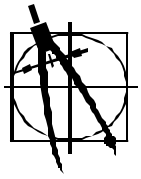
Umpqua Basin Watershed Council

Elk Creek Temperature Study 1998

Procedure, results and preliminary analysis

December 10, 1998



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Elk Creek Temperature Study 1998

Abstract

Temperature data from 28 continuously sampling sensors was obtained from monitoring sites in the Elk Creek watershed. With one exception, the seasonal maximum from each site was within the range between 69.7 and 87.7 °F.

Analysis of the data from sites located between 3 and 12 miles of the respective headwater source suggests that there is a characteristic minimum value to the seasonal maximum that increases in the downstream direction at the rate of about 1.25 °F per mile. At distances greater than 12 miles, the seasonal maximum appeared to fluctuate around a constant value of about 85°F.

The seasonal maximum of the 7-day average of the daily maximum temperatures tended to be consistently about 3 degrees lower than the corresponding seasonal maximum.

The maximum change between the daily maximum and minimum value (ΔT) with one exception, varied between 5.4 and 15.7 °F. The exception site was a small shallow stream in an open pasture and it had a maximum ΔT of 20.3 °F. The variation in the ΔT values appeared to be independent of the position of the site within the watershed and also independent of the distance from the headwater source.

Objective and scope of the study:

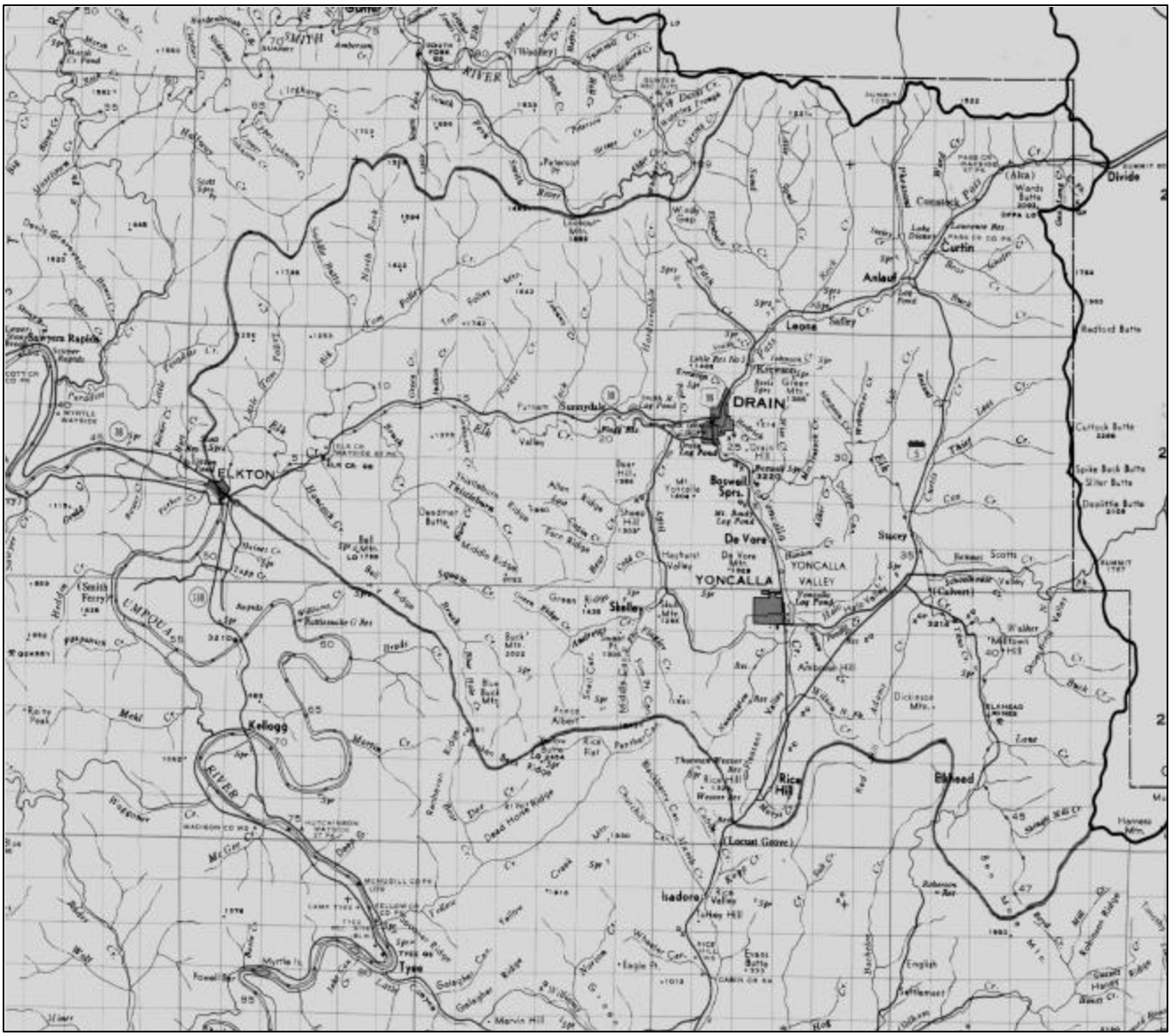
The objective this study was is to gain insight on how stream temperatures vary within a watershed. A synoptic approach was taken by distributing 24 data sensors throughout the watershed with the intent of eliminating the between-year variability in the data. It is expected that this data will provide 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 Elk Creek Watershed is shown in Map 1. It is located in north central Douglas County and is about 350 square miles in size. The watershed is

located entirely in what is known as the Willamette Valley even though it is part of the Umpqua Watershed. The elevation at the mouth is 90 feet and the elevation of the defining ridges ranges from 800 to over 2000 feet.
A large proportion of the watershed is classified as alluvial valley and the streams show the characteristic meander pattern associated with this landform.
The Elk Creek watershed represents about 6% of the entire Umpqua basin and is a significant supply source to the main stem segment.



Map 1 Elk Creek Watershed

Land ownership:

Less than 20% of the watershed is federally managed and larger timber companies manage approximately 40%. Due to the high percentage of

private ownership, the watershed tends to receive low priorities for restoration and enhancement projects.
The watershed has been recognized as a significant source area for sea-run trout.

For further technical information about the Elk Creek watershed see the following Roseburg BLM watershed analysis documents:

East Elk WAU October 1996.

Brush Creek, Hayhurst Valley and Yoncalla April 1996.

Description of the study:

Site Selection:

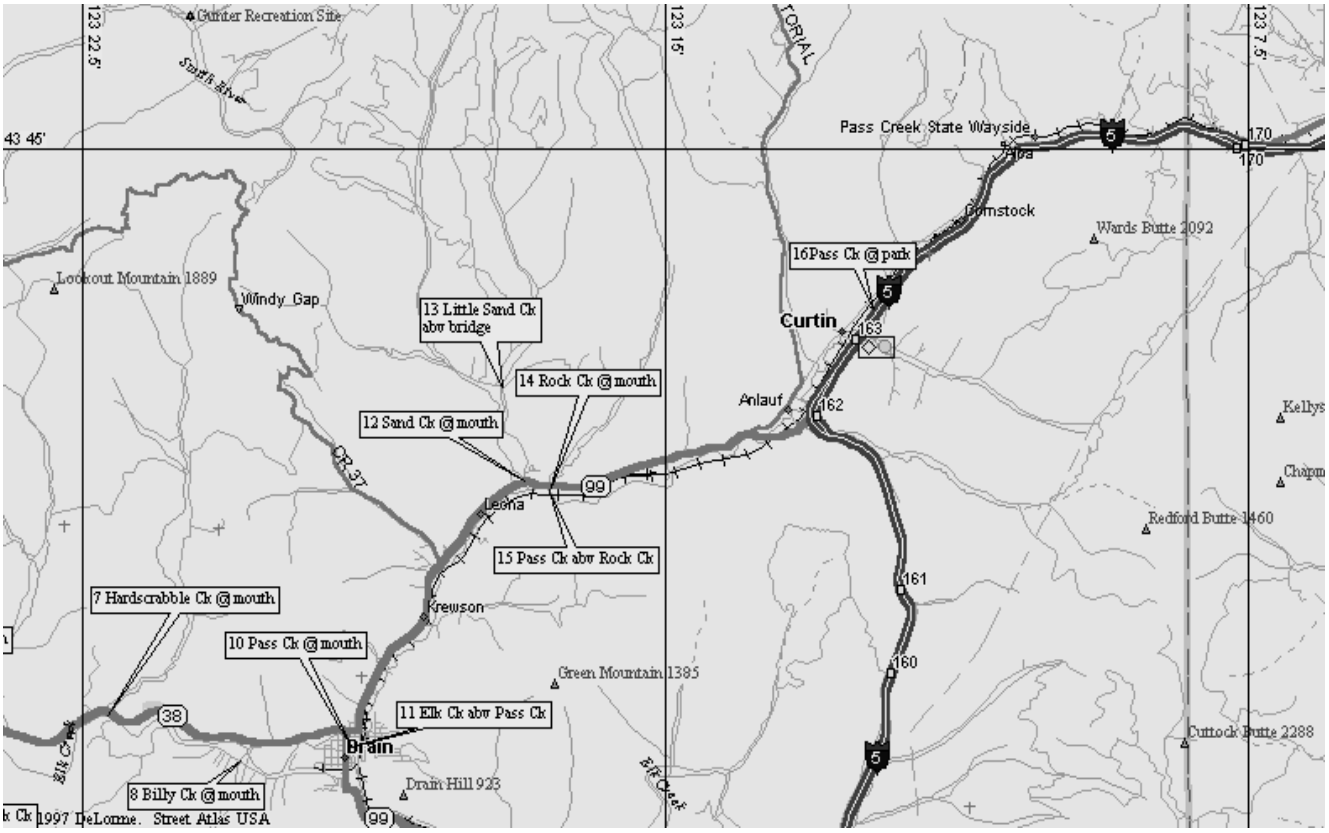
Twenty-four site locations were chosen to obtain a representative sample of the various types of streams throughout the watershed. Data records were also obtained from three Douglas County and two BLM monitoring stations for a total of 29 stations.
The numbered sites are shown on maps 2-4 and the corresponding names are listed in Table 1 below. Sites with decimal extensions represent the BLM and Douglas County sites.

Deployment and Collection:

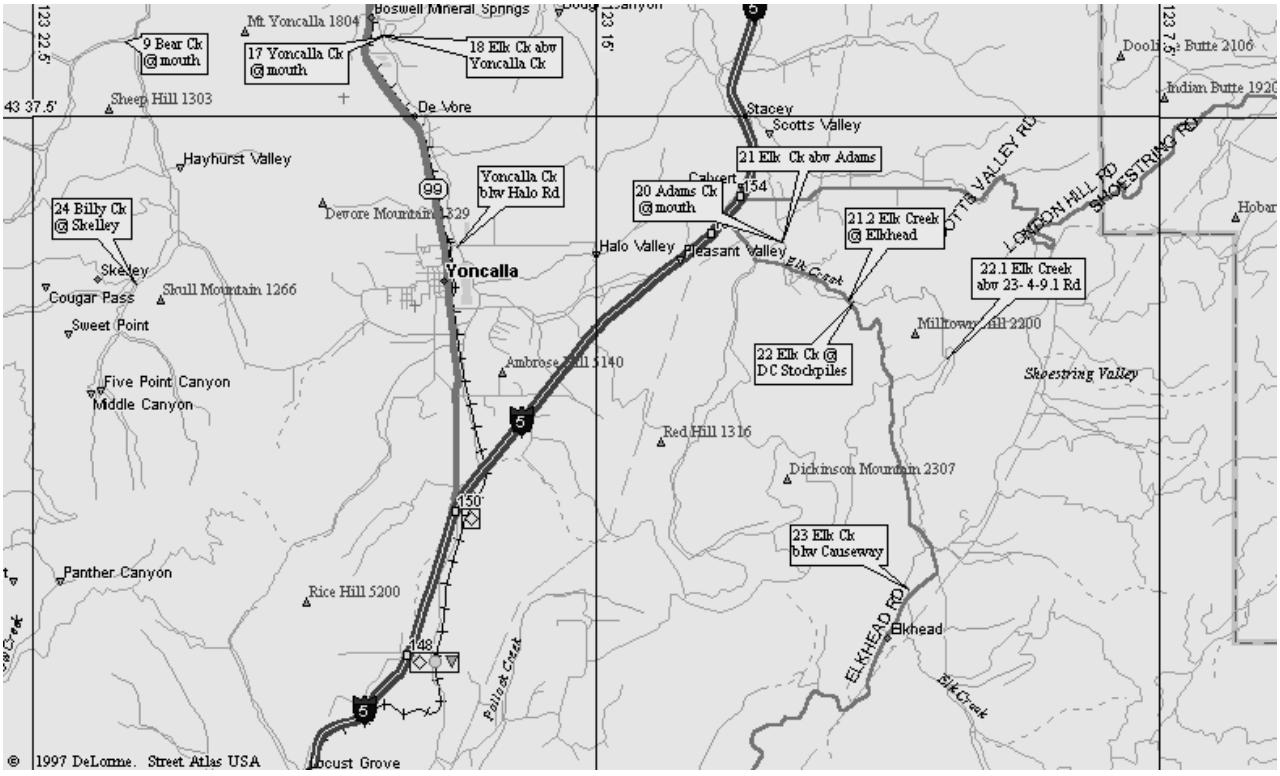
The 24 UBWC "Vemco" units were deployed between July 8 and July 10, The units were set to record temperature at 20-minute intervals.
Permission was obtained from landowners to access the sites located on private property. The sensor unit at site 24, Billy Ck @ Skelley was inadvertently destroyed by a construction project and no data was retrieved from this site.
All of the UBWC units were collected on September 22.

Table 1 Monitoring Sites

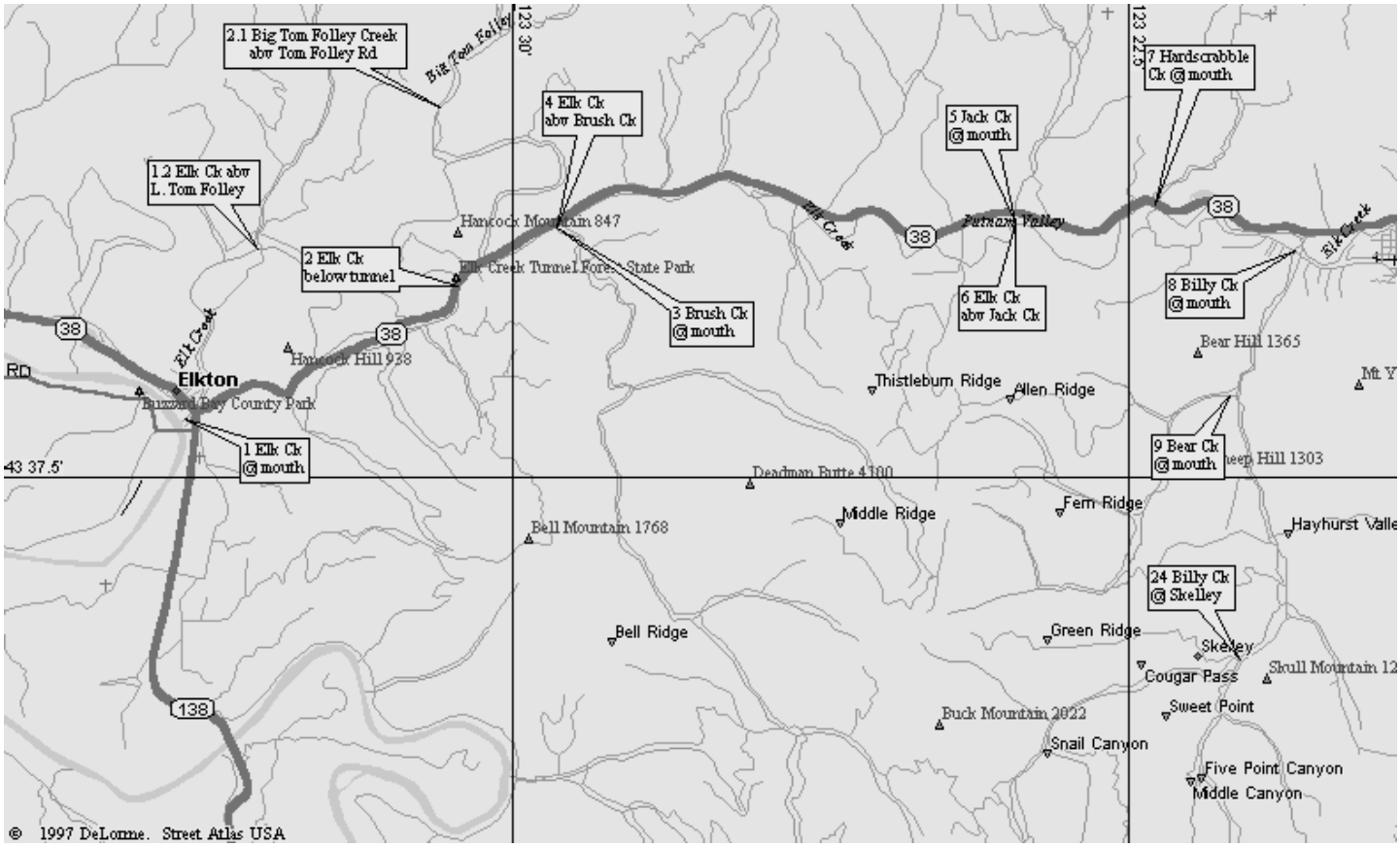
	Site Name	Data
1	Elk Cr @ Mouth	UBWC
1.2	Elk Ck Abv L. Tom Folley	County
2	Elk Ck Blw Tunnel	UBWC
2.1	Tom Folley @ Tom Folley Rd	BLM
3	Brush Cr @ Mouth	UBWC
4	Elk Ck abv Brush Ck	UBWC
5	Jack Ck @ Mouth	UBWC
6	Elk Ck Abv Jack Ck	UBWC
7	Hardscrabble @ Mouth	UBWC
8	Billy Ck @ Mouth	UBWC
9	Bear Ck @ Mouth	UBWC
10	Pass Ck @ mouth	UBWC
11	Elk Ck abv Pass Ck	UBWC
11.2	Elk Ck blw Yoncalla Ck	County
12	Sand Ck abv hwy 99	UBWC
13	Little Sand Ck abv Bridge	UBWC
14	Rock Ck @ Mouth	UBWC
15	Pass Ck abv Rock Ck	UBWC
16	Pass Ck @ Park	UBWC
17	Yoncalla Ck @ Mouth	UBWC
18	Elk Ck abv Yoncalla Ck	UBWC
19	Yoncalla Ck @ Halo Rd	UBWC
20	Adam's Ck @ Mouth	UBWC
21	Elk Ck abv Adam's Ck	UBWC
21.2	Elk Ck @ Elkhead	County
22	Elk Ck @ DC Stock pile	UBWC
22.1	Elk Ck abv rd 23-4-9.1	BLM
23	Elk Ck blw Causeway	UBWC
24	Billy Ck @ Skelley*	UBWC



Map 2 Pass Creek Site Locations



Map 3 Yoncalla Ck and Upper Elk Site Locations



Map 4 Lower Elk Site Locations

Field Documentation:

A camcorder was used to document the exact sensor location and general characteristics of each UBWC deployment site. A computer program was used to extract digital picture .jpg files for each site that shows the downstream and upstream views as well as the sensor location. These files are available in the attached 3 ½ disks labeled Elk Pictures.

A VHS recording entitled "Elk Creek Temperature 1998 – Field Notes" is also available for viewing or copying. The emphasis of this video was to document the location of the sensor unit. However, it also provides information about the general characteristics of each site.

Data sheets for each UBWC site were also developed that describes some of the site characteristics and also contains a chart that shows the raw temperature data used to calculate the temperature statistics. (See Supplemental Data / Appendix A – Site Data Sheets.)

Accuracy Checks:

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. Chart 1 shows the results from a typical temperature test. Tables 1and 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.

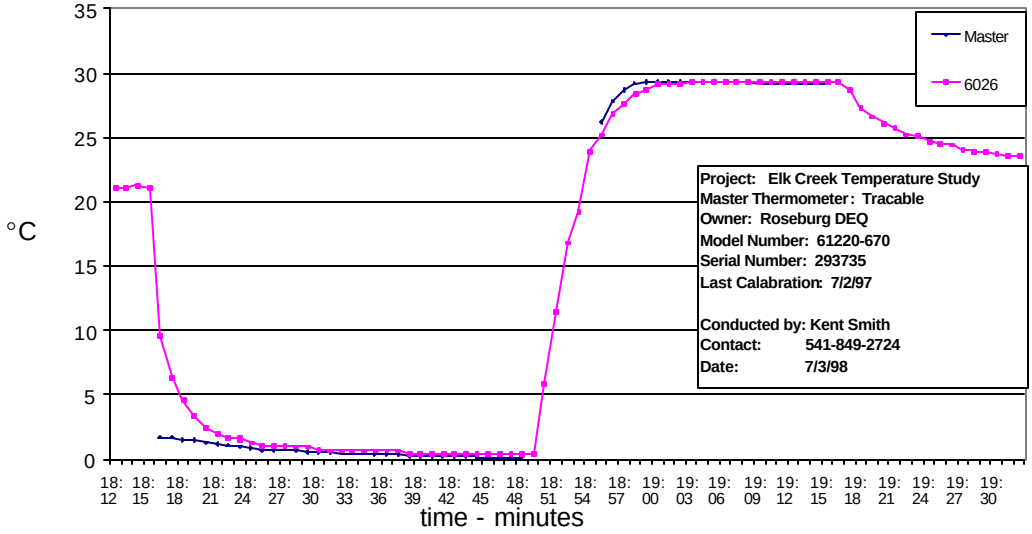


Chart1: Typical accuracy check for a Vemco unit.

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

Results:

Each UBWC unit produced over 5000 readings that were loaded into an Excel® file. The end points of the data files were then "trimmed" to exclude data recorded while the units were out of the water. It should be noted that sites 7 and 19 were trimmed to different dates since it was apparent that these units had been exposed to air temperatures by receding streamflow. The BLM data was also trimmed to different values but all units contained data from the peak temperature period. Chart 2 shows a typical pattern for the 1998 season.

The raw data for the UBWC and BLM sits was processed through the DEQ "Tempture" Version 1.1 Macro, which effectively extracts key statistics. The macro was not used on Douglas County data since it was already reduced to maximum and minimum values when it was provided to UBWC.

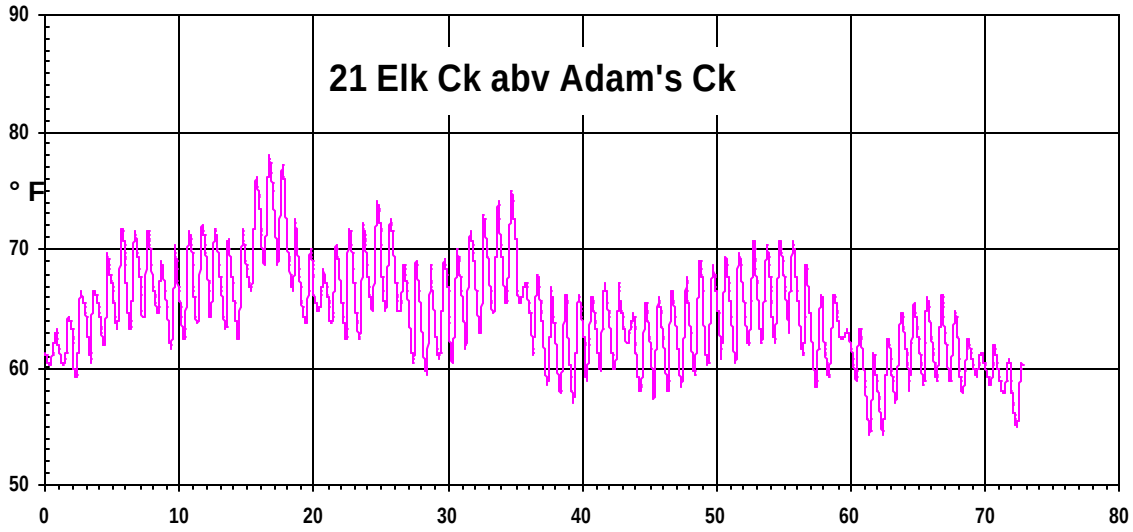


Chart 2: Typical temperature data for the 1998 season.

The seasonal maximum, 7-day maximum and ΔT values are shown in Chart 3. Table 2 contains all of the results produced by the DEQ "Tempture" program:

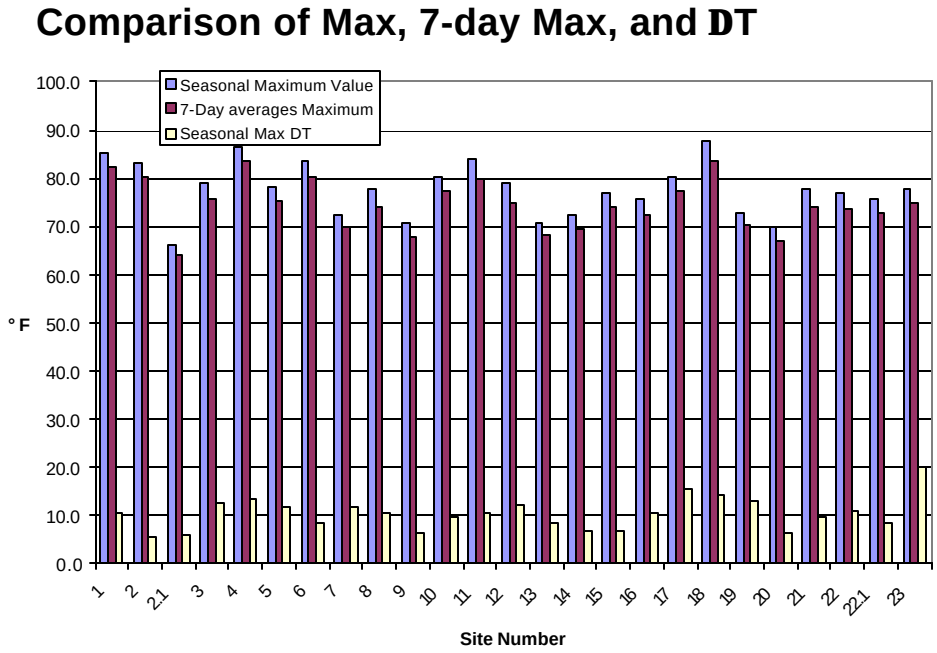


Chart 3 Summary of Max, 7-day Max and ΔT statistics

Table 2 Statistical Summary Table.

Site Name	Lat	Long	Start Date	Stop date	Seasonal Maximum		Seasonal Minimum		Seasonal Max DT		7-Day averages			
					Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	DT
1 Elk Cr @ Mouth	43° 38.025	123° 33.942	07/11/98	09/21/98	07/27/98	85.3	09/11/98	62.4	08/31/98	10.4	07/27/98	82.2	76.3	5.8
2 Elk Ck Blw Tunnel	43° 39.208	123° 30.688	07/11/98	09/21/98	07/28/98	83.0	09/11/98	62.4	09/15/98	5.4	07/26/98	80.2	76.3	3.9
2.1 Tom Folley @ Tom Folley Rd	43° 40.753	123° 30.892	06/16/98	09/09/98	07/28/98	66.1	06/17/98	51.4	06/20/98	5.8	07/28/98	64.3	61.6	2.7
3 Brush Cr @ Mouth	43° 39.719	123° 29.58	07/11/98	09/21/98	07/27/98	78.9	09/11/98	55.7	07/16/98	12.8	07/25/98	75.6	64.5	11.2
4 Elk Ck abv Brush Ck	43° 39.712	123° 29.51	07/11/98	09/21/98	07/27/98	86.7	09/10/98	58.9	08/31/98	13.6	07/26/98	83.4	73.5	9.9
5 Jack Ck @ Mouth	43° 39.752	123° 23.891	07/11/98	09/21/98	07/27/98	78.3	09/11/98	56.2	07/26/98	11.9	07/25/98	75.1	64.6	10.6
6 Elk Ck Abv Jack Ck	43° 39.752	123° 23.891	07/11/98	09/21/98	07/27/98	83.7	09/21/98	61.3	08/03/98	8.7	07/26/98	80.2	73.6	6.6
7 Hardscrabble @ Mouth	43° 39.905	123° 22.166	07/11/98	08/10/98	07/28/98	72.3	08/08/98	58.1	08/10/98	11.7	08/07/98	69.7	60.9	8.8
8 Billy Ck @ Mouth	43° 39.507	123° 20.443	07/11/98	09/21/98	07/27/98	77.7	09/10/98	55.4	07/26/98	10.5	07/25/98	73.9	65.3	8.7
9 Bear Ck @ Mouth	43° 38.194	123° 21.195	07/11/98	09/21/98	07/27/98	70.6	08/19/98	53.0	09/06/98	6.5	07/25/98	67.7	62.5	5.2
10 Pass Ck @ mouth	43° 39.673	123° 19.052	07/11/98	09/21/98	07/27/98	80.2	09/11/98	59.2	08/03/98	9.9	07/26/98	77.2	69.4	7.8
11 Elk Ck abv Pass Ck	43° 39.673	123° 19.052	07/11/98	09/21/98	07/27/98	84.0	09/10/98	56.8	08/03/98	10.6	07/26/98	79.9	71.9	8.0
12 Sand Ck abv hwy 99	43° 42.009	123° 16.33	07/11/98	09/21/98	07/27/98	78.9	09/10/98	54.3	08/03/98	12.2	07/26/98	75.0	65.5	9.5
13 Little Sand Ck abv Bridge	43° 42.8961	123° 17.093	07/11/98	09/21/98	07/27/98	70.9	09/10/98	50.9	07/16/98	8.5	07/25/98	68.1	61.1	7.0
14 Rock Ck @ Mouth	43° 41.937	123° 16.494	07/11/98	09/21/98	07/27/98	72.3	09/11/98	52.5	09/11/98	6.7	07/26/98	69.7	64.7	5.0
15 Pass Ck abv Rock Ck	43° 41.937	123° 16.494	07/11/98	09/21/98	07/28/98	77.1	09/11/98	56.8	09/01/98	7.0	07/27/98	73.9	69.3	4.6
16 Pass Ck @ Park	43° 43.586	123° 12.323	07/11/98	09/21/98	07/28/98	75.9	09/11/98	55.1	07/16/98	10.6	07/26/98	72.5	64.2	8.3
17 Yoncalla Cl @ Mouth	43° 38.32	123° 17.847	07/11/98	09/21/98	07/27/98	80.5	09/10/98	52.2	09/11/98	15.7	07/25/98	77.2	68.2	9.0
18 Elk Ck abv Yoncalla Ck	43° 38.36	123° 17.847	07/11/98	09/21/98	07/27/98	87.7	09/10/98	56.8	07/26/98	14.3	07/25/98	83.4	70.7	12.7
19 Yoncalla Ck @ Halo Rd	43° 36.274	122° 16.797	07/11/98	09/08/98	07/28/98	72.9	09/06/98	55.4	09/07/98	13.0	07/27/98	70.4	67.1	3.3
20 Adam's Ck @ Mouth	43° 36.262	123° 12.494	07/11/98	09/21/98	07/27/98	69.7	09/11/98	53.3	07/25/98	6.6	07/26/98	67.0	61.8	5.1
21 Elk Ck abv Adam's Ck	43° 36.262	123° 12.494	07/11/98	09/21/98	07/27/98	78.0	09/11/98	54.3	08/12/98	9.9	07/26/98	74.0	65.8	8.2
22 Elk Ck @ DC Stock pile	43° 35.663	123° 11.367	07/11/98	09/21/98	07/27/98	77.1	09/11/98	52.7	08/31/98	11.2	07/26/98	73.6	65.5	8.1
22.1 Elk Ck abv rd 23-4-9.1	43° 35.163	123° 10.311	06/18/98	09/30/98	07/28/98	75.8	09/30/98	53.8	08/31/98	8.4	07/26/98	72.7	67.1	5.6
23 Elk Ck blw Causeway	43° 32.872	123° 10.819	07/11/98	09/21/98	07/28/98	77.7	09/17/98	52.5	09/16/98	20.3	09/02/98	74.9	60.6	14.2

Site Name	Days > 55 F	Days > 64 F	Days > 70 F	Hours > 55 F	Hours > 64 F	Hours > 70 F	Warmest day of 7-day max			Agency
							Date	Maximum	Minimum	
1 Elk Cr @ Mouth	73	73	68	1751.7	1727.3	1249.7	07/27/98	85.3	79.6	InSight
2 Elk Ck Blw Tunnel	73	73	58	1751.7	1646.0	1094.3	07/28/98	83.0	78.6	InSight
2.1 Tom Folley @ Tom Folley Rd	84	5	0	1805.5	44.0	0.0	07/28/98	66.1	63.5	BLM
3 Brush Cr @ Mouth	73	72	47	1751.7	1122.7	324.7	07/27/98	78.9	67.2	InSight
4 Elk Ck abv Brush Ck	73	73	65	1751.7	1624.3	1077.0	07/27/98	86.7	76.2	InSight
5 Jack Ck @ Mouth	73	66	34	1751.7	1059.7	264.7	07/27/98	78.3	67.2	InSight
6 Elk Ck Abv Jack Ck	73	73	61	1751.7	1696.3	1021.3	07/27/98	83.7	75.9	InSight
7 Hardscrabble @ Mouth	31	27	6	743.7	414.0	28.7	08/05/98	71.7	63.3	InSight
8 Billy Ck @ Mouth	73	65	27	1751.7	943.0	162.7	07/27/98	77.7	68.3	InSight
9 Bear Ck @ Mouth	73	34	1	1701.3	349.7	2.7	07/27/98	70.6	65.2	InSight
10 Pass Ck @ mouth	73	68	43	1751.7	1498.0	556.7	07/27/98	80.2	71.7	InSight
11 Elk Ck abv Pass Ck	73	72	52	1751.7	1499.0	742.3	07/27/98	84.0	74.7	InSight
12 Sand Ck abv hwy 99	73	66	35	1743.3	989.3	217.0	07/27/98	78.9	68.0	InSight
13 Little Sand Ck abv Bridge	73	36	2	1692.3	344.7	7.3	07/27/98	70.9	64.1	InSight
14 Rock Ck @ Mouth	73	39	3	1728.3	573.3	29.7	07/27/98	72.3	66.9	InSight
15 Pass Ck abv Rock Ck	73	62	26	1751.7	1196.7	268.3	07/28/98	77.1	71.7	InSight
16 Pass Ck @ Park	73	61	16	1751.7	820.7	93.3	07/28/98	75.9	67.5	InSight
17 Yoncalla Cl @ Mouth	73	70	49	1737.7	1088.3	378.0	07/27/98	80.5	71.2	InSight
18 Elk Ck abv Yoncalla Ck	73	73	62	1751.7	1555.0	896.0	07/27/98	87.7	73.8	InSight
19 Yoncalla Ck @ Halo Rd	60	55	8	1439.7	902.0	48.7	07/28/98	72.9	69.2	InSight
20 Adam's Ck @ Mouth	73	30	0	1727.3	277.3	0.0	07/27/98	69.7	64.7	InSight
21 Elk Ck abv Adam's Ck	73	64	27	1745.3	982.3	181.0	07/27/98	78.0	68.6	InSight
22 Elk Ck @ DC Stock pile	73	62	27	1727.0	858.7	132.7	07/27/98	77.1	68.3	InSight
22.1 Elk Ck abv rd 23-4-9.1	105	67	20	2493.5	980.5	129.0	07/28/98	75.8	69.4	BLM
23 Elk Ck blw Causeway	73	71	52	1731.3	1140.7	381.7	09/04/98	76.2	61.6	InSight

Preliminary Analysis

It is apparent from looking at Chart 2 that there is considerable variability in the data at a single site. Chart 3 indicates that there is also considerable variability between the sites. The goal of this preliminary analysis is to gain some insight on the nature of this variability.

Range of variability

The Seasonal maximums from the various sites ranged between 87.7 and 66.1 °F. The 7-day maximums lagged the seasonal maximums by an average of –3.2 ° with a maximum difference of –4.4 °F. With one extreme exception, the maximum ΔT value ranged from 15.4 to 10.3 °F. The exceptionally exposed site (site #23) had a maximum ΔT of 20.3°F.

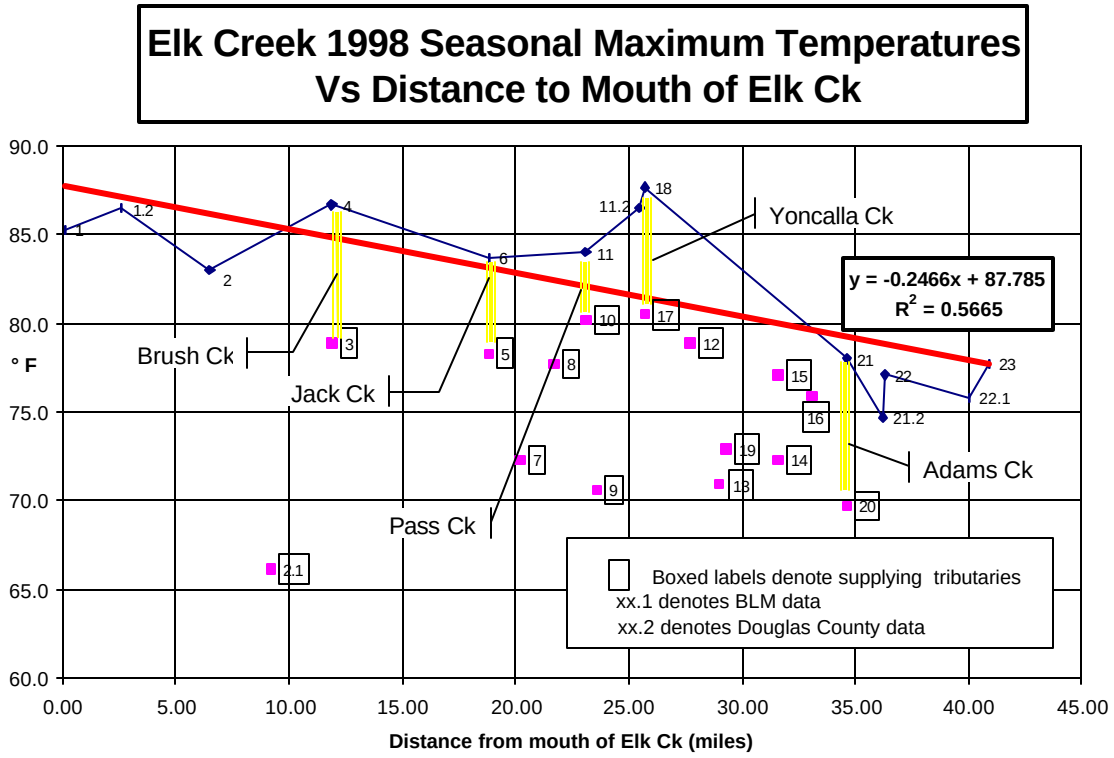


Chart 4 Seasonal Maximums Vs Distance to Mouth of Elk Creek.

Variability associated with position in the watershed.

Chart 4 shows how the seasonal maximum temperature varies along Elk Creek from the mouth to the headwaters. The connected points represent the Elk Creek data and the boxed points mark the data from the tributaries.

Points of Interest

- There is a significant rise in temperature between site 21 (Elk Creek above Adams Creek) and site 18 (Elk Creek above

Yoncalla Creek.) This region was not sampled in the study and no explanation is available at this time. It is expected that exposed channel and/ or shallow flow depths contribute to stream heating in this area.

- The boxed tributary data shows that the contributing tributaries run consistently cooler. The sites that were located at the mouth of their respective tributary are named on the chart. The other sites were located further upstream on the respective tributary.

- Note that site 2.1 Tom Folly Ck at Tom Folley Rd appears to be exceptionally low. This site is a BLM site and no information is known at this time about the actual deployment location or of the accuracy of the instrument. It is recommended that this point be treated as an outlier and be excluded from further analysis until more information is available.

Chart 5 shows a similar plot for the ΔT values. Note that, with the exception of site 23 which was discussed above, all of the values fall between the values of 5.4 and 15.7 °F with the average value of 10.3 °F. Note also that the distribution of the ΔT values appears to be fairly consistent across the watershed suggesting that the ΔT variation between the sites is independent of the position if the site within the watershed.

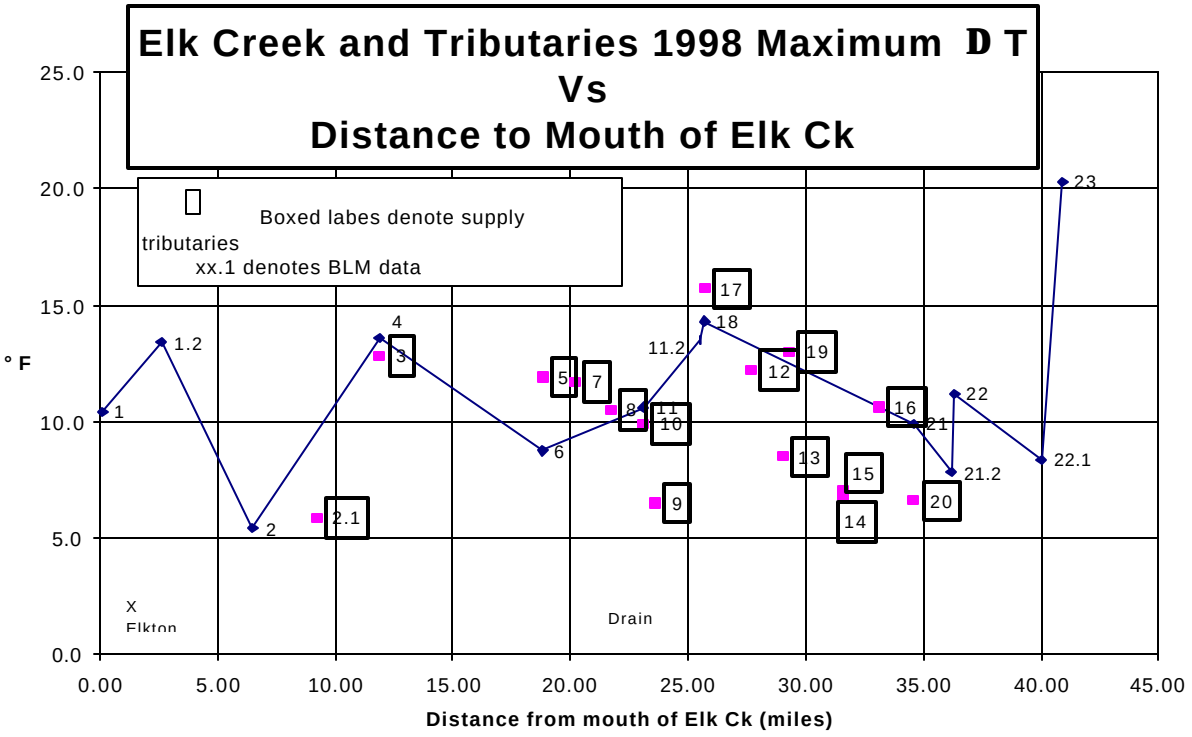


Chart 5 Maximum ΔT Vs Distance to Mouth of Elk Creek

Variability associated with size of the subwatershed

Watershed size directly relates to streamflow quantity as well as channel size parameters. In this analysis, distance from the respective headwater source point was used as an index of size. Chart 6 shows the distribution of the seasonal maximum temperatures plotted against distance from the respective source point. The data was plotted on a logarithmic scale to reduce clustering of the data points. It is interesting to note that, with the exception of site 2.1, the values in the range from 3 to 12 miles appear to be grouped above a minimum value that increases as the streams get larger. This pattern suggests that there may be a threshold value for the minimum of the seasonal maximum temperatures that is directly related to the distance from the source supply.

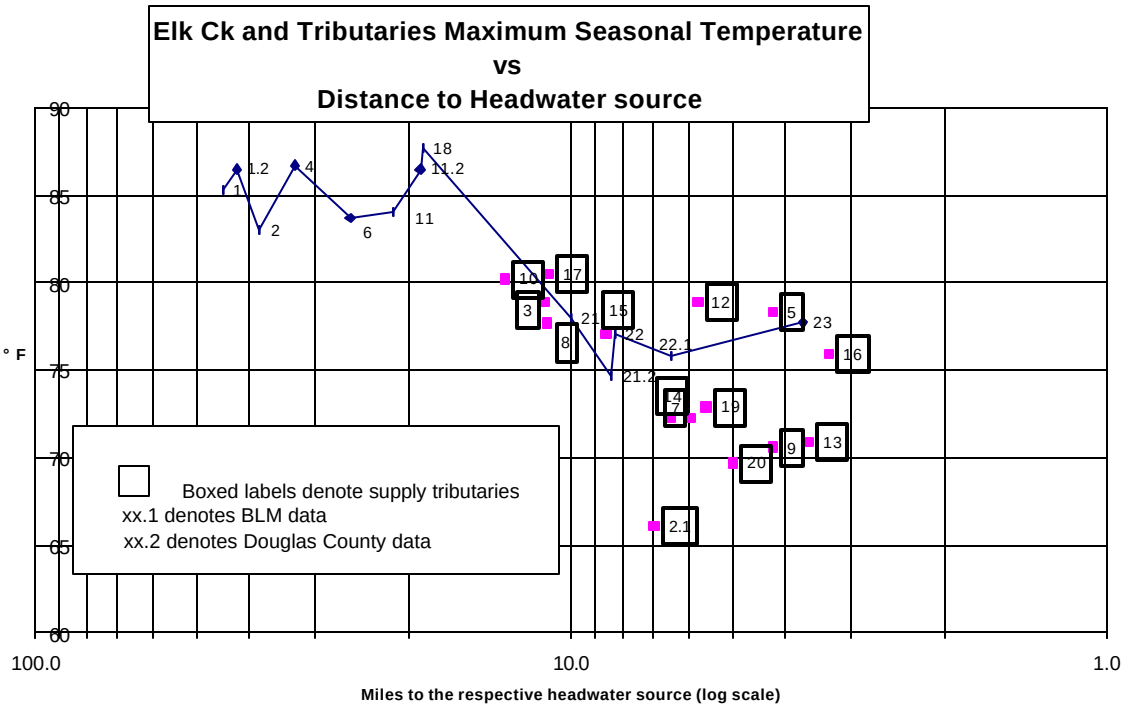


Chart 6 Seasonal Max Temperature Vs Distance From Headwater Source.

Chart 7 shows a regression plot of selected sites with "minimum" maximum values. In the range between 3 and 12 miles, the downstream heating rate is about 1.25°F per mile. In the range between 12 to 45 miles the value appears to be constant at about 83°F.

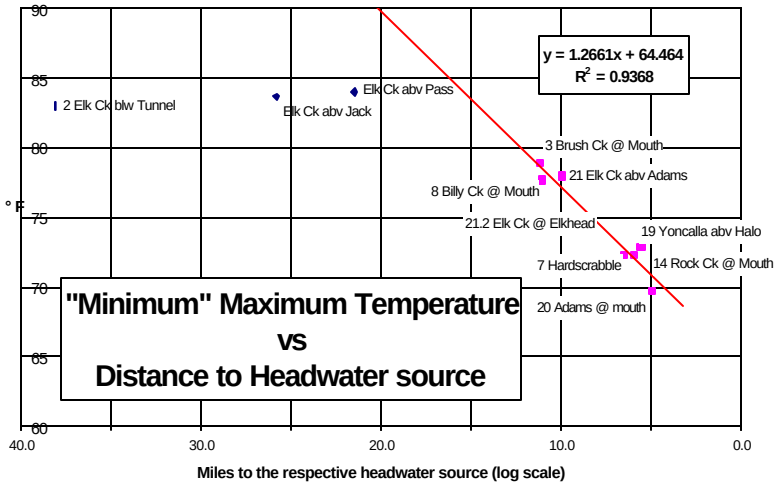


Chart 7 Plot of sites near the minimum threshold value.

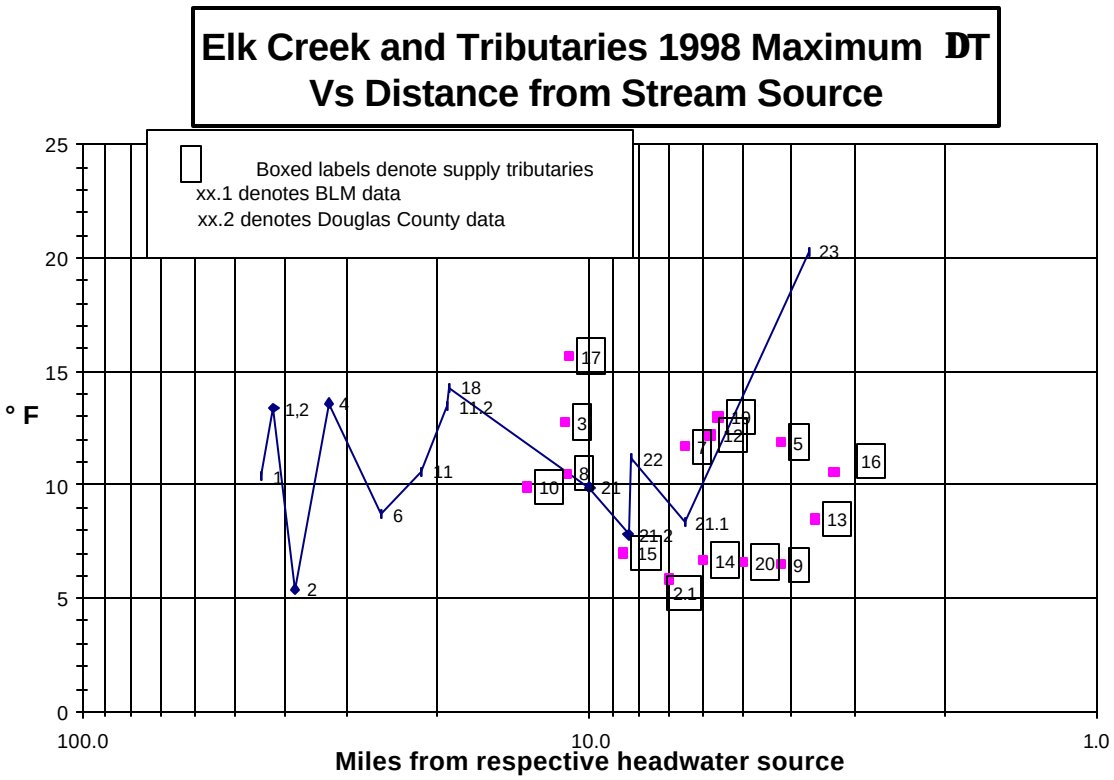


Chart 8

Chart 8 suggests that the variability in ΔT is independent of watershed size as well as being independent of position within the watershed as shown in chart 5.

Conclusions

This study effectively identifies the range and variability of the summer temperatures in the Elk Creek watershed. The preliminary analysis indicates that there may be a characteristic threshold for the watershed that limits the amount that the seasonal maximum temperature can be lowered. If this pattern is evident in other watersheds, finding and defining this threshold could be a key component of a Temperature Management Plan.

This study should make obvious the value of an intensive, synoptic approach in defining the temperature characteristics of a watershed.

Other Information

About the Data used for the analysis

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

Vemco Data

Appendix B contains the specifications for the Vemco minilogger 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 information was obtained from the ODFW stream database. The error between any two stations is estimated as +/- 0.2 miles.

Position

The longitude and latitude were measured from a portable GPS device. These values were checked against the "Street Atlas USA®" software program by DeLorme. Appendix B Table 4 contains the data used for the comparison check. 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:

24 Vemco Miniloggers
Sony HandyCam camcorder
Traceable thermometer
GPS unit
rebar wire
surgical tubing
hip waders
brush clippers

Further Information

Contact InSight Consultants at InSight@rosenet.net 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.
2. .jpg picture files of each site.
3. Raw data files from each site.