Water Temperature Evaluation of the Marys River, Greasy Creek, and Muddy Creek Watersheds

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For the Marys River Watershed Council

Summary

Stream temperature gages placed at 42 locations in 1998 and 21 locations in 1999 throughout the Marys River, Greasy Creek, and Muddy Creek watersheds indicated that most streams have water temperatures low enough to support trout during the summer. Exceptions to this are the main channel of the Marys River from the Harris covered bridge to the Willamette River and Muddy Creek downstream of Bellfountain. The water in these stretches is probably naturally warm due to the terrain, distance from the headwaters, and a lack of cooling groundwater within these valley-floor locations. Some portions of tributaries approach or slightly exceed threshold temperatures for trout due to a lack of shading, water withdrawals or both. Included are lower Oliver Creek, lower Greasy Creek, lower Woods Creek, and lower Shotpouch Creek and a segment of the Tumtum River into which it flows. These have been identified as high priority for restoration since increased shading along these reaches is likely to reduce water temperature to levels favorable for trout.

Purpose

The purpose of this study was to better understand water temperature patterns throughout the Marys River watershed. Particularly, we wanted to know where water temperature was favorable for cutthroat trout during the summer and where there were opportunities to reduce water temperature to benefit trout.

Introduction

A grant was provided by OWEB in early 1998 to purchase water temperature gages to evaluate water temperature in the Marys River watershed. Also, we borrowed some gages from the Philomath High School. Forty two temperature gages were successfully deployed in summer, 1998. A smaller number of gages (26) were successfully deployed in summer, 1999. We put about one-half of the gages in locations throughout the upper Marys River watershed and the Marys River main channel downstream to Corvallis. The other one-half we put in the Greasy Creek and Muddy Creek watersheds. We selected sites to correspond with locations were water temperature changes were anticipated. This included major tributaries, especially at their junction with the main channel, and selected sites along the main channel. Obtaining landowner permission to place a gage in a stream flowing through private land was a time-consuming process so we tried as much as possible to use public road crossings for gaging sites.

When we began this study we realized that some landowners were sensitive to how the temperature data would be used by government agencies in the future. There was particular concern that the data would be used by the Department of Environmental Quality (DEQ) to identify stream segments for inclusion on the 303d list. Streams on the 303d list are considered water quality limited and, in the future, may be subject to a total daily maximum load (TMDL) allocation process. We felt that the water temperature study should occur without the threat of landowners being subject to a 303d listing so we purposely did not officially complete all the quality control measures recommended by DEQ. This means that our data will be categorized as "educational" and not of appropriate quality for placing a stream on the 303d list. Nevertheless, we feel confident that the data is of good quality and is appropriate for the purposes of this study.

Groundwater enters streams in the Marys River watershed at about 55° F and then warms when it is exposed to the air. Stream attain an equilibrium temperature with groundwater inputs, ground temperature, and water evaporation pushing to cool the stream and solar radiation and air temperature pushing to warm the stream. Commonly, the temperature of a stream increases in a downstream direction. A useful way of comparing streams and displaying longitudinal patterns of stream temperature is to plot temperature against distance from drainage divide. Distance from drainage divide is determined by measuring the length of stream from the gaging site upstream to the drainage divide along the longest tributary (Figure 1). The drainage divide can be envisioned as that upstream area which funnels rainfall to the gage site.

Some of the temperature gages we used were manufactured by Onset Computing and others by Vemco. Each is small and capable of storing temperature information for months at a time. We set the gages to take a reading of water temperature every 40 minutes. The gages were placed such that they remained underwater during low flows. Gages were placed in flowing water and anchored to a rock or root. At the end of summer, the gage records were compiled and daily maximum values extracted. We then calculated a 7-day moving average of these maximum values and identified periods when these values were the highest (Figure 2). The 7-day moving average of maximum temperature is the way temperature is expressed in water quality standards established by the State of Oregon. In addition, the reaction of fish to water temperature is assumed to be more related to high temperatures over a week than simply one day.

The lower graph in Figure 2 provides an example of the record of 7-day average water temperatures for one site in 1998. In that year, there were three periods when the water temperature was unusually high. The warm spell in late July was the warmest. However, we did not have all gages installed in the watershed by late July. Therefore, we have used values from the mid-August hot spell in 1998. For 1999, we used values for a early August hot spell, which was also the hottest period of the summer.

Streamflow was measured at selected sites in late summer, 1998 using a Marsh-McBurney velocity meter. In addition, vegetative cover above the stream was measured using a spherical densiometer at 50-foot intervals from 0 to 300 feet upstream of the temperature gage site. Stream width was measured and substrate type (cobble, gravel, sand/silt, clay, bedrock) was also determined at 50-foot intervals. Furthermore, the type, density, and height of vegetation were described for each interval. Finally, channel gradient was determined using a clinometer.

Results

Maximum water temperature values averaged about 2° F greater in 1998 than in 1999 (Table 1 and Table 2). Air temperature was higher than average in 1998, while stream water levels were also higher than average due to abundant rain from winter to early summer. Higher air temperature usually leads to warmer water temperature while higher water level usually leads to cooler water temperature. Air temperatures were about average in 1999 and stream water levels were about normal during mid-summer. However, by late summer stream levels were less than normal due to a prolonged period with no rain. Differences between years are great enough to prevent pooling data for the two years. Consequently, results for the two years are reported separately.

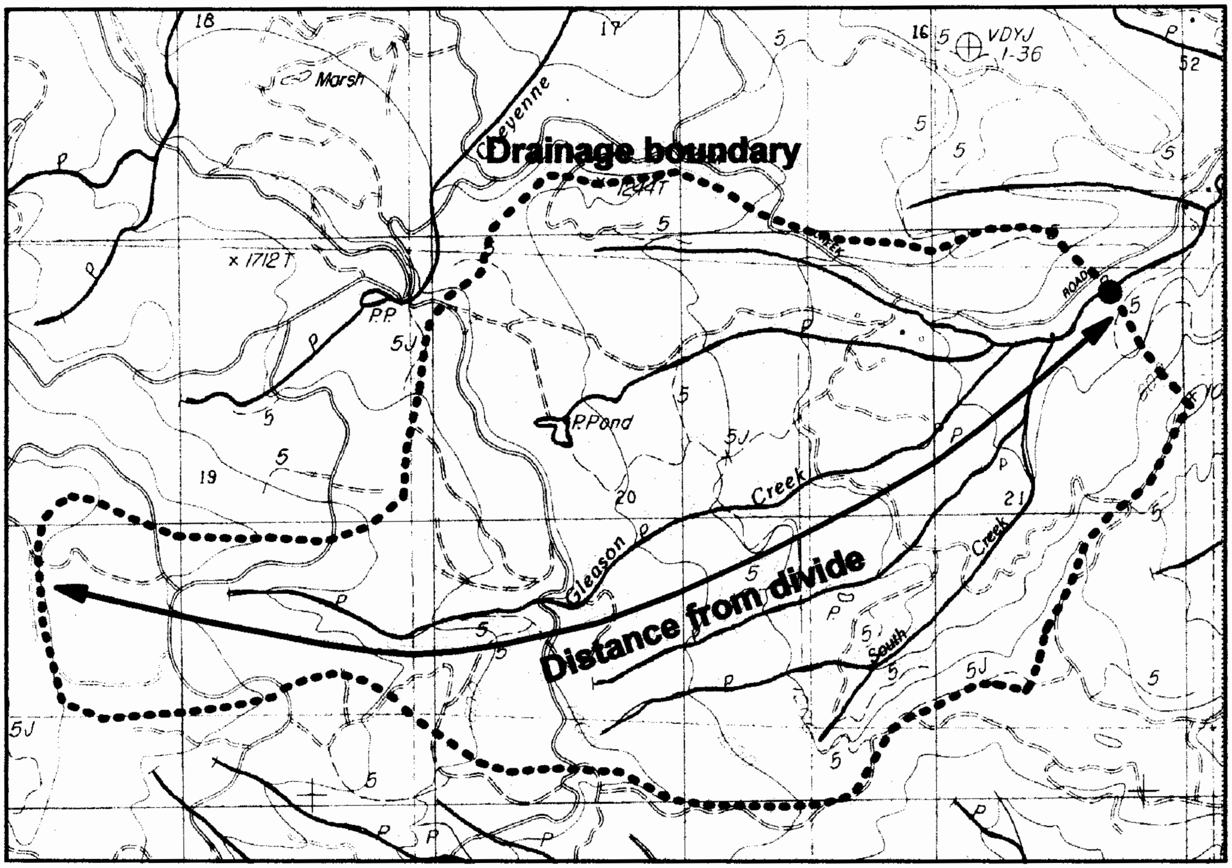

Figure 1. Distance from divide is determined by measuring from the gaging site to the drainage boundary (or divide) along the longest route.

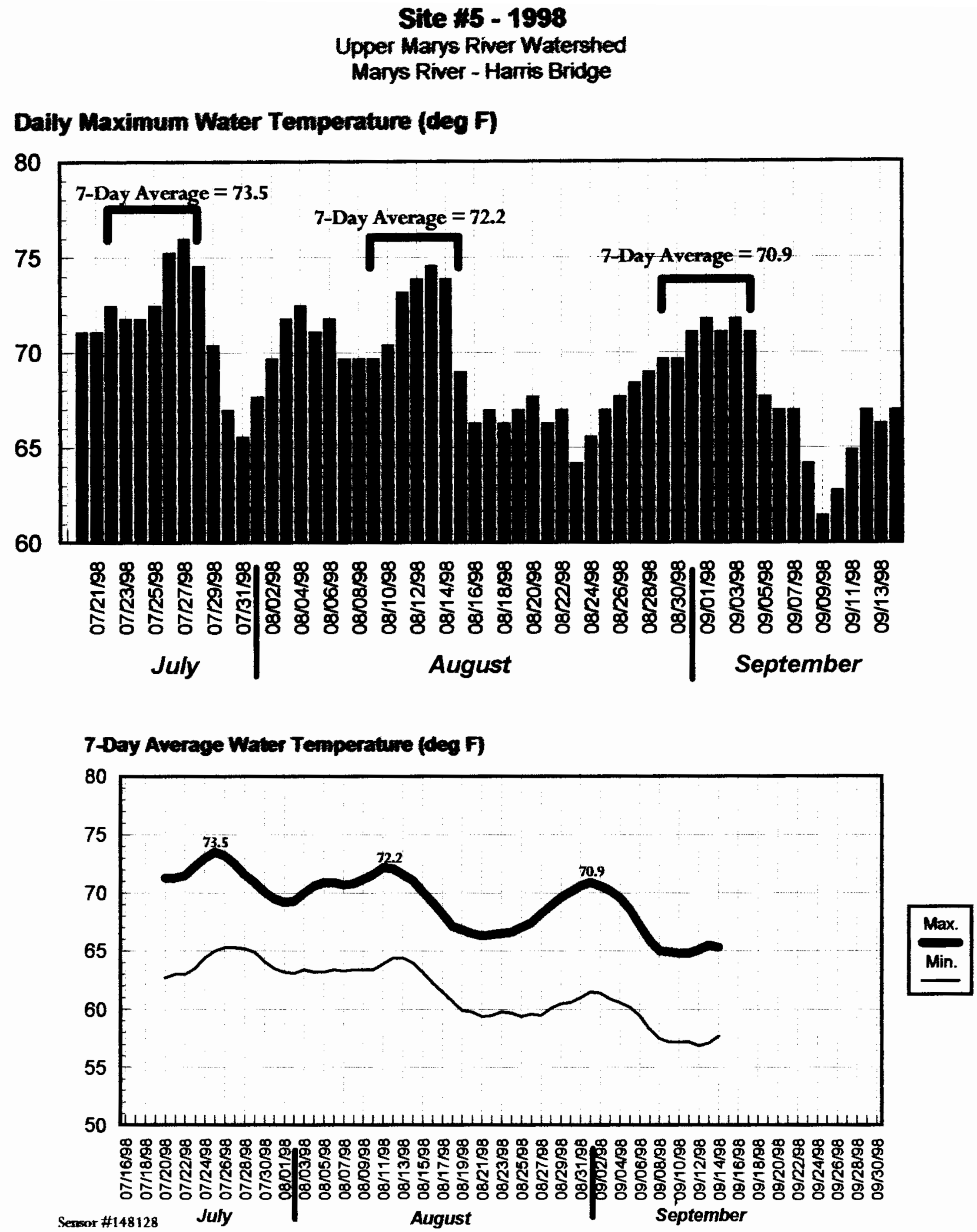

Figure 2. Daily values for maximum water temperature and 7-day running average for site #5. The period of the greatest 7-day average in August was from the 9th to the15th. The 7-day average of maximum and minimum water temperatures for the entire summer (1998) are shown in the lower graph.

Table 1. Water temperature and other site characteristics for the Marys Watershed.

Site	Distance from Divide (miles)	Mid-August, 1998 7-Day Max. (Deg F)	Early August, 1999 7-Day Max. (Deg F)	1998 Minus 1999 (Deg F)	Flow, 1998 (cfs)	Vegetative Cover (percent)
30	1.9	63.0				
12	2.4	61.0	59.5	1.5		
8	3.0	62.9				
9	3.2		60.9			
1	3.4	65.2	63.8	1.4		
13	3.6	62.9				
19	3.7		61.2			
31	4.5	65.9	63.3	2.6		
25	4.5	64.1				
0	5.0	65.5				
22	5.7		65.0			
21	6.5	70.3				
20	6.9	65.8	63.1	2.7		
14	7.1	68.1				
11	10.0	65.2	62.1	3.1		
15	11.7	67.8	65.3	2.5		
18	12.4	65.7	63.5	2.2	2.2	
17	14.0	64.9	64.5	0.4		
16	14.5	64.8	62.9	1.9	4.6	
6	18.1		72.0			
5	18.6	72.2				
7	20.2		71.8			
4	21.3	73.0	71.0	2.0		
2	24.9	73.9	73.3	0.6	9.8	
34	27.3	76.8	74.6	2.2		
35	28.6		72.6			
35	29.8		73.2			
37	32.4		70.9			
103	34.2	75.2	72.2	3.0		
119	36.1	75.0				
101	39.2	75.7	72.7	3.0		

Table 2. Water temperature and other site characteristics for the Greasy and Muddy Watersheds.

Site	Distance from Divide (miles)	Mid-August, 1998 7-Day Max. (Deg F)	Early August, 1999 7-Day Max. (Deg F)	1998 Minus 1999 (Deg F)	Flow, 1998 (cfs)	Vegetative Cover (percent)
Greasy Creek Watershed						
206	1.2	57.7				95
201	2.4	62.4			1.5	99
207	3.1	61.4			2.7	95
205	3.4	61.3			5.0	98
202	4.5	67.0			3.6	87
208	4.7	64.5				93
203	5.7	67.2			2.7	85
209	7.0	66.6			5.0	
204	9.7	71.8			5.3	82
Muddy Creek Watershed						
115	2.4	61.2				100
112	3.1	62.4			1.1	99
108	3.2	66.8			1.2	
107	4.2	64.3				71
113	5.3	65.4			3.4	93
110	6.0	68.1			3.0	88
114	6.4		64.5		1.8	
111	8.7	68.0			4.9	54
106	9.7	67.0	64.9	2.1	4.5	92
105	18.3	73.3	71.8	1.5	4.1	61
118	25.2		69.0		9.2	
Oak Creek Watershed						
102	7.2	69.5				

Maximum 7-day water temperatures were surprisingly cool throughout much of the study area. Tributary streams were commonly in the low to high 60's (Figure 3 and Figure 4). Assuming that cutthroat trout can inhabit streams where the 7-day maximum water temperature is less than 69° F, only the Marys River main channel downstream of Harris, Muddy Creek downstream of Bellfountain, and the very downstream portions of Greasy Creek and Woods Creek were incapable of supporting trout in August, 1998. The pattern was similar for the cooler 1999 summer, with slight increases in the extent of stream system capable of supporting trout (Figure 5 and Figure 6).

The general warming trend with increasing distance from divide is shown for 1998 in Figure 7. Warming trends with increasing distance from drainage divide were similar for the three sub-watersheds. Values for some sites plotted a distance from the general trend and can be explained by certain physical characteristics. Streamflow at site #108 was a mere trickle and probably explains why the water is warmer than expected. Site #21 is at the downstream end of Woods Creek; immediately upstream of the gage the creek flows through a pond and has sparse shade. Site #204 at the downstream end of Greasy Creek also had sparse shade upstream of the gage. A large flux of cool groundwater from Marys Peak and ridges along the west boundary of the watershed is likely the reason that sites #11, #15, #18, #17, and #16 are much cooler than expected. The terrain is composed of highly fractured volcanic rock and non-summer precipitation is high. This results a substantial amount of groundwater being released into the river during summer months. Finally, the channel upstream of site #34 is deeply incised with exposed basalt rock. The dark color of the rock and hampered air movement may cause this segment of the Marys River main channel to be warmer than expected.

The rate at which a stream warms between two sites (degrees per mile) are plotted against the water temperature at the upstream site are shown for the August, 1998 data in Figure 8. The coolest streams in the watershed warm the most with only small incremental warming once the stream reaches about 67° F. The section of Marys River downstream of the Tumtum River confluence (#17) to the Harris covered bridge (#5) warms considerably faster than would be expected by the general trend shown in Figure 8. Again, water temperature upstream of site #17 is probably being kept abnormally cool by the flux of cool groundwater. Groundwater influences are less downstream of site #17 and so it increases over 7° F in only 4.6 miles.

When stream warming rate is plotted against distance from divide, it is apparent that most stream warming occurs within 1 to 7 miles from the divide (Figure 9). At further distance from divide the stream warming rate drops to about 0.2° per mile. Again, the warming rate within the section of Marys River from the Tumtum River confluence to the Harris covered bridge appears as an anomaly.

Data from August, 1999 indicates a somewhat different temperature pattern for the Marys River main channel downstream of site #34 (Figure 10). With a greater number of gaging sites between Marys River Estates (#34) and Philomath (#37) in 1999, the data indicate that the river actually cools several degrees in this reach. Here, the river changes from a bedrock-dominated channel to a gravel-rich channel. The presence of deep

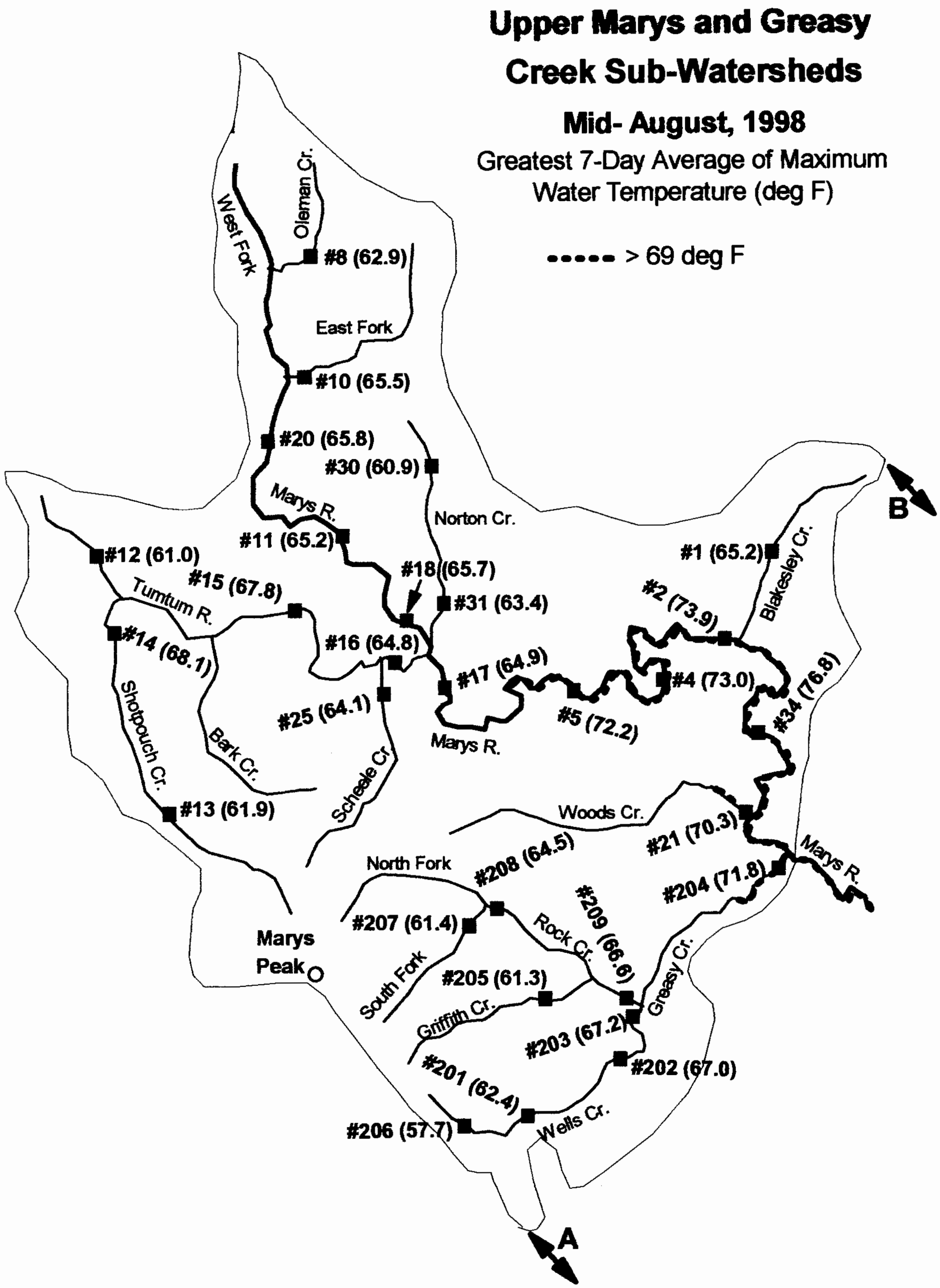

Figure 3. Upper Marys River and Greasy Creek - values for the greatest 7-day average of maximum water temperatures for mid-August in 1998.

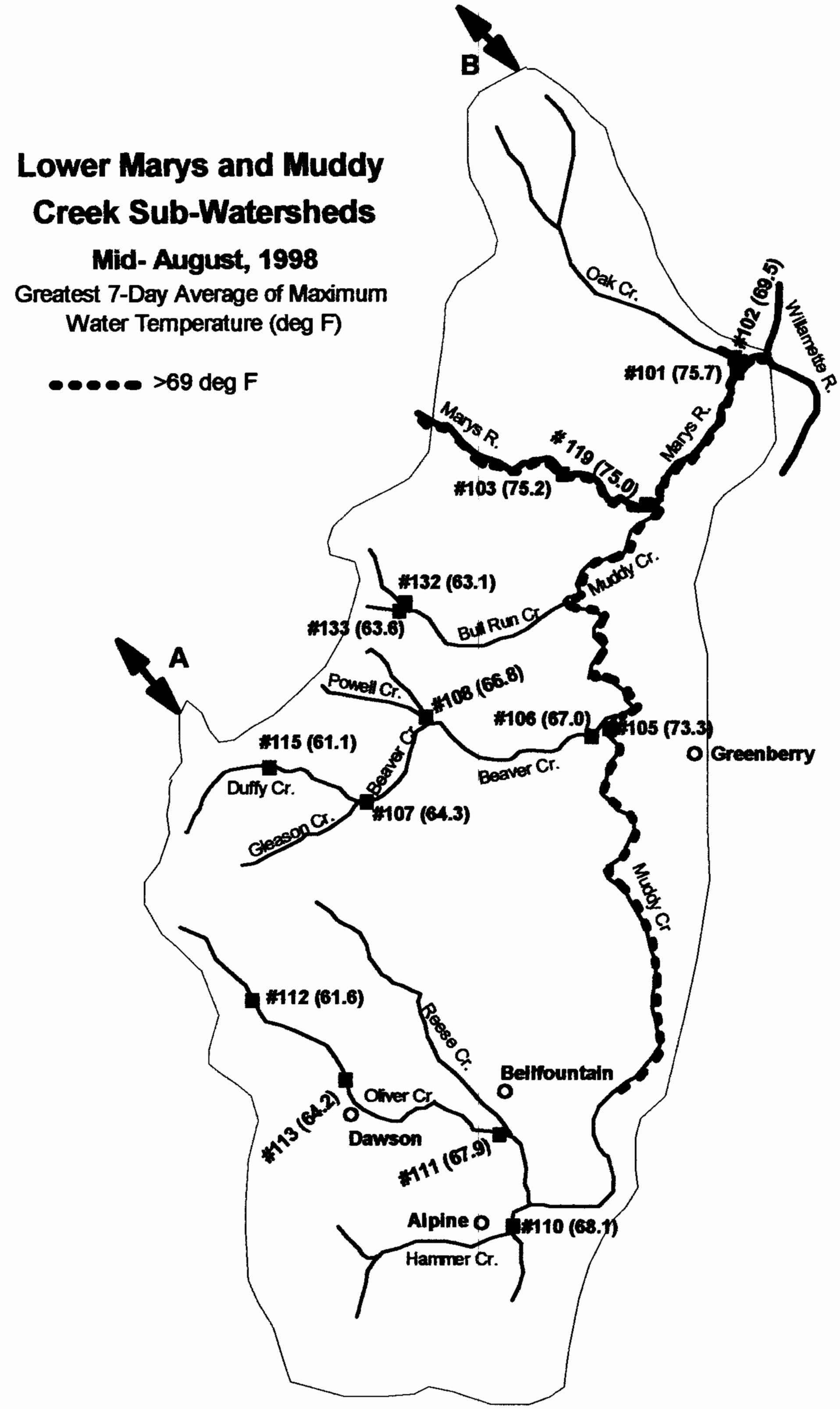

Figure 4. Lower Marys River and Muddy Creek - values for the greatest 7-day average of maximum water temperatures for mid-August in 1998.

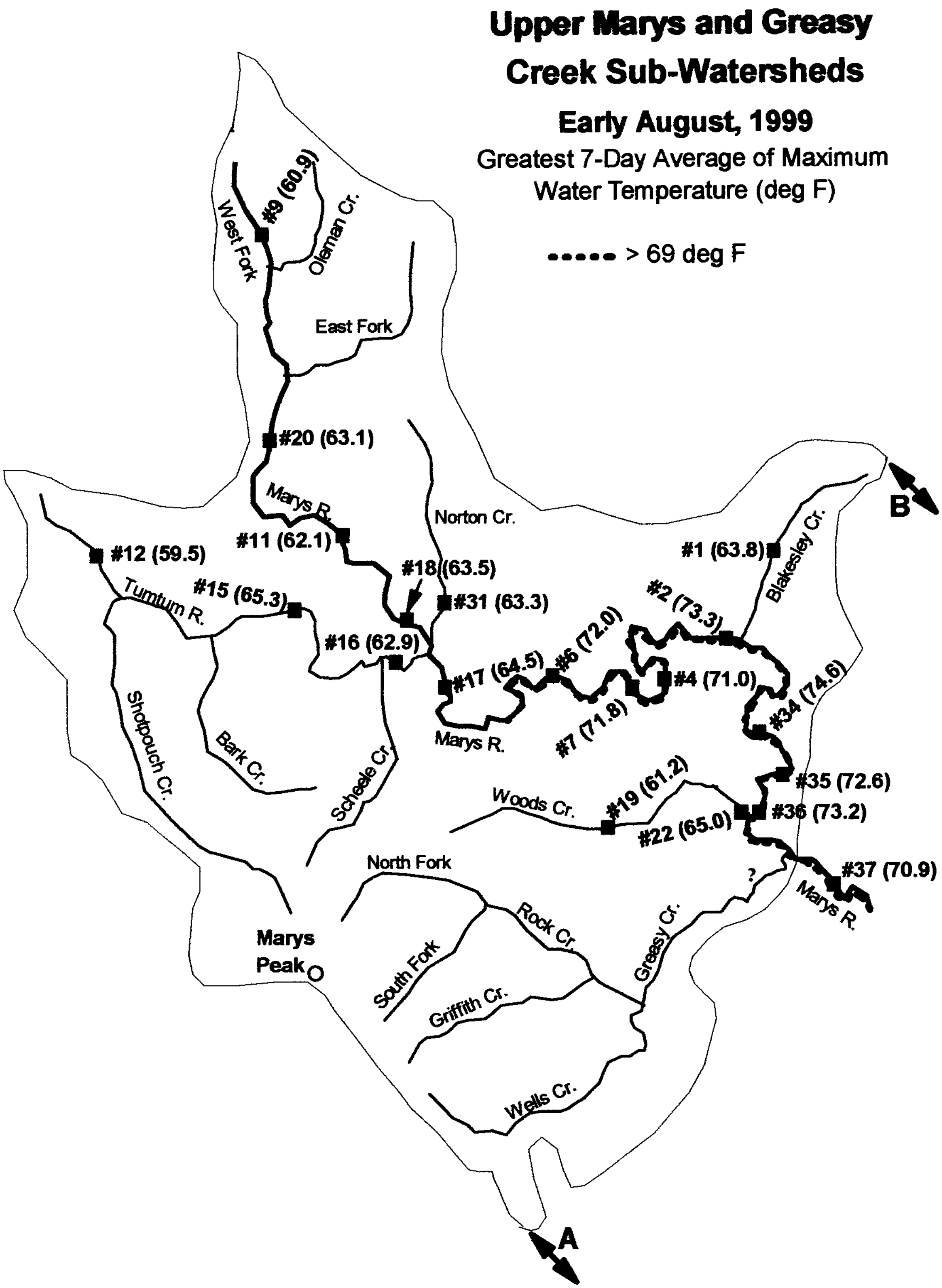

Figure 5. Upper Marys River and Greasy Creek - values for the greatest 7-day average of maximum water temperatures for early August in 1999.

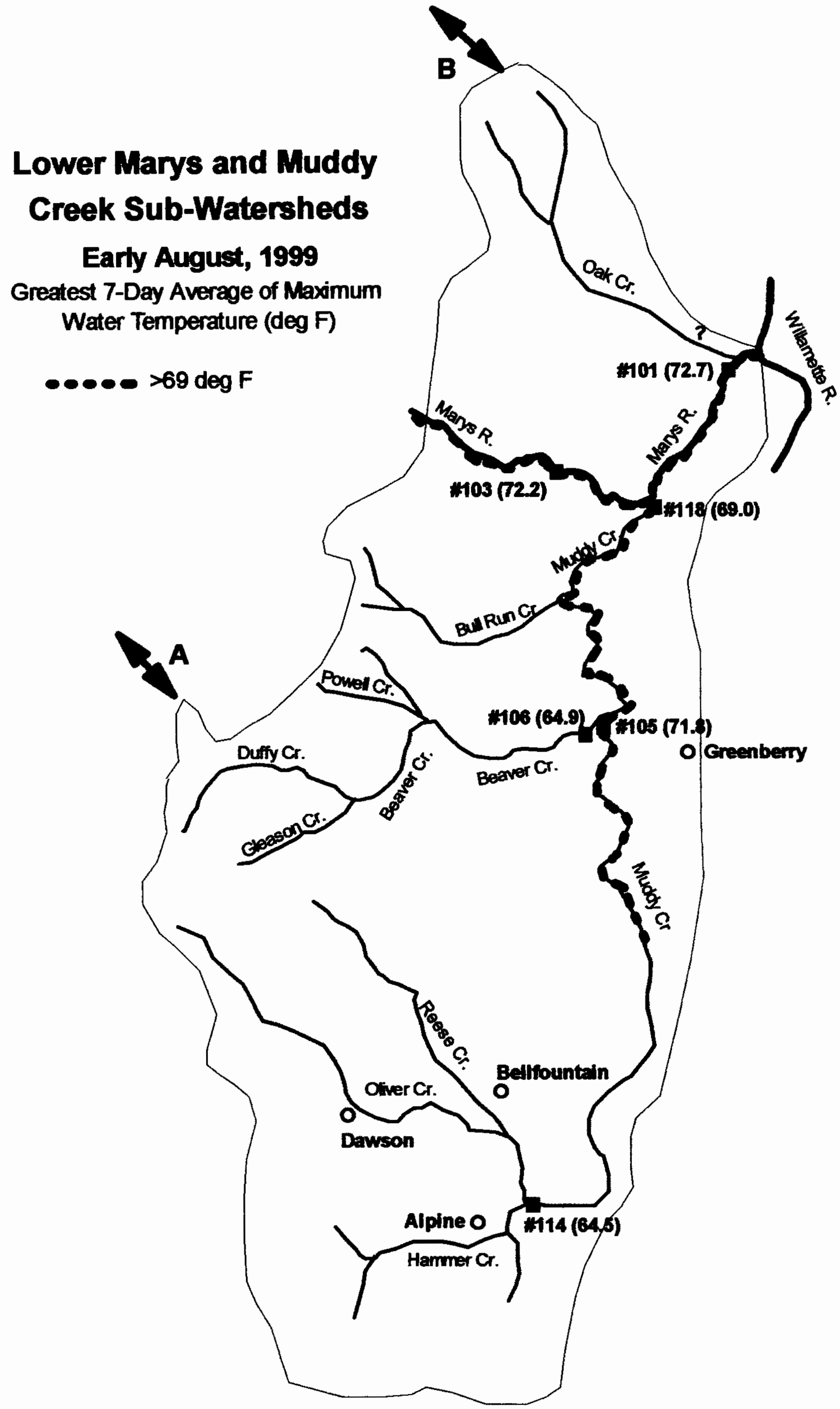

Figure 6. Lower Marys River and Muddy Creek - values for the greatest 7-day average of maximum water temperatures for early August in 1999.

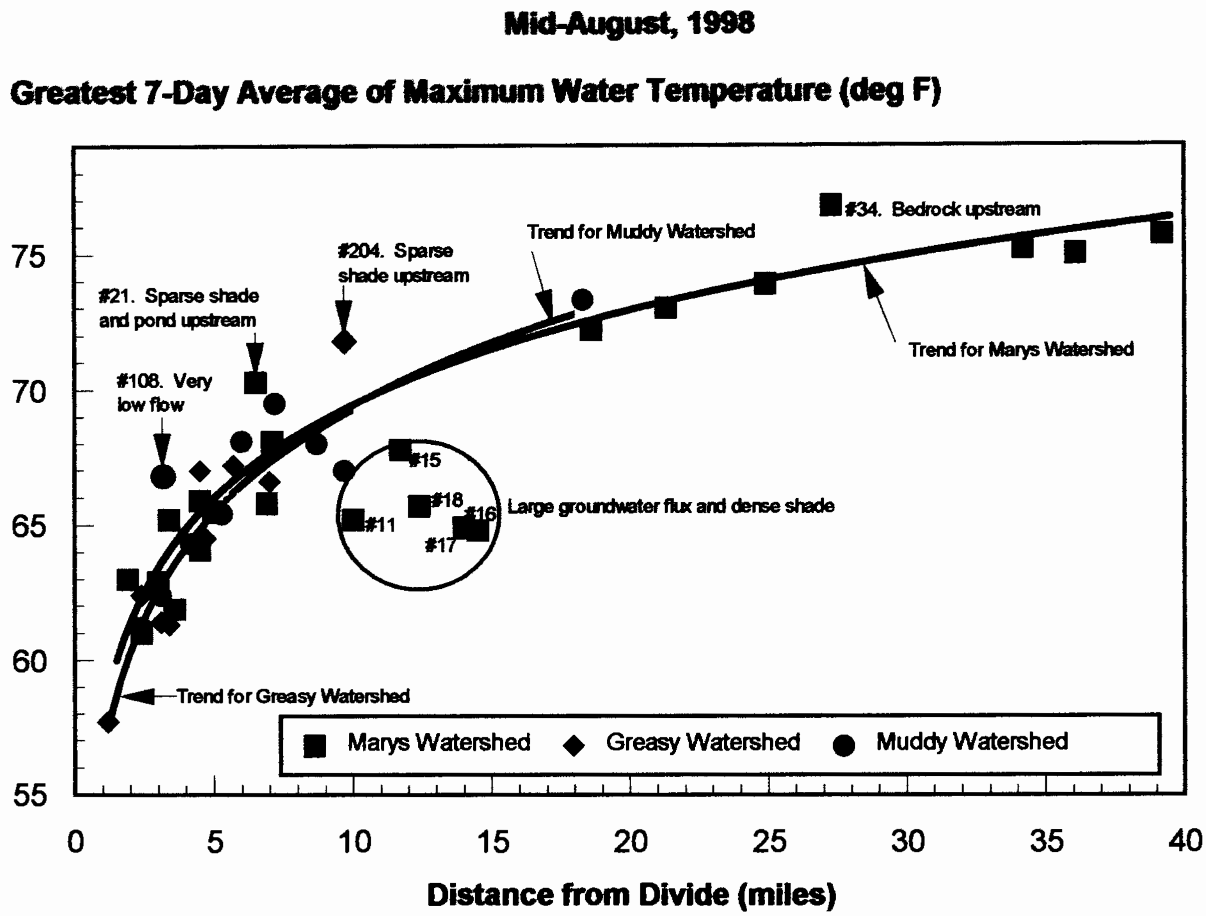

Figure 7. General warming trend for streams with increasing distance from divide in mid-August 1998. The 3 sub-watersheds had warming rates that were nearly equal. Certain sites may deviate from the general trend due to unusually large amounts of groundwater entering the stream, sparse shading, or low flow.

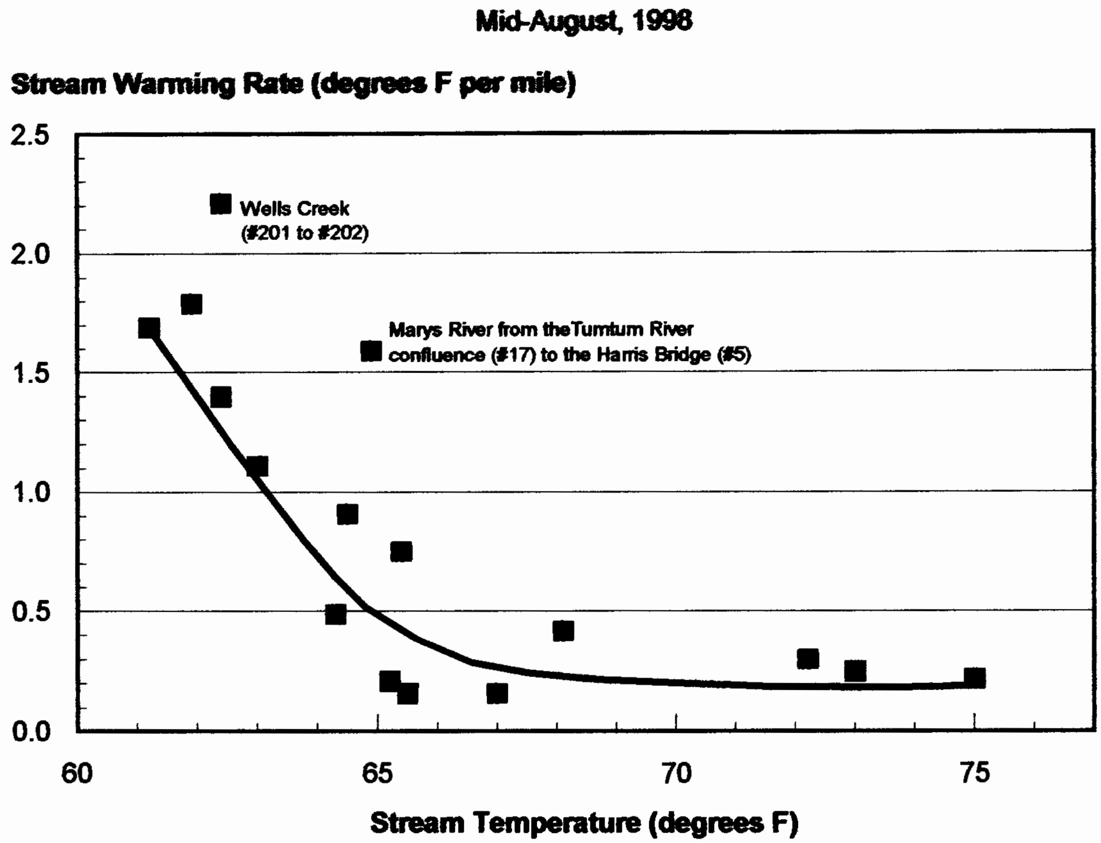

Figure 8. Stream warming rate (degrees per mile) between neighboring gaging sites vs. stream temperature at the upstream site. Warming rates were greatest where the stream is coldest and then approaches a low value once the stream temperature reaches about 66 deg F. Variation from the trend is probably due to differences in groundwater and tributary inputs and shade.

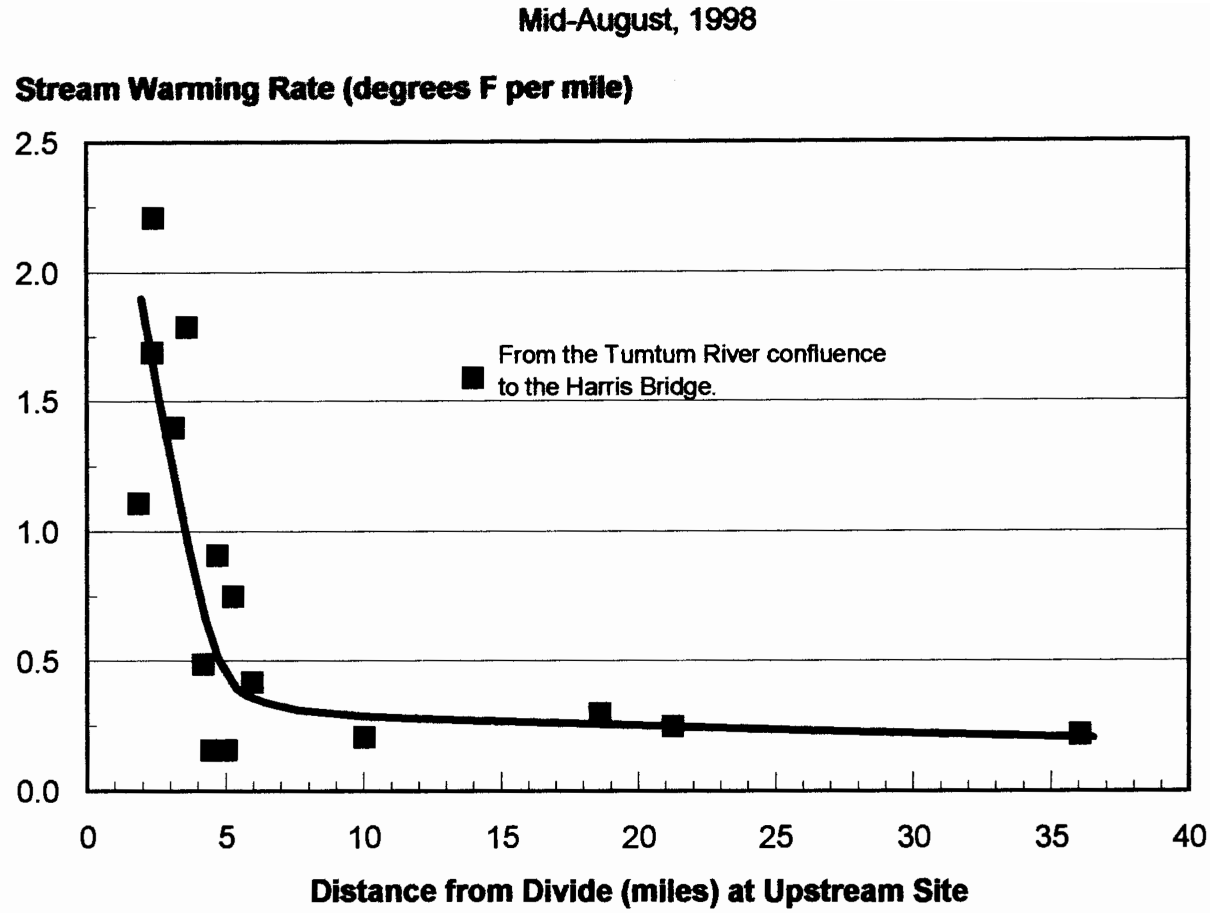

Figure 9. Stream warming rate (degrees per mile) between neighboring gaging sites vs. distance from divide at the upstream site. Warming rates were greatest in the headwaters, decrease rapidly in a downstream direction, and then approach low values at about 6 miles from the divide. Variation from the trend is probably due to differences in groundwater and tributary inputs and shade.

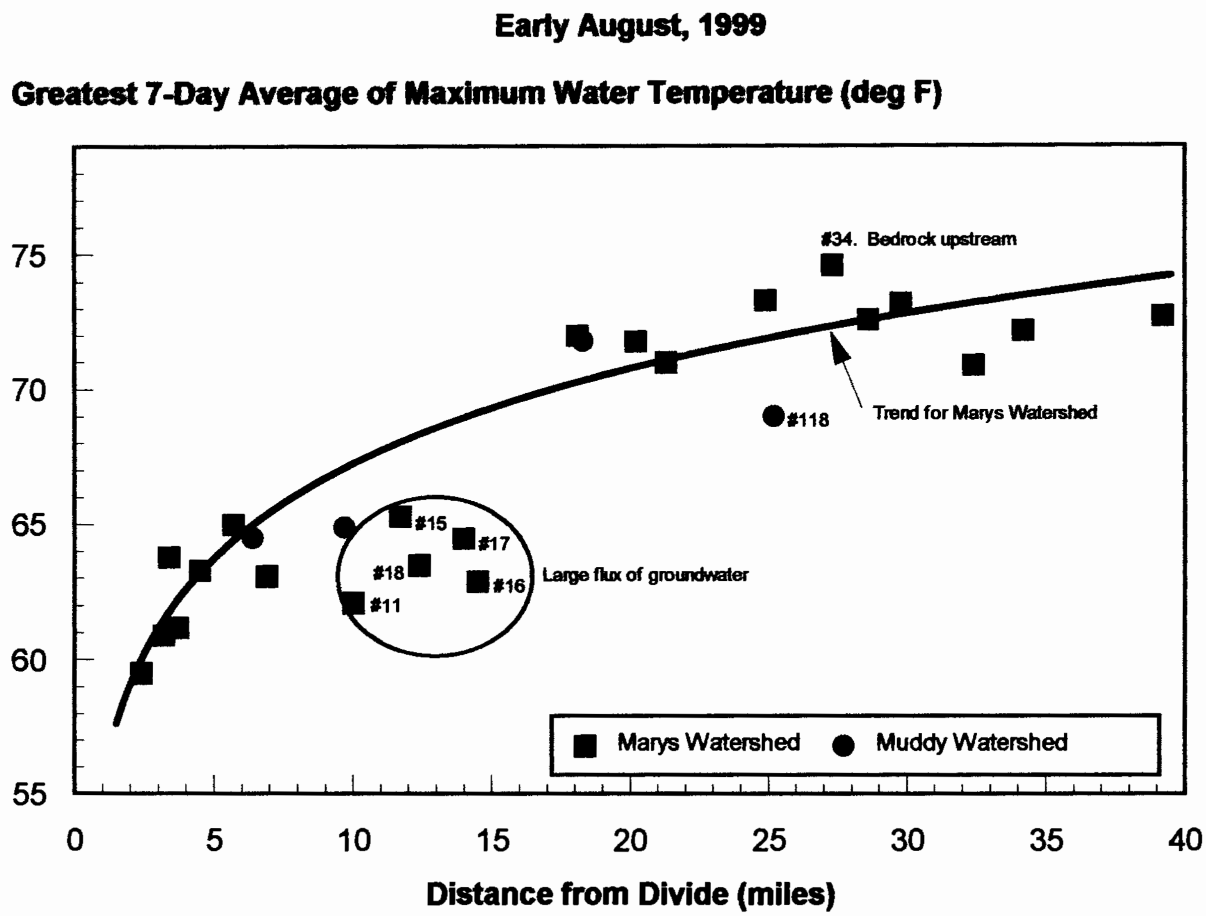

Figure 10. General warming trend for streams with increasing distance from divide in early August 1999. The greater number of Marys River sites between Wren and Corvallis in 1999 illustrates the spatial variability of temperature in this reach. Certain sites may deviate from the general trend due to unusually large amounts of groundwater entering the stream, sparse shading, or low flow.