Corvallis Watershed Stream Temperature Monitoring
Summer 2012
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Introduction

The City of Corvallis and the Siuslaw National Forest have cooperatively monitored stream temperatures in the Rock Creek Watershed during the summers of 2005, 2006, 2010, 2011 and 2012. The objectives of the ongoing stream monitoring are:

- to characterize the stream temperatures throughout the watershed.
- to determine the effects of restoration efforts, such as plantation thinning, riparian planting and wood placement.
- to determine if it is possible to measure effects of the reservoir on downstream temperatures, if any.

This report documents the results from the summer of 2012, and is a continuation of the results of the report dated April 18, 2012 that summarized the monitoring efforts for the summer of 2011. One of the goals in 2012 was to gather more data around the reservoir in order to determine whether downstream effects could be detected. The question regarding the effects of the reservoir will be explored in detail in this report.

In addition to monitoring stream temperatures, air temperature was also monitored in 2012 at one site to compare air and water temperature trends, and to see how warm the 2012 summer had been compared to previous summers.

Figure 1 shows the location of the sites.

The results are summarized in Table 1, which shows the 7-day average maximum temperatures for the sites.

Table 1: Seven-day average maximum temperatures for stream and reservoir water temperatures, all years of monitoring. Sites that are above the state standard are highlighted in red print.

STREAM	LOCATION	STATION number	1978 7-day ave max	1980 7-day ave max	2005 7-day ave max	2006 7-day ave max	2010 7-day ave max	2011 7-day ave max	2012 7-day ave max	Objective	Degrees (F) warmer in 2012 than 2011
S FK Rock Creek	upstream from Connection Creek	2120			60.8		59.2	60.12	61.74	watershed characterization, bracketting Connection Cr	**1.62**
Tributary to S FK Connection Creek	Tributary is upstream from and next to Connection Creek	2121			61.2		58.8	59.61	60.76	watershed characterization	**1.15**
S FK Rock Creek	Above weir tied to trash rack	2122			60.9		58.8	60.14	61.51	watershed characterization	**1.37**
S FK Rock Creek AIR TEMP		2122					79.06	79.11	83.22	comparing air temp	**4.11**
Rock Cr mainstem Water Temp	downstream from confluence of N Fk and S FK Rock Creek	2123			66.4	67.5	61.9	61.04	63.4	monitor effects of reservoir	**2.36**
Rock Cr mainstem AIR TEMP	downstream from confluence of N Fk and S FK Rock Creek	2123			81	92				compare air temp	
Stilson Creek	upstream from rd 111	2124			62.5		60.2	61.39	62.12	watershed characterization	**0.73**
Rock Creek mainstem	upstream from rd 111 bridge	2125			67.8		63.2	64.4	65.25	watershed characterization, monitor changes in riparian area and stream substrate restoration	**0.85**

Rock Creek mainstem AIR TEMP	upstream from rd 111 bridge	2125					81.3				
Middle Fork Rock Creek	upstream from rd 3405	2126			62.3		59.6	61.44	62.35	watershed characterization	**0.91**
Griffith Creek	upstream from weir	2127			60.9		59.3	60.19	61.6	watershed characterization	**1.41**
Rock Creek	below bridge near entrance gate	2128					64.2	65.66	66.33	watershed characterization	**0.67**
Griffith Creek	below thinning unit approx 1 mi from intake	2129					61.5	60.27	61.57	monitor thinning effects	**1.3**
Rock Cr mainstem	at waterline crossing upstream of Griffith Cr	2130					63.9	65.2	65.98	bracket outflow	**0.78**
Rock Cr mainstem	0.08 miles upstream from Trib "b"	2131					61.9	63.13	LOST	watershed characterization	
Rock Cr mainstem	at City/pvt boundary above outflow in log complex	2132					63.3	64.49	65.84	bracket outflow	**1.35**
S Fk Rock Creek	below thinning stand	2133	63.5	65.94			58.3	59.26	LOST	monitor thinning effects	
N Fk Rock Creek spillway below dam	pool below spillway	2134						77.04		brackett reservoir	
Dam outlet small channel	Just below dam in small channel fed by valve leakage	2135							60.12	Determine temperatures just below dam without spillway influence	
S Fk Rock Creek	above thinning stand (HCC in 1979?)		60.54	58.13							
S Fork Rock Creek	above dam outlet and confluence with N Fork Rock Cr	2136						62.12	62.99	bracket reservoir	**0.87**
Top of Spillway at reservoir	Near metal ladder below sill	2161							78.91	bracket reservoir	
North Fork Rock Creek	Above reservoir where creek enters reservoir	2160							60.66	bracket reservoir	

Reservoir, tied to tower rope, top probe initially	Installed June 5 2012 at 14" below water surface, 55' above bottom. Moved on 8/29/2012 to 105" below water surface,	2162							74.6	bracket reservoir	
Reservoir, tied to tower rope, near top	Installed June 5 2012 at 3'9" below water surface, 50' from bottom anchor	2163							70.87	bracket reservoir	
Reservoir, tied to tower rope, middle depth	Installed on June 5 2012 25'7" below water surface, 28.4' from bottom anchor	2164							62.61	bracket reservoir	
Reservoir, tied to tower rope, near bottom	Installed 3.7' from bottom anchor	2165							60.65	bracket reservoir	
Griffith Creek	mouth of creek	2166							62.86	Bracket effects of Griffith Creek	
Rock Creek	just downstream of Griffith Cr mouth	2167							65.81	Bracket effects of Griffith Creek	
Spillway/dam outlet channel, 7-day ave. max between 6/14 and 8/14	Just below spillway and dam outlet channel convergence, and upstream of South Fork Rock Creek confluence.	2168							71.4		
Spillway/dam outlet channel, 7-day ave. max between 8/14 and 11/15	Just below spillway and dam outlet channel convergence, and upstream of South Fork Rock Creek confluence.	2168							61.1		
Bottom of Spillway	In gravel channel just below spillway, moved from stagnant pool location used in 2011.	2169							76.99		
Ranking of summer air temps, based on 37 years of dta from Cannibal Mountain RAWS station			15th (middle of ranking)	30 (lower third of ranking)	10 (upper third of ranking)	1 (hottest temperature year on record, Cannibal Mt.)	20 (middle of ranking)	7 (upper third of ranking)	17 of 38 years (middle of ranking)		

Observations from the Summer 2012 Data

The 7-day average maximum air temperature was 4.11°F warmer in 2012 than in 2011, which influenced stream temperatures. All stream temperature sites that were also monitored in 2011 were warmer in 2012. The difference between the two years for the 7-day average maximum water temperatures ranged from 0.73 to 1.62 °F. All of the sites monitored for water temperature show a similar seasonal pattern as the air temperatures, suggesting a strong correlation between air and water temperatures. This strong correlation has been observed in previous years. See the Appendix for individual site data.

Most sites, as in previous years, met the DEQ water quality standard of staying at or below 64°F for the 7-day average maximum temperature. The Rock Creek mainstem was around a degree higher than 64°F from just downstream of the Middle Fork to the mouth. As expected, the highest stream temperature (66.35°F) was below the main gate and bridge, and upstream from the confluence with Greasy Creek.

For the last three years, there is a consistent correlation between stream temperature and drainage area (Figure 1). The slope of the trend line for these three years is fairly consistent, and varies between 0.35 and 0.38. The Rock Creek mainstem site below the dam and the mouth of the South Fork Rock Creek (map point 2123) is below the trend line in 2011 and 2012, which suggests it is cooler than would be expected for the drainage area at this point.

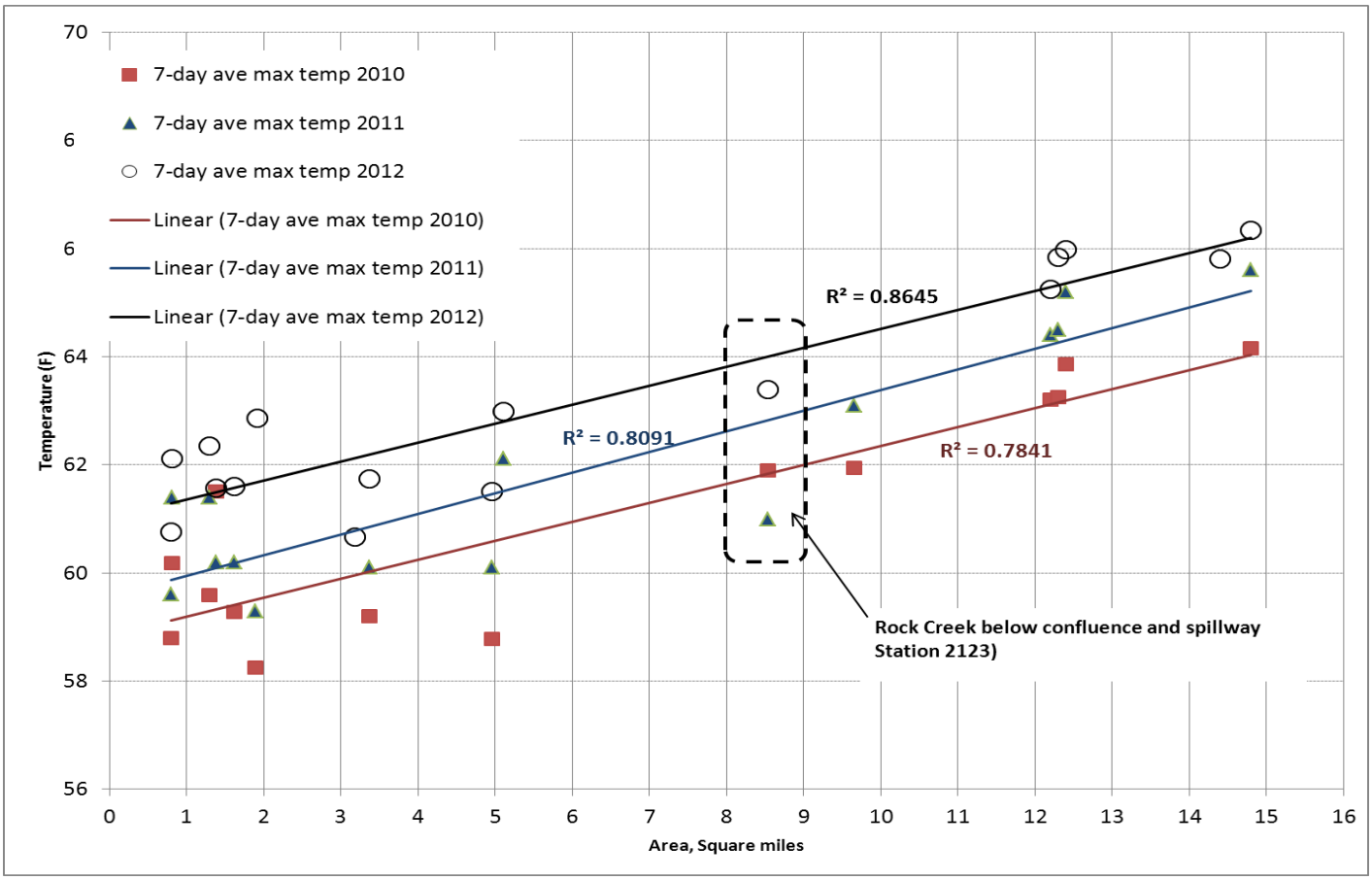

Figure 1. Graph comparing site temperature for 3 years versus drainage area in square miles above the site. The relationship, i.e. the slope of the trend line is relatively consistent between years of monitoring. Site 2123, which is in the mainstem of Rock Creek below the confluence of the dam outflow and the South Fork Rock is on the trend line in 2010, and slightly below the trend line in 2011 and 2012. The relationship

of the temperature to the drainage area at this site, relative to the trend in the watershed as a whole, suggests that this site is cooler than would be expected.

Reservoir temperature monitoring methodology

Several temperature probes were deployed in and around the reservoir in 2012. The goal was to determine the thermal regime in the reservoir, and whether or not it was influencing downstream temperatures.

Probe locations in and around the reservoir are:

- The North Fork Rock Creek streambed just above the upstream limit of the reservoir. (Station 2160).
- Four probes were placed in the reservoir at different depths on a rope tied to the valve tower. (Stations 2162, 2163, 2164 and 2165)
- Top of the spillway near the metal ladder and below the concrete sill. (Station 2161)
- Bottom of spillway. (Station 2169)

To bracket the area where the South Fork Rock Creek, spillway and dam outlet channels, and the Rock Creek mainstem merge, probes were placed in the following locations:

- In the channel that is fed by the dam valve leakage, and above the spillway channel, to monitor the water temperatures just below the dam. (Station 2135)
- In the channel that is below the confluence of the spillway and the valve leakage channel, and above the confluence of the South Fork Rock Creek and the mainstem Rock Creek. (Station 2168)
- In the South Fork Rock Creek just upstream of the confluence with the mainstem. (Station 2136)
- In the mainstem of Rock Creek just below the confluence with the South Fork Rock Creek. (Station 2123)

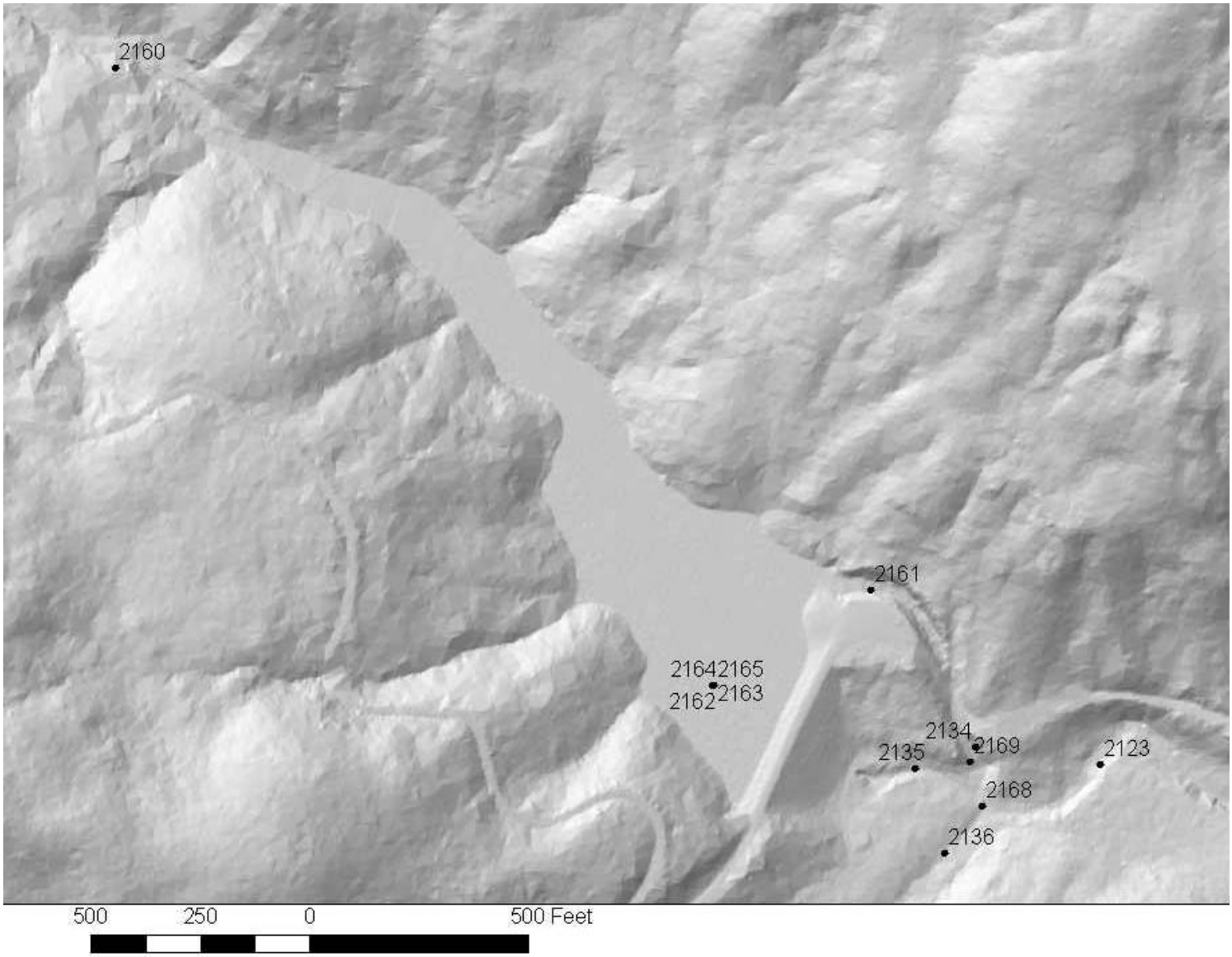

Figure 1: Shaded relief map showing the location of temperature monitoring sites around the reservoir.

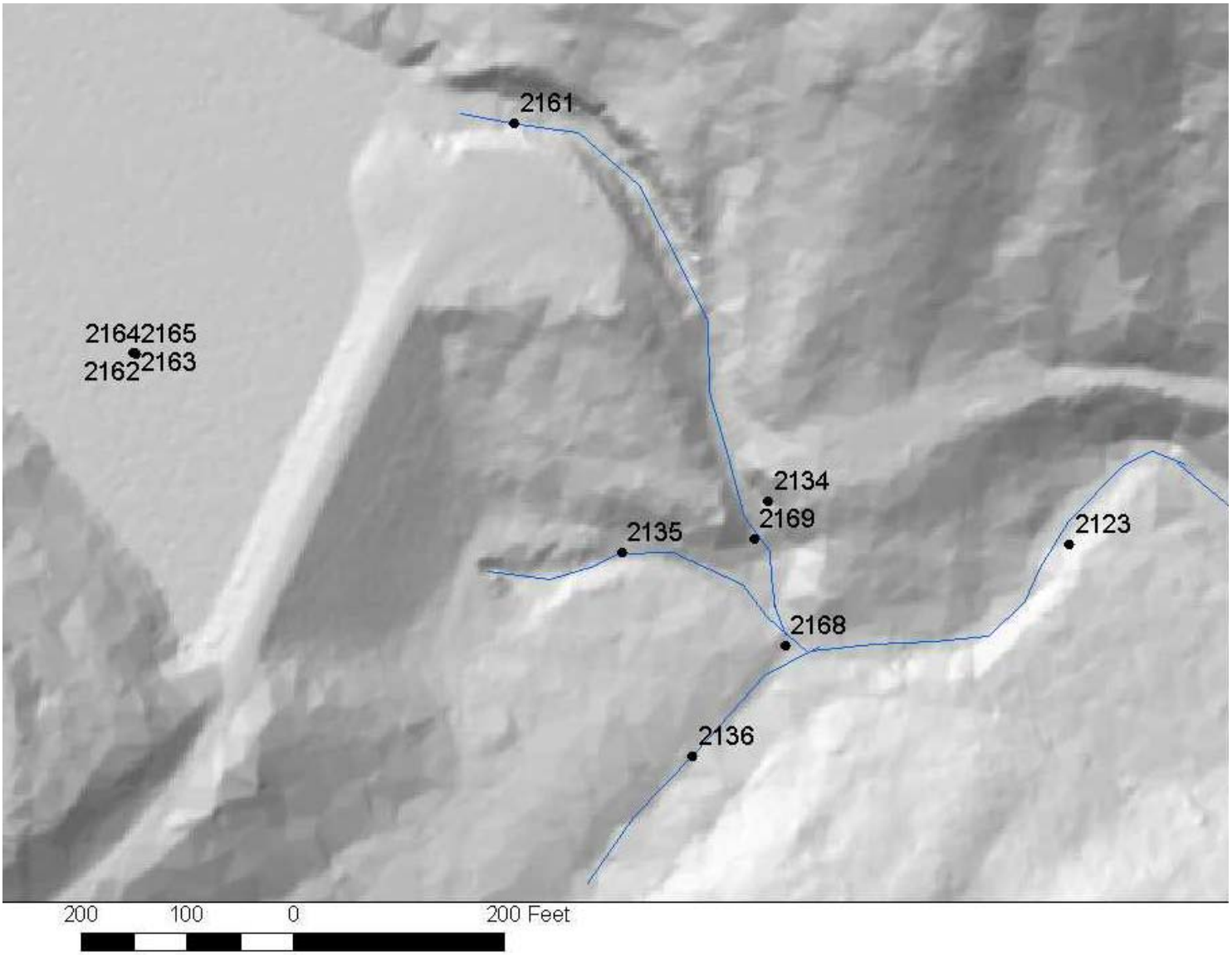

Figure 2: Shaded relief map showing the location of temperature monitoring sites in and below the reservoir.

When the probes were installed on June 5, 2012 around the reservoir, the ones fastened vertically to the rope attached to the tower were placed at the depths described in Table 2. During the summer, the reservoir level gradually declines. On August 13, the reservoir stopped flowing over the spillway. The water level continued to drop until October 8, then the reservoir began to gradually fill again. The spillway was flowing again on November 2. To accommodate the drop in the water level, the top probe was re-positioned to a lower level on the rope attached to the tower in the reservoir on August 29, 2012, as described in Table 2. Figures 3 and 4 show a graphic representation of the relationship of the reservoir level to the probe depths over the summer.

Table 2: Depths of temperature probes in the reservoir during the summer, 2012.

GIS station	**In Reservoir, tied to rope suspended from tower.**	**Installation on June 5, 2012**	**Location on August 29, 2012**	**Pick-up on 11-1-2012**
2162	Probe serial #10154257	14 inches below surface of water, 55 feet from bottom anchor	On August 29, Mike and Jon checked the probes on the rope. The top probe was 14" above the water surface. Water surface had been dropping about 0.1 foot per day. It was relocated to a postion 105" below the water surface. It is now 5 feet below what was the second probe down (1015244).	11/1/2012 depth, 8 ft 8 in from water surface. Weight at bottom was 56 ft 2 inches from water surface
2163	Probe serial #10154244	50 feet from bottom anchor	On August 29, Mike and Jon checked the probes on the rope. This probe is now the top probe, and is 45" below the water surface.	11/1/2012 3 ft 9 in from water surface. Weight at bottom was 56 ft 2 inches below water surface
2164	Probe serial #10154245	28.4 feet from bottom anchor	Same location	11/1/2012 25 ft 7 inches below water surface. Weight at bottom of rope was 56 ft 2 inches below water surface
2165	Probe serial #10154239	3.7 feet from bottom of of reservoir anchor	Same location	11/1/2012 50 ft 3 inches below water surface. Weight at bottom of rope was 56 ft 2 inches below water surface.

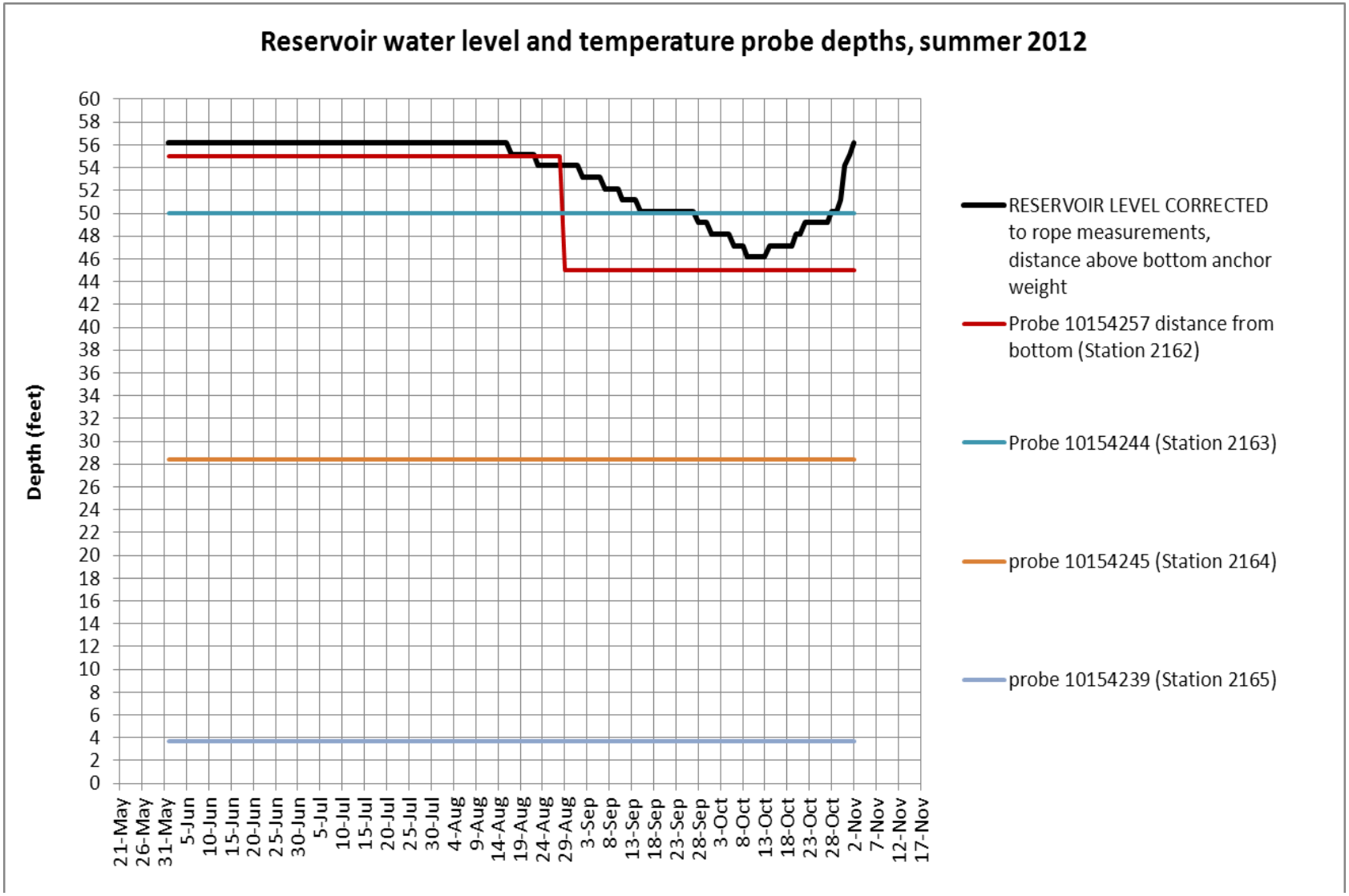

Figure 3: Graph showing the reservoir water levels and the probe depths through the summer, 2012. The '0' depth is the anchor on the rope suspended from the valve tower that rested on the reservoir bottom. On August 29, the top probe that was nearest the water surface was moved to a deeper location on the rope to keep it submerged as the reservoir levels dropped. On September 13, the water level dropped enough to expose the second probe to the air. The times when the probes were not submerged have been taken into account in the data analysis. Depth units are in feet.

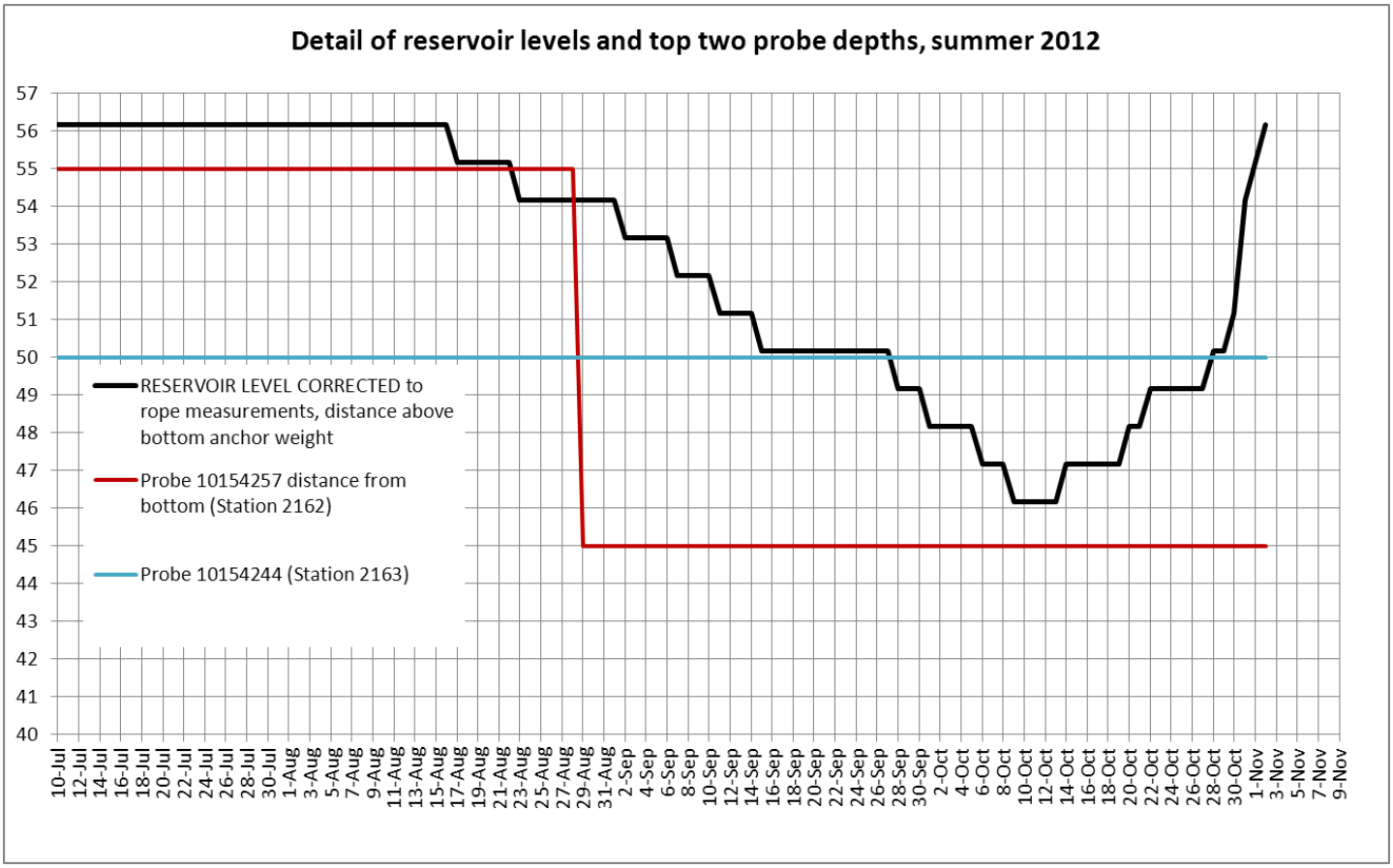

Figure 4: Detail of figure 3 (previous one) showing the reservoir water levels through the summer and the top two probes' depth.

The two probes near the top showed a pattern through the summer that followed the stream temperatures and air temperatures, i.e. warm days correlate to warm temperatures in the surface waters of the reservoir. See Figure 5.

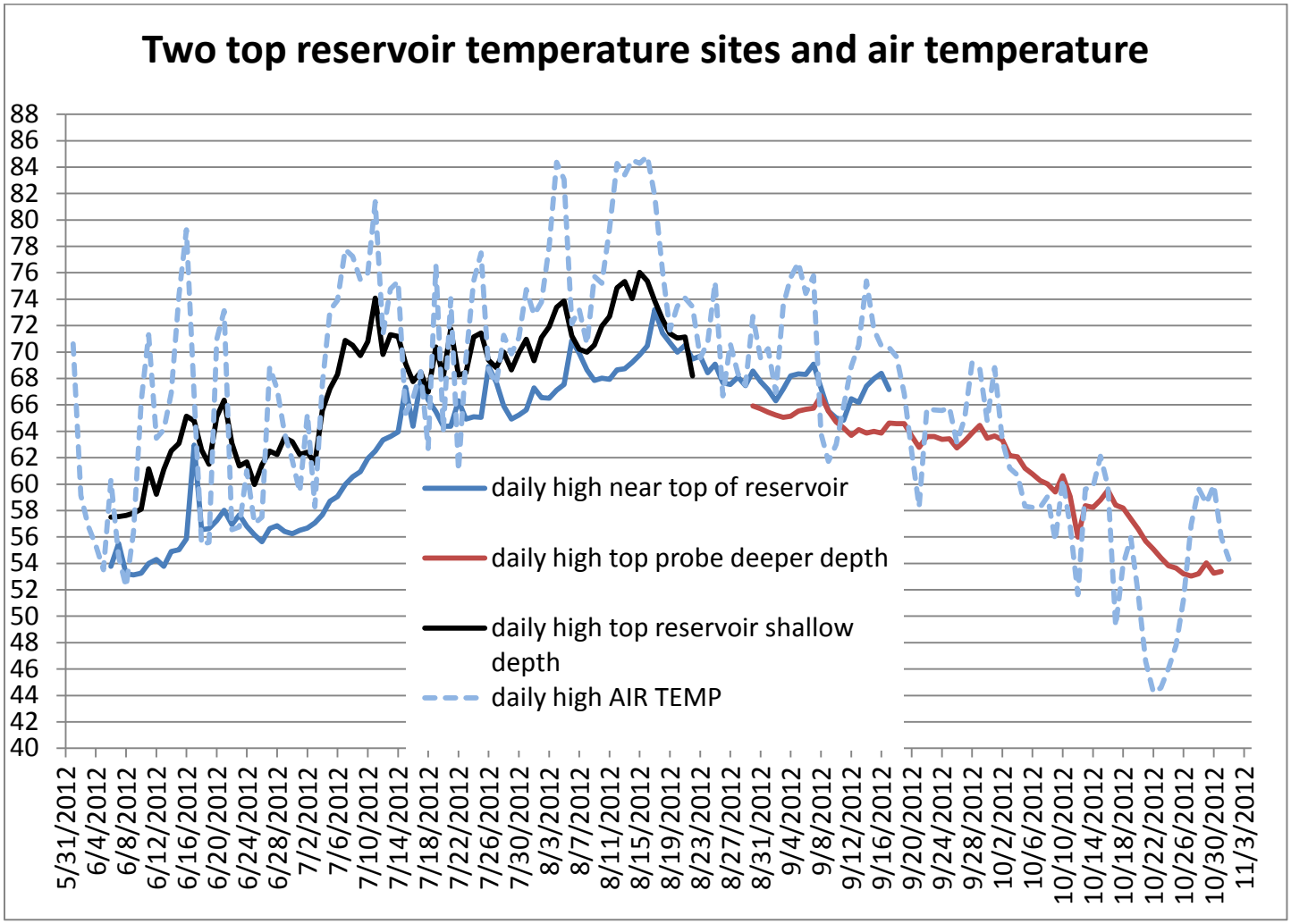

Figure 5: Graph comparing two top probes in reservoir with air temperature. The vertical axis shows the reseroivr depths in feet. For the air temperature data, it also represents the temperature in degrees F.

The two deeper probes, one at the midpoint depth of approximately 28 feet, and one 3 feet from the bottom, showed steady warming through the summer. They started out at approximately 46F on June 5, and gradually warmed up to a maximum daily temperature of 62.61°F for the mid depth and 60.65°F for the bottom depth. The mid-level probe's highest temperature occurred on 8/17, while the bottom of the reservoir reached its peak temperature almost a month later on 9/12. The lower portion of the reservoir gradually warms up during the course of the summer, while the top of the reservoir fluctuates with the weather. (Figure 6)

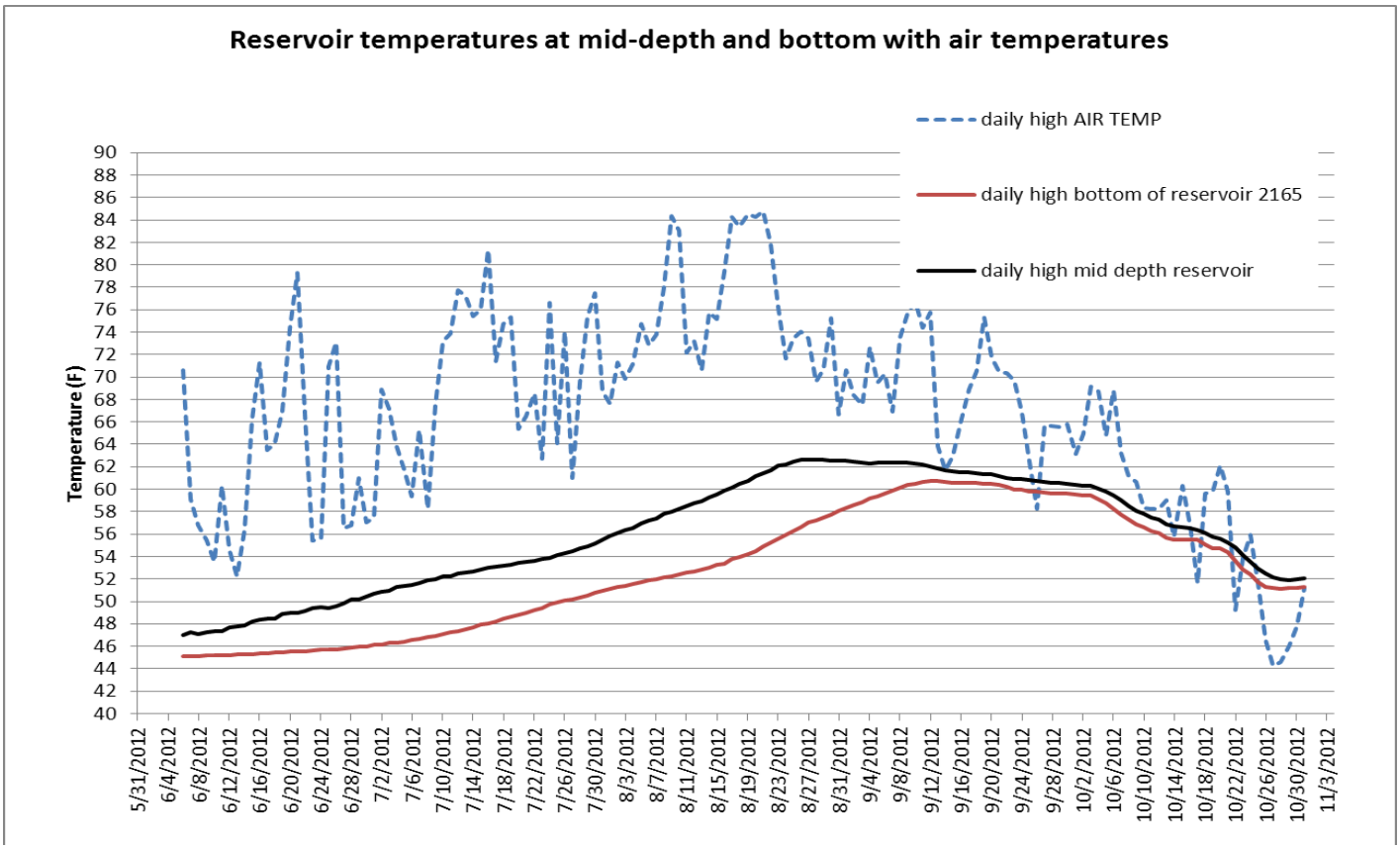

Figure 6. Comparing air temperatures to the reservoir temperatures at the mid-depth of 28 feet and the reservoir bottom.

The temperatures at the bottom of the reservoir, and in the dam valve drainage channel had identical temperature patterns; however, the drainage channel had slightly more day-to-day fluctuations, since the surface of the drainage channel was exposed to the air. After August 25, the bottom of the reservoir was slightly warmer than the channel below the dam. (Figure 7)

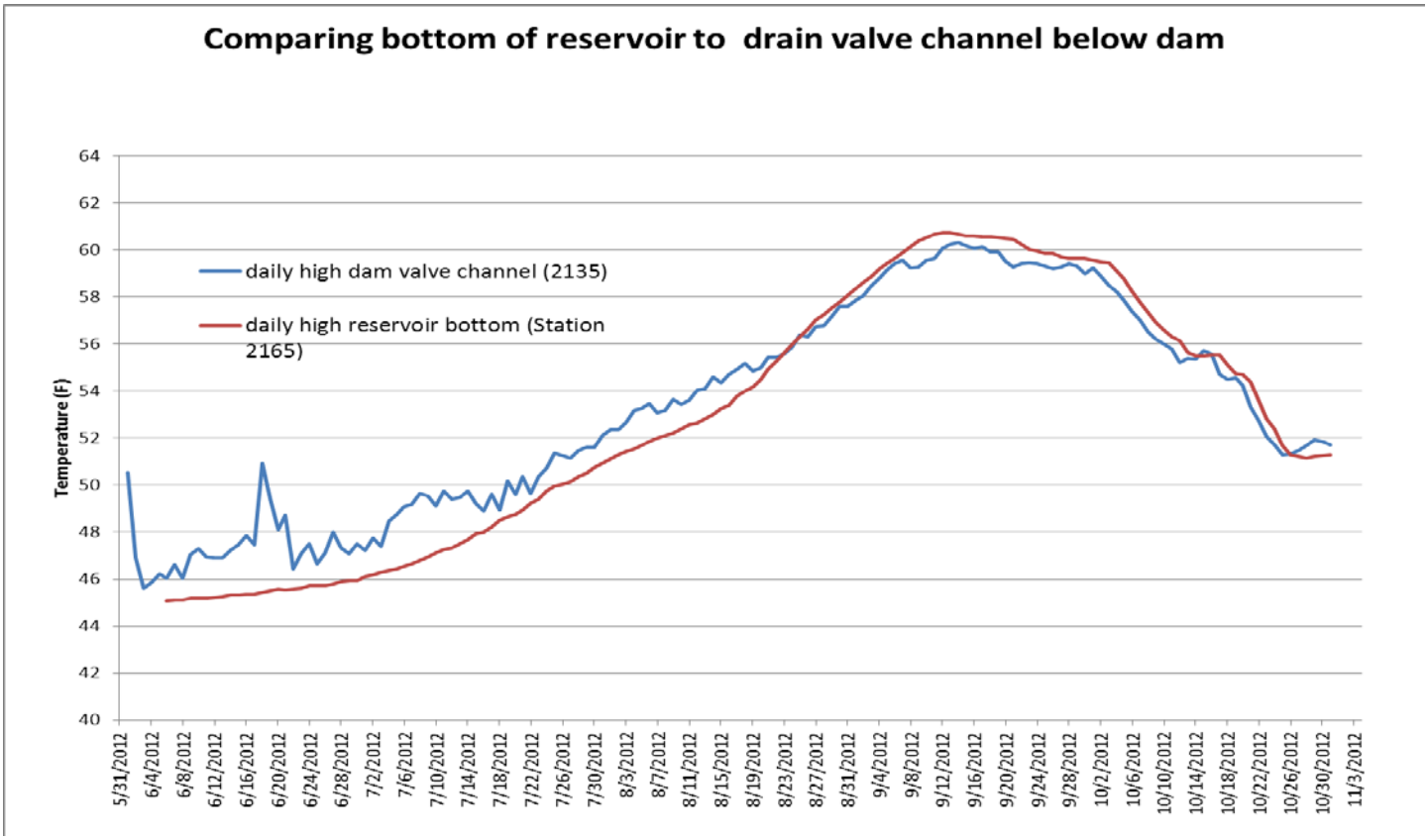

Figure 7. Comparing the temperatures at the bottom of the reservoir with the small channel draining out of the drainage valve at the base of the dam.

Figure 8 shows the temperature data for 4 sites near the dam. The probe below the spillway and dam valve, but upstream from the confluence (Station 2168, black line), monitored the mixing of the bottom of the reservoir and the spillway. Station 2168 shows a sudden drop in temperature on August 14 when the spillway stops flowing; it dropped from 70F to 56F for a daily maximum high in less than 2 days. The water temperature data for the top of the spillway (Station 2161, red line) ends on August 14; the bottom of the spillway (Station 2169, blue line) continues until August 31.

During the early part of June, when higher flows are in the spillway, the three surface water temperatures, the spillway sites and the site between the spillway and confluence, are almost identical. Starting around July 22, Site 2168 below the spillway and above the confluence (black line) diverges from the spillway temperatures, and becomes progressively cooler as flows in the spillway diminish. Once the spillway is no longer flowing, the temperatures just above the confluence are almost the same as the bottom of the reservoir. Note that the influence of the spillway diminishes during the latter part of the July and the first two weeks of August, when the warmest air temperatures and the highest temperatures in the reservoir occur.

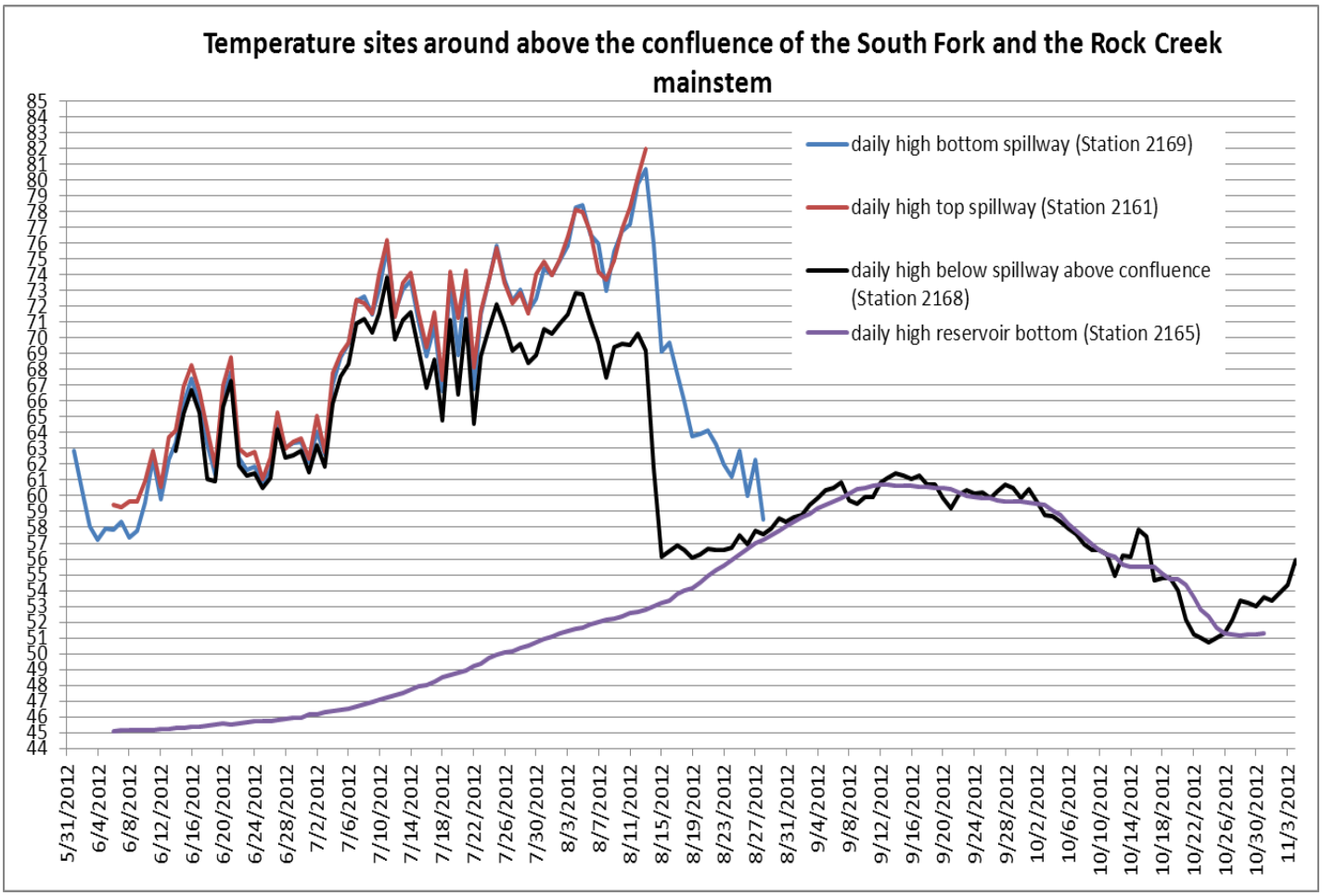

Figure 8. Temperature data near the dam and above the confluence of the South Fork Rock Creek and the mainstem of Rock Creek.

Temperatures in the top of the reservoir and the spillway are obviously warmer than the stream temperatures in the South Fork Rock Creek and the mainstem of Rock Creek below the dam. The question is: Does the flow out of the reservoir have a significant effect on downstream temperatures? Some comparisons of the temperature trends for sites that bracket the confluence of the dam spillway channel, the South Fork Rock Creek and the mainstem lead to interesting observations.

Figure 9 shows the 2012 season's daily maximum temperatures for three sites around the confluence of the South Fork Rock Creek with the mainstem of Rock Creek, and are the ones that most closely bracket the contributing flow from the reservoir.

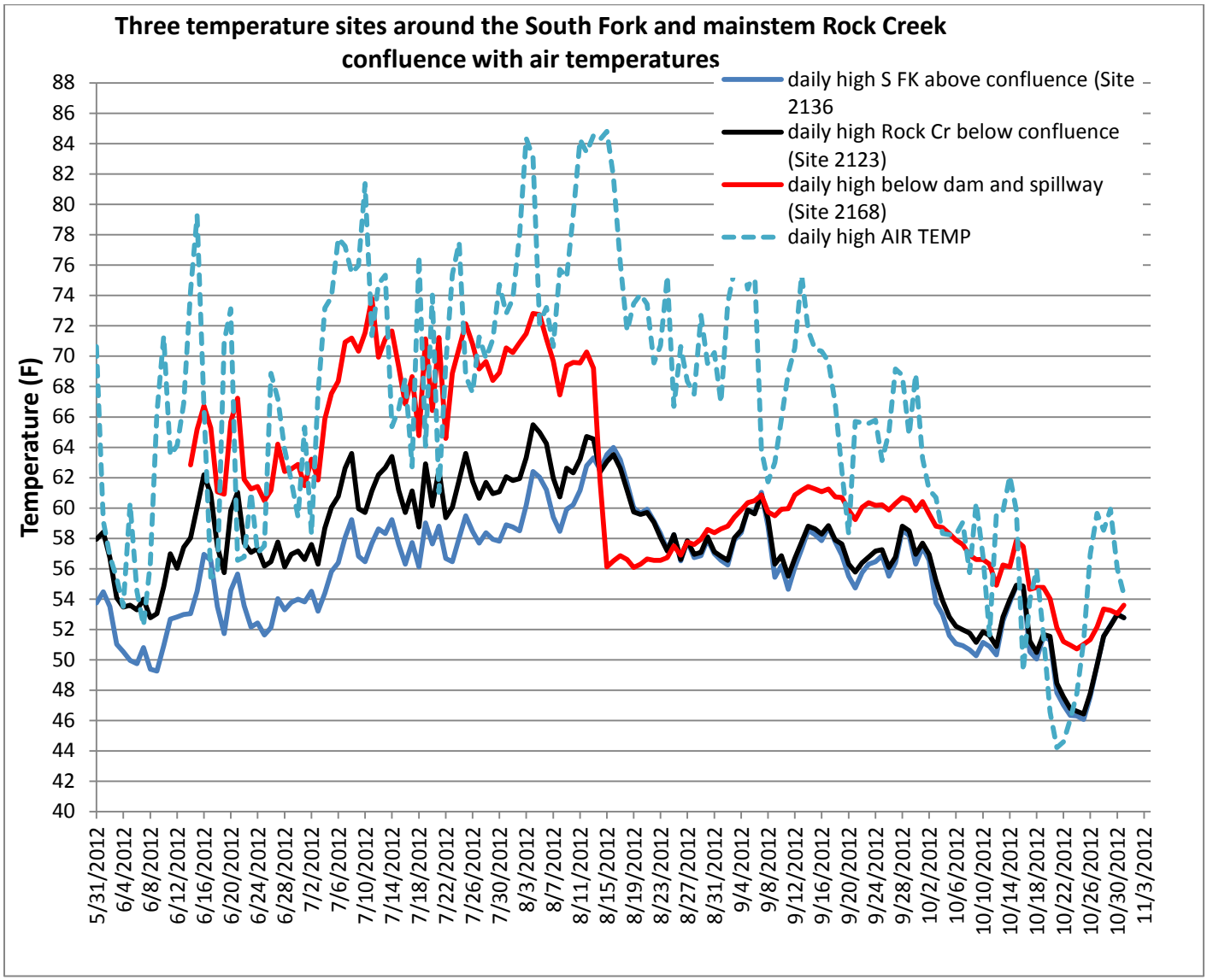

Figure 9. Graph comparing the three temperature sites that bracket the confluence of the South Fork Rock Creek and the mainstem, along with daily maximum air temperatures.

Figure 10 shows the daily maximum temperatures for three sites from June 14 to August 11: The South Fork Rock Creek above the confluence (site 2136), the site below the spillway and above the confluence (site 2168) and the mainstem of Rock Creek just below the confluence (site 2123), as well as air temperature. Linear trend lines have been added to the graph. The overall increase in temperature for the three sites is as follows:

- Site 2168, below the spillway and above the confluence was the warmest, and has an overall increase in temperature of 9 degrees F.
- Site 2136, the South Fork Rock Creek above the confluence, was the coolest of the three sites, and had an increase of 7.5 degrees F.
- Site 2123, the mainstem of Rock Creek below the confluence, was warmer than the South Fork of Rock Creek, but increased at a slower rate, and had an overall increase of 5.75 degrees F.

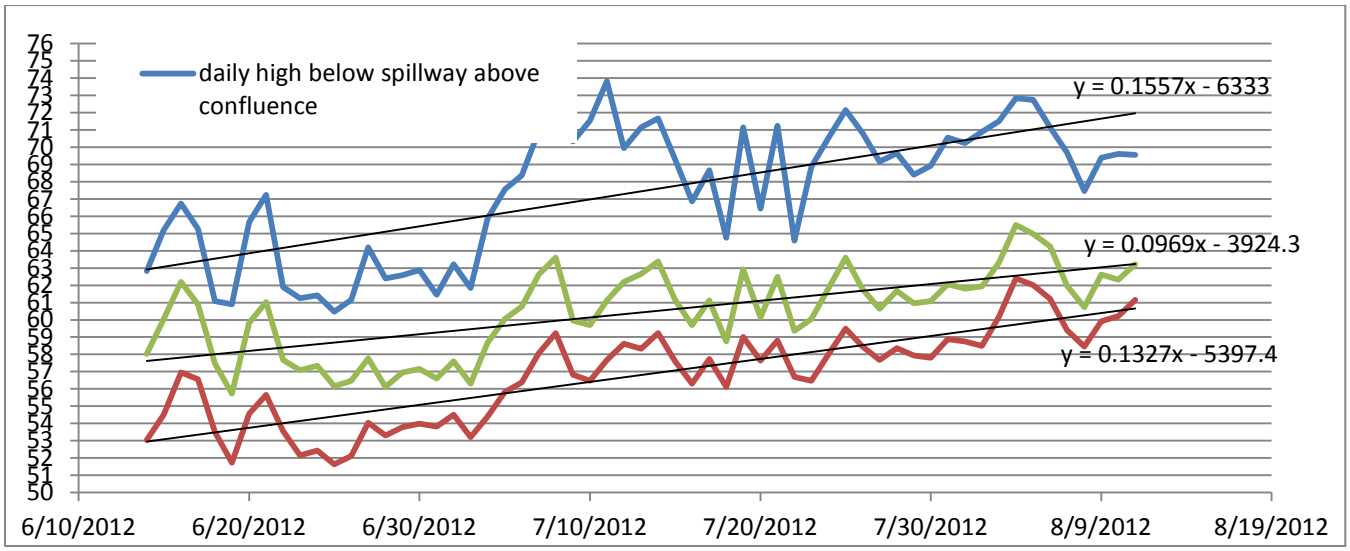

Figure 10. Graph showing the daily maximum high temperatures for Site 2168, below the spillway and above the confluence; Site 2136, South Fork Rock Creek above the confluence; and Site 2123, Rock Creek mainstem below the confluence.

The following two graphs (Figures 11 and 12) show the temperature difference between the South Fork Rock Creek above the confluence (Site 2136), and the mainstem of Rock Creek below the confluence (Site 2123). These two sites bracket the outflow and contribution of the spillway to Rock Creek. Note that during the period of time that the spillway is flowing, until August 13, 2012, the temperature difference between the two sites is declining (Figure 11). If the warm water from the spillway made a significant contribution during the summer, the trend would be expected to be flat or increasing. One explanation for the data shown in Figure 11 is that the flow from the spillway is declining over the summer, and the thermal contribution to the mainstem, relative to the flow in the South Fork Rock Creek, is also declining.

The biggest difference in temperature between the two sites, 5.3F, occurs on June 21 when the South Fork's maximum daily temp is 55.6°F, and the mainstem is 61.0°F. In other words, the biggest influence of the spillway occurs in June, when stream temperatures are cooler.

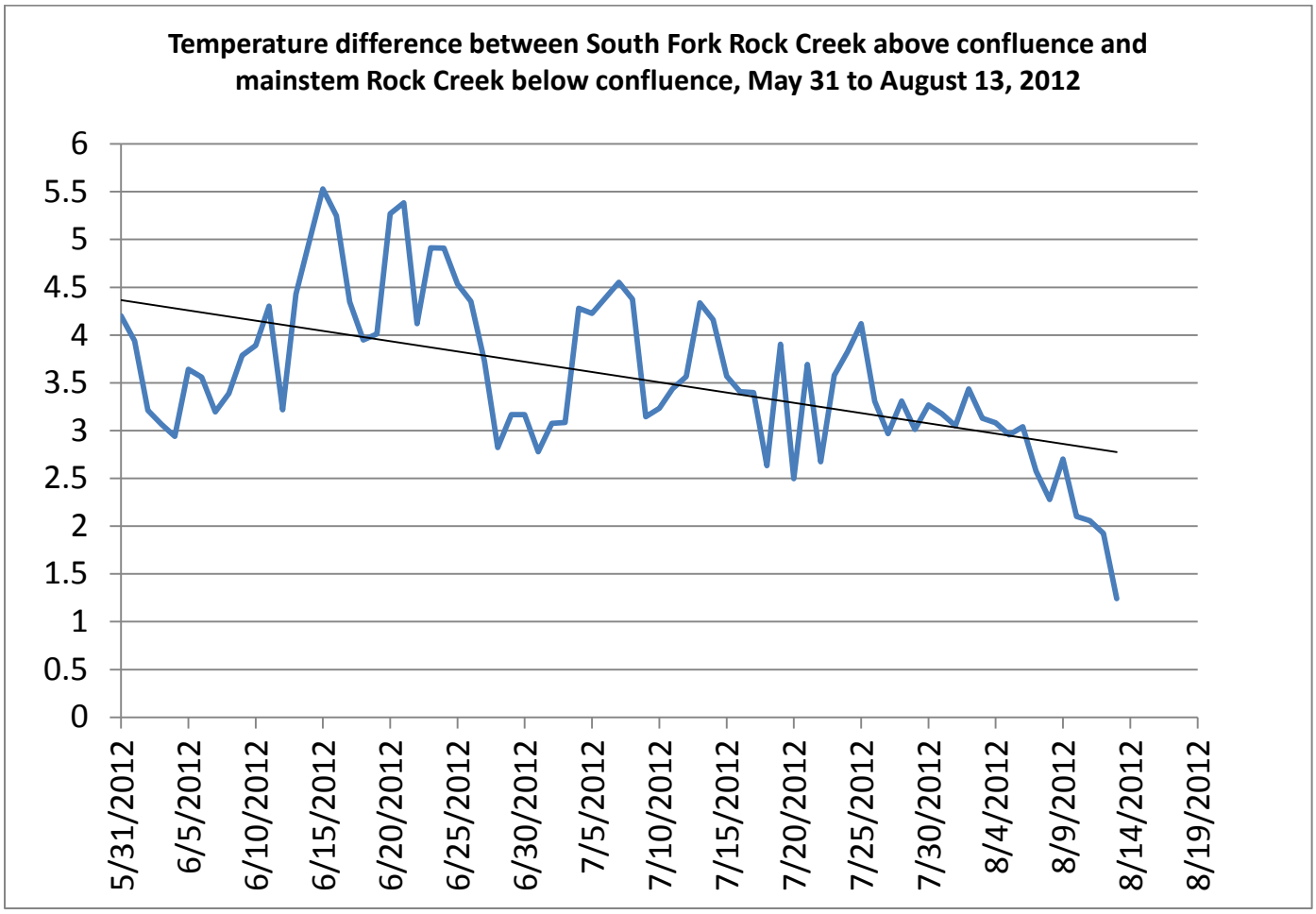

Figure 11. Graph of the difference in temperature beween the South Fork Rock Creek above the confluence and the Rock Creek mainstem below the confluence.

Figure 12 is similar to the preceding graph, in that it shows the temperature difference between the two sites through the monitoring period. This graph shows that without the contribution of the spillway after August 14, the temperature difference between the south fork and the mainstem range from -0.5 to 1.5 degrees, depending on air temperature. For a brief period of time in mid-August, around August 14 to August 24, the mainstem was actually cooler than the South Fork; therefore the difference is a negative number. The baseline difference in temperature between these two sites, therefore, is between -0.5 and 1.5 F.

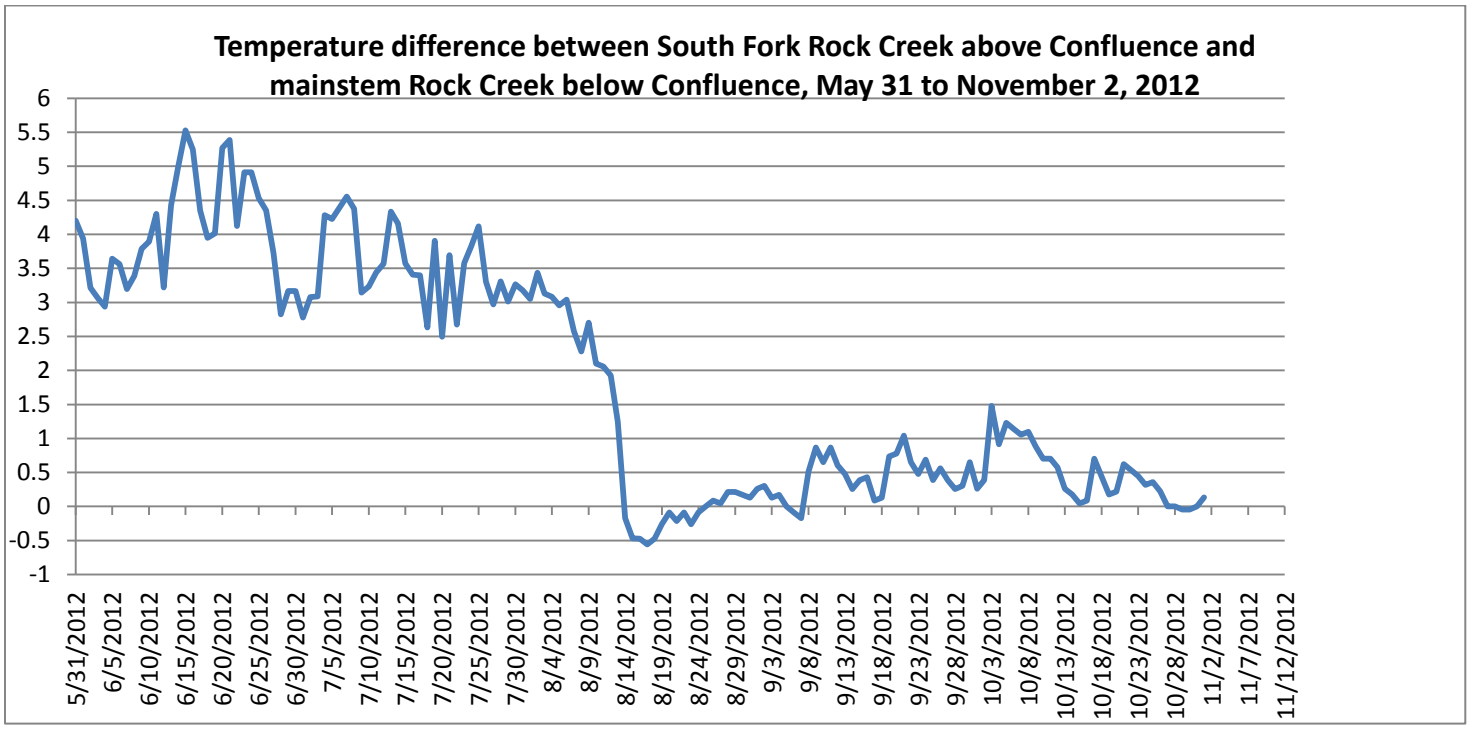

Figure 12. Graph of temperature difference between the South Fork Rock Creek above the confluence and the Rock Creek mainstem below the confluence for the full monitoring period in 2012. Note that after the spillway stops flowing on 8/14/2012, the temperature difference is between -0.5 and 1.5 F.

Figure 13 is the same data as Figure 12, but for 2011. Note that the temperature difference between the South Fork starts to decrease in early July, over a month before the spillway stops flowing.

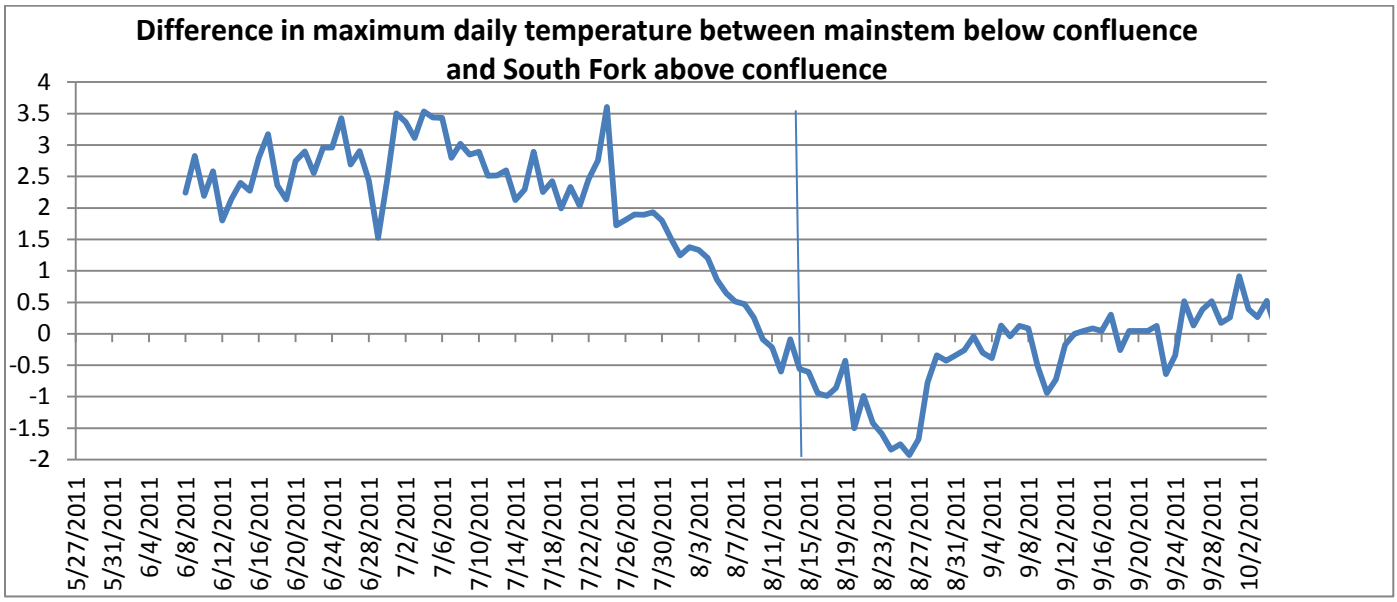

Figure 13. Differences in temperature between the South Fork Rock Creek at the trash rack and the mainstem below the confluence in 2011. Note that the differences in temperature decrease starting on July 28, which is two weeks before the reservoir drops below the level of the spillway, and the spillway is dry. The vertical line marks the date when the spillway flow stops on August 15.

Finally, Figure 14 shows the 7-day average maximum temperature as well as the daily maximum temperature for the Rock Creek mainstem site below the confluence and compares it to the difference in temperature between the South Fork Rock Creek site (2136) above the confluence and the mainstem below the confluence (Site 2123). The 7-day average maximum temperature for the mainstem below the confluence stays below the 64F state standard for water temperature. In addition, when the temperature difference is the greatest between the two sites in mid-June, and presumably the reservoir is having the greatest influence on downstream temperatures, the 7-day average maximum temperature for the mainstem reaches a high of 60F on June 17. This is also a period of warmer air temperatures for the month of June.

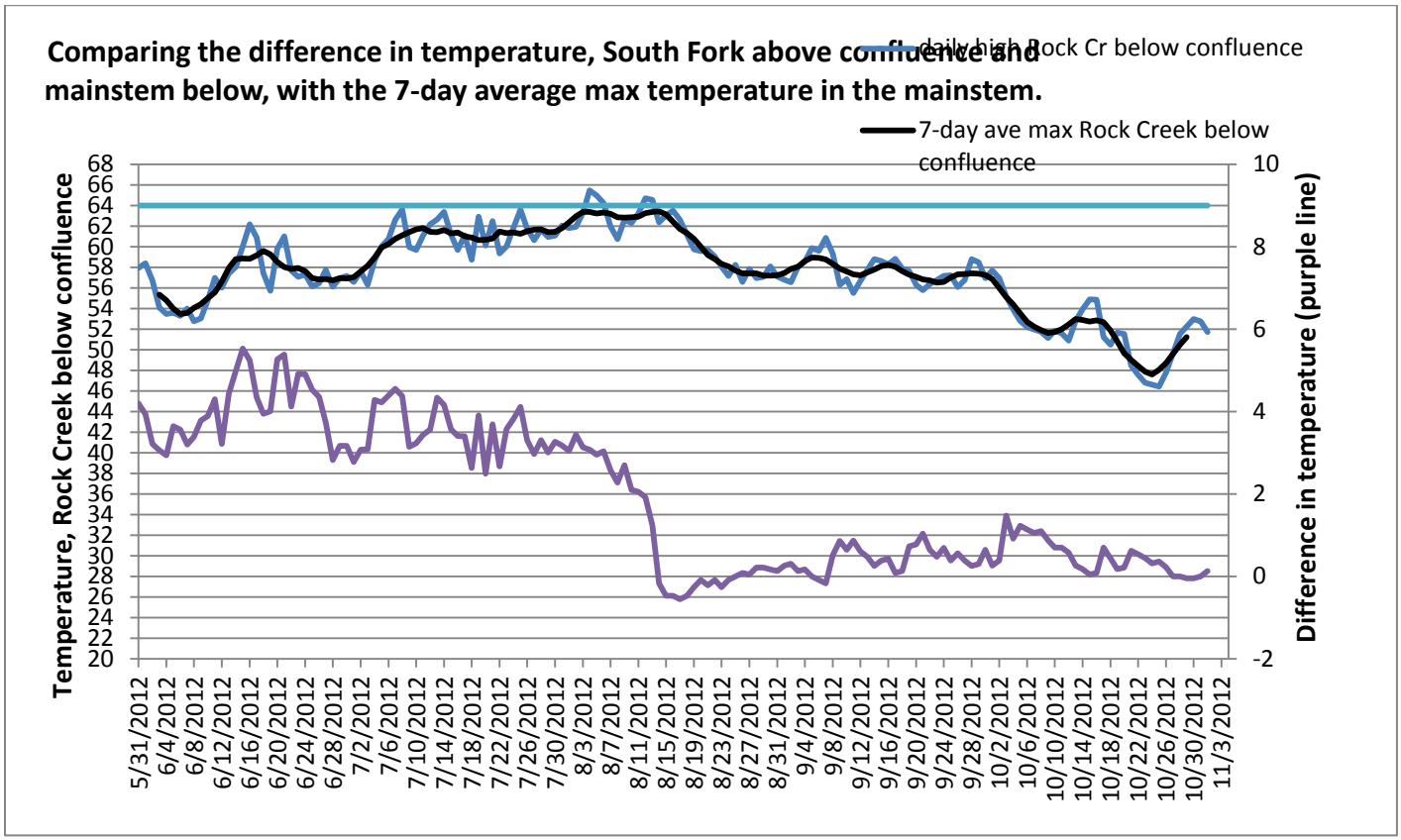

Figure 14. Graph comparing the daily maximum temperatures and 7-day average maximum temperatures for the mainstem below the confluence and the difference in temperature between the South Fork above the confluence and the mainstem below the confluence. The scale on the left axis is Temperature (F), and the scale on the right refers to the lower line on the graph, which is the difference in temperature.

DISCUSSION

For the most part, water temperatures in the Corvallis Watershed met state water quality standards in 2012. The exception is the Rock Creek mainstem from just downstream of the Middle Fork Rock Creek to the mouth, and the upper level of the reservoir. The mainstem is only a maximum of 2.33 F above the state standard of 64F at the warmest point near the confluence with Greasy Creek, and temperatures above 64F lasted from August 2 to August 19 at that site. For the reservoir, the upper surface 7-day average maximum temperature reached 70 .87

F. The highest 7-day average maximum temperature for the mid-level of the reservoir at a depth of approximately 25 feet was 62.6 F. See Appendix A for the graphs of the individual sites.

Both air and water temperatures were slightly warmer than in 2011.

Several probes were deployed in and around the reservoir to determine its effects on downstream temperatures (Figure 14). Based on the data, the effect of the reservoir and spillway on downstream temperatures is minimal, and more likely to be seen in the early part of the summer. The difference in temperature between the South Fork and the mainstem below the confluence is greatest in the middle of June. However, the maximum daily water temperature on June 15 below the confluence was 62F,. Between May 31 and August 14, 2012, the DIFFERENCE in maximum daily water temperatures between the South Fork above the confluence and the mainstem below the confluence gradually declines to 1.25 degrees on August 13. During the summer, the flow over the spillway also decreases and stopped completely on August 14. Therefore, the amount of warm water entering the Rock Creek mainstem from the spillway, compared to the flow from the South Fork gradually diminished.

Based on the relationship of stream temperature to drainage area, as shown in Figure 1, the water temperatures below the confluence in the mainstem are actually below what would be expected.

This data suggests that during the warmest part of the summer, which was the first two weeks in August for the summer of 2012, the effect of the spillway was negligible. After the spillway flow was shut off completely, the difference in temperature between the South Fork and the mainstem ranged from 0 to 1.48(?) degrees F. Since the spillway was no longer an influence, it can be assumed that this is the normal range of temperature differences between these two sites. If the maximum difference of 1.48 is subtracted from the maximum difference in June, the amount of temperature difference attributable to the spillway in June might only be 3 degrees at the most.

Air temperature also influences stream temperature. The warmest air temperature was from August 3 to August 15, during the diminishing flow from the spillway. After August 15, air temperatures gradually declined. In 2012, a drop in air temperature coincided with the end of the spillway flow for the summer. All of the sites show a decline in water temperatures after August 14, showing a common response to air temperatures.

CONCLUSION

The water temperatures in most of the Corvallis Watershed are meeting state water quality standards. The reservoir appears to be having an insignificant effect on downstream temperatures.