.31	49	49	42	1175.5	1173.0	781.5	08/08/00	80.8	74.2	UBWC
MU25 Weatherly Ck @ bridge	43° 39' 42.12	123° 44' 8.31	84	67	23	2015.0	800.5	113.5	07/31/00	75.9	64.9	UBWC
MU26 Upper Weatherly	43° 42' 8.77"	123° 43' 4.45	84	4	0	1843.5	13.0	0.0	07/31/00	64.5	61.1	UBWC
MU27 Lutzsinger Ck near mouth	43° 39' 12.57	123° 43' 4.83	84	19	0	1971.0	179.5	0.0	07/31/00	68.8	63.6	UBWC
MU28 Upper Lutzsinger Ck	43° 37' 35.74	23° 41' 57.39	84	4	0	1817.5	13.5	0.0	07/31/00	64.8	60.8	UBWC
MU29 Butler Ck @ mouth	43° 39' 24.11	23° 42' 36.04	84	7	0	1737.5	17.0	0.0	07/31/00	65.3	60.5	UBWC
MU30 Paradise Ck @ mouth	43° 40' 20.84	123° 39' 4.29	84	69	20	2015.5	873.0	112.5	07/31/00	74.0	66.3	UBWC
MU31 Upper Paradise	43° 42' 31.06	23° 35' 29.44	84	7	0	1682.5	20.0	0.0	07/31/00	65.4	60.5	UBWC
MU32 Umpqua River abv Paradise	43° 40' 20.47	123° 39' 5.56	84	84	78	2015.5	2015.5	1659.0	08/01/00	81.4	77.0	UBWC
MU33 Sawyer Ck near mouth	43° 37' 57.54	123° 39' 57.4	84	70	21	2015.5	984.0	140.0	07/31/00	74.7	66.1	UBWC
MU34 S Fork Sawyer Ck @ mouth	43° 36' 10.37	123° 40' 12.3	82	18	0	1734.0	88.5	0.0	07/31/00	67.3	59.2	UBWC
MU35 E Fork Sawyer @ mouth	43° 36' 11.11	123° 40' 12.3	82	17	0	1570.5	62.5	0.0	07/31/00	67.3	58.7	UBWC
MU36 Heddin Ck @ bridge	43° 36' 29.1"	23° 37' 12.17	82	20	0	1882.5	173.5	0.0	07/31/00	67.2	63.2	UBWC
MU37 Melh Ck @ bridge	43° 34' 45.98	23° 35' 37.15	82	19	0	1859.0	144.5	0.0	07/31/00	67.1	62.2	UBWC
MU38 Upper Melh	43° 33' 30.78	23° 37' 14.69	82	39	2	1818.0	347.0	3.0	07/30/00	70.1	60.8	UBWC
MU39 S Trib Upper Melh	43° 33' 29.91	23° 37' 14.35	82	9	0	1679.0	22.0	0.0	08/01/00	65.0	59.3	UBWC
MU40 Waggoner Ck @ bridge	43° 31' 55.89	23° 34' 10.85	82	61	20	1962.0	622.5	91.5	07/31/00	75.4	64.1	UBWC
MU41 McGee Ck @ mouth	43° 31' 28.34	23° 32' 27.57	82	12	0	1755.5	76.5	0.0	07/31/00	66.2	60.7	UBWC
MU42 Umpqua River abv McGee Ck	43° 31' 28.72	23° 32' 26.04	82	82	68	1967.5	1959.5	1325.5	07/31/00	80.3	75.6	UBWC
MU43 Yellow Ck @ mouth	43° 29' 29.05	123° 29' 3.97	82	67	17	1964.0	861.0	84.5	07/31/00	74.1	66.1	UBWC
MU44 Upper Yellow Ck blw Bear Ck	43° 30' 36.19	123° 26' 9.04	82	25	0	1855.0	184.5	0.0	07/31/00	69.4	62.4	UBWC
MU45 Little Canyon Ck @ mouth	43° 28' 34.03	23° 28' 54.62	81	25	0	1854.0	218.0	0.0	07/31/00	68.4	62.1	UBWC
MUA1 Little Paradise @ mouth	43° 40' 18.05	23° 37' 29.88	60	15	0	1267.6	114.0	0.0	07/31/00	68.3	62.2	Arsenault
MUA2 Paradise Ck abv Little Paradi	43° 40' 18.6"	23° 37' 30.56	60	52	26	1439.6	594.0	146.0	07/31/00	77.9	64.7	Arsenault
MUA3 Paradise Ck blw Cedar	43° 40' 58.05	23° 37' 34.67	60	33	3	1398.8	317.6	10.0	07/31/00	70.8	63.8	Arsenault
Summary Statistics *Air Temperature Data Not Included												
Maximum:			93.0	93.0	78.0	2231.5	2147.5	1659.0		81.4	77.0	
Minimum:			45.0	0.0	0.0	305.5	0.0	0.0		60.9	51.1	
Difference:			48.0	93.0	78.0	1926.0	2147.5	1659.0		20.5	26.0	
Average:			79.7	37.2	13.4	1780.1	574.2	190.4		70.5	64.0	

Notes to Table 1 and Chart 9:

- The seasonal maximum value is the highest daily temperature measured at a site.
- The maximum ΔT represents the largest observed 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 Oregon State criteria for stream temperatures.
- The "MU Air Mill Creek" entry is air temperature measured at the same site as the MU 05 stream temperature logger (Mill Creek above Camp Creek).

Chart 9   Seasonal Max, Min, and ΔT values



Statistics for a Given Day:

The advantage of a synoptic study is that it provides the opportunity to compare the stream temperatures at all of the sites at exactly the same point in time. For this analysis, August 8, 2000 was selected since most of the sites had their seasonal maximum on that date. Table 2 provides some of the site statistics for that day. The maximum and minimum data represent the extreme values for the 24-hr period starting at midnight and the ΔT value is the difference between these values. The mean is the average of all of the readings (typically 48) over the 24-hr period. The simple average of the max and minimum values is also shown to compare with the mean value of all of the readings. If the mean is lower than the simple average it indicates that there are more “cool” values than “hot” values and provides an indication of the relative duration of solar exposure for the day.

Site Name	Max Temp °F	Min Temp °F	Mean Temp °F	(Max +Min)/2 °F	Δ T °F	Rate of Heating: Max Rate °F / hr	Mim Rate °F / hr	Δ Rate °F / hr	Time of Min	Time of Max	Paired Sites
MU01 Mill Ck @ mouth	76.01	72.04	74.15	74.03	3.97	0.64	-2.38	3.02	4:00 AM	4:30 PM	
MU02 Double Barrel Ck @ mouth	61.75	53.30	55.44	57.53	8.45	5.14	-2.84	7.98	5:00 AM	1:30 PM	@
MU03 MillCk abv Double Barrel	73.66	69.47	71.45	71.57	4.19	1.80	-1.80	3.60	8:30 AM	2:30 PM	@
MU04 Camp Ck @ mouth	71.32	63.71	67.27	67.52	7.61	1.20	-3.48	4.68	8:30 AM	6:30 PM	
MU05 Mill Ck abv Camp Ck	74.72	69.57	72.35	72.15	5.15	1.24	-1.22	2.46	7:00 AM	3:00 PM	#
MU06 Mill Ck blw Loon Lake	73.88	72.68	73.31	73.28	1.20	0.60	-0.60	1.20	8:00 AM	8:30 PM	#
MU07 Lake Ck abv lake	78.24	75.11	76.46	76.68	3.13	0.64	-1.26	1.90	8:00 AM	5:00 PM	
MU08 Soup Ck @ mouth	59.26	58.12	58.47	58.69	1.14	0.58	-0.58	1.16	8:30 AM	4:00 PM	$
MU09 Lake Ck abv Soup Ck	71.49	67.35	69.21	69.42	4.14	1.20	-1.78	2.98	7:30 AM	5:00 PM	$
MU10 Lake Ck @ 13818	73.71	68.90	71.62	71.31	4.81	1.22	-1.22	2.44	8:00 AM	4:00 PM	
MU11 Buck Ck @ mouth	69.41	61.84	65.17	65.63	7.57	1.16	-1.76	2.92	7:30 AM	3:30 PM	%
MU12 Camp Ck abv Buck Ck	71.15	65.58	67.90	68.37	5.57	1.20	-1.20	2.40	8:00 AM	5:00 PM	%
MU13 Otter Ck @ mouth	67.27	58.63	62.70	62.95	8.64	1.18	-1.76	2.94	4:00 AM	3:30 PM	&
MU14 Camp Ck abv Otter Ck	71.75	64.40	67.70	68.08	7.35	1.18	-2.98	4.16	7:00 AM	4:30 PM	&
MU15 Little Camp Ck @ mouth	65.89	60.15	62.66	63.02	5.74	0.58	-1.74	2.32	8:00 AM	5:00 PM	**
MU16 Upper Little Camp Ck	68.82	59.60	62.57	64.21	9.22	2.92	-4.68	7.60	8:00 AM	4:30 PM	
MU17 Camp Ck abv Little Camp Ck	69.43	63.32	66.05	66.38	6.11	1.18	-2.34	3.52	7:30 AM	2:30 PM	**
MU18 Small trib @ mouth	68.23	59.88	63.70	64.06	8.35	1.16	-2.90	4.06	8:00 AM	5:00 PM	()
MU19 Camp Ck abv trib	64.46	60.43	62.45	62.45	4.03	0.58	-1.16	1.74	5:30 AM	3:00 PM	()
MU20 Trib @ mouth	64.52	58.23	60.61	61.38	6.29	0.58	-2.30	2.88	8:30 AM	4:30 PM	
MU22 Belshazzar Ck near mouth	60.93	58.37	58.91	59.65	2.56	1.14	-1.70	2.84	7:00 AM	8:30 PM	
MU23 Little Mill Ck near mouth	61.84	58.14	59.95	59.99	3.70	0.58	-1.70	2.28	5:00 AM	7:00 PM	<>
MU24 Umpqua R abv Little Mill Ck	80.84	74.24	77.22	77.54	6.60	3.80	-1.90	5.70	5:00 AM	3:00 PM	<>
MU25 Weatherly Ck @ bridge	74.68	63.77	68.47	69.23	10.91	2.42	-2.88	5.30	7:00 AM	12:30 AM	
MU26 Upper Weatherly	64.54	60.23	62.37	62.39	4.31	0.58	-1.14	1.72	7:00 AM	2:30 PM	
MU27 Lutzsinger Ck near mouth	67.64	61.57	64.58	64.61	6.07	1.16	-1.18	2.34	9:00 AM	4:30 PM	
MU28 Upper Lutzsinger Ck	63.64	59.35	61.63	61.50	4.29	0.58	-2.28	2.86	9:00 AM	5:30 PM	
MU29 Butler Ck @ mouth	65.33	58.74	61.26	62.04	6.59	1.16	-4.00	5.16	9:30 AM	12:00 AM	
MU30 Paradise Ck @ mouth	73.66	63.94	68.36	68.80	9.72	1.74	-2.34	4.08	8:30 AM	4:00 PM	><
MU31 Upper Paradise	65.12	59.66	62.00	62.39	5.46	1.16	-1.74	2.90	9:00 AM	3:30 PM	
MU32 Umpqua River abv Paradise C	82.40	75.48	78.21	78.94	6.92	1.88	-2.52	4.40	8:30 AM	4:30 PM	><
MU33 Sawyer Ck near mouth	74.11	64.38	69.18	69.25	9.73	1.20	-2.90	4.10	8:00 AM	6:30 PM	
MU34 S Fork Sawyer Ck @ mouth	65.80	58.35	61.64	62.08	7.45	1.16	-2.30	3.46	8:30 AM	5:00 PM	%%
MU35 E Fork Sawyer @ mouth	67.33	57.89	61.52	62.61	9.44	1.18	-1.76	2.94	8:30 AM	4:00 PM	%%
MU36 Heddin Ck @ bridge	67.81	61.76	64.54	64.79	6.05	0.58	-3.46	4.04	8:30 AM	5:30 PM	
MU37 Melh Ck @ bridge	66.78	61.58	64.02	64.18	5.20	2.32	-3.48	5.80	7:30 AM	4:00 PM	
MU38 Upper Melh	69.48	61.09	65.96	65.29	8.39	1.16	-2.90	4.06	7:30 AM	8:30 PM	)(
MU39 S Trib Upper Melh	64.99	58.96	61.59	61.98	6.03	1.16	-1.72	2.88	7:00 AM	5:00 PM	)(
MU40 Waggoner Ck @ bridge	72.32	64.67	67.59	68.50	7.65	1.20	-2.40	3.60	7:30 AM	5:00 PM	
MU41 McGee Ck @ mouth	66.51	60.74	63.17	63.63	5.77	1.16	-2.34	3.50	7:00 AM	5:00 PM	&#
MU42 Umpqua River abv McGee Ck	80.02	74.71	77.14	77.37	5.31	0.64	-1.90	2.54	9:00 AM	4:00 PM	&#
MU43 Yellow Ck @ mouth	74.11	64.96	68.49	69.54	9.15	1.22	-2.42	3.64	6:30 AM	2:30 PM	
MU44 Upper Yellow Ck blw Bear Ck	68.52	60.72	64.29	64.62	7.80	0.60	-3.44	4.04	7:17 AM	5:17 PM	
MU45 Little Canyon Ck @ mouth	68.43	61.76	64.83	65.10	6.67	0.60	-2.32	2.92	6:08 AM	6:08 PM	
MUA1 Little Paradise @ mouth	67.45	60.53	63.46	63.99	6.92	1.47	-1.45	2.92	7:30 AM	3:30 PM	(*)
MUA2 Paradise Ck abv Little Paradis	77.28	62.96	68.78	70.12	14.32	2.35	-3.05	5.40	12:00 AM	3:30 PM	(*)
MUA3 Paradise Ck blw Cedar	71.07	61.77	66.05	66.42	9.30	1.45	-2.20	3.65	7:30 AM	6:30 PM	
MUair Mill Ck Air Temperature	88.54	57.99	68.76	73.27	30.55	9.72	-19.44	29.16	6:27 AM	4:27 PM	

Table2 Selected statistics from the 24-hr period on August 8, 2000.

Heating rates were calculated from the temperature change between consecutive 30-minute readings. The maximum rates occurred during daytime heating and the negative minimum rates show the rate of nighttime cooling. In general, there appears to be a strong association between high ΔT and high rates of heating. Taking the difference between the maximum and minimum rates eliminates all of the heat flux that is constant throughout the 24-hour period. In other words, the rate difference is solely dependent on the diurnal effects under steady-state flow conditions.

The time data indicates the time of day that the maximum or minimum value first occurred. The time of minimum provides an indication of the time of day that the sun first starts to affect the water temperature - latter times suggest more morning shade. Likewise, the time of maximum indicates the point where the solar heating component is no longer greater than the heat loss component. Early PM time for the maximum suggests better afternoon shade.

The Paired Site column denotes sites that were located at the confluence of two streams - similar symbols denote the paired sites that are discussed in the next section.

Spatial Analysis of the Data

A basic objective of this project is to better understand the response pattern of the stream temperatures within the watershed. On a two dimensional chart, it is helpful to plot the "given day" statistics as a function of the stream distance from the mouth and also the stream distance from the source ridge. Each approach provides a different perspective for analysis.

Site Distance from the mouth of the Umpqua River

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 corresponding temperature of a contributing tributary at the point of confluence. Chart 10

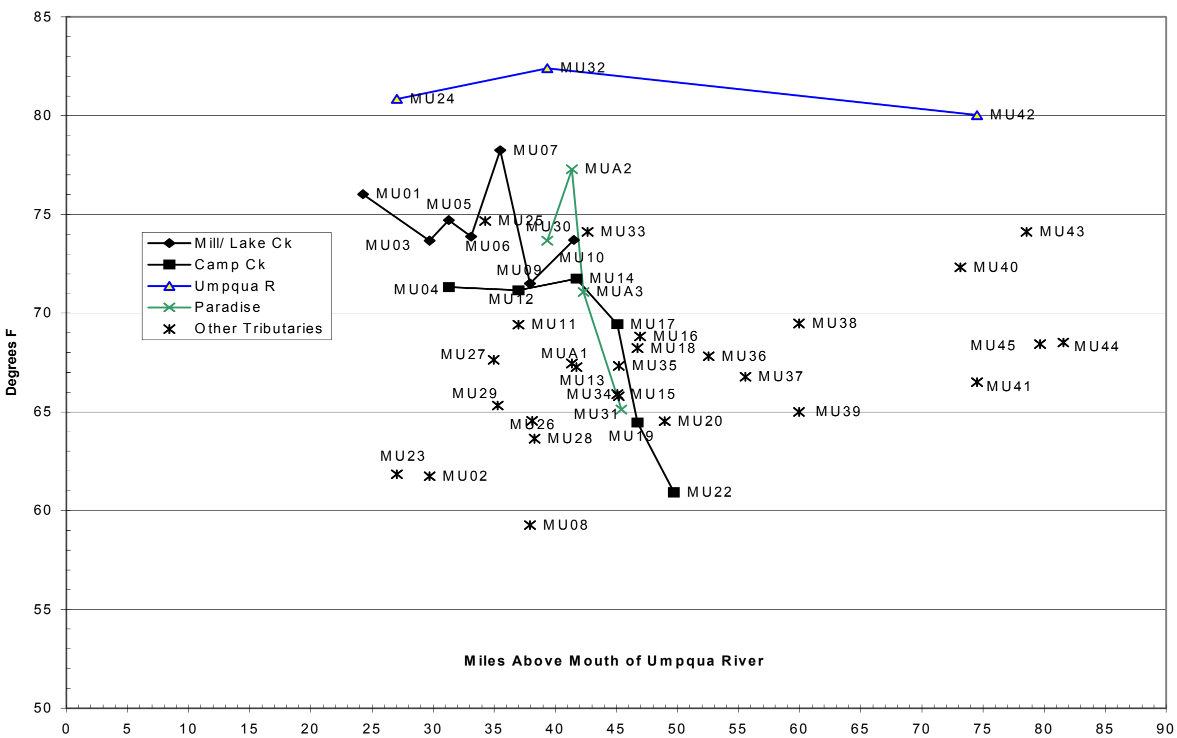


Chart 10 Maximum 8/8/2000 Temperatures by River Mile

shows the maximum temperatures observed on 8/8/00 as a function of their distance from the mouth of the Umpqua River. The "paired sites" listed in Table 3 are located at the same distance value and have the same elevation. For example, MU09, Soup Creek at the mouth and MU09, Lake Creek above Soup Creek, are both 38 miles from the mouth of the river.

However, the distance to the source of Soup Creek is less and the associated stream is smaller than Lake Creek at the point of confluence. In general the smaller tributaries have cooler temperatures while similar sized streams tend to have similar temperatures. Of course the smaller tributaries typically have less water, which may equate to reduced availability of quality habitat. Consequently, the relatively small mixing area with both cooler temperatures and ample water may represent rather scarce points with optimal habitat conditions for fish and other aquatic organisms.

Note that the Umpqua River is considerably warmer than all of the other sites and that tributaries change temperature at a faster rate with respect to distance. The Mill/Lake data series appears to be more jagged – a result of the influence of Loon Lake. The site MU07 is at the mouth of Lake Creek as it enters Loon Lake and is influenced by shallow backwater from the lake. The site pair, MU08 and MU09, is located near the mouth of Soup Creek and both appear to be unusually cool. This result is rather surprising since the shade in this area doesn't appear to be exceptional. A possible explanation may be a high water table with a significant groundwater influence.

The maximum temperature at Site MUA2 on Paradise Creek appears to be exceptionally high with recovery occurring as the stream continues downstream to the mouth at site MU30. Since the property owner provided this data, details about the site condition are not known at this time.

The temperature of the Umpqua River is expected to increase slowly in the downstream direction and some of the variability in the Umpqua River data may be from "edge effects" that influence flow rate, depth and temperature along the edges of the river. This source of in-channel variability is not as pronounced in the smaller streams since the data logger can typically be placed directly in the active portion of the channel.

The values of the minimum temperatures shown in Chart 11 are, of course, lower and tend to be more compressed. The average annual temperature of the basin is probably in the low 50's and the extent that the minimum stream temperature is above that value represents the excess heat accumulated over the summer. The Mill/Lake Ck system and the Umpqua River are notable with higher minimum temperatures - a result of more exposed water surface.

Chart 12 shows the variation in ΔT between the sites. Since the solar radiation is the only variable that changes regularly on a daily basis, most of the ΔT value at a site is associated with changes in the amount of solar energy received by the stream. Vegetative shade, topographic shade, cloud cover, stream azimuth, and solar path influence the amount of solar energy received at the water surface on any give day. Sites with high ΔT are apparently receiving a higher level of solar energy per unit volume of water throughout the day. Large streams and rivers may experience a lower ΔT because a larger volume of water is being heated for the same solar input. This effect is confirmed with the Umpqua River data that shows moderate ΔT values while having high maximum temperatures. Site MUA2 on Paradise Creek appears to be exceptionally high suggesting high solar input and relatively shallow water. Site MU06 is located at the outlet of Loon Lake and the data suggests that the lake outflow is coming from the cooler, deep-water portion of the lake, not from the warm surface of the lake.

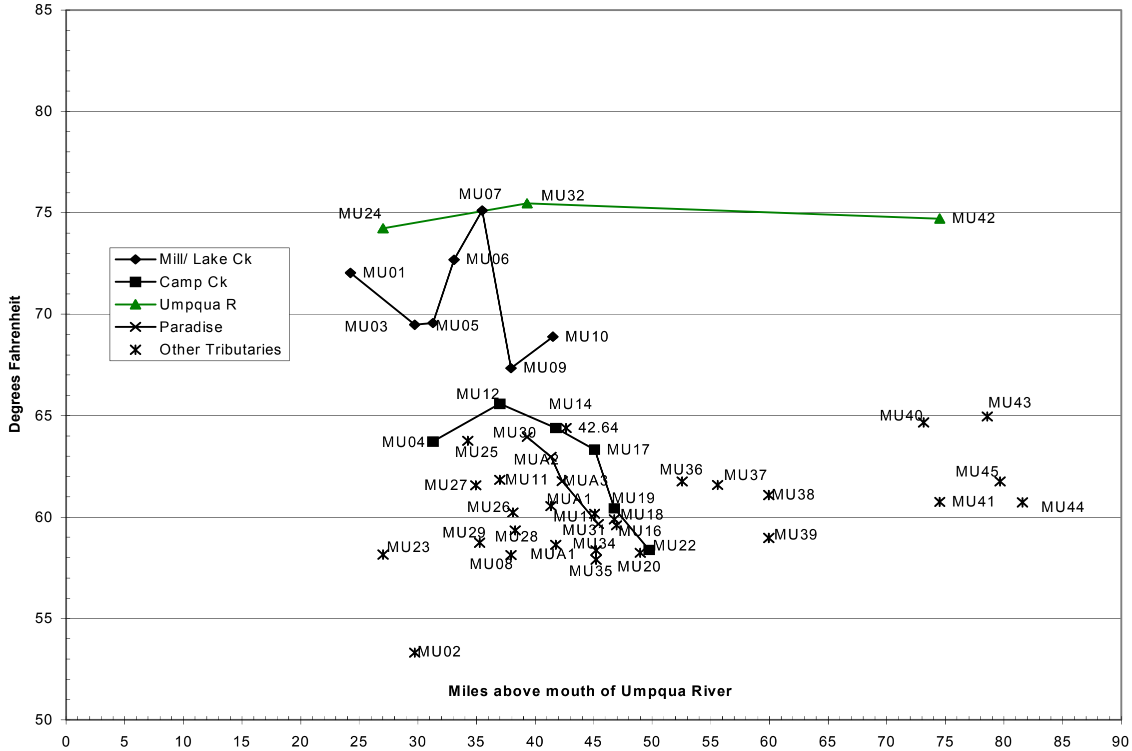


Chart 11 Minimum 8/8/2000 Temperatures by River Mile

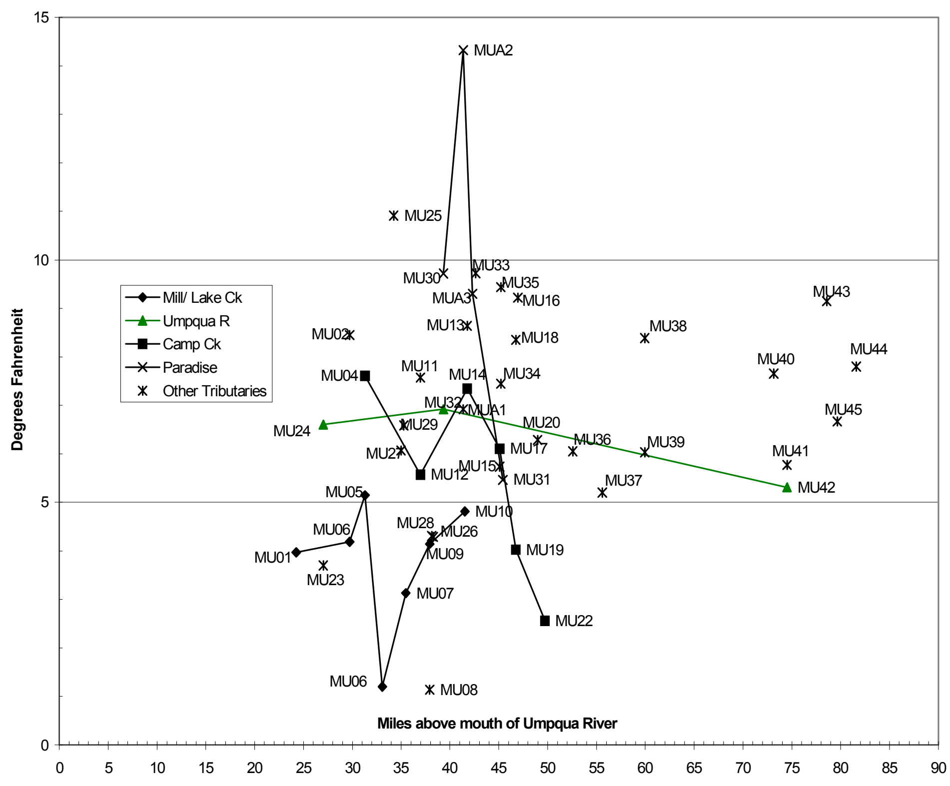


Chart 12 ΔT Values for 8/8/2000 plotted by River Mile

Site Distance from the source ridge

It was noted in the preceding discussion 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 increasing 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 health and development of 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. 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 a significantly different geologic area or have different watershed geometry. For that reason, this type of comparison is effective only when made in the same geographic area and, even then, there may be considerable variability. It should be noted that this sorting does not directly account for differences in absolute elevation between sites but it does account, to some extent, for vertical drop from the source ridge.

Charts 13 and 14 shows how the maximum and minimum temperatures observed on 8/8 varied as a function of the distance of the site from the stream's respective source ridgeline. The streams that are in the 5 to 15 mile range from their source may represent the best cool water summer habitat. Streams less than 5 miles may be cooler but may not have sufficient water. Streams located more than 15 miles from the source may be getting too warm.

Since the streams associated with a particular ridge distance will tend to have similar size and flow characteristics, one would expect they would have similar temperatures if they had similar shade characteristics. It is readily apparent from Charts 13 and 14 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, most of the remaining variability can be associated with differences in shade. Consequently, the chart provides a "first cut" view of sites that may benefit from improved shade. However, it needs to be emphasized that there may be other factors that would cause a particular site to have elevated temperatures and a local field assessment would be required before a site-specific management plan could be developed.

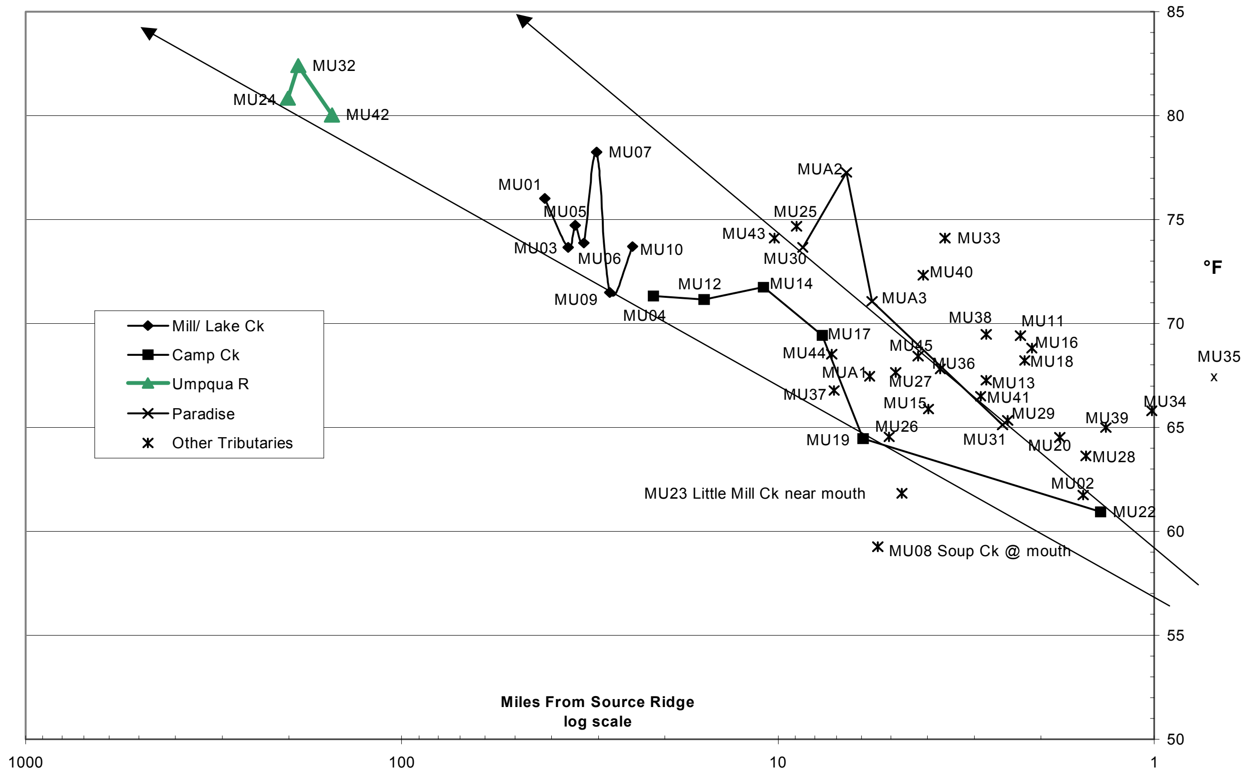


Chart 13 Maximum 8/8/2000 Temperatures by Distance From Source

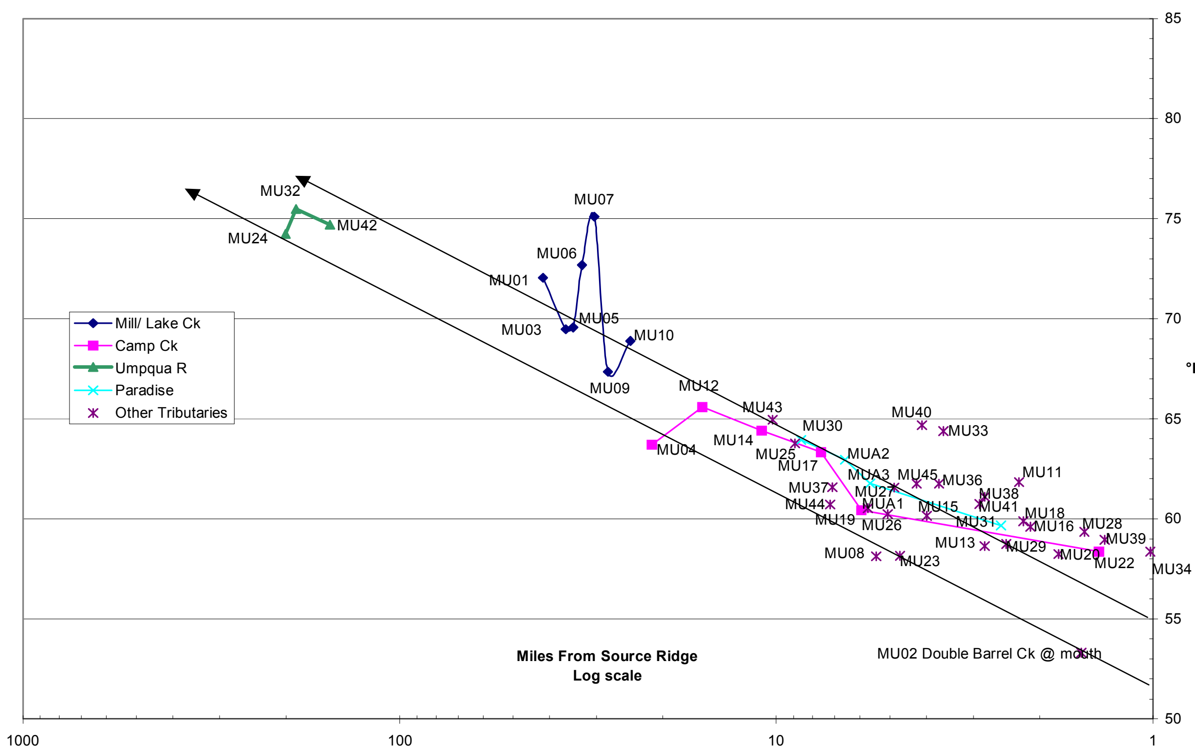


Chart 14 Minimum 8/8/00 Temperatures by Distance from the Source

The sites along the lower edge of the data 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, with temperatures further above the line, may bring the maximum temperatures down to at least this level. The question remains open whether the line represents 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 streams in the 5 to 15 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 in temperature.

Note that the distance is plotted on a logarithmic scale. The exceptionally long distance to the source of the Umpqua River provides an opportunity to see this type of data extended another order of magnitude. Previous studies have noted that the lower edge of the data cluster (identified by the arrow) tends to have a characteristic slope for a given watershed. The equation for the lower edge of the max values is:

$$T \sim 10 \log D + 57.$$

This means that the temperature for this line at mile 1 is 57°F and will increase by 10 °F for every distance multiple of 10. Notice that the slope of Paradise Creek is higher with an equation:

$$T \sim 18 \log D + 58.$$

This equation is consistent with the values found for the Elk Creek water temperature study in 1998. The implication is that there may be a regional characteristic that results in higher temperatures for this area. Quantity of available groundwater and/or groundwater temperature are possible factors.

Note that MU23 –Little Mill Ck and MU08-Soup Ck lie below the curve suggesting exceptional groundwater influence, which depresses the maximum temperature. However, these sites are on the line for the minimum values in Chart 14 and the 1-mile intercept is about 52°F, which is the expected groundwater temperature. It is of interest to note that, for the minimum values, the Paradise Creek data appears to have the same slope as the rest of the watershed but with about a 3 °F temperature displacement.

The corresponding ΔT values shown in Chart 15 indicate that the ΔT values tend to be somewhat higher in the 2 to 15 mile range. This result is consistent with the previous studies. It is thought that, for very small streams, the higher proportion of groundwater limits the daily temperature fluctuation. For the larger streams, the larger quantity of water (greater depth) limits the temperature increase generated by the solar radiation. As previously discussed, the 2-15 mile streams may be particularly important to the fishery resource during the summer season and shade management may be effective in lowering stream temperatures of the streams with high ΔT values in this zone.

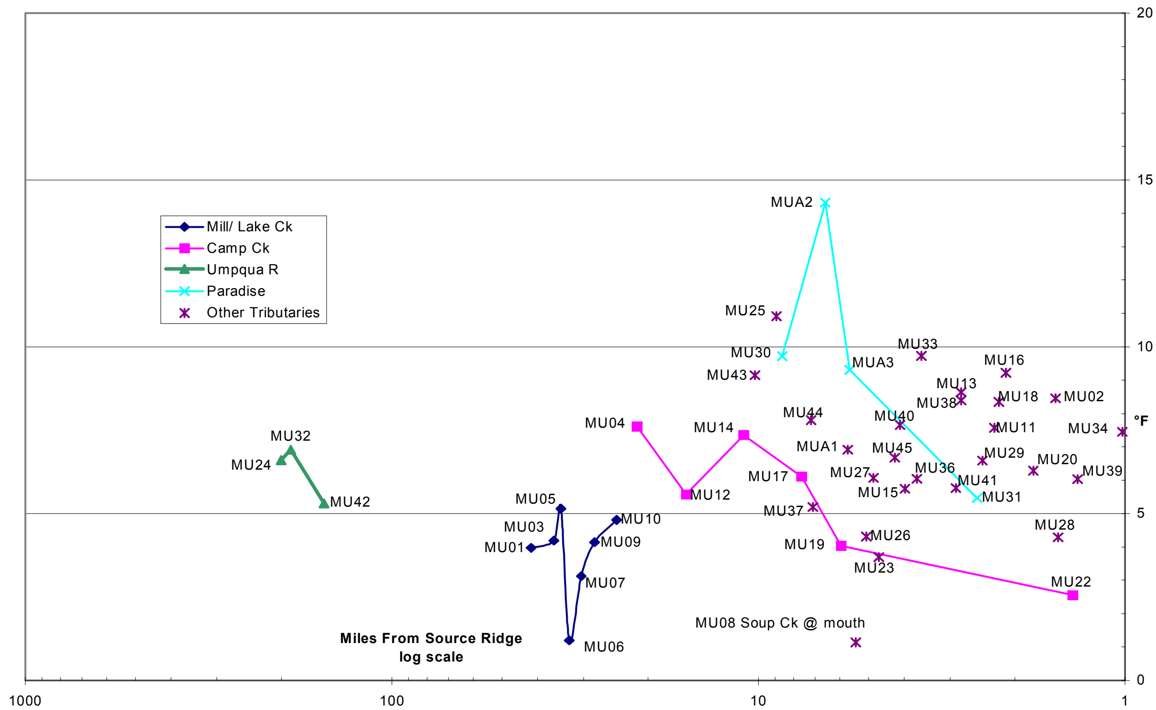


Chart 15 ***ΔT Values For 8/8/00 By Distance From Source***

Conclusions

When the results of the Lower Umpqua River study are combined with the previous studies several important points can be inferred.

Key Observations:

- For this collection of data, the zone of maximum temperatures below 64 °F extended from 0 to about 5 miles as shown in Chart 13. This is a shorter distance than observed in previous studies.
- There is a general tendency for streams to heat in the downstream direction. However, downstream temperatures for individual streams can be colder than points upstream if conditions are significantly different. (Example: Paradise Creek and Camp Creek.) The implication is that local conditions can significantly affect the stream temperature during low flow conditions but these conditions do not persist further downstream.
- The warmer sites appear to have a strong association with exposure to direct solar radiation (absence of shade) based on general observation.
- The low flow period represents an extreme condition in the stream channels. Surface flow velocities 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 Soup Creek site is a good example of possible groundwater influence.
- Maximum ΔT values may tend to occur between 8 and 15 miles of the ridgeline.
- The rate of downstream heating (°F/mile) appears to be lower in the Lower Umpqua region compared to the Elk Creek watershed.

Management Implications:

The small tributaries may be providing important thermal refuge areas for the cold-water fish species and other aquatic life if these areas have cooler temperatures and sufficient water. Pools in the smaller tributaries could also be beneficial if they maintain sufficient water and have cover. 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 and 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. In particular, determine the relative contributions of local conditions and upstream influence.
- Correlate fish presence data with the temperature data to identify the optimum habitat zones if they exist.
- Develop a temperature management plan for the Umpqua Basin
- Monitor the stream temperature at the 5 reference sites each year to provide a link between current conditions and the previous studies.
- Compile all of the data from the Stream Temperature Characterization Studies into a CD format along with analysis, site data, and site photos. Emphasis would be on comparison of regional heating patterns and identification of management potential.
- 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

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:

- 50 temperature 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 2.5 hr. Shows details of each sensor location and some general site characteristics.
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.

Conversion Tables

°C	°F
10.0	50.0
10.5	50.9
11.0	51.8
11.5	52.7
12.0	53.6
12.5	54.5
13.0	55.4
13.5	56.3
14.0	57.2
14.5	58.1
15.0	59.0
15.5	59.9
16.0	60.8
16.5	61.7
17.0	62.6
17.5	63.5
18.0	64.4
18.5	65.3
19.0	66.2
19.5	67.1
20.0	68.0
20.5	68.9
21.0	69.8
21.5	70.7
22.0	71.6
22.5	72.5
23.0	73.4
23.5	74.3
24.0	75.2
24.5	76.1
25.0	77.0
25.5	77.9
26.0	78.8
26.5	79.7
27.0	80.6
27.5	81.5
28.0	82.4
28.5	83.3
29.0	84.2
29.5	85.1
30.0	86.0

°F = (1.8 x °C) +32

°F	°C
50	10.0
51	10.6
52	11.1
53	11.7
54	12.2
55	12.8
56	13.3
57	13.9
58	14.4
59	15.0
60	15.6
61	16.1
62	16.7
63	17.2
64	17.8
65	18.3
66	18.9
67	19.4
68	20.0
69	20.6
70	21.1
71	21.7
72	22.2
73	22.8
74	23.3
75	23.9
76	24.4
77	25.0
78	25.6
79	26.1
80	26.7
81	27.2
82	27.8
83	28.3
84	28.9
85	29.4
86	30.0
87	30.6
88	31.1
89	31.7
90	32.2

°C = (°F-32) / 1.8

Miles	Kilometers
1	1.61
2	3.22
3	4.83
4	6.44
5	8.05
6	9.66
7	11.27
8	12.87
9	14.48

Miles	Kilometers
0.62	1
1.24	2
1.86	3
2.49	4
3.11	5
3.73	6
4.35	7
4.97	8
5.59	9

Acres	Hectares
1	0.40
2	0.81
3	1.21
4	1.62
5	2.02
6	2.43
7	2.83
8	3.24
9	3.64

Acres	Hectares
2.47	1
4.94	2
7.41	3
9.88	4
12.36	5
14.83	6
17.30	7
19.77	8
22.24	9