FINAL REPORT
OWEB GRANT 209-2021-7205
Wolf Creek Basin Restoration Monitoring-EM

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Table of Contents

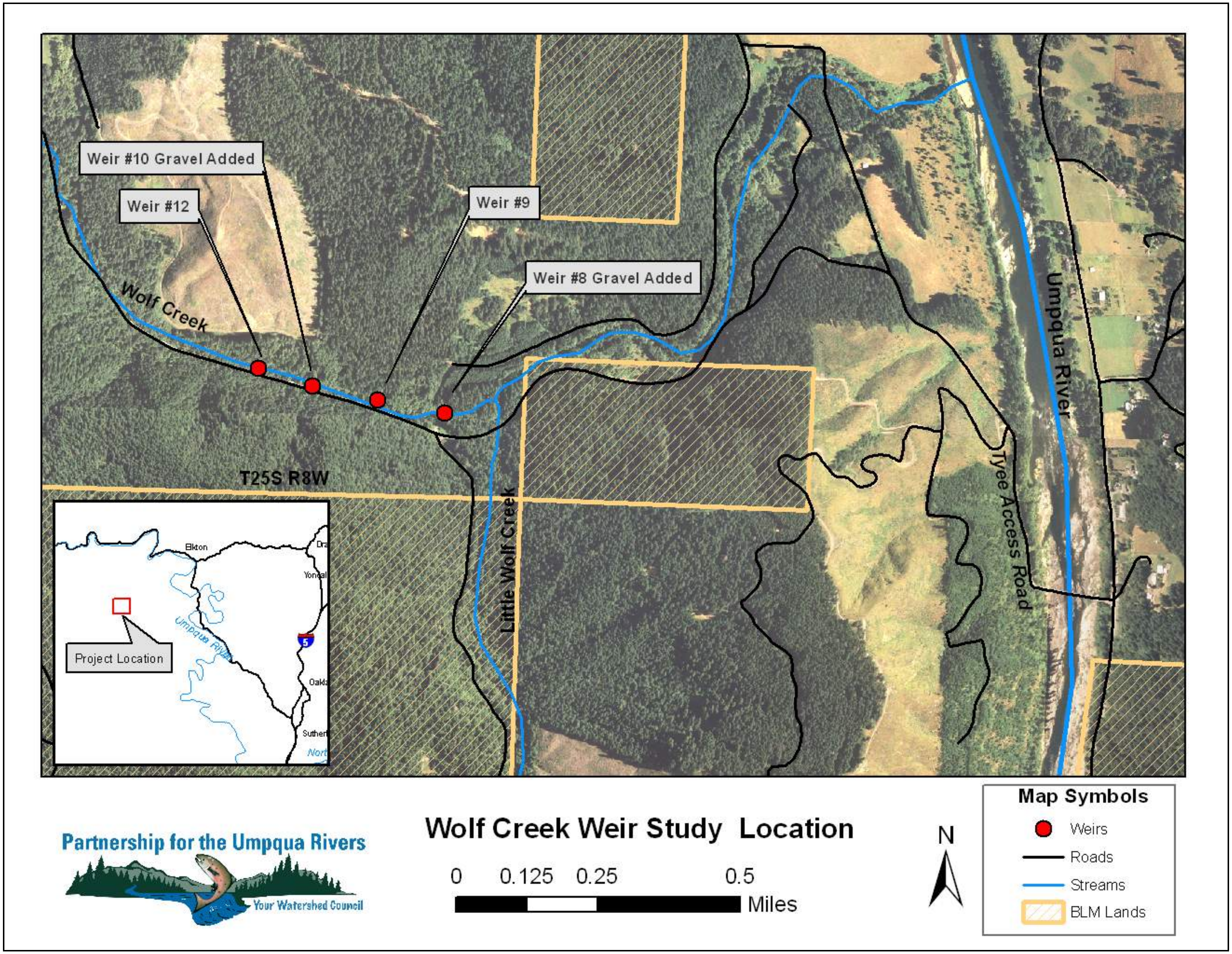
Introduction

The Wolf Creek 6th-field watershed restoration project is the site of long-term extensive and intensive effectiveness monitoring efforts of stream restoration projects occurring throughout the entire watershed. Wolf Creek, a 23,500 acre watershed, enters the Umpqua River 90 miles upstream of the ocean and contains over 30 miles of fish habitat. Monitoring has been a collaborative effort between Oregon Department of Fish and Wildlife (ODFW), Bureau of Land Management (BLM), Oregon Department of Water Resources (OWRD), U.S. Geological Survey (USGS), Aquatic and Riparian Effectiveness Monitoring Program (AREMP), Oregon State University (OSU) and the Partnership for the Umpqua Rivers (PUR). Grant 209-2021-7205 funded a specific sub-set of these monitoring efforts to determine the effectiveness of augmenting boulder weirs with gravel at the time of weir construction to document the effects of gravel on the temperature distribution within a stream. Two weirs constructed without the addition of gravel were compared to two weirs where gravel was added after weir construction. Fig. 1, on the next page, is a map of the project area.

Lowering and maintaining areas of reduced stream temperatures is a major benefit of stream and riparian restoration projects. It has long been documented that man caused changes to streams and riparian areas have been responsible for increased stream temperatures that also have produced changes to the hyporheic region (Hancock, 2002). We can prescribe ideal stream temperatures for salmon and wildlife but, in many places, irrespective of anthropogenic changes these ideal temperatures are unachievable. Much research has gone into trying to understand what affects stream temperatures and if there are best management practices that might enable the creation of areas of lower stream temperatures. The debate still goes on with some controversy over the relative influence of many factors, most notably shade/solar radiation, air temperature and substrate. Many field studies have been conducted over a wide range of stream sizes and conditions which have found that increasing hyporheic flow through gravel can affect stream temperature. Hyporheic exchange occurs when stream surface water downwells through gravel beds and travels subsurface before returning to the main surface flow. In a report prepared for Portland General Electric, “Potential Effects of Gravel Augmentation on Temperature”, the authors conducted a literature search citing 16 studies that reported the “increasing hyporheic exchange through gravel can affect stream temperatures” (Grant, 2006). Though increasing flow through the hyporheic zone is not expected to change the mean bulk temperature of a river, it may reduce maximum temperatures providing a localized refuge for juvenile fish during the heat of the day.

The lower mainstem Wolf Creek has significant bedrock dominated reaches and very high winter flows. Full spanning large boulder weirs were the choice of the planners to help slow velocities, provide winter high flow refuge and create sections were substrate would accumulate without being swept out of the system every winter. In addition the weirs would produce summer pools in long bedrock stretches where there had been no refuge. With the advantage of the weirs to retain gravel, it was decided to augment a number of weirs with gravel right after weir construction to see if we could jump start substrate accumulation and production of hyporheic flow and ground water connection.

Figure 1: Map of Wolf Creek Weir Study Area



Design

A. The project was designed to allow comparison of temperature data collected from freshly placed boulder weirs, which were then augmented with gravel upstream of the boulder weirs, to those that were not augmented but over time were expected to naturally accumulate native gravel moving through the system. Three quarter to one and one half cubic yard boulders were placed forming a diagonal bank to bank weir designed by PUR, ODFW and BLM hydrologists. One hundred cubic yards of six inch minus, unsorted and unwashed gravel was added to Weir #8 and to Weir #10. This gravel was purchased from a local stockpile which was nine miles from Wolf Creek and had been obtained from the mainstem Umpqua River. Weir and gravel placement was completed by July 27, 2009. The weirs were located in, a mostly bedrock, four tenths of a mile stretch on lower Wolf Creek where winter flows can be very high and log structures would not have been appropriate – sets of photos for each weir are included in this report. Weir #8 Appendix J: Photos 2-24, Weir #9 Appendix K: Photos 25-31, Weir #10 Appendix L: Photos 32-40, Weir #12 Appendix M: Photos 41-47.

B. The purpose of the sampling design was to be able to pick up any changes in the temperature thermograph phase peak of the water entering the gravel upstream of the weir and that of the water exiting gravel and boulder weir downstream. For this purpose, Onset Tidbit v2 temperature data loggers were deployed at the upstream edge of the gravel augmentation at three or more sites across the lateral face of the gravel. Three or more temperature data loggers were deployed across the downstream lateral face of the weir to measure the water exiting the gravel below the weir. Other loggers were buried at Weir #8 in an attempt to measure the temperature of the water in the gravel.

C. Cross-sections were measured in 2009 upstream of all boulder weirs immediately after construction and again after gravel augmentation. This provided baseline measurements and an indicator of the depth of the added gravel. Control non-augmented weirs were measured for baseline data after weir construction. Cross-sections were continued to be monitored each summer in 2010, 2011 and 2012. Two sets of cross-sections were performed at each weir: 1. Just upstream of the weirs varying from mid-weir to 26 feet, and 2. Further upstream varying from 113 to 130 feet. The upstream sites were chosen by the hydrologists as an area where they would expect deposition of substrate due to the reduction in velocity caused by the weirs. Velocity is directly related to the relative particle size that the water can carry. As the velocity is slowed by the weirs and the water backs up substrate will be deposited upstream.

D. Pebble counts were performed with each cross-section in order to document changes and to allow for comparison of bed load composition to temperature over the years.

Methods

A. Temperature Data Loggers: The procedure for deploying temperature data loggers in gravel bars came from personnel conversations with Barbara Burkholder, who was then a graduate student at OSU under Gordon Grant doing hyporheic flow research on gravel bars in the Clackamas River (Grant G. R., 2006) and from her Master's Thesis: (Burkholder, 2007). Onset Tidbit v2 water temperature recorders were placed in late spring or early summer and retrieved late summer or fall depending on flows and logistical concerns. Water temperature recorders were set to record every half hour. They were tied to rocks to prevent movement of the devices and hidden in the streams. Careful site selection was made to ensure there would be good flow and mixing (not stagnant) and thought was given to what the late summer flows might be to ensure the site would be representative of the stream at that location (Dunham, 2005). Where possible, temperature loggers were placed at the same sites as the previous year. If relocation was necessary they were moved as little as possible and a letter (a, or b) was added to the ID# to indicate a slight change in location. Field Data Sheets were used to record a detailed site location description, site I.D. #, personnel, logger serial #, date & time deployed, NIST thermometer temperature after 20 minutes of deployment as close to the half hour as possible, depth of the water where placed and photo numbers. Prior to stream placement, pre-deployment accuracy checks were performed on all devices according to established protocols (The Oregon Plan for Slamon and Watersheds, 1999). Water temperature recorders were placed in warm and ice water baths comparing temperatures to National Institute of Standards and Technology (NIST) certified VWR Traceable Digital Thermometers that are inspected annually for accuracy by the ODEQ Lab. Post-deployment accuracy checks were completed after retrieval of the water temperature recorders using the same method. Field accuracy checks were also conducted comparing NIST Thermometer temperatures to that of the water temperature recorders at the time of deployment, mid-season, and at the time of retrieval – comments are recorded at each audit noting any visible change of conditions and current depth of water. Care is taken to check the temperature with the digital thermometer near the location of the water temperature recorder and close to the half hour. All continuous temperature data collected were downloaded using Onset's HOBOware Pro software and summarized using Microsoft Excel software. A DEQ temperature macro (for Microsoft Excel software) modified by Kent Smith for Excel 2007/2010 and for ODEQ's current temperature criteria (DEQ, 2011) was used to summarize temperature logger statistics. All pre-deployment accuracy checks, post-deployment accuracy checks, and field audits were compiled on ODEQ's ExampleContinuousSample.xls workbooks (ODEQ, 2009) and submitted to the ODEQ lab. For this report, degrees Fahrenheit were chosen as the unit of temperature instead of degrees Celsius for ease of communication to the public and for magnification of small changes. TidbiT v2 Water Temperature Data Loggers (UTBI-001) support a range of -20° to 30°C (-4° to 86°F) in water at an accuracy of ±0.2°C @ 25°C (0.36°F @ 77°F and a resolution of 0.02°C at 25°C and 0.04°F at 77°F. All pre and post season accuracy checks for all our units, for all years were within the DEQ threshold of 0.5° for A quality data.

B. Cross-sections: Cross-sections were performed as per ODFW protocol, *USDA Stream Channel Reference sites: An Illustrated Guide to Field Techniques* (Harrelson, 1994) and Stream Inventory Handbook (USFS, 1999). Sites for cross-section were established using rebar where possible to mark each site (at a few sites we used a nail on a tree). Field data sheets recorded site description and notes, as well as distance from the rebar, height to the line, terrain, substrate and water depth at each small change in terrain. In 2009, 2010 and 2011 cross-sections were measured with a measuring tape, small level and stadia rod. In 2012 we received a small grant from the Cow Creek Band of the Umpqua Tribe of Indians for the purchase of a laser level, laser receiver, tripod, new stadia rod and accurate laser rangefinder. In 2012 we used the new equipment. Results matched well to previous years, see Appendix C: Figure

Photo 1: Early cross-section work in Wolf Creek

C. Pebble Counts: Wolman Pebble counts were performed following the *USDA Stream Channel Reference sites: An Illustrated Guide to Field Techniques* (Harrelson, 1994) and Stream Inventory Handbook (USFS, 1999). Pebble Counts were preformed once a year starting crossing under the cross-section line and then crossing at one pace upstream and one downstream. The Wentworth scale (USGS) was used measuring the intermediate axis of a minimum of 100. Results were tabulated and turned into percentages. Results are reported with cross-section data – Appendix C: Figures 6-13.

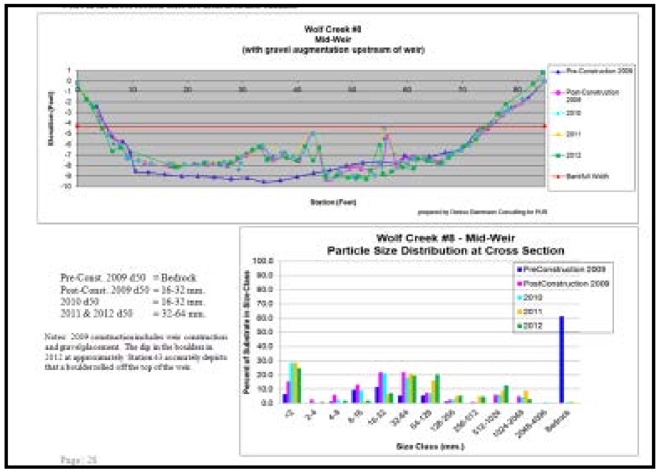
D. Photo Points: Photo points were established with each cross-section (Shaff, 2007) (Hall, 2002). Metal tags were nailed to trees designating where to stand when taking the photo.

Results:

Data Interpretation – Cross-sectons and Pebble Counts

Appendix C: Figures 6-13 display annual cross-section profiles and pebble counts at two locations for each weir for the 2009-2012 time period.

Hindsight indicates that these locations do not necessarily fully represent the extent of change that occurred. In some cases, such as above Weir #9 there was a large deposition of sand/silt on the left upstream bank between our cross-section sites. This may indicate that we chose too far upstream for our upstream cross-section, therefore our cross-section and pebble count data may not optimally depict changes to the composition of the bed that actually did occur due to the weirs. This site in particular is mentioned because BLM fish biologists recently found a large number of lamprey ammocoetes in the newly deposited substrate at this location. None had been found in this area before due to lack of available substrate.



Example cross-section & pebble count chart

Weir #8 and #10, the gravel augmentation sites, had pre- and post-construction cross-section data which show approximately one foot of gravel Appendix C: Figure 6 and Figure 10, having been placed. The d50's (d50= the mean diameter of the particle size distribution which means that 50% of the particles measure are larger than the d50 value and 50% are smaller) for both of these sites show a decrease in substrate size due to the added gravel covering the mostly bedrock reaches. It is easy to determine visually from the particle size distribution chart that these sites were dominated by bedrock and that our gravel augmentation immediately changed that condition. Baseline conditions were collected for the control, Weirs #9 and #12 (no gravel added), as well as the upstream sites at all four weirs.

All cross-sections were repeated in 2010, 2011 and most in 2012. No dramatic changes were evidenced in the cross-section charts, though there was some accumulation in spots and some washing out in others.

Weir #8 continued to demonstrate some particle size change over the years at the mid-weir cross-section. Sand increased from around 5% to nearly 30% of all of the size classes. There were also significant in the 16-128 mm size class. The 122' upstream site gained some sand, a 20% to over 40% change in class size distribution.

Weir #9 at the 221' upstream cross-section demonstrated some reduction of exposed bedrock and an increase in sand class size distribution from 35% to almost 70%. The 115' upstream cross-section showed a similar increase in sand distribution.

The cross-section chart for the site at 29' above Weir #10 shows a dramatic change for gravel placement in 2009, then little change for 2010 and some additional accumulation in 2011. Bedrock exposure was reduced from approximately 8% to zero with the gravel placement. The sand component fluctuated between 8% and 42% from an initial 8%. The 32-64 size class also showed high variability, ranging from 12% to 35% over the study period. The 130' upstream cross-section shows interesting changes after 2009, with some loss and some accumulation across the cross-section. Bedrock exposure was reduced from 52% to 31% and the sand component increased dramatically from 24% to 60%.

Weir #12 at 29' upstream appeared to have lost some substrate, though bedrock exposure was reduced and sand accumulated. At 113' little change occurred to the cross-section with bedrock being reduced and sand increasing.

Comments regarding streambed composition:

Since the weirs act as a barrier to bedload movement, the most upstream weir (Weir #12) should tend to fill first with subsequent downstream filling when the gravel overtops the weir. It would be of interest to monitor the fill rates of the respective weirs and the corresponding storm event history. Annual photo points taken at low flow could provide useful information on gravel accumulation at weir placement projects.

The addition of the weirs represents a significant change to channel hydraulics of the study reach and the channel gradually adjusts in response to these changes. However, most channel forming changes occur during extreme high-flow events at which time there is significant bedload movement and erosive forces acting within the channel. If the boulder weirs survive these high flows they will undoubtedly serve as gravel accumulation points and contribute to the beneficial diversity of the stream. Even if the weirs fail, the presence of the boulders in the stream will contribute to the diversity of the system. The stable, long term, condition of this stream reach will be determined for the most part by the largest flow event experienced after the weir installation. The project should be reevaluated after a five-year or greater event.

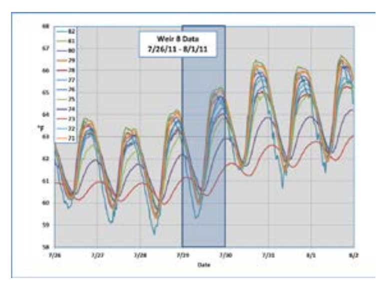
Data Interpretation – Water Temperature Data

Overview:

Water temperature data was collected at all of the weirs from 2009-2012 and baseline temperature was collected for 2007 and 2008. *Appendix P: 30' Thermograph Plot 2007-2012* show the characteristic unique seasonal patterns in the temperature data for each site. Appendix F, G, H, and I display charts for 2009, 2010, 2011 and 2012 for all data loggers at times of highest stream temperature and at times of lowest stream flow. Appendix E provides the typical analytical temperature summary data for every thermograph. This inter-season and inter-year variability makes direct comparison of data from different time periods problematic. Likewise, during periods of transitional weather conditions, the data loggers may respond to the transient conditions at different rates, making identification of consistent relationships between the units more difficult. For that reason, periods of uniform, "steady-state" conditions were selected to compare the relative thermal response characteristics of the various sites. These periods occur when there are several consecutive "clear sky" days and the thermographs show a uniform rate of diurnal heating over the time interval.

Besides prevailing weather, flow conditions and changes in the solar path introduce variability into the data. To observe these effects, "early season" and "late season" sample dates were selected for the 2011 and 2012 seasons. The late season conditions were characterized by lower flows, lower solar angle and shorter days. Appendix A: Figure 2 (Wolf Creek Stream Flow) shows that the flow regime for 2011 and 2012 were very similar and that the streamflow diminished by more than 50% during the summer study period. Appendix A: Figure 3 is included to provide reference comparison of winter flows over the study time period from a stream gauge within a mile on Little Wolf Creek. Appendix A: Figure 4 is also from the Little Wolf Stream Gage, providing more frequent flow information catching rain events for comparison during the summer.

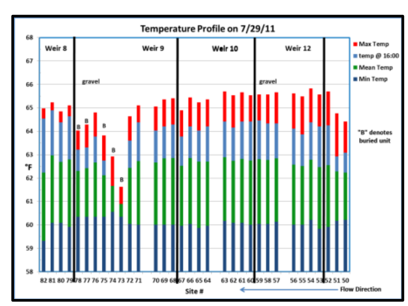
Appendix D: Figures 17-20 (Weirs 8-12) show the stream temperature seven day plots for the "steady-state" periods selected for this analysis. The shaded section in the plot area represents the time interval selected for detailed analysis.



Example 7 day temperature plot

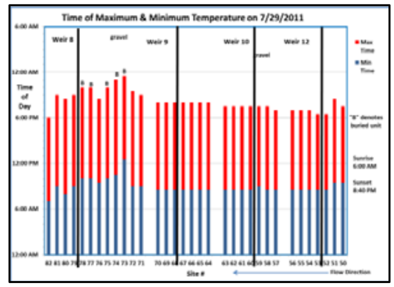
The following sets of charts (Appendix D: Figure 14-20) were developed to display relevant statistics to quantify the characteristic response of the individual data loggers under "steady-state" conditions for a specific 24-hour period.

Figure 14: Temperature Profile – Appendix D quantifies the thermal response of each unit using the maximum, minimum, mean and temperature value observed at 16:00. The latter value provides a synoptic view of the data and provides an indication of the relative timing at each site. The data columns are ordered relative to their longitudinal position in the stream and to the weir locations. Since the location of some of the sites changed slightly between seasons, a unique location index was established for the 2011 and 2012 years. Details of the respective deployment locations are in described in the discussions for the individual weirs.



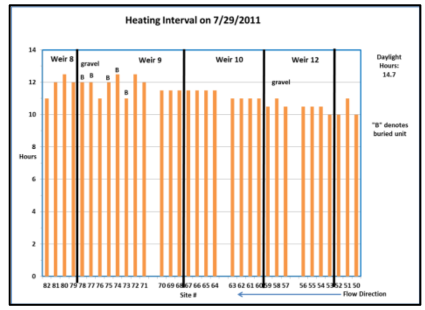
Example from Figure 14

Figure 15: Time of Maximum and Minimum Temperature – Appendix D. These times occur when the net heat flux to the unit reverses direction and is related to the time of sunrise and sunset. The time of sunrise and sunset is displayed for the sample date for reference.



Example from Figure 15

Figure 16: Heating Interval – Appendix D. Displays the length of time the unit receives heat within the 24-hour cycle and there is a corresponding increase in temperature. The daylight hours (sunset – sunrise) is displayed for the sample date for reference.



Example from Figure 16

An overview look at the Temperature Profile charts shows a relatively small range of variability between the sites and does not show an obvious association with the weirs. However, a better understanding of the thermal dynamics of our streams can be gained by understanding the information that is contained in the data.

Chart sets Appendix D: Figure 15 and Figure 16 serve to quantify the variability in the solar influences at the individual sites. Each day has a unique solar path and each site has unique shading characteristics determined by local and topographic shade features.

Unit index info for 2011 and 2012:

2011

Site	Unit SN	Location
50	2026959	WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
51	1297657	WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
52	2321274	WC12 - Downstream #3 - Right Side of Main Weir (Facing US)
53	2026942	WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
54	1297653	WC12 - Downstream #4 - near Mid Weir
55	2321286	WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
56	1297661	WC12 - Downstream #2a - 32 ft. Downstream
57	2026932	WC10 - Upstream #2a - 115 ft. Upstream
58	2321280	WC10 - Upstream #1a - Face of Gravel - 26ft from MidWeir
59	2321277	WC10 - Upstream #3a - above Weir in Gravel Leading Edge - Rt Side (Facing US)
60	1297652	WC10 - Downstream #4 - Downstream near Far Right Side of Weir (Facing US)
61	1297668	WC10 - Downstream #2 - Downstream near Middle of Weir
62	2026947	WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)
63	1297662	WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster
64	1297655	WC9 - Upstream #1a - 107 ft. Upstream
65	2321272	WC9 - Upstream #2a - 50 ft. Upstream to Left (Facing US) of US#2
66	2026946	WC9 - Upstream #4 - 50 ft.Upstream to Left (Facing US) of US #2 - Buried 2" in Sand
67	1297670	WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
68	2026956	WC9 - Downstream #3 - in Right Side of Weir (Facing US)
69	2026937	WC9 - Downstream #1a - in Left Side of Weir (Facing US)
70	2321278	WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
71	1297664	WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb
72	1297665	WC8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel
73	1297650	WC8 - Upstream #8a - Buried in 5" MudNearBank-43' US fromWeirAtLeftEdge (FaceUS)
74	2026953	WC8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)
75	2026943	WC8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)
76	1297656	WC8 - Upstream #5 - 27' Upstream on Upstream Face of Gravel
77	2026955	WC8 - Upstream #7a - Buried 12" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)
78	2026958	WC8 - Upstream #6 - Buried 14" in Gravel Just Upstream from Weir
79	2026935	WC8 - Downstream #2a - To Right of Middle of Weir - Downstream of Gravel Face
80	2296306	WC8 - Downstream #1a - in Center of Weir
81	1297667	WC8 - Downstream #3a - 53' Downstream on Right of MidStream (Facing US)
82	1297671	WC7 - Downstream of Entire Study Area

2012

Site	Unit SN	Location
0	2026959	WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
1	1297657	WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
2	2026942	WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
3	2026946	WC12 - Downstream #3a - Right Side of Main Weir (Facing US)
4	1297653	WC12 - Downstream #4 - near Mid Weir
5	2321286	WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
6	1297661	WC12 - Downstream #2a - 32 ft. Downstream
7	2026932	WC10 - Upstream #2a - 115 ft. Upstream
8	2321280	WC10 - Upstream #1a - Upstream 26ft from MidWeir
9	2321277	WC10 - Upstream #3b - 3 ft. Upstream from Weir - MidWeir
10	1297652	WC10 - Downstream #4a - Downstream near Far Right Side of Weir (Facing US)
11	1297668	WC10 - Downstream #2 - Downstream near Middle of Weir
12	2026947	WC10 - Downstream #1a - In Weir Left Side (Facing US)
13	1297662	WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster
14	1297655	WC9 - Upstream #1a - 107 ft. Upstream
15	1297670	WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
16	2321272	WC9 - Upstream #2a - Mid Weir Just Upstream
17	2026956	WC9 - Downstream #3a - in Right Side of Weir (Facing US)
18	2026937	WC9 - Downstream #1a - in Left Side of Weir (Facing US)
19	2321278	WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
20	1297664	WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb
21	2026958	WC8 - Upstream #8b - Buried in 5" Mud Upstrm fromWeir NearLeftBank (FaceUS) at Ford
22	1297665	WC8 - Upstream #4a - 42' Upstream on Upstream Face of Gravel near Rt Side (FaceUS)
23	1297656	WC8 - Upstream #5a - 16' Upstream on Upstream Face of Gravel Midstream
24	2026953	WC8 - Upstream #7a - Buried 10" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)
25	2026955	WC8 - Upstream #6a - Buried 12" in Gravel Upstrm of Main Weir near RtBank (FaceUS)
26	1297650	WC8 - Downstream #1b - near Center of Weir
27	2026935	WC8 - Downstream #2b - To Right Side of Weir (Facing US)- Downstream of Gravel Face
28	1297667	WC8 - Downstream #3b - 35 ft. Downstream MidStream (Facing US)
29	2026943	WC7 - Downstream of Entire Study Area

Appendix J: Photos #14-24 attempt to provide some visual framework to the understanding of where the temperature loggers were placed for Weir #8.

Narrative interpretation of the results at each weir, starting from the upstream end of the project area.

Weir 12

2011 sites		
Site	**Logger SN**	**Location Description**
50	2026959	WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
51	1297657	WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
52	2026942	WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
53	2321274	WC12 - Downstream #3 - Right Side of Main Weir (Facing US)
54	1297653	WC12 - Downstream #4 - near Mid Weir
55	2321286	WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
56	1297661	WC12 - Downstream #2a - 32 ft. Downstream
2012 Sites		
0	2026959	WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
1	1297657	WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
2	2026942	WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
3	2026946	WC12 - Downstream #3a - Right Side of Main Weir (Facing US)
4	1297653	WC12 - Downstream #4 - near Mid Weir
5	2321286	WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
6	1297661	WC12 - Downstream #2a - 32 ft. Downstream

Note: Location of the highlighted site changed slightly. A large tree had fallen down covering the site where logger #3 had been placed in 2011 and previous years.

The 2012 temperature profile data, Appendix D: Figure 14, show units 0 &1 as having uncharacteristically lower temperatures. The temperature plots for Weir 12 for these sites are characteristic of a spring source and the pronounced phase shift in Appendix D: Figure 20 suggests a desynchronized groundwater influence. It is rather unusual to detect these discrete upwelling points in streams because the point of emergence is usually small and the cold water emerging is quickly diffused into the main body of water. Unit 3 is also noticeably cooler and may be more representative of the prevailing stream temperature in the Weir #12 reach.

In 2011 the 7/29 data shows these units only slightly cooler - possibly a result of small differences in placement of the data loggers. However, by 9/9/11, it appears that units 50 and 55 may have become partially covered with silt or algae with data characteristic of a buried unit. (During the field audit 9/6/2011, the field notes remark that Unit 55 appears to be affected by ground water seepage rather than the main stream flow.) At this time, the difference between 51 and the rest of the units is less.
At lower flows, the hyporheic flow component is proportionally larger which could diminish the difference between these units.

In conclusion, the data for sites 2 & 6 (52 & 56) may be most representative of the prevailing temperature of this reach with the cooler units being influenced by groundwater upwelling and the warmer units being heated by the boulders. It is interesting to note that the maximum temperatures of units 3, 4, & 5 (53, 54 & 55) appear to be generally higher, particularly in 2012 and are located in close proximity of the weir boulders. More sunlight may have been heating the boulders in 2012 due to less shading at certain times of the day because of tree removal on the hillside across the road (See Appendix B: Figure 5). Water acts nearly as a blackbody to long-wave radiation (Chaplin, 2013) and other studies have indicated that massive heated objects can noticeably warm the water in the immediate vicinity (Watershed Sciences, 2003) (Smith, River Temperature Variability on the LowerUmpqua , 2009). This effect may be accounting for some of the variability in the weir data though it was less noticeable on 9/9/11.

Weir 10 – Gravel Added 2009

Site	Logger SN	Location Description
2011 sites		
Site	**Logger SN**	**Location Description**
57	2026932	WC10 - Upstream #2a - 115 ft. Upstream
58	2321280	WC10 - Upstream #1a - 26ft from MidWeir
59	2321277	WC10 - Upstream #3a - above Weir in Gravel Leading Edge - Rt Side (Facing US)
60	1297652	WC10 - Downstream #4 - Downstream near Far Right Side of Weir (Facing US)
61	1297668	WC10 - Downstream #2 - Downstream near Middle of Weir
62	2026947	WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)
63	1297662	WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster
2012 sites		
7	2026932	WC10 - Upstream #2a - 115 ft. Upstream
8	2321280	WC10 - Upstream #1a - Upstream 26ft from MidWeir
9	2321277	WC10 - Upstream #3b - 3 ft. Upstream from Weir - MidWeir
10	1297652	WC10 - Downstream #4a - Downstream near Far Right Side of Weir (Facing US)
11	1297668	WC10 - Downstream #2 - Downstream near Middle of Weir
12	2026947	WC10 - Downstream #1a - In Weir Left Side (Facing US)
13	1297662	WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster

Note: Location of the highlighted sites changed slightly. There were several large storm events over the winter 2011-2012 which rearranged some boulders and deposited additional bedload. See Appendix A: Figure 3 for winter flows in Little Wolf Creek. Site 9 was relocated one boulder over from Site 59 because of fill conditions changing from 2012. Substrate was deposited between 2011 and 2012 at #60, so the logger had to be moved 1 foot to stay in good flow (#10). Site 62 was moved a few feet from the previous year to keep it in good flow (#12).

With the exception of Unit 12, the Weir #10 temperature data appears to be uniform within the accuracy limits of the data loggers and there is no noticeable effect associated with the weir. Upon retrieval, Unit 12 was found to be buried approximately 1" in sand which may explain the muted temperature plot. It is of interest to note on the profile chart, Appendix D: Figure 14, that units 10 & 11 appear to be slightly warmer. They are located very near the weir boulders which may have served as a source for long-wave radiant heating.

Weir 9 – No Gravel Added

2011 sites

Site	Logger SN	Location Description
64	1297655	WC9 - Upstream #1a - 107 ft. Upstream
65	2321272	WC9 - Upstream #2a - 50 ft. Upstream to Left (Facing US) of US#2, Mid-Weir
66	2026946	WC9 - Upstream #4 - 50 ft. Upstream to Left (Facing US) of US #2 - Buried 2" in Sand
67	1297670	WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
68	2026956	WC9 - Downstream #3 - in Right Side of Weir (Facing US)
69	2026937	WC9 - Downstream #1a - in Left Side of Weir (Facing US)
70	2321278	WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream

2012 sites

Site	Logger SN	Location Description
14	1297655	WC9 - Upstream #1a - 107 ft. Upstream
15	1297670	WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
16	2321272	WC9 - Upstream #2a - Mid Weir Just Upstream
17	2026956	WC9 - Downstream #3a - in Right Side of Weir (Facing US)
18	2026937	WC9 - Downstream #1a - in Left Side of Weir (Facing US)
19	2321278	WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream

Note: The placement pattern of Site 68 differed between 2011 and 2012. Site 68 had filled with substrate over the winter, requiring that Site 17 be moved one rock over. Site 66 was a special test site that was not repeated in 2012.

The temperature data associated with Weir #9 also appears to be quite uniform, suggesting negligible influence from the weir. Unit 18 was found close to coming out of the water when a field audit was performed on 8/28/2012. The logger was tied to a small rock so field personnel turned it over thus placing the unit face down into the substrate. This placement may account for the lower temperature on 9/7/12. It is of interest to note the data from Unit 66 to be slightly warmer that of Unit 65. Unit 66 was buried in 2” of sand in a narrow chute between two boulders where the water was rapidly moving through the chute. Unit 65 was placed just upstream in front of the right boulder. (See Photo #2 to right.) Typically buried units have a damped thermal response and lower maximum temperatures. It may have been possible that long-wave radiation from the two opposing boulders created an oven-like effect that affected Unit 66 even though it was slightly buried in the sand. Unit 65 did not have the benefit of the “oven” effect.

Photo 2: Weir 9 Upstream Logger Sites 65 & 66

Weir 8 – Gravel Added 2009

2011 sites

Site	Logger SN	Location Description
71	1297664	WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb
72	1297665	WC8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel
73	1297650	WC8 - Upstream #8a - Buried in 5" Mud Near Bank-43' US fromWeirAtLeftEdge (FaceUS)
74	2026953	WC8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)
75	2026943	WC8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)
76	1297656	WC8 - Upstream #5 - 27' Upstream on Upstream Face of Gravel
77	2026955	WC8 - Upstream #7a - Buried 12" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)
78	2026958	WC8 - Upstream #6 - Buried 14" in Gravel Just Upstream from Weir
79	2026935	WC8 - Downstream #2a - To Right of Middle of Weir - Downstream of Gravel Face
80	2296306	WC8 - Downstream #1a - in Center of Weir
81	1297667	WC8 - Downstream #3a - 53' Downstream on Right of MidStream (Facing US)
82	1297671	WC7 - Downstream of Entire Study Area

2012 sites

Site	Logger SN	Location Description
20	1297664	WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb
21	2026958	WC8 - Upstream #8b - Buried in 5" Mud Upstream from Weir Near Left Bank(FaceUS)
22	1297665	WC8 - Upstream #4a - 42' Upstream on Upstream Face of Gravel near Rt Side (FaceUS)
23	1297656	WC8 - Upstream #5a - 16' Upstream on Upstream Face of Gravel Midstream
24	2026953	WC8 - Upstream #7a - Buried 10" in Gravel - 5' UpStream, Rt of Midstream (Facing US)
25	2026955	WC8 - Upstream #6a - Buried 12" in Gravel Upstream of Main Weir near RtBank (FaceUS)
26	1297650	WC8 - Downstream #1b - near Center of Weir
27	2026935	WC8 - Downstream #2b - To Right Side of Weir (Facing US)- Downstream of Gravel Face
28	1297667	WC8 - Downstream #3b - 35 ft. Downstream MidStream (Facing US)
29	2026943	WC7 - Downstream of Entire Study Area

Note: With the exception of unit pairs 71 & 20 and 82 & 29, all of the unit locations are slightly different (highlighted) between 2011 and 2012.

With the exception of the buried units, the temperature pattern appears to be uniform, albeit slightly lower than that of the other weirs. This may be a characteristic of this particular stream reach which has a slightly different aspect and has better shading.
With regard to the buried units; units 73 and 21 were buried in mud and show a more damped response than the units buried in gravel as expected due to reduced thermal conductivity.

Units 77 & 78 were buried 12 and 14 inches respectively on the upstream side of the weir and had higher temperatures than units 74 & 75 that were buried in 5 inches of gravel 42 feet upstream from the weir. These results suggest that surface water is passing through the fresh gravel behind the weir but the effect of this cooler water is not readily apparent in the downstream data. This observation is consistent with the notion that cool zone anomalies do occur in streams but, due to rapid dispersion, their zone of influence is very small and difficult to locate and measure. However, fish can find these areas and use them as thermal refugia.
The results for the 2012 buried units were consistent with the 2011 data.

Conclusions:
This study indicates that, while the weirs installed in Wolf Creek did not have an apparent effect on the bulk temperature of the stream, it is likely that the increase in gravel placement and accumulation producing an associated increase in the hyporheic component is providing discrete thermal refugia areas that would benefit temperature sensitive aquatic species. Gravel laden stream reaches may lose "surface flow" sooner during receding flow conditions however; water temperature in associated pools may become lower as the percent of surface water contribution diminishes and the hyporheic component becomes more dominant. The weirs have the added benefit of adding important diversity to the aquatic system. For example, research has shown that the interstitial micro-habitat within the gravels with hyporheic flow is very complex (Boulton, 1998).

Suggestions for further study:

1. While it is difficult to measure the effect of the hyporheic flow component on the bulk stream temperature, the data from the buried data loggers indicate that conditions within the gravel are cooler. It would be helpful to better understand the temperature distribution pattern and flow rate within the gravel component and compare it with open water conditions. For example, on a reach with no surface flow, measure stream temperature at the upstream end where surface water is entering the gravel and again the downstream end where water is emerging from the gravel. There should be a temperature gradient along the length of the gravel bar that could be detected by buried units. While the temperature gradient at the exiting gravel-water interface would be very steep, it may be possible to identify micro-refugia conditions at the interface. Dye studies or an intercepting trench across the bar could provide hyprorheic flow-rate information.
2. The temperature data from units 0 and 1 (2012 data for Weir #12) indicated the possibility of influence from a submerged groundwater source. As indicated in the discussion, these points are rare and difficult to find but of very high value to cold-water species during the hot summer periods (think oasis in a hot desert). It would be of interest to verify the presence of these sources and attempt to map the temperature gradient around them. There might also be an opportunity to monitor usage by aquatic life with an underwater "trail" camera.
3. The narrative discussion suggested that some of the data loggers experienced elevated radiant long-wave heating from adjacent rock boulders. The effect of long-wave (IR) on water isn't always appreciated since water is transparent to short-wave (light) radiation. It may be of interest to attempt to measure the temperature gradients around large massive objects such as rock islands and bridges. The intensity of the radiation varies from a point source as the inverse square but varies directly with distance from an "infinite" sheet such as the sky or tree canopy. Also, the influence of long-wave heating from warm air could be studied by comparing night-time heat loss with prevailing night-time air temperature.

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Thanks to Dave Williams, OWRD Water Master for Douglas County and his field crews for gathering flow data on Wolf Creek during the period of our study.
Thank you to Roseburg Resources Co. for permitting the boulder weirs and this study to occurr on their property.
Thanks to Denise Dammann for help and advice on placement of temperature data loggers and for data preparation of the cross-section, pebble counts and temperature results.
Special thanks to Kent Smith, Insight Consulting, for sharing his insights and years of knowledge gained studying the anomolies of river water temperature and the relationship to its surroundings. His help is greatly appreciated in charting and analyzing our data with a keen eye and mind to figure out what is going on in the field where so many variables are affecting what those little temperature loggers record. Thank you Kent for teaching us all the power of “the squiggle”. So much information is lost if only summary data is reported. We have Kent to thank for making sure that the temperature data presented on the Umpqua Explorer (www.umpquaexplorer.info) has all of the raw data available for perople to work with.

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Appendix A: Flow Charts

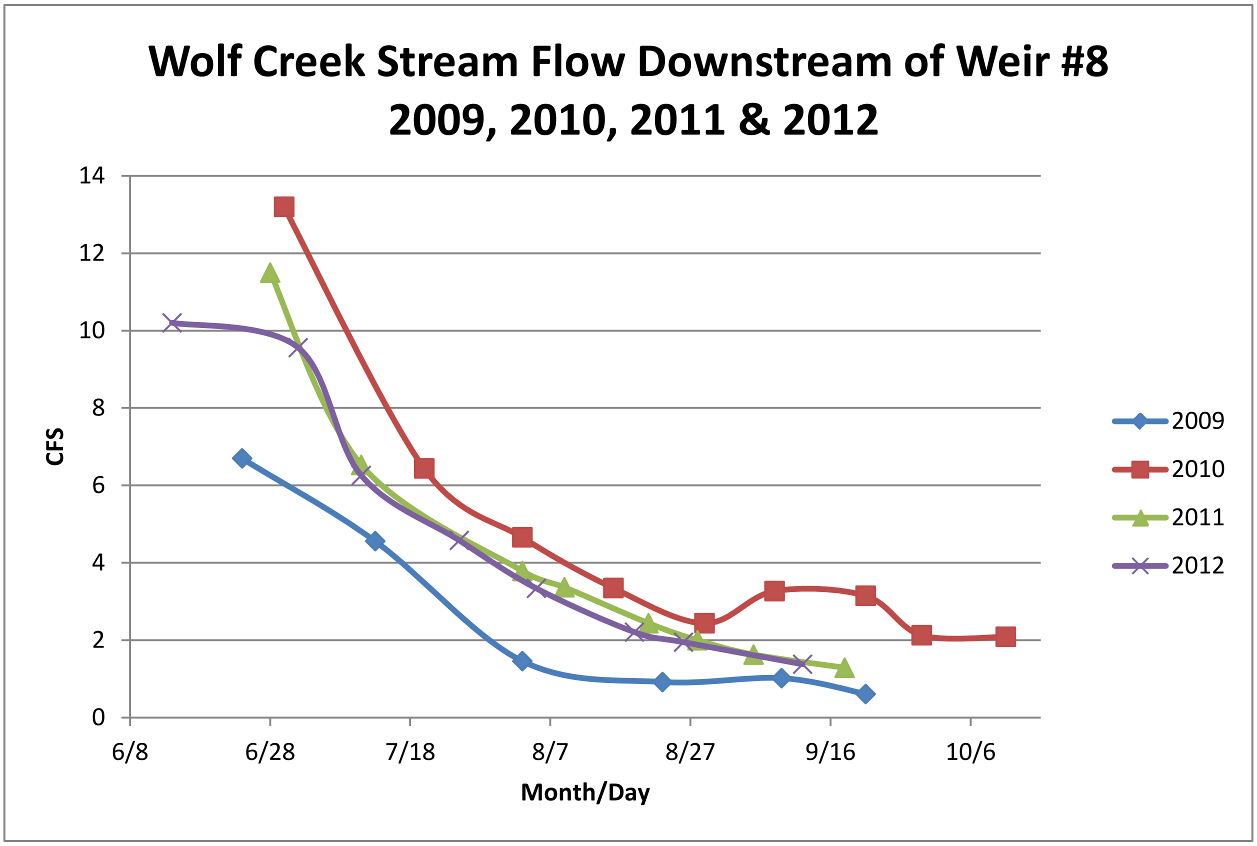


Figure 2: Wolf Creek Stream Flow Data Courtesy of Dave Williams, OWRD Water Master Douglas County, Oregon

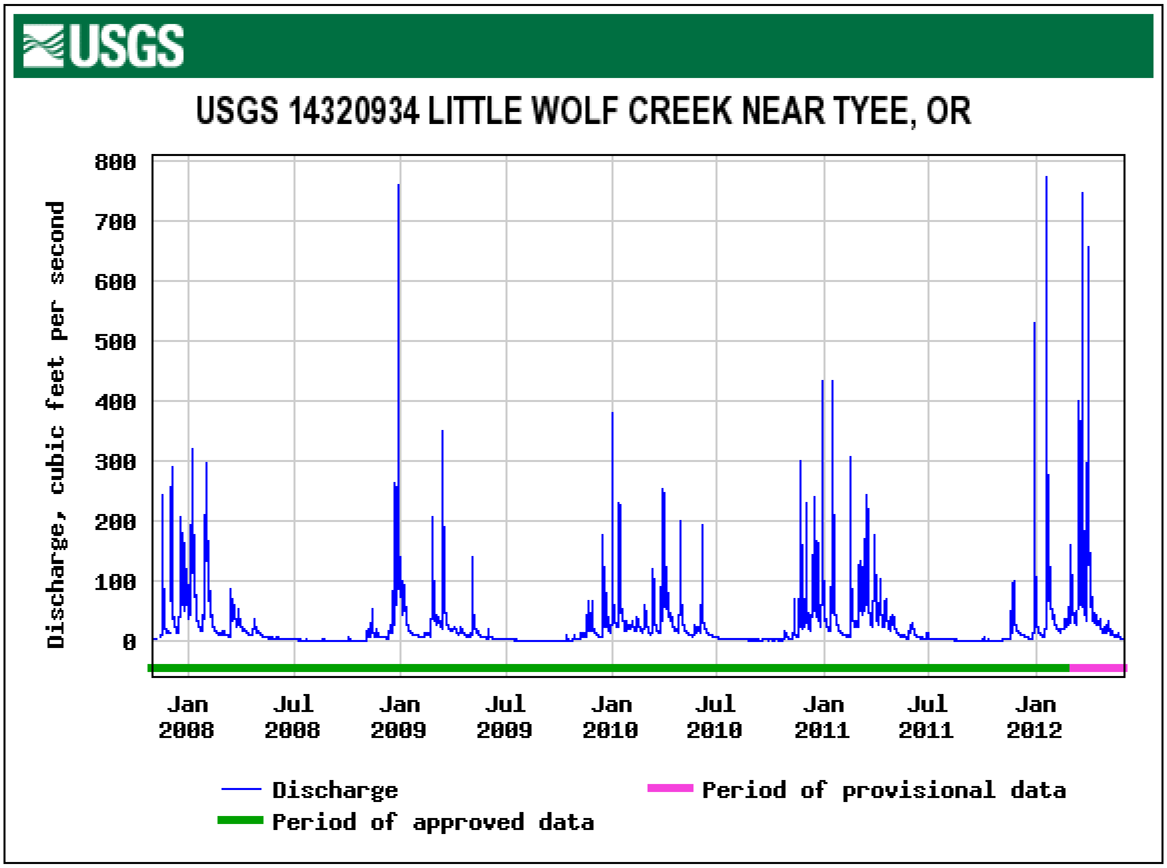


Figure 3: USGS stream flow from 2008-2009. This stream gage is within a mile of the Wolf Creek weir sites but it is on a tributary to Wolf Creek called Little Wolf. It is included here to demonstrate relative rain amounts since we had no winter data for Wolf Creek which was collected manually.

Appendix A: Flow Charts

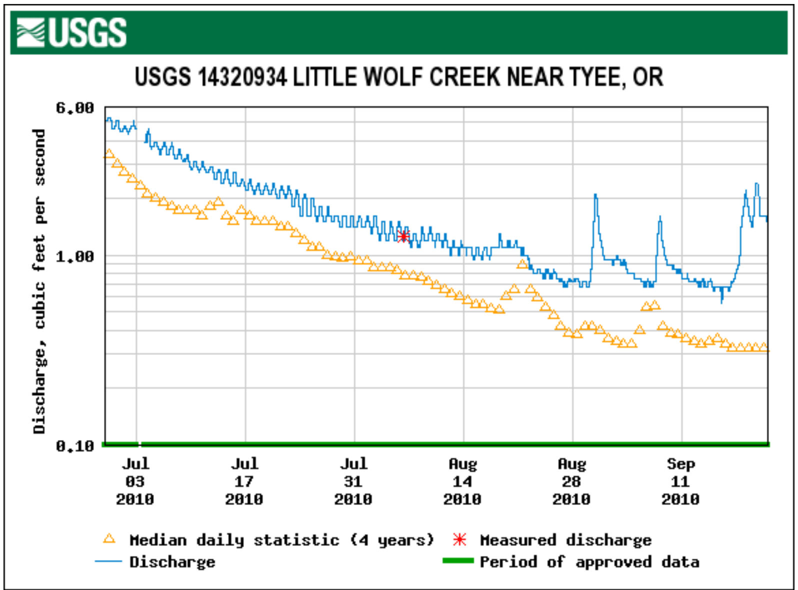
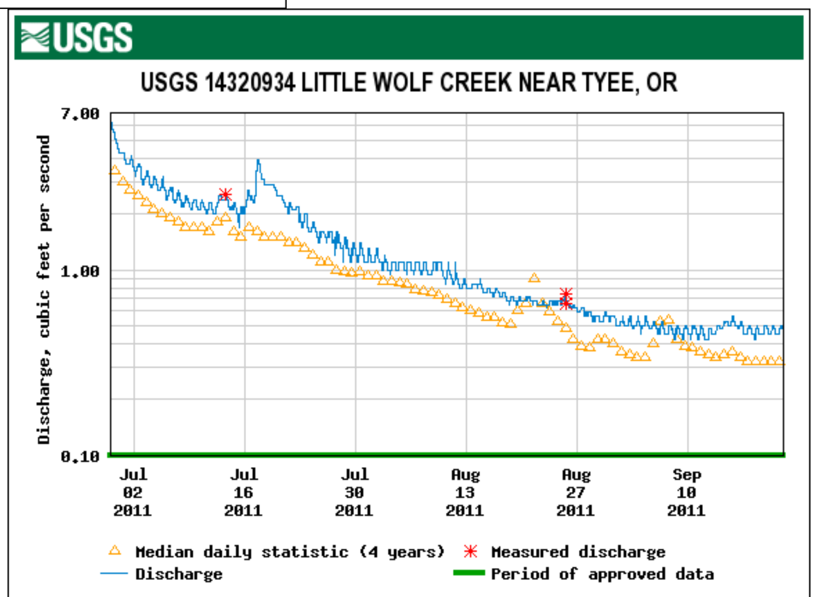
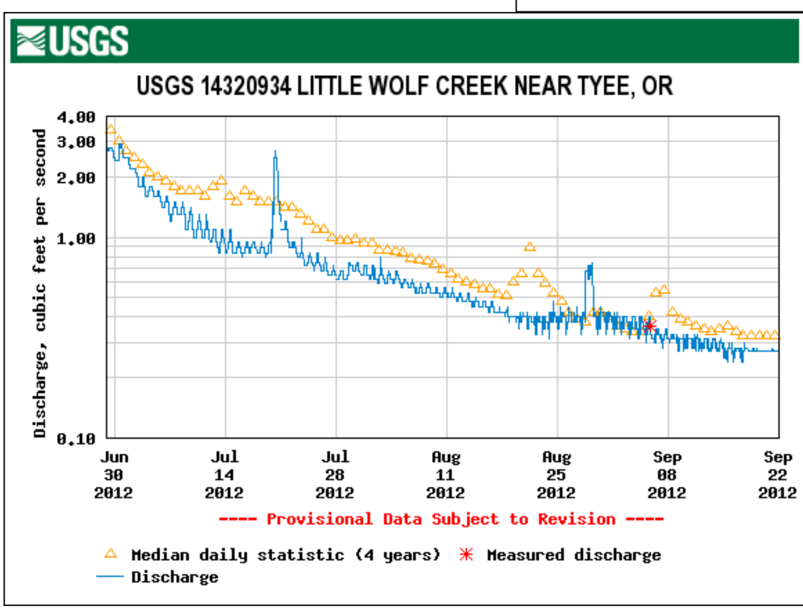


Figure 4: Expanded flow data from Little Wolf Creek stream gage 2010, 2011 and 2012 providing detail of rain events that may not show on the Wolf Creek data (Figure 2) because of the lower frequency of collection.

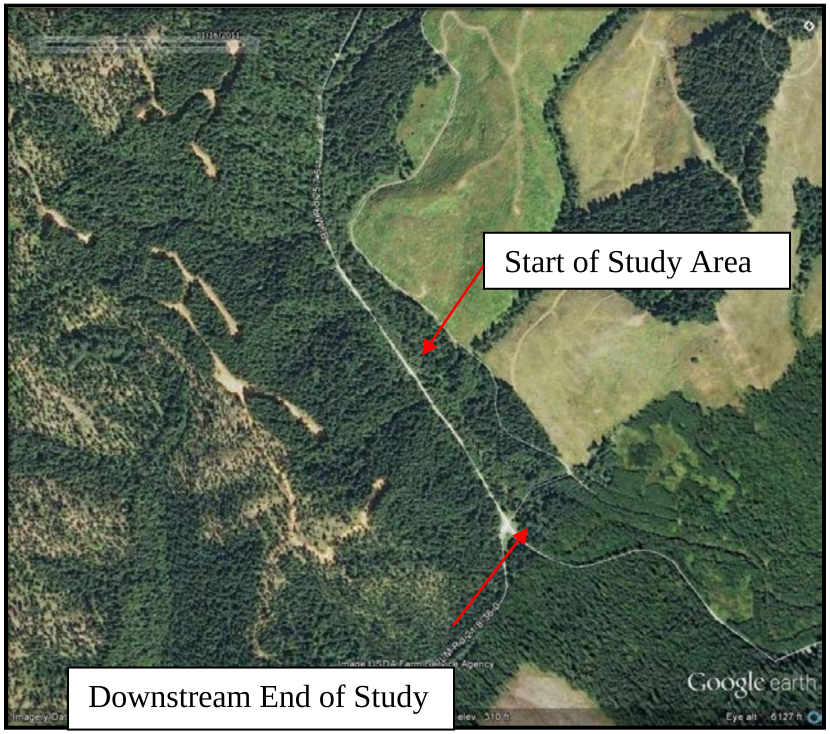




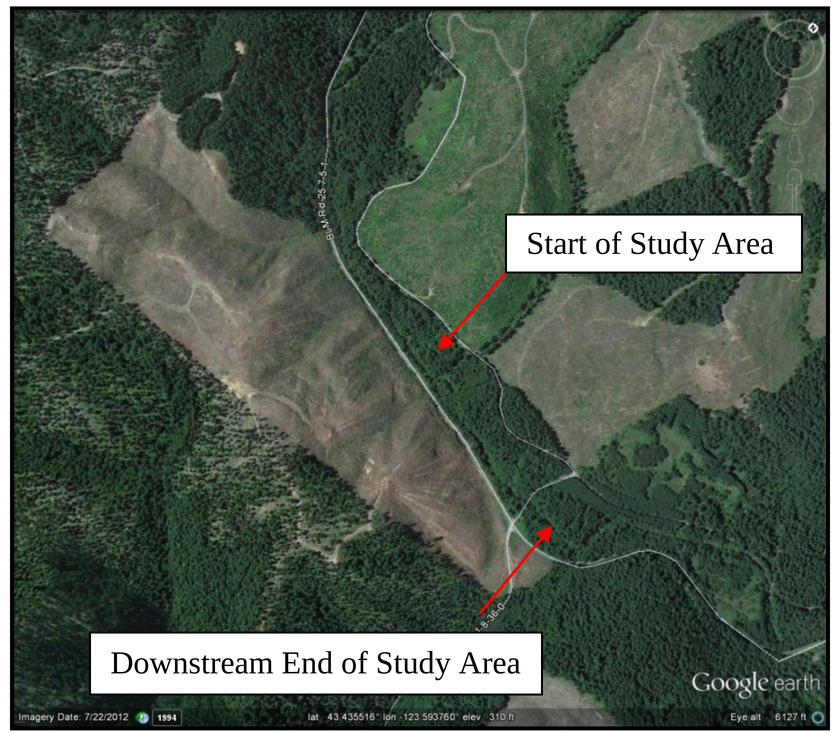
Appendix B: Google Earth Images

Figure 5: Google Earth images taken in 2011 & 2012

A timber harvest occurred during the fall of 2011 clearing the slope across the road from the study area. As there was only a thin row of alders between the creek and the road adjoining the harvest area more sunlight may have reached weirs 12, 10 & 9 in 2002. At Weir 8, Wolf Creek is further from the road and has more riparian trees so it may have been less affected.

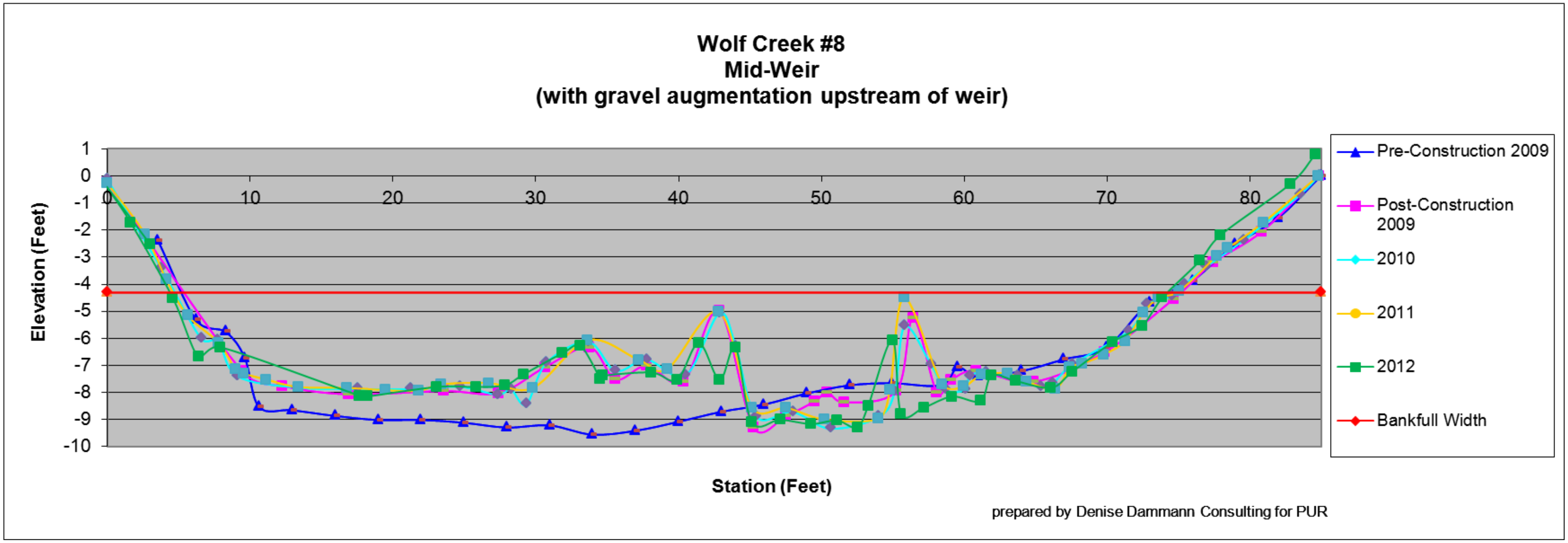


Google Earth view of area surrounding weir study 8/1/2011



Google Earth view of area surrounding weir study 7/22/2012

Figure 6: 2009-2012 Wolf Creek Weir #8 Mid-Weir. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.



Pre-Const. 2009 d50 = Bedrock
Post-Const. 2009 d50 = 16-32 mm.
2010 d50 = 16-32 mm.
2011 & 2012 d50 = 32-64 mm.

Notes: 2009 construction includes weir construction and gravel placement. The dip in the boulders in 2012 at approximately Station 43 accurately depicts that a boulder rolled off the top of the weir.

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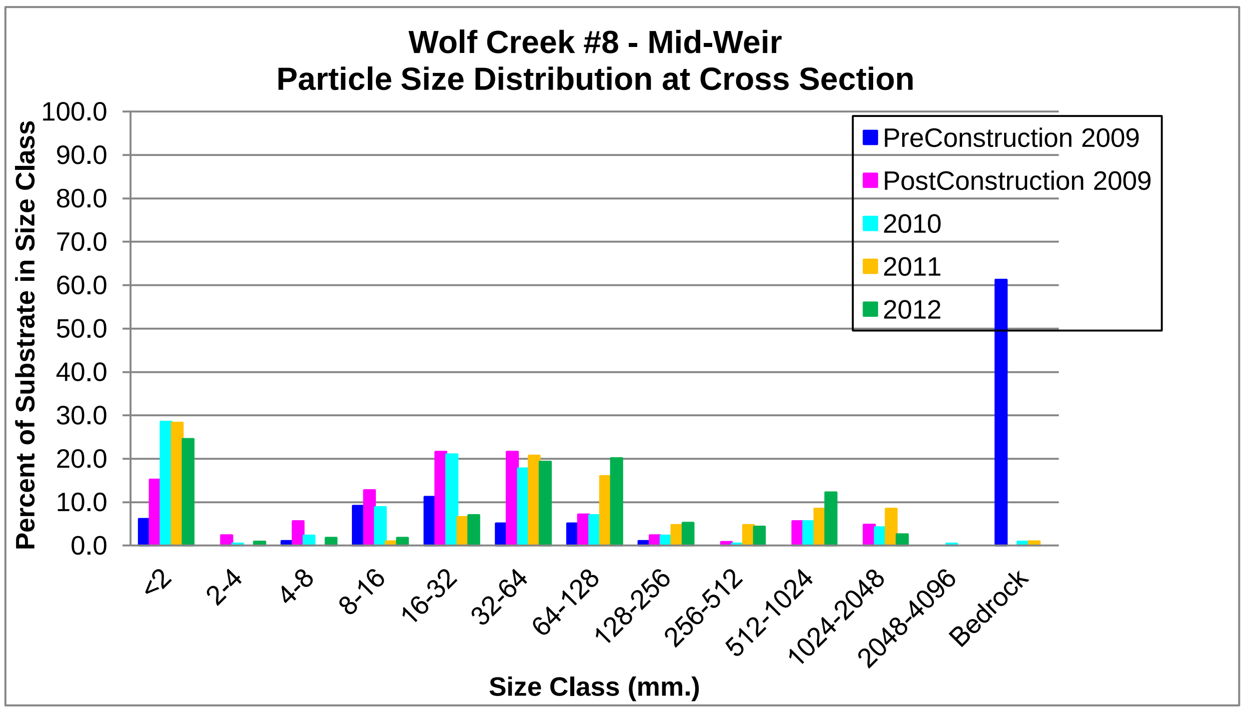
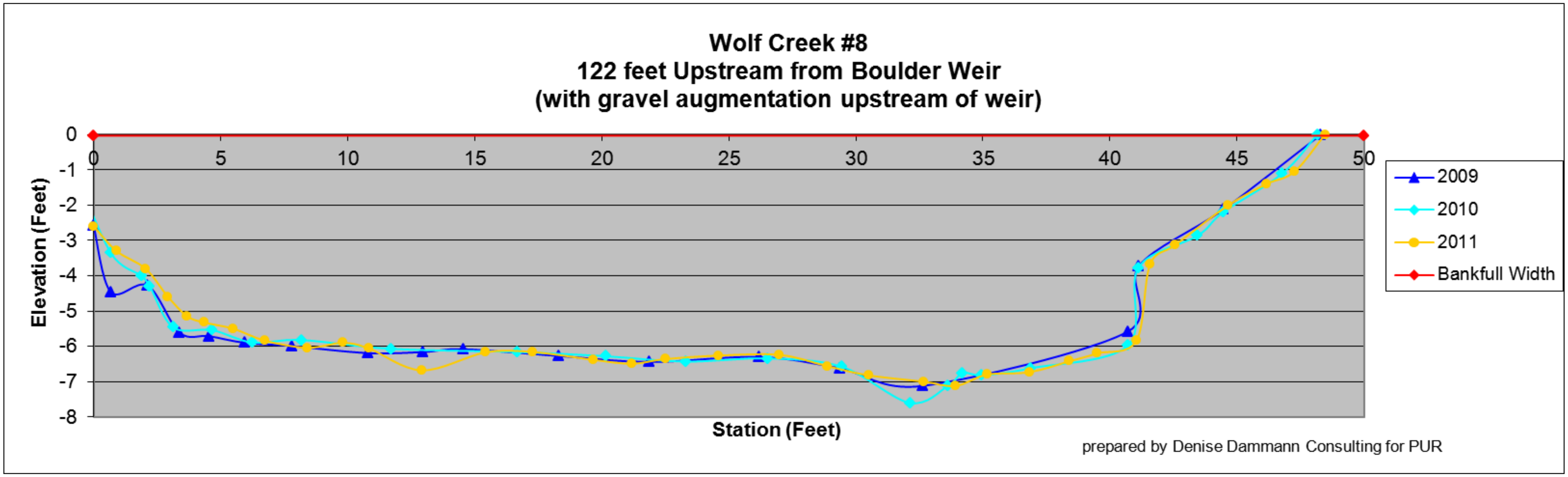


Figure 7: 2009-2012 Wolf Creek Weir #8 upstream 122 feet. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.



2009 & 2010 d50 = 128-256 mm.

2011 d50 = 32-64 mm.

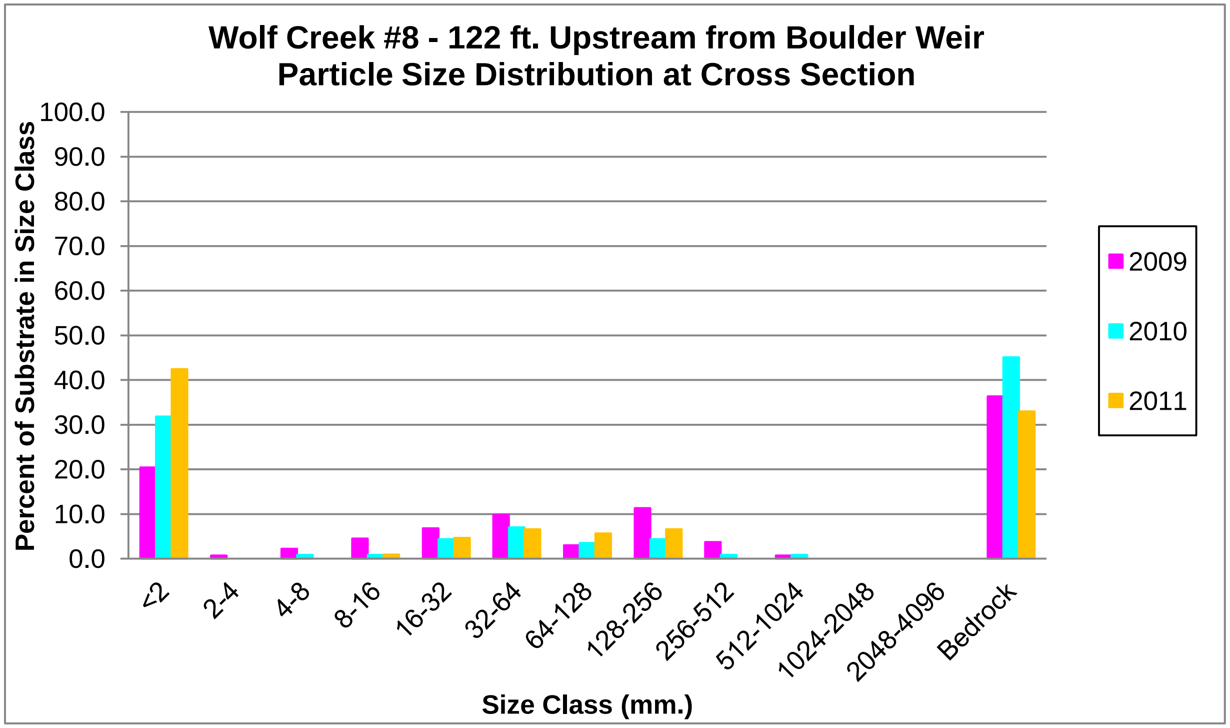
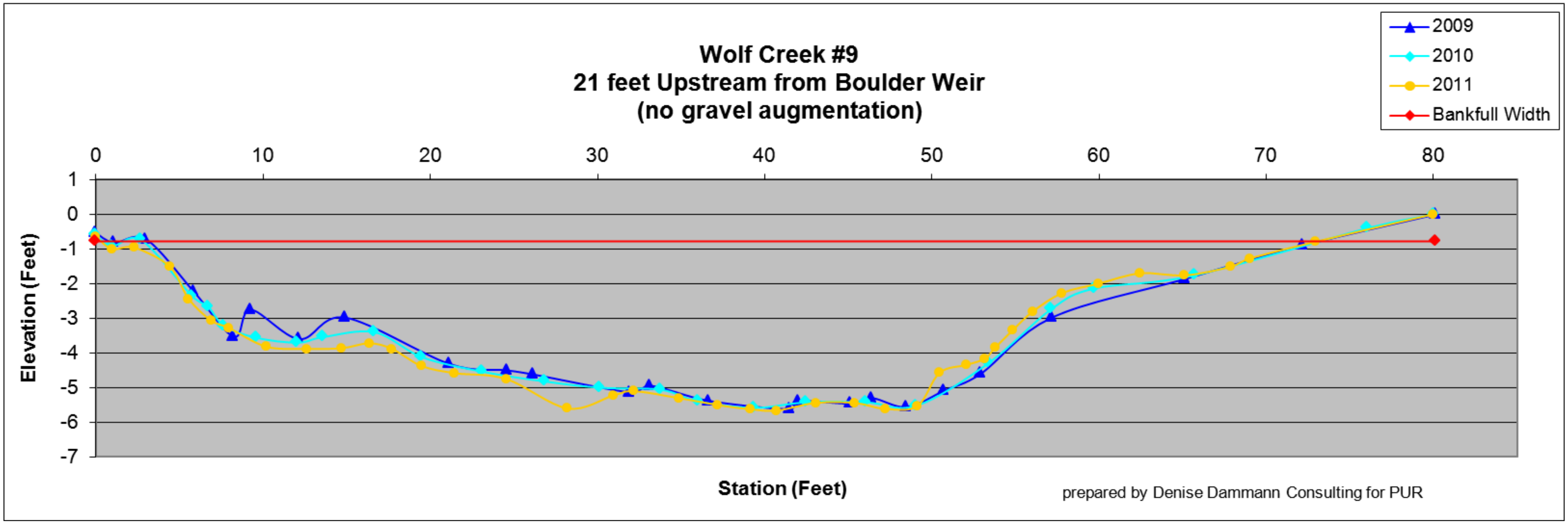


Figure 8: 2009-2012 Wolf Creek Weir #9 upstream 21 feet. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.



2009 d50 = 32-64 mm.
2010 & 2011 d50 = <2 mm.

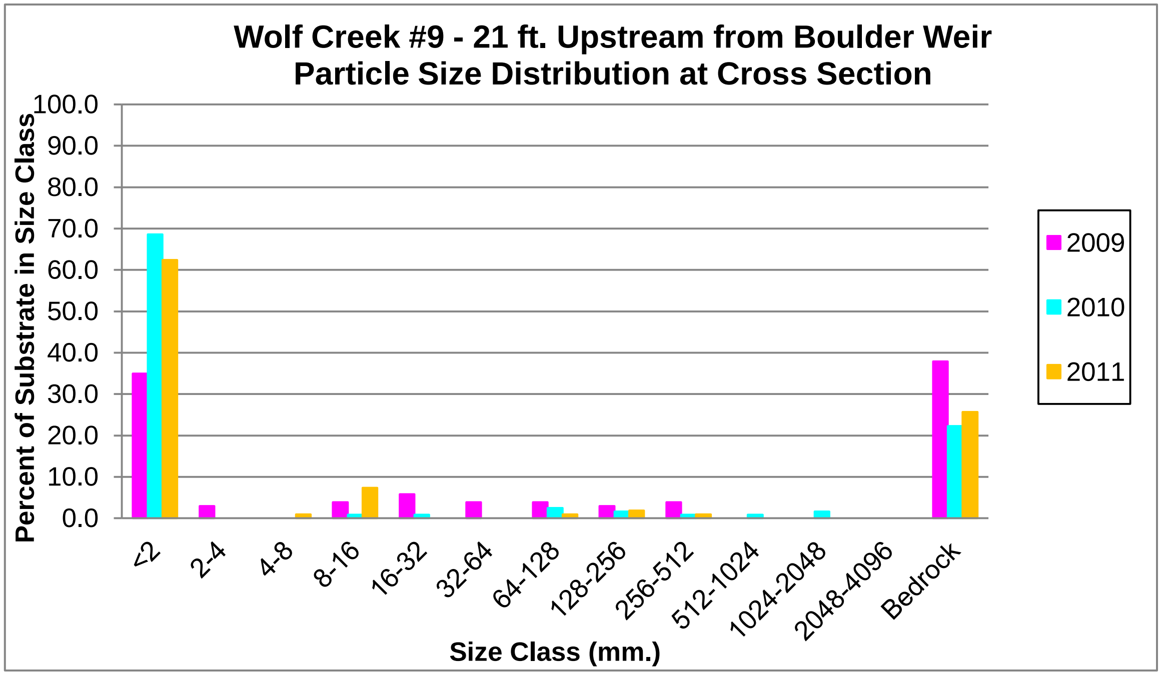
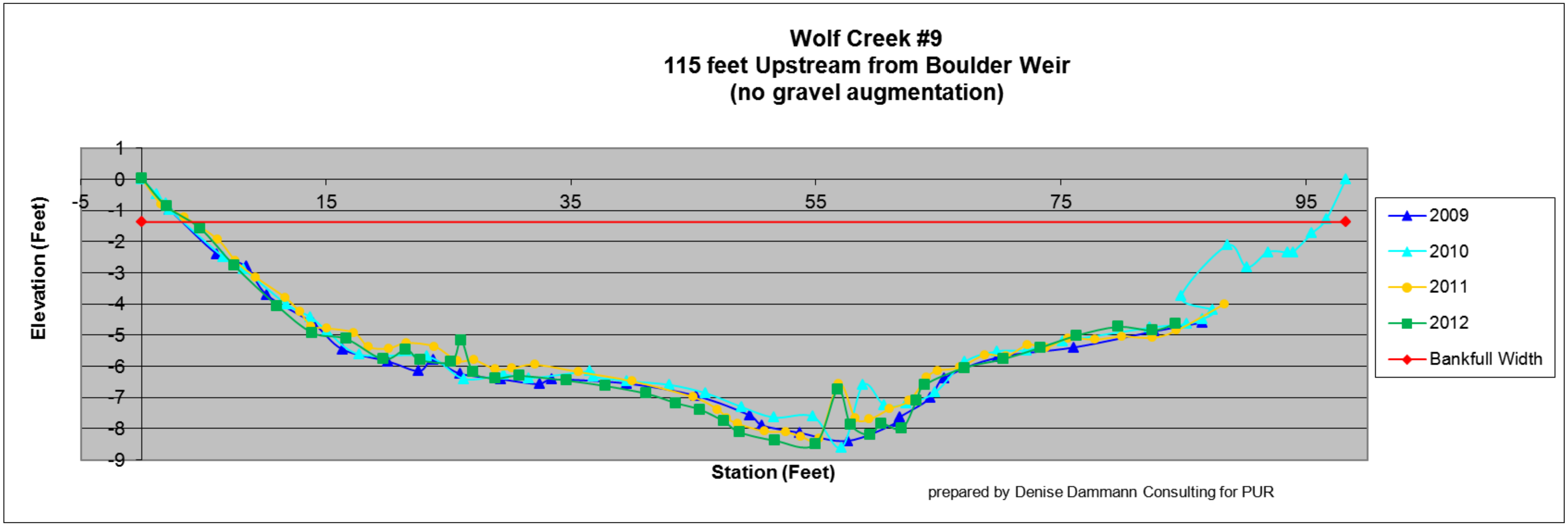


Figure 9: 2009-2012 Wolf Creek Weir #9 upstream 115 feet. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.



2009 d50 = 128-256 mm.
2010 & 2011 d50 = <2 mm.
2012 d50 = 32-64 mm.

Note: A tree and root are in the cross section's right (facing downstream).

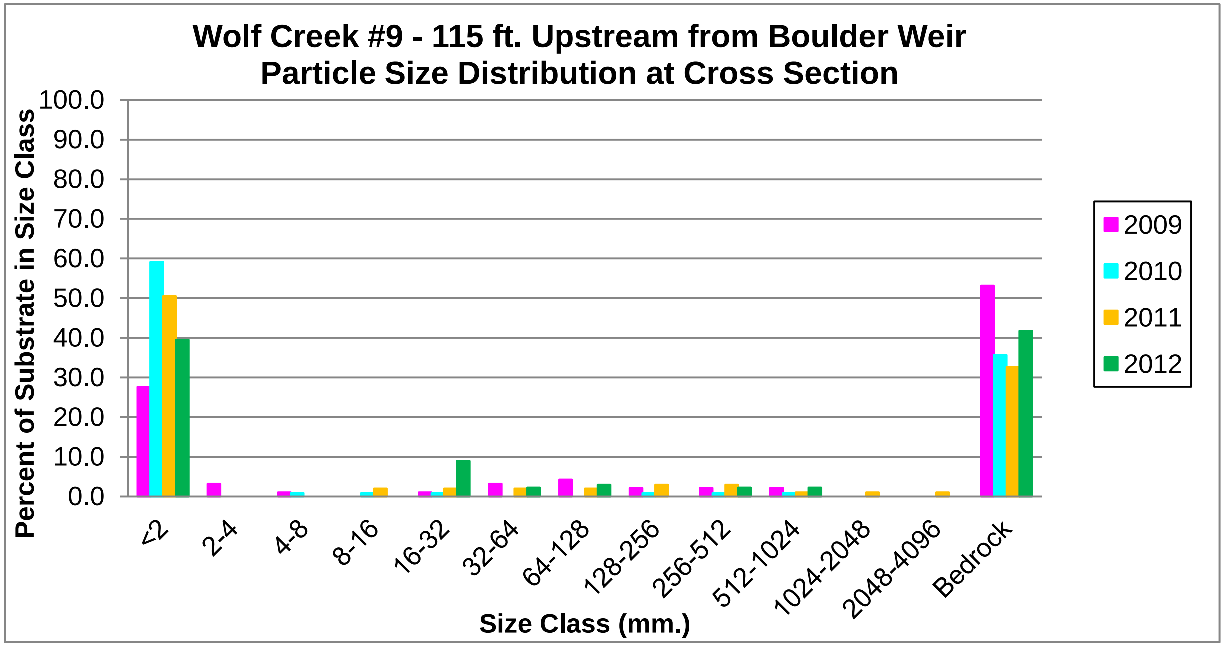
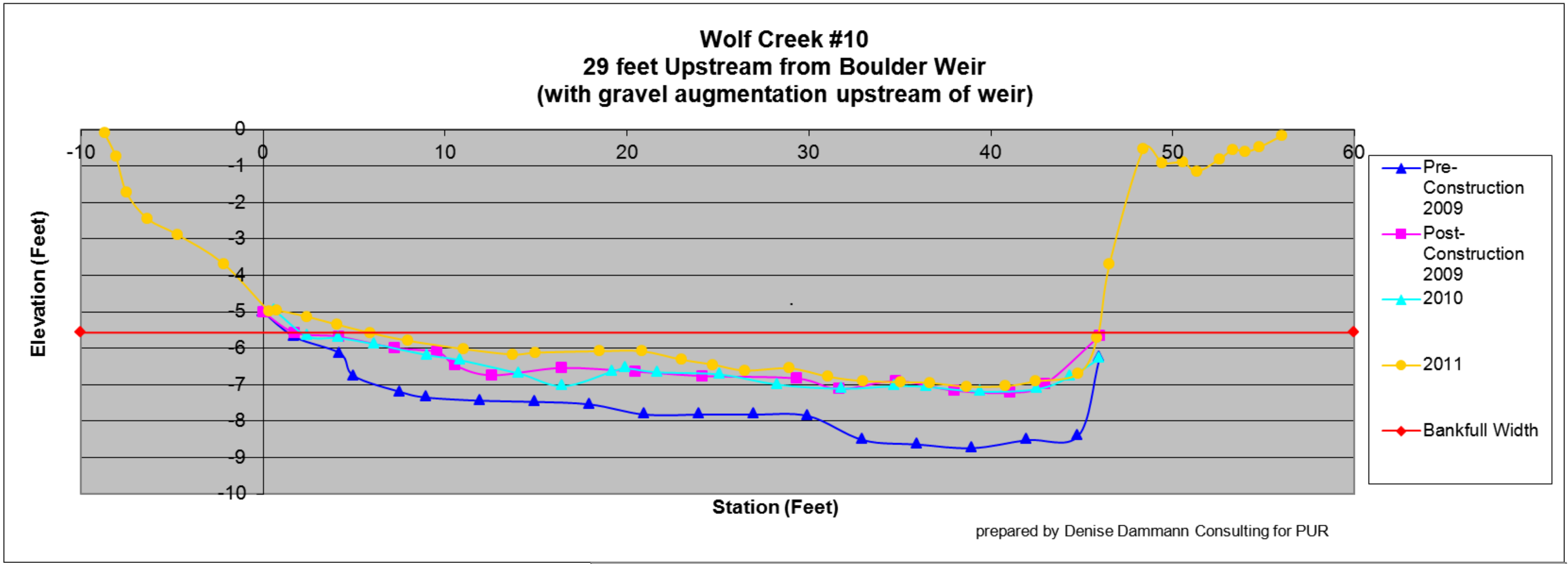
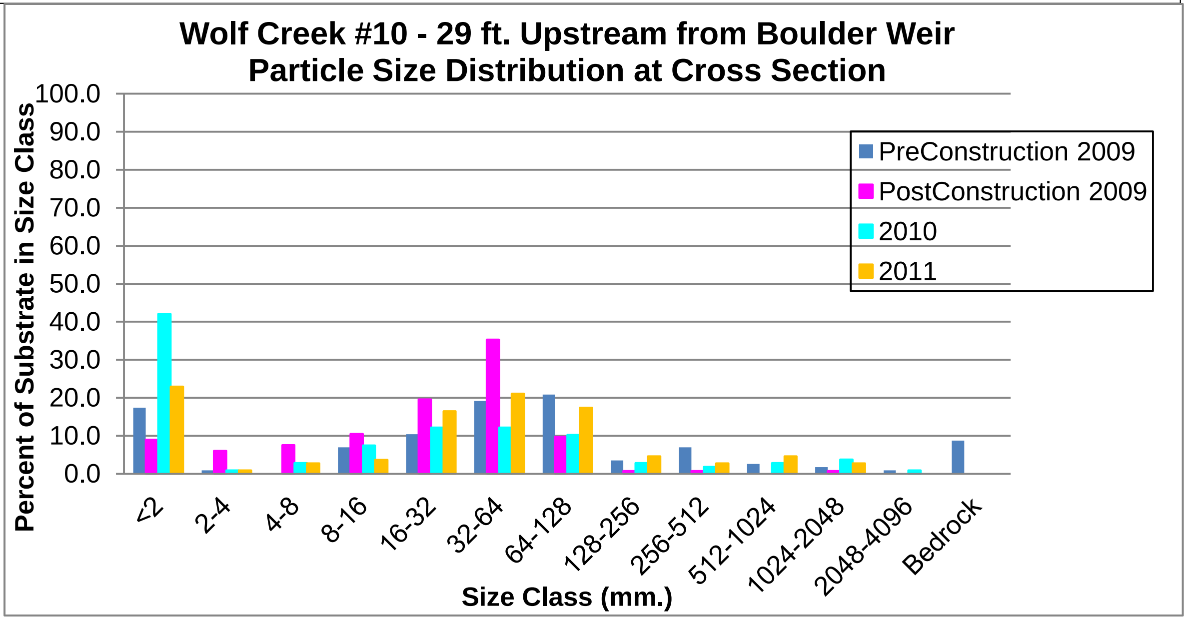


Figure 10: 2009-2012 Wolf Creek Weir #10 upstream 29 feet. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.

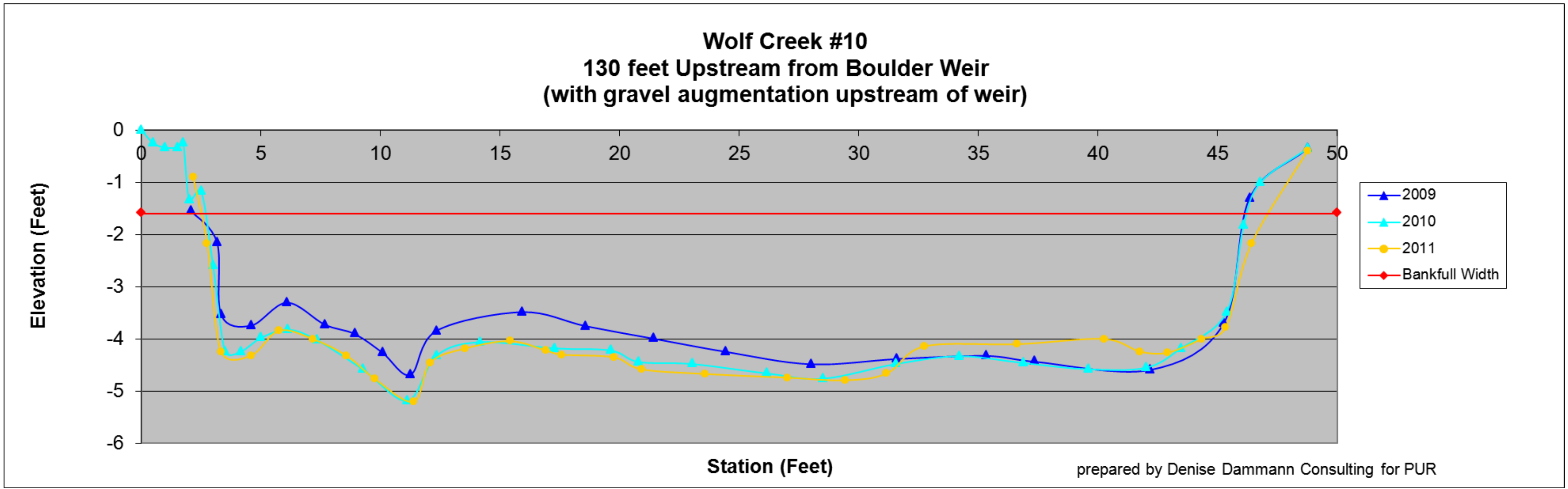




Pre-Const. 2009 d50 = 32-64 mm.
Post-Const. 2009 d50 = 16-32 mm.
2010 d50 = 8-16 mm.
2011 d50 = 32-64 mm.

Note: 2009 construction includes weir construction and gravel placement.

Figure 11: 2009-2012 Wolf Creek Weir #10 upstream 130 feet. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.



2009 d50 = Bedrock
2010 & 2011 d50 = <2 mm.

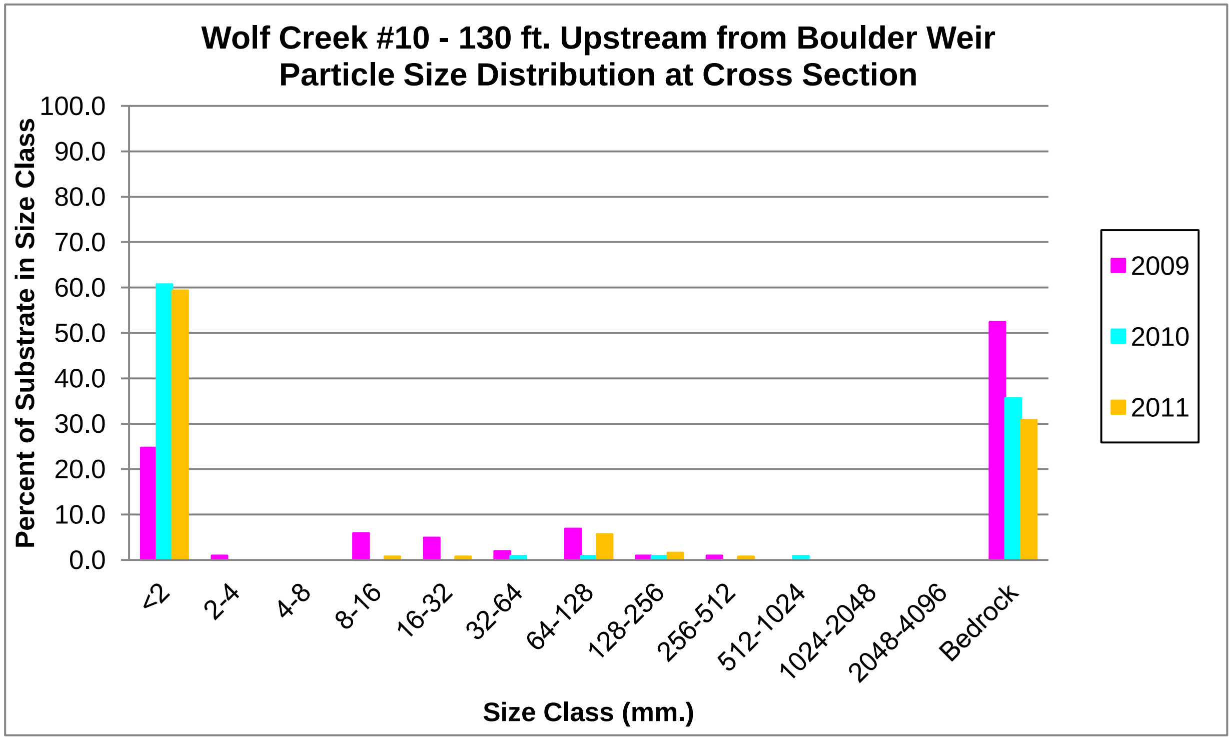
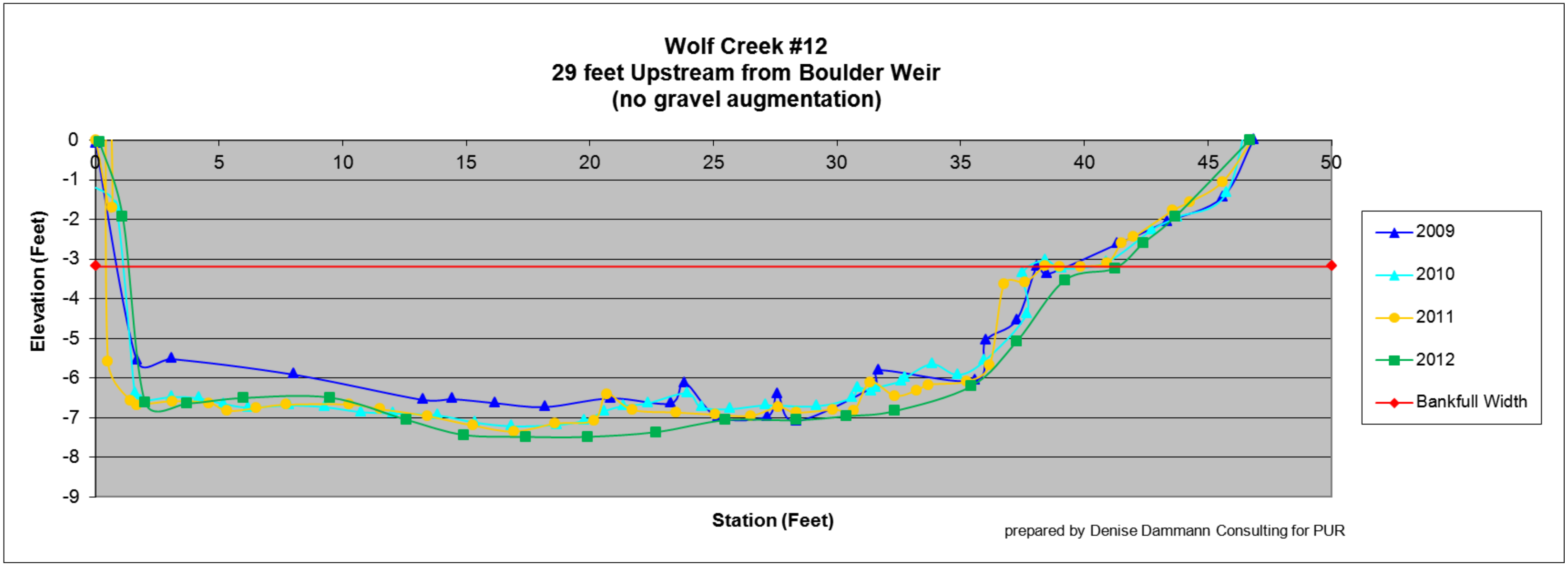
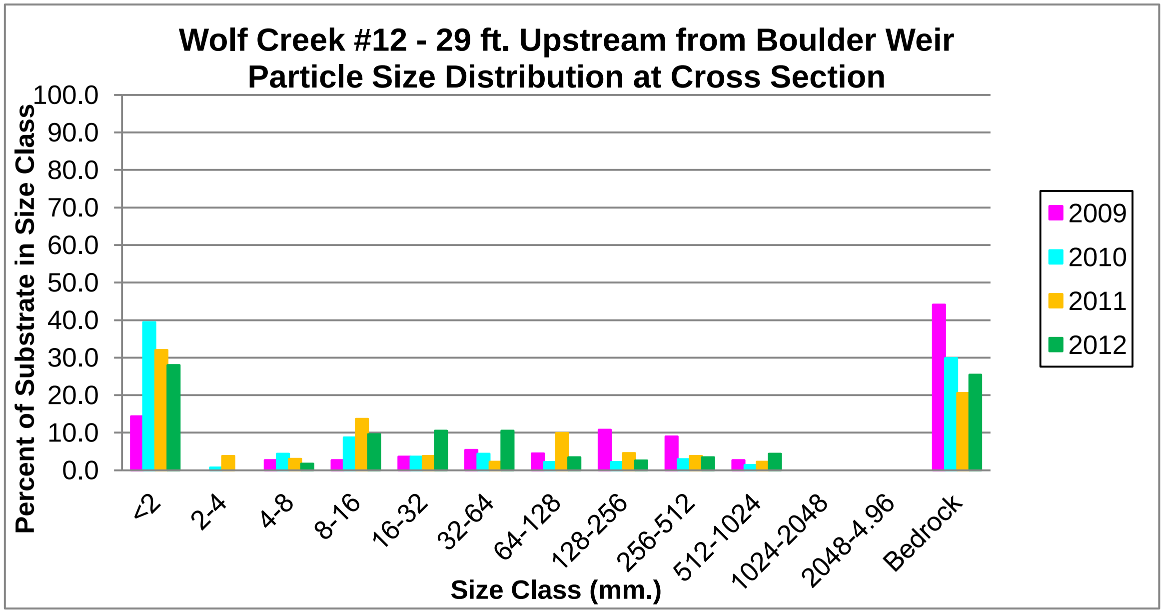


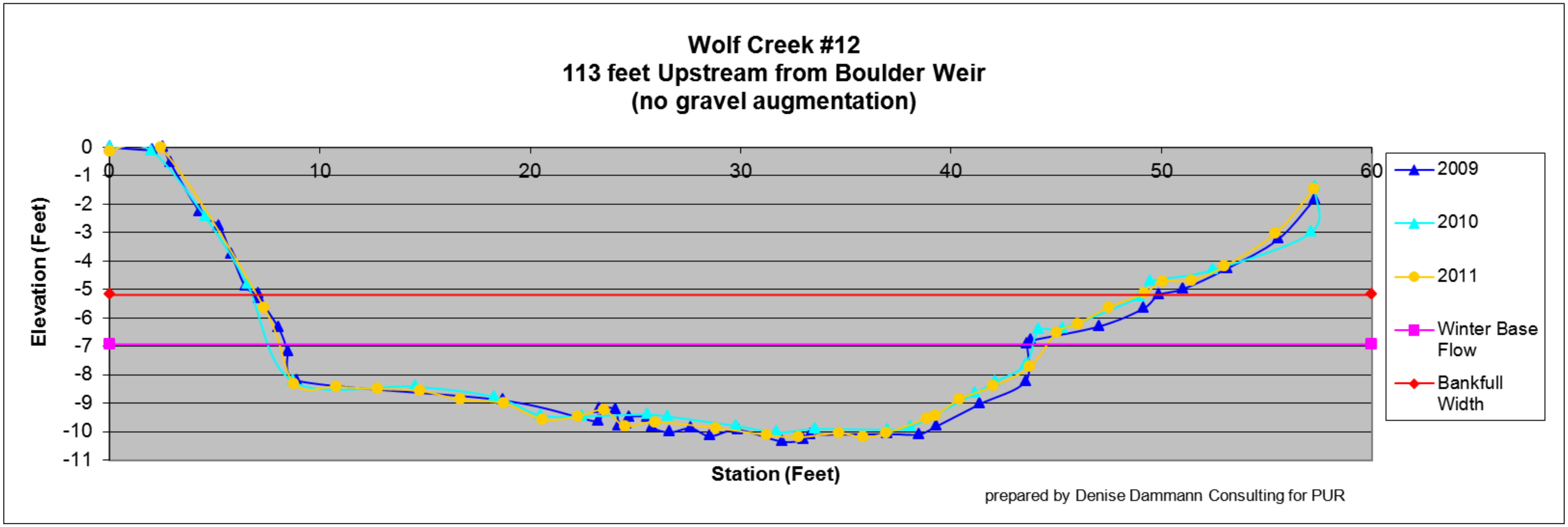
Figure 12: 2009-2012 Wolf Creek Weir #12 upstream 29 feet. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.

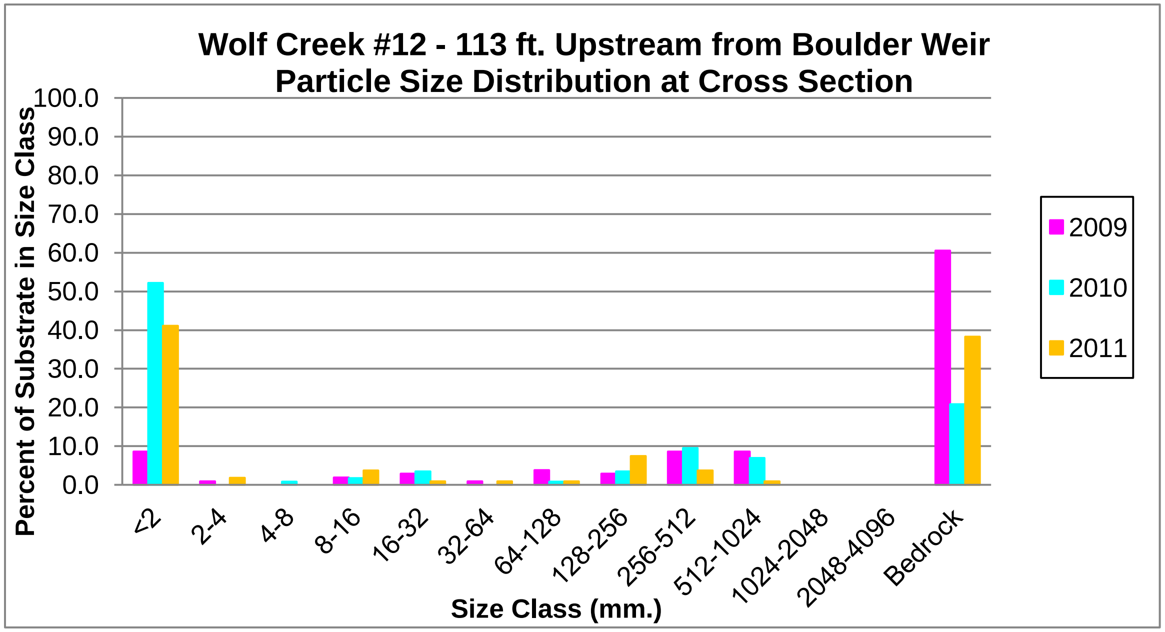




2009 d50 = 256-512 mm.
2010 & 2011 d50 = 8-16 mm.
2012 d50 = 32-64 mm.

Figure 13: 2009-2012 Wolf Creek Weir #12 upstream 113 feet. Cross-sections and Wolman pebble count particle size distributions using the Wentworth scale. The zero station is on the left side of the creek facing downstream for all cross sections. All of the distances upstream from weirs in the cross section titles are measured mid-channel.

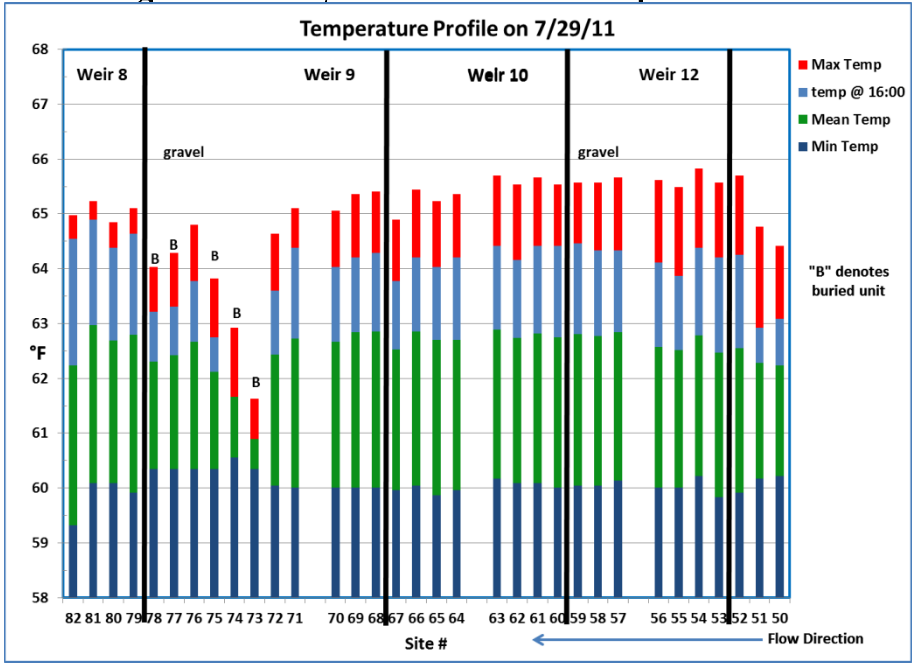


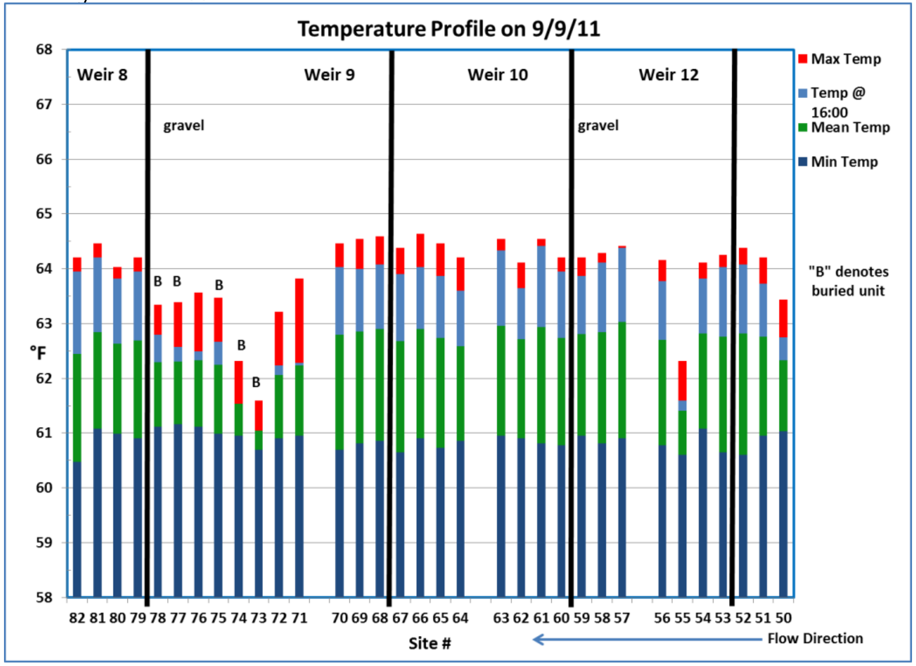


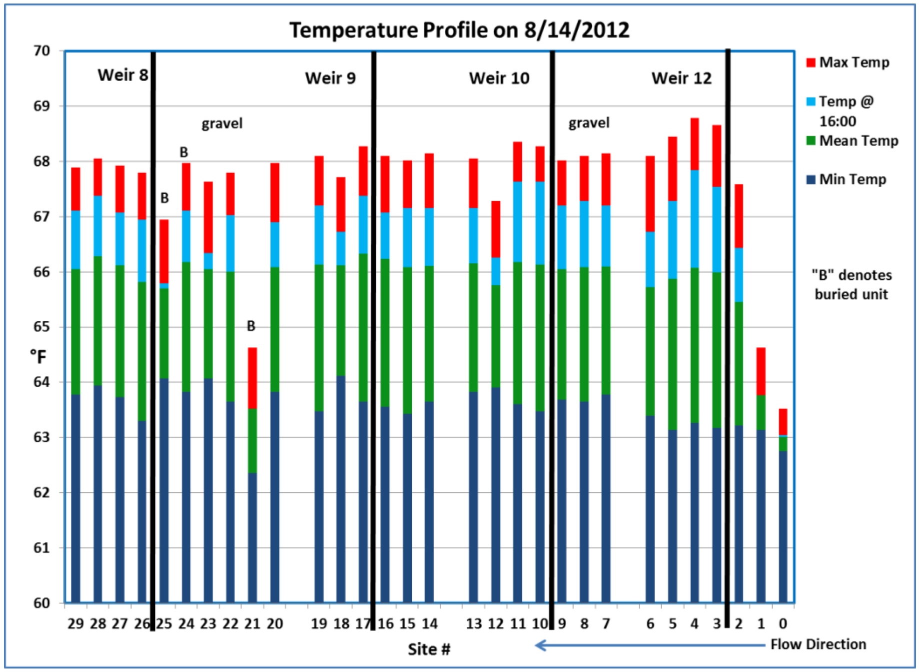
2009 d50 = Bedrock
2010 d50 = <2 mm.
2011 d50 = 128-256m

Appendix D: Temperature Interpretation Charts

Figure 14: Early and Late Season Temperature Profiles during Steady-State Weather Conditions 2011 & 2012







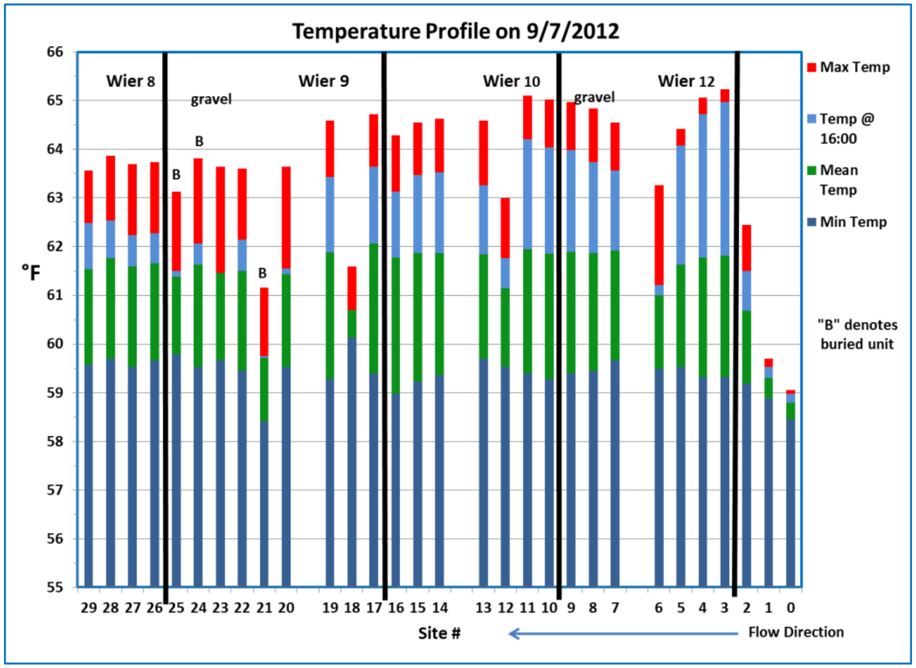
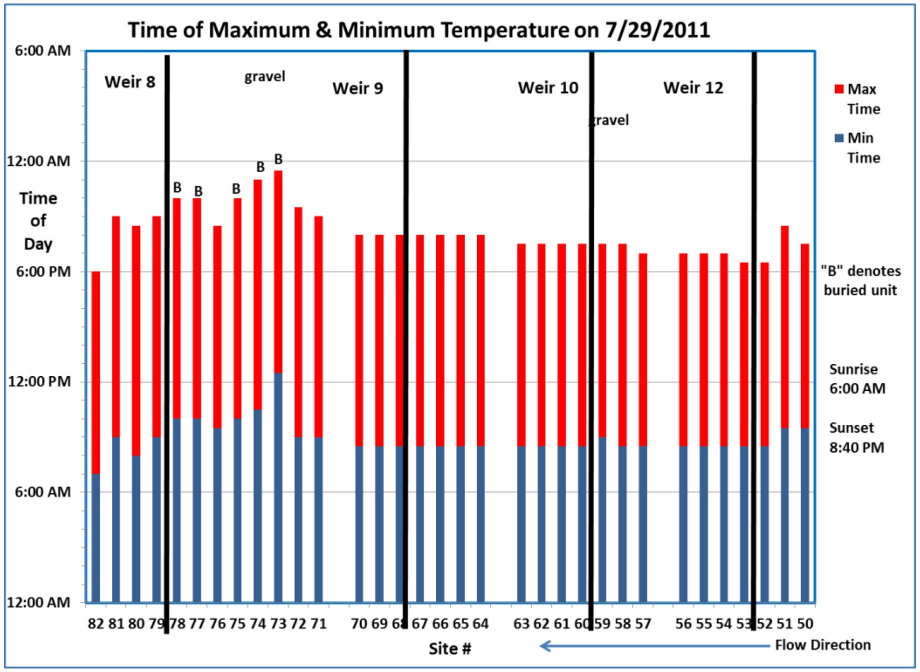
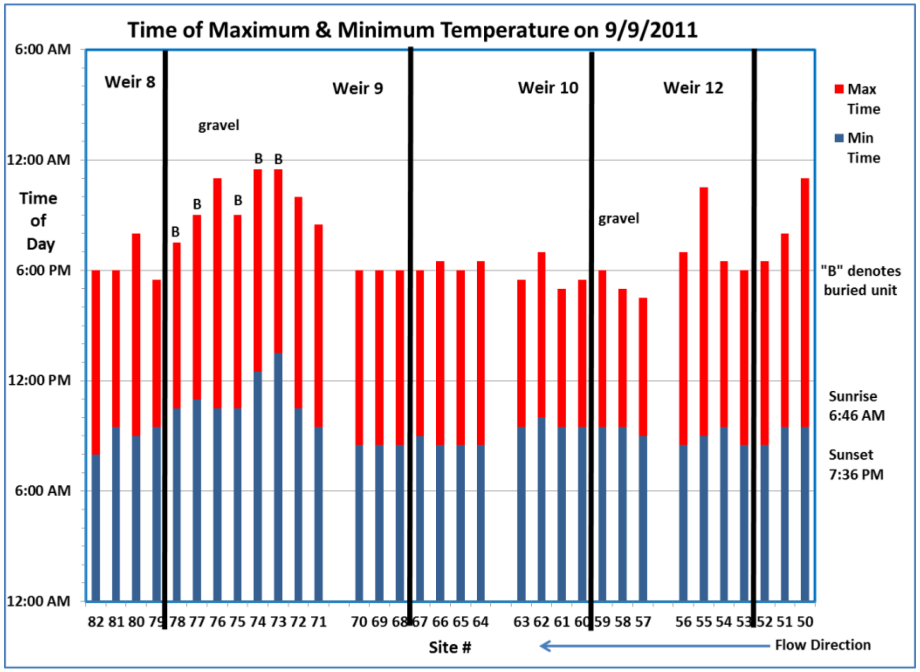
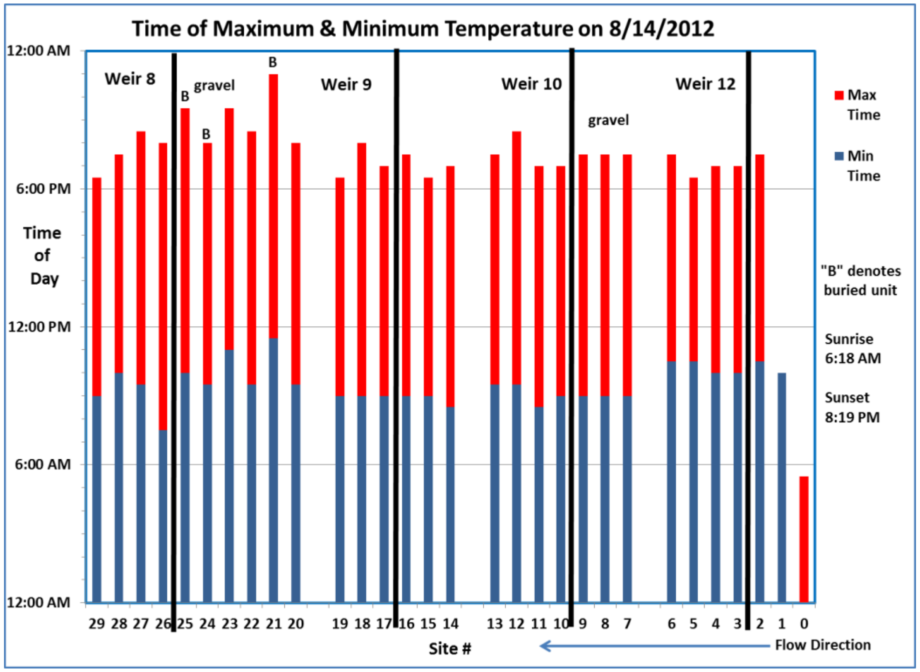
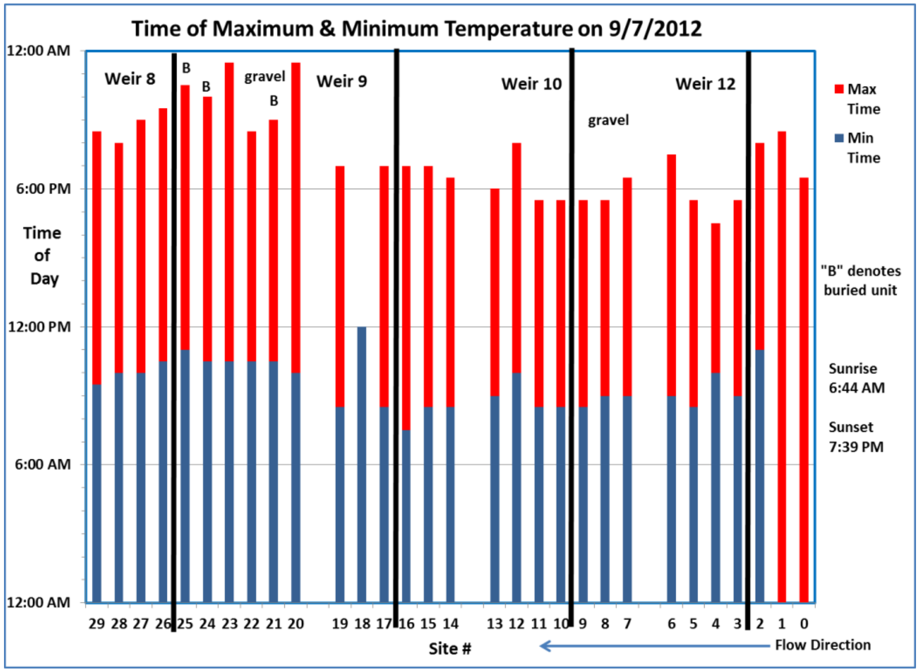


Figure 15: Time of Maximum & Minimum Temperature, Early & Late Season, during Steady State Summer Weather Conditions 2011 & 2012



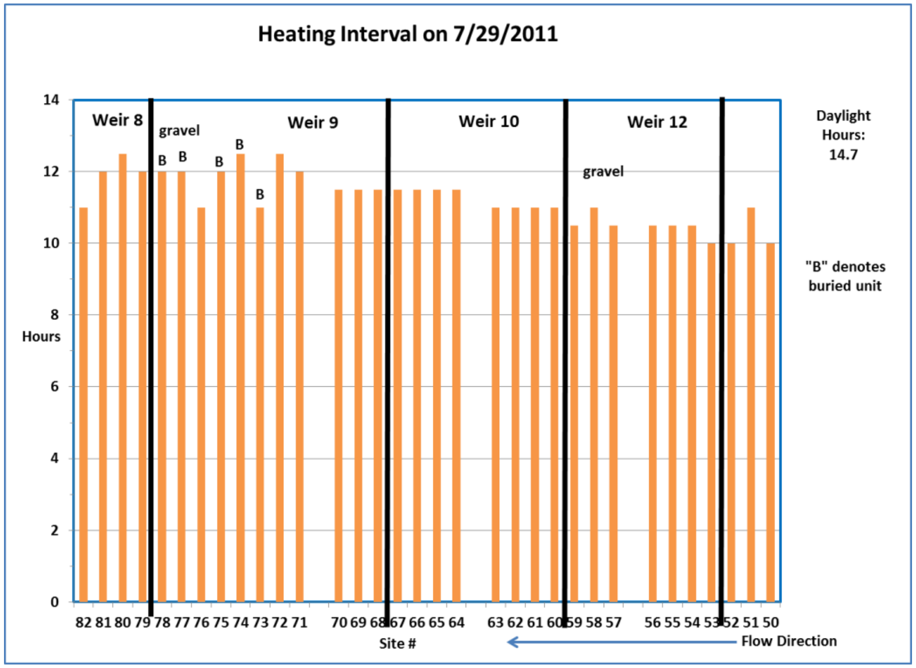


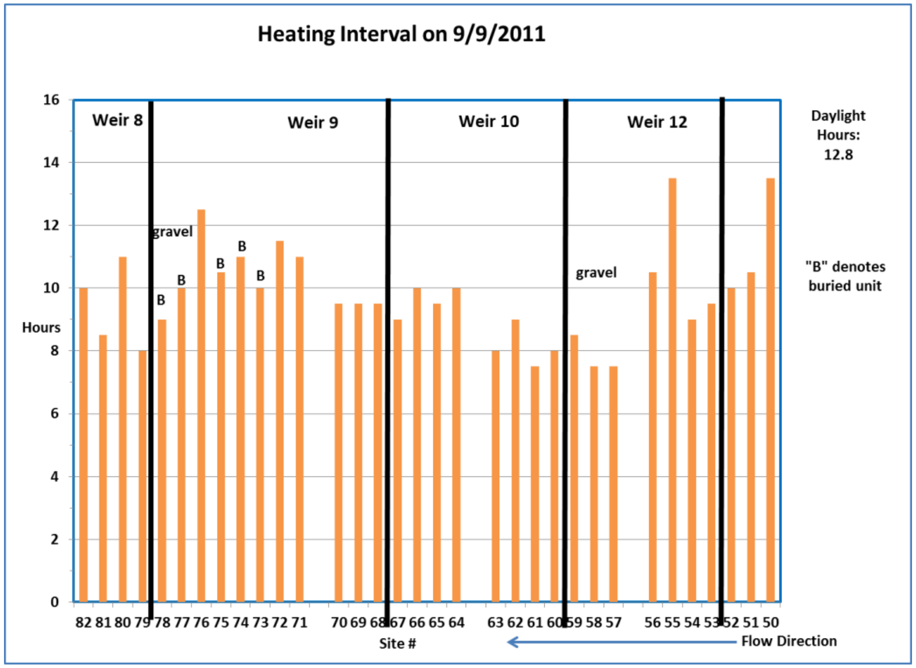


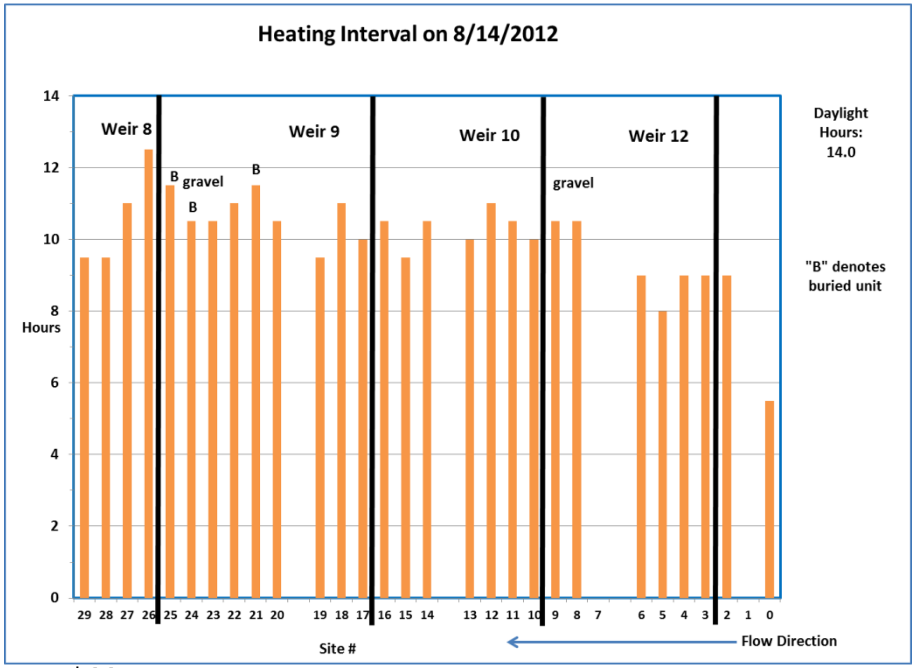


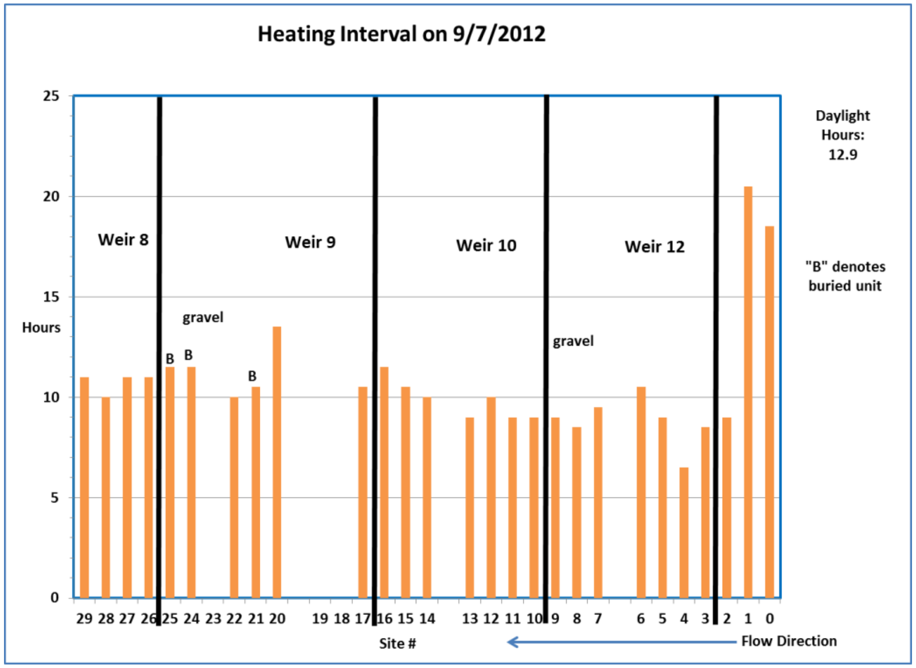
Appendix D: Temperature Interpretation Charts

Figure 16: Heating Interval Charts, Early and Late Season, during Steady State Summer Weather Conditions 2011 & 2012



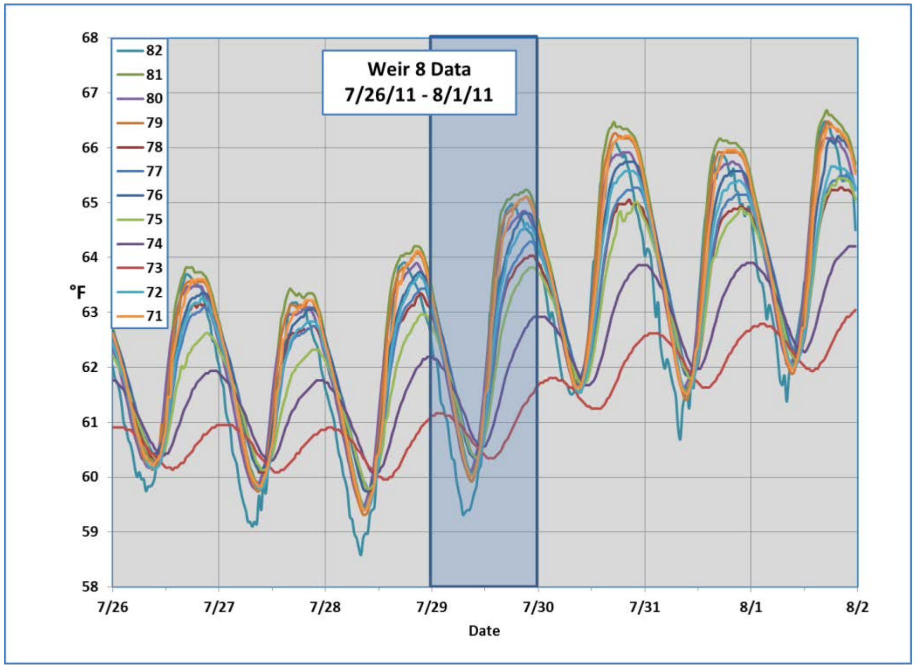


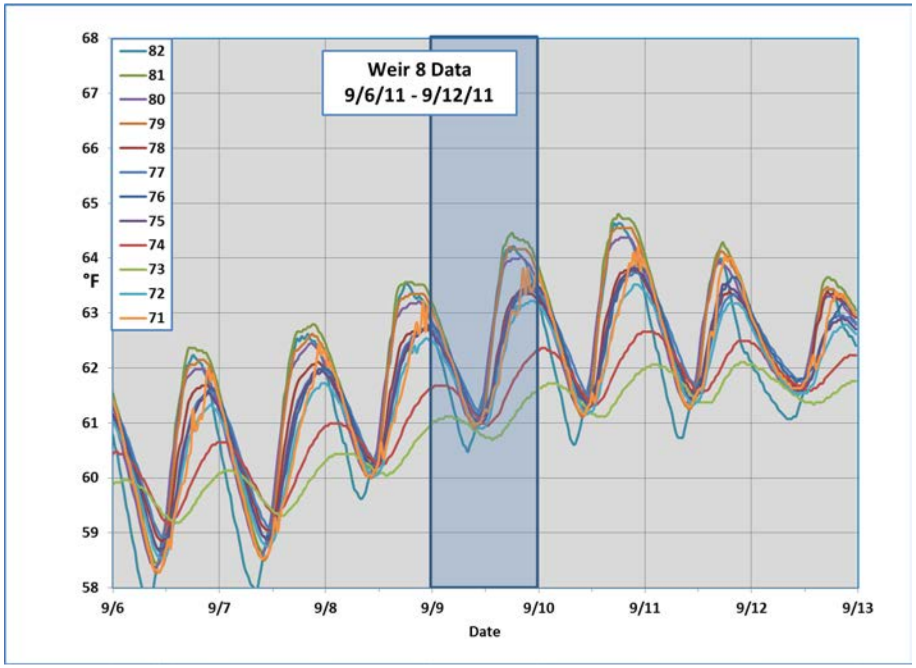


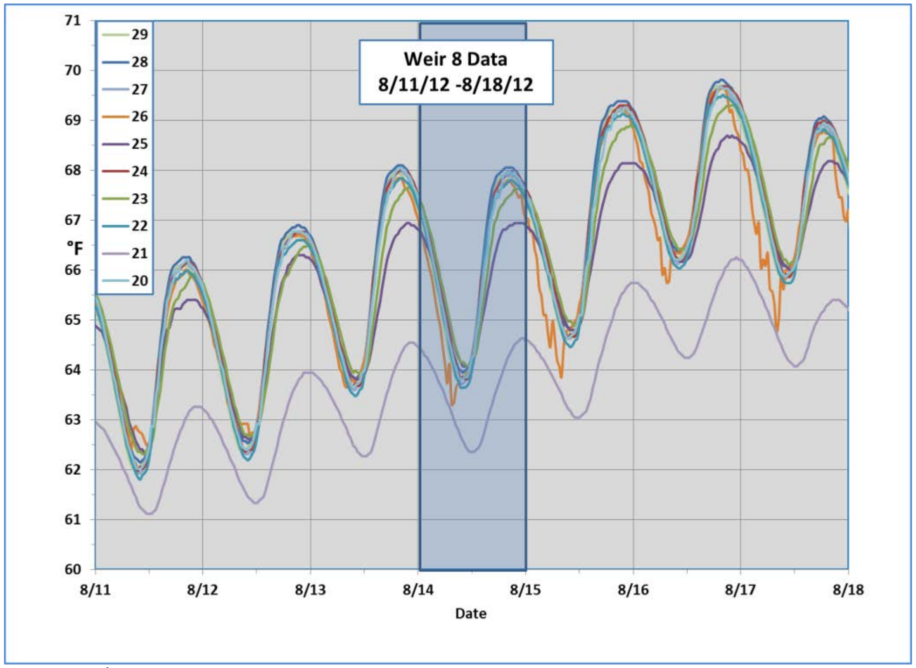


Appendix D: Temperature Interpretation Charts

Figure 17: Weir 8 Temperature Charts, Early and Late Season, during Steady State Summer Weather Conditions 2011 & 2012







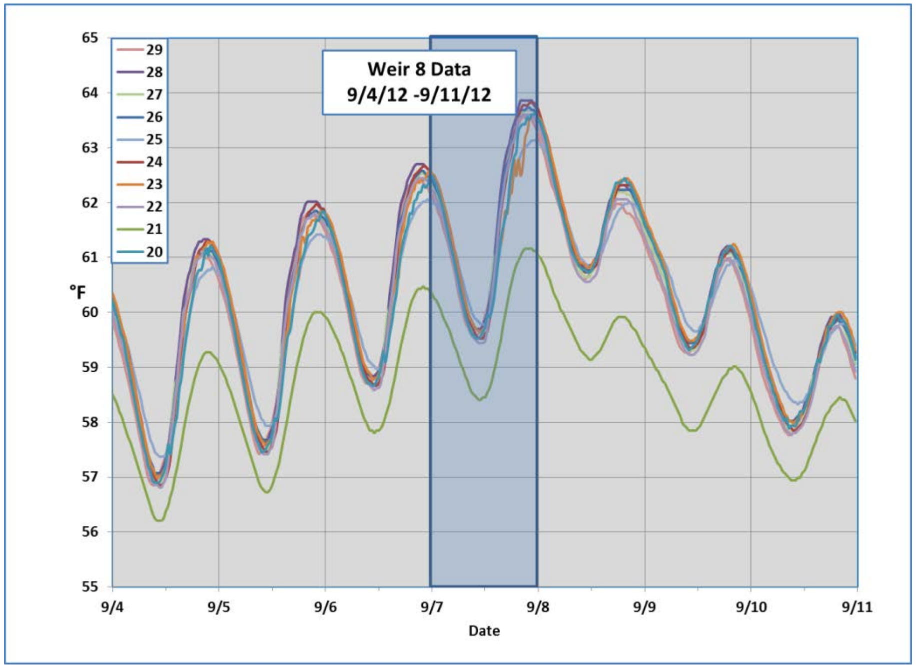
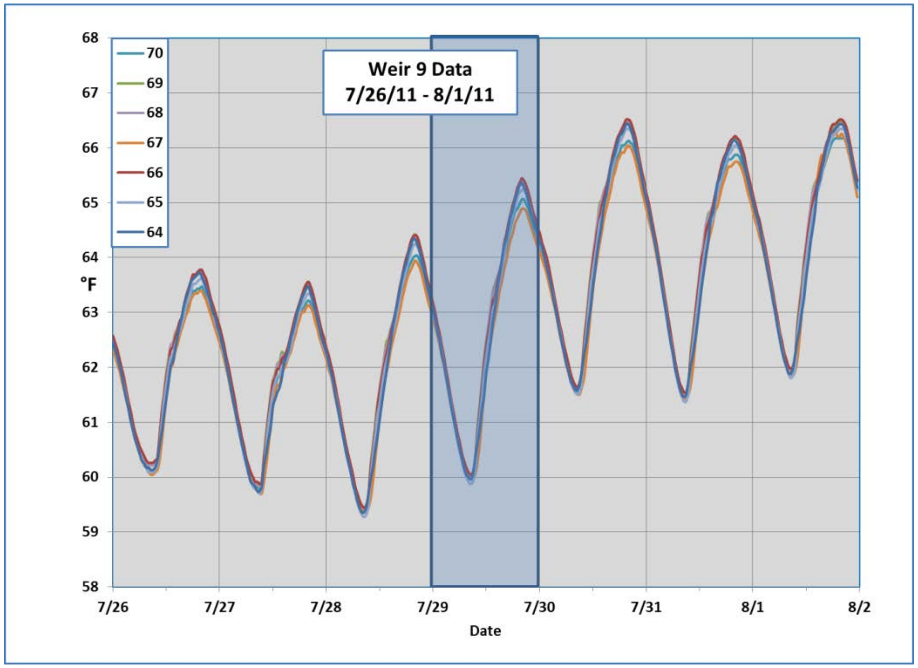
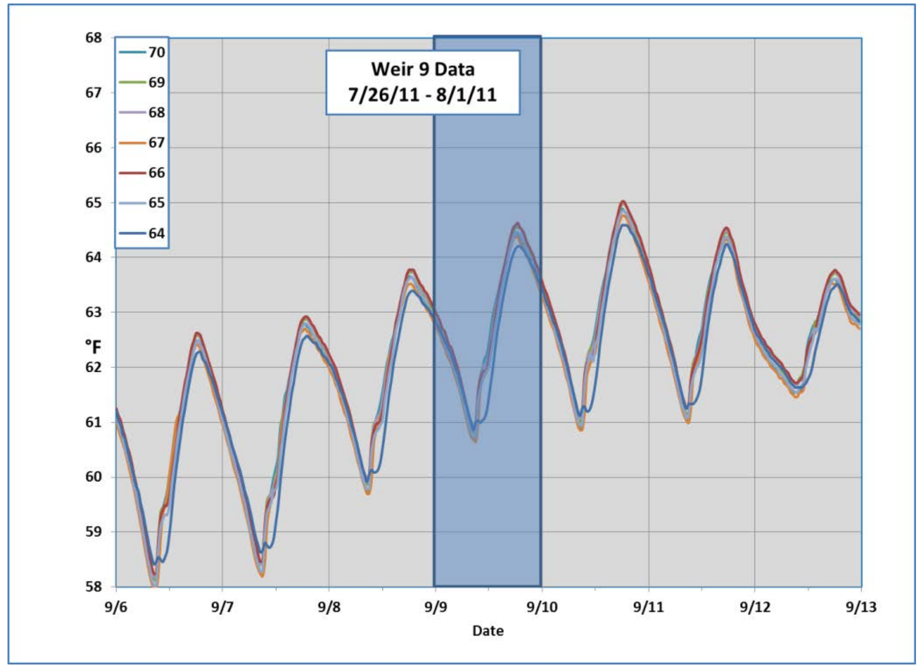
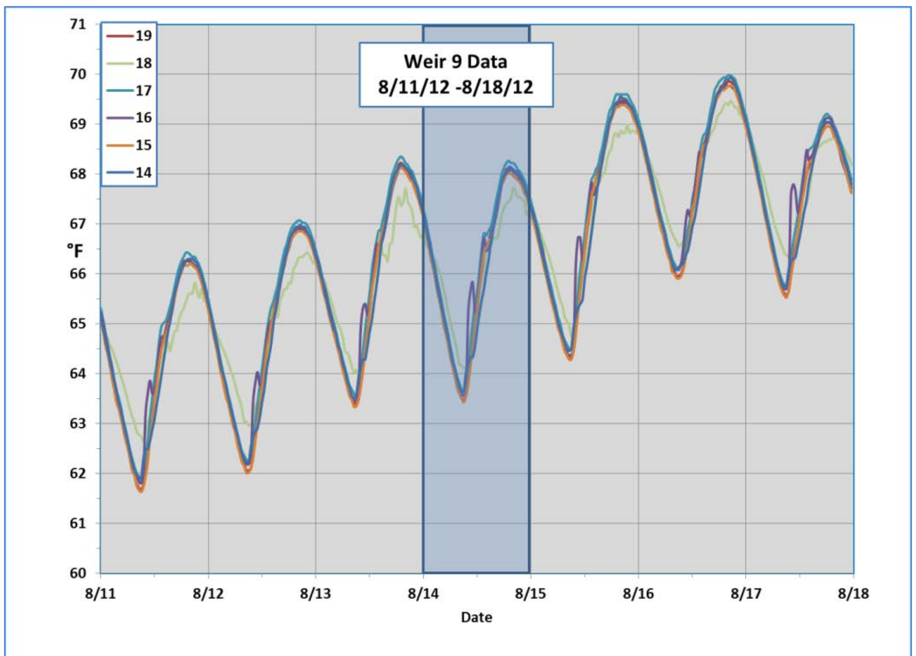
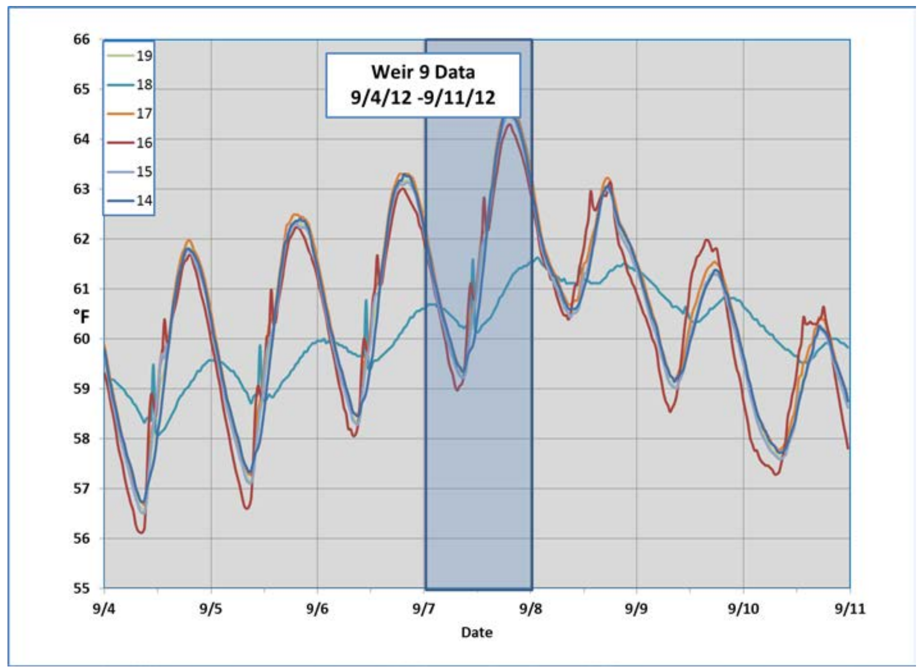


Figure 18: Weir 9 Temperature Charts, Early and Late Season, during Steady State Summer Weather Conditions 2011 & 2012



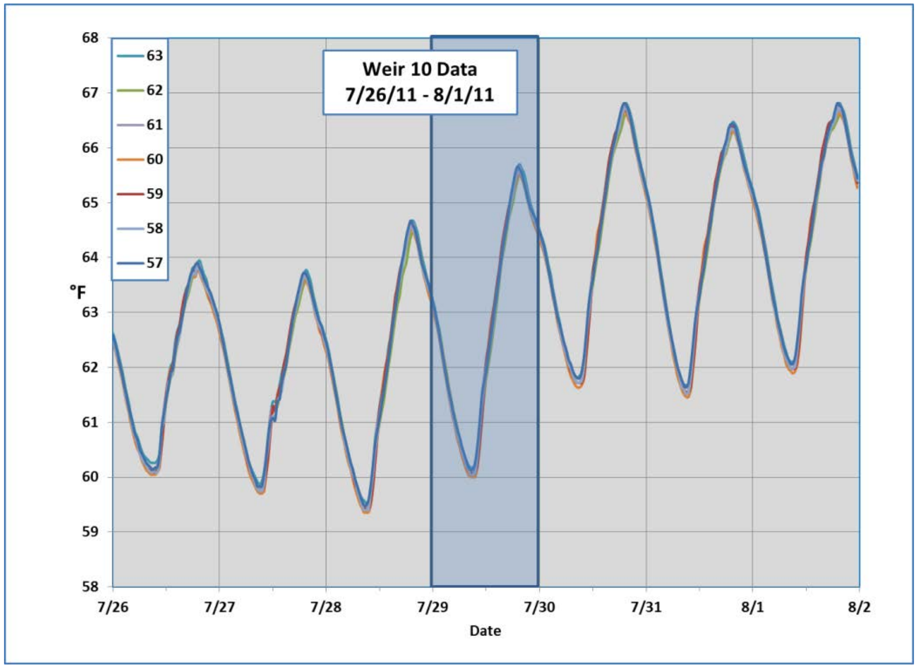


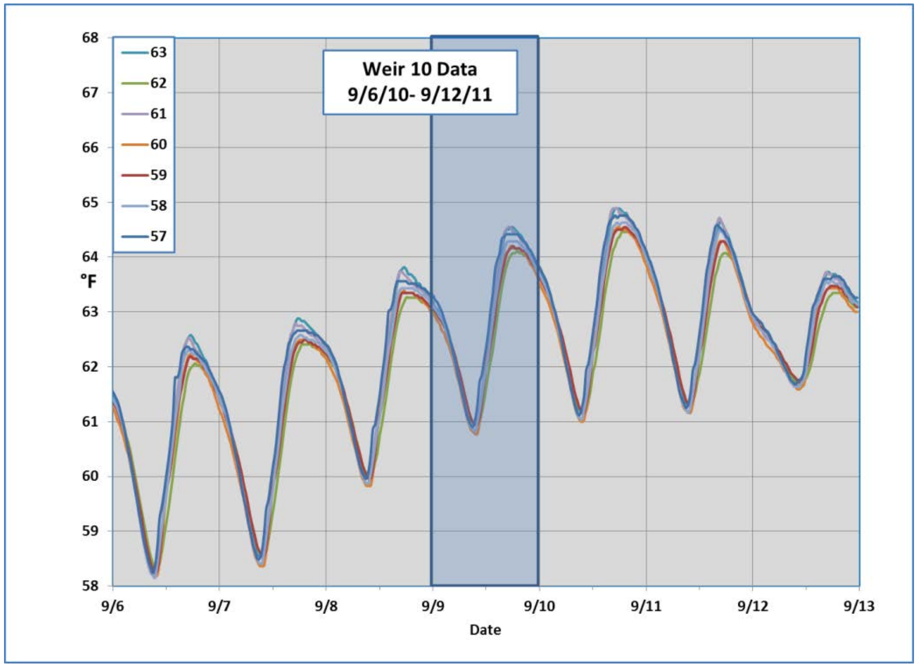


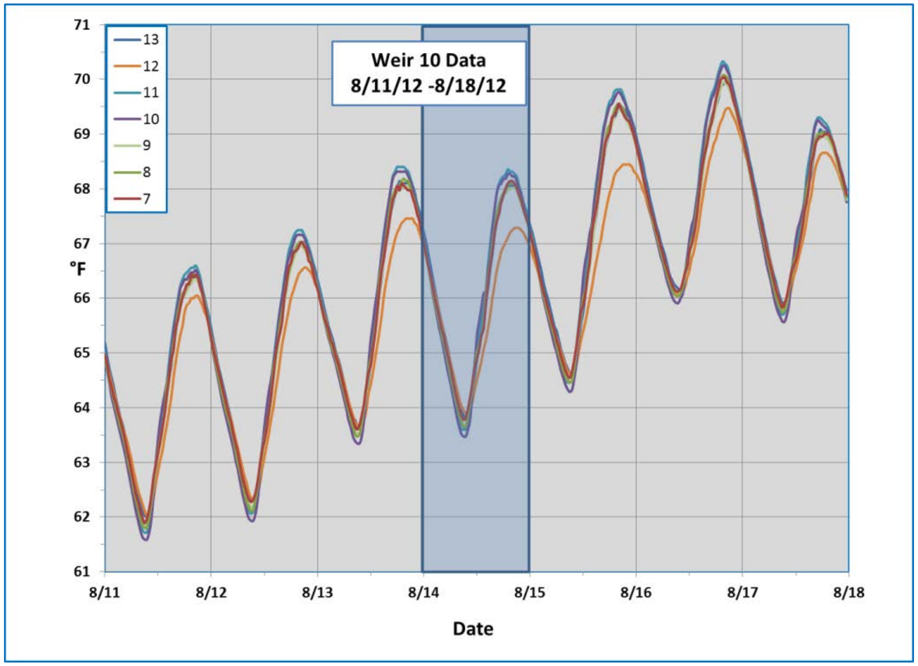


Appendix D: Temperature Interpretation Charts

Figure 19: Weir 10 Temperature Charts, Early and Late Season, during Steady State Summer Weather Conditions 2011 & 2012







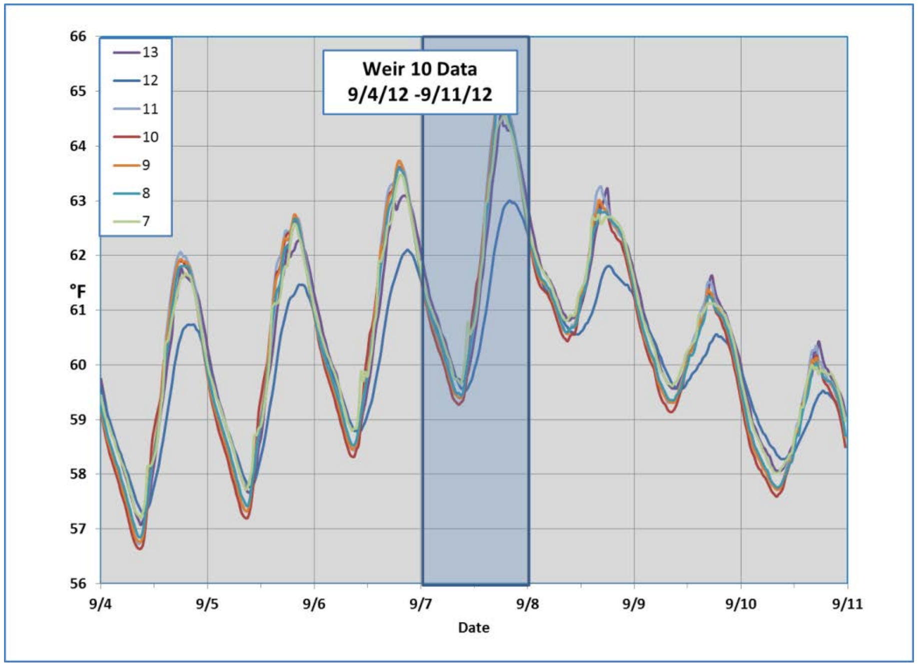
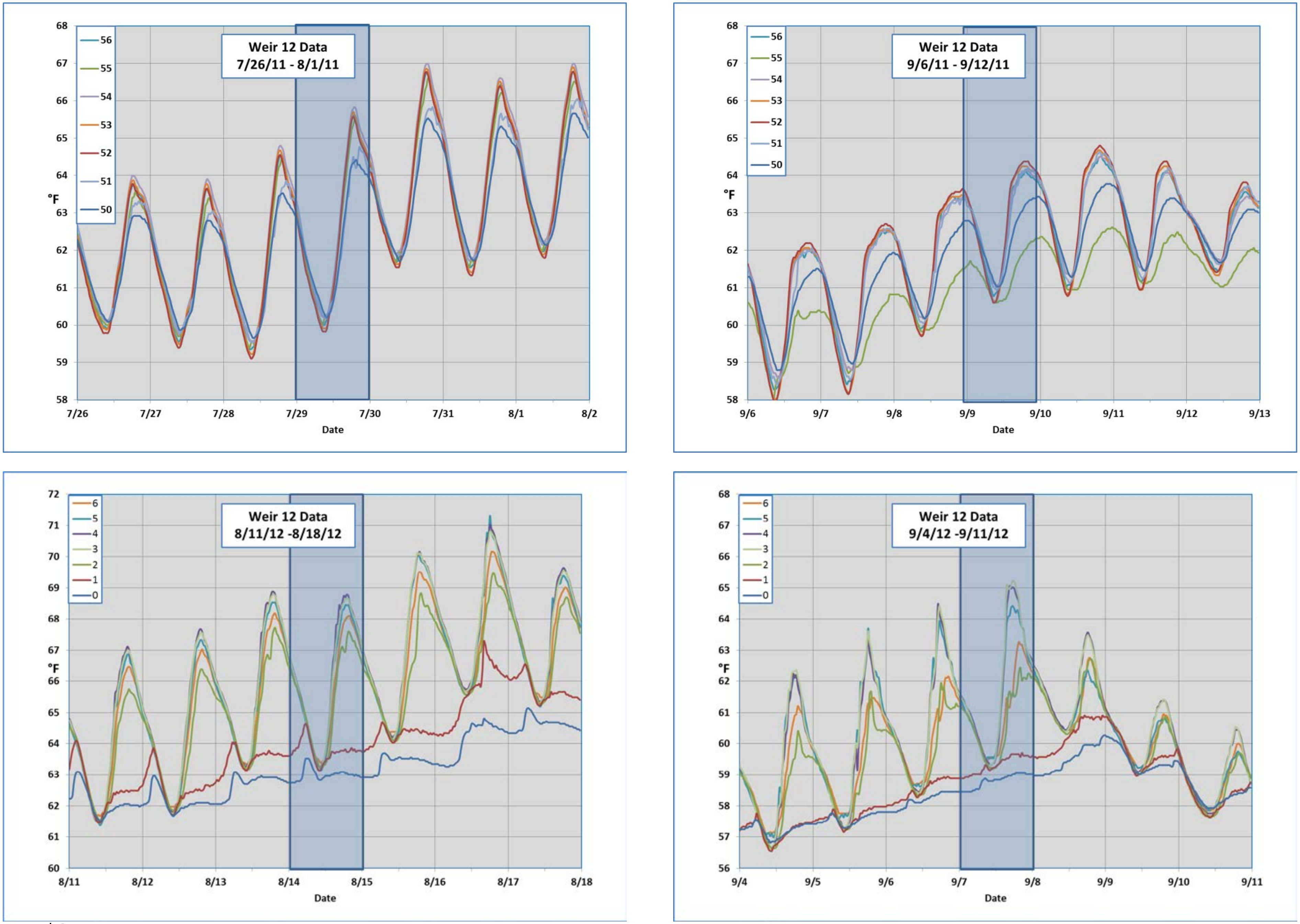


Figure 20: Weir 12 Temperature Charts, Early and Late Season, during Steady State Summer Weather Conditions 2011 & 2012



Appendix E: Wolf Creek Summary Data 2007-2012

Site Name	Start Date	Stop date	Seasonal Maximun		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
			Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	Δ T
Wolf Creek #8 - Downstream	07/13/07	10/01/07	08/02/07	70.5	09/25/07	48.6	08/01/07	8.1	07/25/07	69.0	63.2	5.8
Wolf Creek #9	07/19/07	10/01/07	08/02/07	70.6	09/25/07	47.6	08/13/07	9.0	07/25/07	69.1	63.0	6.0
Wolf Creek #10 - Upstream 200 ft.from Structure	07/19/07	10/01/07	08/02/07	71.2	09/25/07	47.6	08/13/07	9.6	07/25/07	69.4	63.1	6.2
Wolf Creek #10 - Downstream from Structure	07/19/07	10/01/07	08/02/07	70.2	09/25/07	48.4	08/29/07	8.1	07/25/07	69.2	63.6	5.7
Wolf Creek #10 - in Boulder Weir	07/19/07	10/01/07	08/29/07	80.2	09/25/07	47.4	08/29/07	29.4	08/28/07	75.0	54.3	20.6
Wolf Creek #18 A - in Boulder Weir	07/13/07	10/01/07	07/24/07	67.3	09/25/07	48.3	07/27/07	6.3	07/25/07	66.2	61.4	4.8
Wolf Creek #18 B - 3 ft. Downstream from Weir	07/13/07	10/01/07	08/02/07	67.1	09/25/07	48.2	08/01/07	6.2	07/25/07	66.1	61.5	4.6
Wolf Creek #18 C- on Surface of Gravel - 50 ft. Upstream	07/13/07	10/01/07	08/02/07	67.1	09/25/07	48.1	08/01/07	6.2	07/25/07	66.1	61.5	4.6
Wolf Creek #18 D - Buried 5" in Gravel - 50 ft. Upstream	07/13/07	10/01/07	07/24/07	65.7	09/25/07	49.5	08/01/07	4.1	07/25/07	64.8	61.7	3.1
Wolf Creek #8 - Downstream	06/20/08	10/07/08	08/16/08	72.3	09/28/08	50.9	07/13/08	9.0	08/15/08	70.3	64.8	5.5
Wolf Creek #10 - Upstream 200 ft. from Structure	06/26/08	10/07/08	08/16/08	73.3	09/23/08	50.0	07/13/08	9.2	08/14/08	71.0	63.9	7.0
Wolf Creek #10 - Downstream from Structure	06/26/08	10/07/08	08/16/08	72.8	09/23/08	50.8	07/13/08	9.3	08/14/08	70.6	64.3	6.4
Wolf Creek #18 A - in Boulder Weir	06/20/08	10/07/08	08/16/08	70.5	09/23/08	50.1	07/13/08	7.5	08/15/08	68.2	62.6	5.6
Wolf Creek #18 B - 3 ft. Downstream from Weir	06/20/08	10/07/08	08/16/08	70.8	09/23/08	50.2	07/13/08	7.6	08/15/08	68.4	62.5	5.9
Wolf Creek #18 E - on Surface of Gravel - 35 ft. Upstream	06/20/08	10/07/08	08/16/08	70.5	09/23/08	50.5	07/13/08	7.3	08/15/08	68.3	62.6	5.7
Wolf Creek #18 F - Buried 5" in Gravel - 35 ft. Upstream	06/20/08	10/07/08	08/16/08	67.4	09/28/08	52.9	07/13/08	3.9	08/15/08	65.9	62.9	3.0
Wolf Creek #18 G - in Weir near Left Bank	06/20/08	10/07/08	08/16/08	70.1	09/23/08	50.1	07/13/08	7.2	08/15/08	67.7	62.4	5.4
Wolf Creek #7 - Downstream of Entire Study Area	07/16/09	09/15/09	07/29/09	75.5	09/15/09	54.5	09/08/09	9.2	07/29/09	73.2	67.6	5.6
Wolf Creek #8 - Upstream #1 - Buried 5' in Gravel - Left Side (Facing US)	08/13/09	09/29/09	08/19/09	67.4	09/29/09	53.5	08/18/09	5.2	08/20/09	65.8	61.6	4.1
Wolf Creek #8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	08/13/09	09/29/09	08/13/09	66.5	09/21/09	53.1	08/14/09	4.8	08/20/09	63.5	61.4	2.0
Wolf Creek #8 - Upstream #3 - Buried in Mud Right Side of Weir (Facing US)	08/13/09	09/29/09	08/13/09	66.7	09/29/09	54.0	08/14/09	3.6	08/20/09	65.0	62.2	2.8
Wolf Creek #8 - Downstream #1 - in Left Side of Weir (Facing US)	08/13/09	09/29/09	08/19/09	68.1	09/29/09	53.2	08/19/09	5.8	08/20/09	65.9	61.6	4.2
Wolf Creek #8 - Downstream #2 - Near Middle of Weir	08/13/09	09/29/09	08/19/09	68.2	09/29/09	53.2	08/19/09	5.9	08/20/09	66.1	61.6	4.5
Wolf Creek #8 - Downstream #3 - Pre-Project Site - Right Side (Facing US)	07/03/09	07/14/09	07/03/09	68.3	07/07/09	58.4	07/04/09	8.1	07/06/09	65.6	59.8	5.8
Wolf Creek #8 - Downstream #3 - Post-Project Site - Right Side (Facing US)	08/13/09	09/29/09	08/19/09	68.1	09/29/09	53.2	08/19/09	5.8	08/20/09	66.1	61.7	4.5
Wolf Creek #9 - Upstream #1 - 40 ft. Upstream	08/13/09	09/29/09	08/13/09	75.4	09/21/09	52.6	08/13/09	11.8	08/16/09	66.8	60.0	6.8
Wolf Creek # 9 - Upstream #2 - 50 ft. Upstream, under Rootwad	08/14/09	09/29/09	08/19/09	68.8	09/21/09	52.9	08/18/09	7.1	08/20/09	66.7	61.3	5.4
Wolf Creek #9 - Upstream #3 - at Face of Boulder Weir Left Side (Facing US)	08/14/09	09/29/09	08/19/09	68.8	09/21/09	52.5	08/18/09	7.1	08/20/09	66.7	61.1	5.5
Wolf Creek #9 - Downstream #1 - in Left Side of Weir (Facing US)	08/14/09	09/29/09	08/19/09	68.6	09/21/09	52.7	08/18/09	7.0	08/20/09	66.5	61.2	5.4
Wolf Creek #9 - Downstream #2 - Post-Project Site - 30 ft. Downstream - Midstream	08/14/09	09/29/09	08/19/09	68.8	09/21/09	52.9	08/18/09	7.0	08/19/09	66.7	61.1	5.6
Wolf Creek #9 - Downstream #2 - Pre-Project Site - 30 ft. Downstream - Mid Stream	07/03/09	07/14/09	07/03/09	68.4	07/07/09	58.5	07/04/09	8.1	07/06/09	65.6	59.8	5.8
Wolf Creek #9 - Downstream #3 - in Right Side of Weir (Facing US)	08/14/09	09/29/09	08/19/09	68.9	09/21/09	52.9	08/18/09	7.0	08/20/09	66.8	61.4	5.4
Wolf Creek #10 - Downstream - Pre-project 2009	07/03/09	07/14/09	07/03/09	68.7	07/13/09	58.7	07/04/09	8.0	07/06/09	65.7	60.0	5.7
Wolf Creek #10 - Upstream #1 - Face of Gravel - Left Side (Facing US)	08/13/09	09/29/09	08/13/09	67.4	09/21/09	53.2	08/16/09	5.3	08/20/09	65.6	61.4	4.2
Wolf Creek #10 - Upstream #2 - 100 ft. Upstream - Same as Previous Years	08/13/09	09/29/09	08/13/09	67.4	09/21/09	52.9	08/15/09	5.0	08/20/09	65.5	61.4	4.1
Wolf Creek #10 - Upstream #3 - above Weir in Gravel Leading Edge - Rt Bank (Facing U	08/13/09	09/29/09	08/19/09	69.2	09/21/09	53.3	08/19/09	7.1	08/20/09	67.1	61.5	5.6
Wolf Creek #10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)	08/13/09	09/29/09	08/19/09	68.9	09/21/09	53.3	08/18/09	6.8	08/20/09	66.9	61.6	5.2
Wolf Creek #10 - Downstream #2 - Dowsntream near Middle of Weir	08/13/09	09/29/09	08/19/09	69.1	09/21/09	52.8	08/18/09	7.5	08/20/09	67.1	61.2	5.9
Wolf Creek #10 - Downstream #3 - in Downstream Boulder Cluster	08/13/09	09/29/09	08/19/09	69.5	09/21/09	53.2	08/18/09	7.6	08/20/09	67.4	61.5	5.9
Wolf Creek #12 - Upstream #1 - at Old Gravel Accumulation Left Side (Facing US)	08/14/09	09/29/09	08/19/09	69.7	09/21/09	52.9	08/19/09	7.9	08/20/09	67.5	61.2	6.3
Wolf Creek #12 - Upstream #2 - Upstream of Entire Study Area	07/03/09	09/29/09	07/29/09	76.3	09/21/09	52.6	08/19/09	8.4	07/30/09	74.0	68.0	6.0
Wolf Creek #12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)	08/14/09	09/29/09	08/19/09	69.8	09/21/09	52.4	08/19/09	8.4	08/20/09	67.7	60.8	6.9
Wolf Creek #12 - Downstream #1 - Left Side of Weir (Facing US)	08/14/09	09/29/09	08/19/09	69.9	09/21/09	52.6	08/19/09	8.3	08/20/09	67.7	61.0	6.6
Wolf Creek #12 - Downstream #2 - Pre-Project Site 2009 - 25 ft. Below Weir	07/03/09	07/14/09	07/03/09	67.9	07/13/09	58.2	07/04/09	7.8	07/06/09	65.0	59.5	5.5
Wolf Creek #12 - Downstream #2 - Post-Project Site 2009 - 25 ft. Below Weir	08/14/09	09/29/09	08/19/09	69.5	09/21/09	52.3	08/19/09	8.3	08/20/09	67.2	60.6	6.6
Wolf Creek #12 - Downstream #3 - Right Side of Main Weir (Facing US)	08/14/09	09/29/09	08/19/09	70.2	09/21/09	52.8	08/19/09	8.5	08/20/09	68.0	61.1	6.9

Appendix E: Wolf Creek Summary Data 2007-2012

Site Name	Days > 60_8 F	Days > 64_4 F	Days > 68 F	Hours > 60_8 F	Hours > 64_4 F	Hours > 68 F	Warmest day of 7-day max Date	Maximum	Minimum
Wolf Creek #8 - Downstream	62	45	13	1225.5	531.5	81.5	07/24/07	70.0	64.7
Wolf Creek #9	57	44	10	1069.5	424.0	58.0	07/24/07	69.9	64.6
Wolf Creek #10 - Upstream 200 ft.from Structure	57	45	15	1069.0	463.5	83.5	07/24/07	70.4	64.7
Wolf Creek #10 - Downstream from Structure	56	41	11	1120.0	449.5	60.0	07/24/07	70.2	65.0
Wolf Creek #10 - in Boulder Weir	58	46	23	1044.0	479.5	132.5	08/29/07	80.2	50.8
Wolf Creek #18 A - in Boulder Weir	52	18	0	796.0	118.5	0.0	07/24/07	67.3	62.9
Wolf Creek #18 B - 3 ft. Downstream from Weir	57	21	0	922.0	148.5	0.0	07/24/07	67.0	63.0
Wolf Creek #18 C- on Surface of Gravel - 50 ft. Upstream	57	20	0	907.5	143.5	0.0	07/24/07	66.9	63.0
Wolf Creek #18 D - Buried 5" in Gravel - 50 ft. Upstream	52	7	0	874.0	57.0	0.0	07/24/07	65.7	63.0
Wolf Creek #8 - Downstream	81	60	23	1482.0	710.0	177.5	08/16/08	72.3	66.5
Wolf Creek #10 - Upstream 200 ft. from Structure	77	61	27	1461.5	723.5	189.5	08/16/08	73.3	66.2
Wolf Creek #10 - Downstream from Structure	78	61	29	1485.5	729.0	201.5	08/16/08	72.8	66.5
Wolf Creek #18 A - in Boulder Weir	74	29	4	1064.5	235.0	27.5	08/16/08	70.5	64.0
Wolf Creek #18 B - 3 ft. Downstream from Weir	73	32	4	1030.5	230.5	27.0	08/16/08	70.8	64.0
Wolf Creek #18 E - on Surface of Gravel - 35 ft. Upstream	74	32	4	1057.0	233.5	26.0	08/16/08	70.5	64.2
Wolf Creek #18 F - Buried 5" in Gravel - 35 ft. Upstream	57	8	0	901.0	91.5	0.0	08/16/08	67.4	64.3
Wolf Creek #18 G - in Weir near Left Bank	71	27	3	987.5	195.5	18.5	08/16/08	70.1	63.8
Wolf Creek #7 - Downstream of Entire Study Area	59	40	18	1149.5	621.5	232.5	07/29/09	75.5	69.7
Wolf Creek #8 - Upstream #1 - Buried 5' in Gravel - Left Side (Facing US)	30	8	0	493.0	93.0	0.0	08/19/09	67.4	62.2
Wolf Creek #8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	24	1	0	352.0	24.0	0.0	08/20/09	64.3	62.9
Wolf Creek #8 - Upstream #3 - Buried in Mud Right Side of Weir (Facing US)	30	7	0	523.5	76.0	0.0	08/19/09	65.9	62.7
Wolf Creek #8 - Downstream #1 - in Left Side of Weir (Facing US)	31	9	1	495.5	99.0	1.0	08/19/09	68.1	62.2
Wolf Creek #8 - Downstream #2 - Near Middle of Weir	31	10	1	514.0	111.5	1.0	08/19/09	68.2	62.3
Wolf Creek #8 - Downstream #3 - Pre-Project Site - Right Side (Facing US)	12	6	2	186.5	53.0	5.0	07/03/09	68.3	60.4
Wolf Creek #8 - Downstream #3 - Post-Project Site - Right Side (Facing US)	31	10	1	510.5	109.5	1.0	08/19/09	68.1	62.3
Wolf Creek #9 - Upstream #1 - 40 ft. Upstream	31	12	2	497.0	117.0	13.0	08/13/09	75.4	63.6
Wolf Creek # 9 - Upstream #2 - 50 ft. Upstream, under Rootwad	30	12	1	487.0	94.0	6.0	08/19/09	68.8	61.9
Wolf Creek #9 - Upstream #3 - at Face of Boulder Weir Left Side (Facing US)	31	12	1	521.0	110.0	5.5	08/19/09	68.8	61.8
Wolf Creek #9 - Downstream #1 - in Left Side of Weir (Facing US)	30	11	1	483.0	91.5	5.0	08/19/09	68.6	61.8
Wolf Creek #9 - Downstream #2 - Post-Project Site - 30 ft. Downstream - Midstream	30	11	1	509.0	102.5	6.0	08/19/09	68.8	61.9
Wolf Creek #9 - Downstream #2 - Pre-Project Site - 30 ft. Downstream - Mid Stream	12	7	2	191.5	53.5	4.5	07/03/09	68.4	60.4
Wolf Creek #9 - Downstream #3 - in Right Side of Weir (Facing US)	30	12	2	518.0	104.5	7.5	08/19/09	68.9	62.0
Wolf Creek #10 - Downstream - Pre-project 2009	12	7	2	193.0	52.5	5.0	07/03/09	68.7	60.7
Wolf Creek #10 - Upstream #1 - Face of Gravel - Left Side (Facing US)	30	7	0	498.5	86.0	0.0	08/19/09	66.6	62.0
Wolf Creek #10 - Upstream #2 - 100 ft. Upstream - Same as Previous Years	28	6	0	478.5	85.5	0.0	08/20/09	66.6	62.9
Wolf Creek #10 - Upstream #3 - above Weir in Gravel Leading Edge - Rt Bank (Facin	32	15	2	552.5	137.0	9.5	08/19/09	69.2	62.1
Wolf Creek #10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US	31	14	2	550.5	132.0	6.5	08/19/09	68.9	62.3
Wolf Creek #10 - Downstream #2 - Dowsntream near Middle of Weir	31	14	3	521.0	129.0	10.5	08/19/09	69.1	61.8
Wolf Creek #10 - Downstream #3 - in Downstream Boulder Cluster	33	17	3	553.0	149.5	15.0	08/19/09	69.5	62.1
Wolf Creek #12 - Upstream #1 - at Old Gravel Accumulation Left Side (Facing US)	31	15	3	515.0	112.0	10.5	08/19/09	69.7	61.8
Wolf Creek #12 - Upstream #2 - Upstream of Entire Study Area	72	51	26	1384.0	667.5	255.5	07/29/09	76.3	69.7
Wolf Creek #12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)	30	15	4	470.5	112.0	14.5	08/19/09	69.8	61.4
Wolf Creek #12 - Downstream #1 - Left Side of Weir (Facing US)	31	15	3	502.5	118.0	13.0	08/19/09	69.9	61.6
Wolf Creek #12 - Downstream #2 - Pre-Project Site 2009 - 25 ft. Below Weir	11	5	0	162.0	33.0	0.0	07/03/09	67.9	60.2
Wolf Creek #12 - Downstream #2 - Post-Project Site 2009 - 25 ft. Below Weir	30	12	3	445.0	87.5	8.0	08/19/09	69.5	61.2
Wolf Creek #12 - Downstream #3 - Right Side of Main Weir (Facing US)	31	18	4	515.5	128.5	15.5	08/19/09	70.2	61.7

Appendix E: Wolf Creek Summary Data 2007-2012

Site Name	Start Date	Stop date	Seasonal Maximun		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
			Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	Δ T
Wolf Creek #7 - Downstream of Entire Study Area - 2010	07/15/10	10/11/10	07/25/10	67.8	10/06/10	51.1	07/15/10	6.4	08/14/10	66.5	62.3	4.2
WC #8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)	07/15/10	10/11/10	07/25/10	66.3	10/06/10	52.6	07/15/10	3.8	08/15/10	65.4	62.9	2.6
WC #8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	07/15/10	10/11/10	07/25/10	68.0	10/06/10	51.1	07/15/10	6.6	08/14/10	66.5	62.2	4.3
WC #8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)	07/15/10	10/11/10	07/25/10	66.6	10/06/10	52.5	07/15/10	4.6	08/15/10	65.7	62.8	2.8
WC #8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel	07/15/10	10/11/10	07/25/10	68.0	10/06/10	50.9	07/15/10	6.5	08/14/10	66.6	62.3	4.3
WC #8 - Upstream #5 - 24' Upstream on Upstream Face of Gravel	07/15/10	10/11/10	07/25/10	67.9	10/06/10	50.9	07/15/10	6.6	08/14/10	66.5	62.2	4.3
WC #8 - Upstream #6 - Buried 15" in Gravel Just US from Weir	07/15/10	10/11/10	08/14/10	66.3	10/06/10	53.0	08/25/10	3.5	08/15/10	65.5	62.8	2.7
WC #8 - Upstream #7 - Buried 12" in Gravel - 12' Upstream, Midstream	07/15/10	10/11/10	08/15/10	64.8	10/07/10	54.0	07/15/10	2.4	08/16/10	64.5	62.9	1.6
WC #8 - Upstream # 8 - Buried in Mud - 44 ft. Upstream, Midstream	07/15/10	10/11/10	08/14/10	66.4	10/06/10	50.9	08/24/10	7.1	08/14/10	65.5	61.4	4.1
WC #8 - Downstream #1a - in Center of Weir	07/15/10	10/11/10	07/25/10	68.0	10/06/10	50.9	07/15/10	6.6	08/14/10	66.6	62.3	4.3
WC #8 - Downstream #2 - Near Middle of Weir - Downstream of Gravel Face	07/15/10	10/11/10	07/25/10	68.0	10/06/10	50.8	07/15/10	6.6	08/14/10	66.6	62.3	4.4
WC #8 - Downstream #3 - 53' Downstream on Right Side (Facing US)	07/15/10	10/11/10	07/25/10	68.0	10/06/10	50.9	07/15/10	6.6	08/14/10	66.7	62.3	4.3
WC #9 - Upstream #1a - 107 ft. Upstream	07/20/10	10/11/10	07/25/10	67.8	10/06/10	50.4	07/24/10	6.1	07/26/10	66.3	61.2	5.1
WC9 - Upstream #2a - Mid Weir Just Upstream	07/20/10	10/11/10	07/25/10	68.4	10/06/10	50.9	07/24/10	6.1	07/26/10	66.9	61.7	5.2
WC #9 - Upstream #3a - Right Side of Weir (Facing US)	07/20/10	10/11/10	07/25/10	68.1	10/06/10	45.2	10/06/10	7.8	08/14/10	66.7	62.0	4.7
WC #9 - Downstream #1 - in Left Side of Weir (Facing US)	07/20/10	10/11/10	07/25/10	68.1	10/06/10	50.7	07/24/10	6.0	07/26/10	66.6	61.6	5.0
WC #9 - Downstream #2 - 21 ft. Downstream - Mid Stream	07/20/10	10/11/10	07/25/10	68.3	10/06/10	50.8	07/24/10	6.1	07/26/10	66.8	61.7	5.2
WC #9 - Downstream #3 - in Right Side of Weir (Facing US)	07/20/10	10/11/10	07/25/10	68.3	10/06/10	50.8	07/24/10	6.1	07/26/10	66.8	61.6	5.1
WC #10 - Upstream #1 - Face of Gravel, 26' from MidWeir- Left Side (Facing US) - 2010	07/16/10	10/11/10	07/25/10	68.5	10/06/10	51.1	07/24/10	6.4	07/26/10	67.0	61.5	5.4
WC #10 - Upstream #2 - 115 ft. Upstream - 2010	07/16/10	10/11/10	07/25/10	68.6	10/06/10	50.5	07/24/10	6.6	07/26/10	67.0	61.3	5.7
WC #10 - Upstream #3 - above Weir in Gravel Leading Edge - Rt Bank (Facing US) - 20	07/16/10	10/11/10	07/25/10	68.6	10/06/10	50.8	07/24/10	6.3	07/26/10	67.0	61.6	5.4
WC #10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US) - 2010	07/16/10	10/11/10	07/25/10	68.4	10/06/10	50.8	07/24/10	6.3	07/26/10	66.9	61.6	5.4
WC #10 - Downstream #2 - Downstream near Middle of Weir - 2010	07/16/10	10/11/10	07/25/10	68.6	10/06/10	51.2	07/24/10	6.4	07/26/10	67.1	61.7	5.3
WC #10 - Downstream #3 - 30 ft. DS from Lower Weir in Boulder Cluster - 2010	07/16/10	10/11/10	07/25/10	68.5	10/06/10	51.1	07/24/10	6.3	07/26/10	67.0	61.7	5.3
WC #12 - Upstream #1a - 30 ft. Upstream at Gravel Face Left Side (Facing US) - 2010	07/16/10	10/11/10	07/25/10	68.2	10/06/10	50.3	07/24/10	6.5	07/26/10	66.7	61.1	5.6
WC #12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream - 2010	07/16/10	10/11/10	07/25/10	68.6	10/06/10	50.8	07/24/10	6.8	07/26/10	67.0	61.1	5.9
WC #12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US) - 2010	07/16/10	10/11/10	07/25/10	68.5	10/06/10	50.2	07/24/10	6.9	07/26/10	67.0	61.0	6.0
WC #12 - Downstream #1a - Far Left Side of Weir (Facing US) - 2010	07/16/10	10/11/10	07/25/10	68.5	10/06/10	51.3	07/24/10	6.6	07/26/10	66.9	61.4	5.6
WC #12 - Downstream #2a - 32 ft. Downstream - 2010	07/16/10	10/11/10	07/25/10	68.6	10/06/10	50.4	07/24/10	6.7	07/26/10	67.0	61.3	5.7
WC #12 - Downstream #3 - Right Side of Main Weir (Facing US) - 2010	07/16/10	10/11/10	07/25/10	68.6	10/06/10	50.4	07/24/10	6.9	07/26/10	67.1	61.1	6.0
WC7 - Downstream of Entire Study Area	07/13/11	09/26/11	08/25/11	68.4	09/18/11	53.9	07/29/11	5.7	08/25/11	66.8	63.1	3.7
WC8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)	07/13/11	09/26/11	08/25/11	67.4	09/18/11	55.5	09/01/11	3.5	08/26/11	66.1	63.5	2.7
WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	07/13/11	09/26/11	08/25/11	68.4	09/18/11	54.5	07/23/11	5.1	08/25/11	66.9	63.3	3.6
WC8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)	07/13/11	09/26/11	08/26/11	65.9	09/18/11	56.4	09/01/11	2.7	08/26/11	65.2	63.5	1.6
WC8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel	07/13/11	09/26/11	08/25/11	67.5	09/18/11	55.0	07/23/11	4.7	08/25/11	66.2	63.3	2.9
WC8 - Upstream #5 - 27' Upstream on Upstream Face of Gravel	07/13/11	09/26/11	08/25/11	67.8	09/18/11	55.2	07/29/11	4.5	08/25/11	66.5	63.6	2.9
WC8 - Upstream #6 - Buried 14" in Gravel Just Upstream from Weir	07/13/11	09/26/11	08/25/11	67.1	09/18/11	55.3	07/24/11	4.2	08/26/11	66.0	63.6	2.5
WC8 - Upstream #7a - Buried 12" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)	07/13/11	09/26/11	08/25/11	67.5	09/18/11	55.8	07/29/11	3.9	08/26/11	66.3	63.6	2.7
WC8 - Upstream #8a - Buried in 5" MudNearBank-43' US fromWeirAtLeftEdge (FaceUS	07/13/11	09/26/11	08/27/11	64.8	09/18/11	56.8	09/01/11	2.1	08/27/11	64.2	63.2	1.0
WC8 - Downstream #1a - in Center of Weir	07/13/11	09/26/11	08/25/11	68.2	09/18/11	54.6	07/23/11	4.8	08/25/11	66.7	63.3	3.4
WC8 - Downstream #2a - To Right of Middle of Weir - Downstream of Gravel Face	07/13/11	09/26/11	08/25/11	68.3	09/18/11	54.5	07/29/11	5.2	08/25/11	66.9	63.3	3.6
WC8 - Downstream #3a - 53' Downstream on Right of MidStream (Facing US)	07/13/11	09/26/11	08/25/11	68.6	09/18/11	54.7	07/29/11	5.1	08/25/11	67.1	63.4	3.6
WC9 - Upstream #1a - 107 ft. Upstream	07/21/11	09/26/11	08/25/11	68.7	09/17/11	54.6	07/23/11	5.4	08/25/11	67.0	63.2	3.8
WC9 - Upstream #2a - Mid Weir Just Upstream	07/21/11	09/26/11	08/25/11	68.6	09/18/11	54.3	07/23/11	5.4	08/25/11	67.0	63.1	3.8
WC9 - Upstream #3b - 1ft US Rt Side of Weir (FaceUS) - logger exposed to sun noticed	07/21/11	09/26/11	08/25/11	68.4	09/18/11	54.3	07/23/11	5.0	08/25/11	66.8	63.1	3.7
WC9 - Upstream #4 - MidWeir Just Upstream - Buried 2" in Sand	07/21/11	09/26/11	08/25/11	68.7	09/18/11	54.5	07/23/11	5.4	08/25/11	67.1	63.3	3.8
WC9 - Downstream #1a - in Left Side of Weir (Facing US)	07/21/11	09/26/11	08/25/11	68.7	09/18/11	54.3	07/23/11	5.4	08/25/11	67.1	63.3	3.8
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream	07/21/11	09/26/11	08/25/11	68.3	09/18/11	54.3	07/29/11	5.1	08/25/11	66.8	63.2	3.6
WC9 - Downstream #3 - in Right Side of Weir (Facing US)	07/21/11	09/26/11	08/25/11	68.7	09/18/11	54.5	07/23/11	5.4	08/25/11	67.1	63.3	3.8

Appendix E: Wolf Creek Summary Data 2007-2012

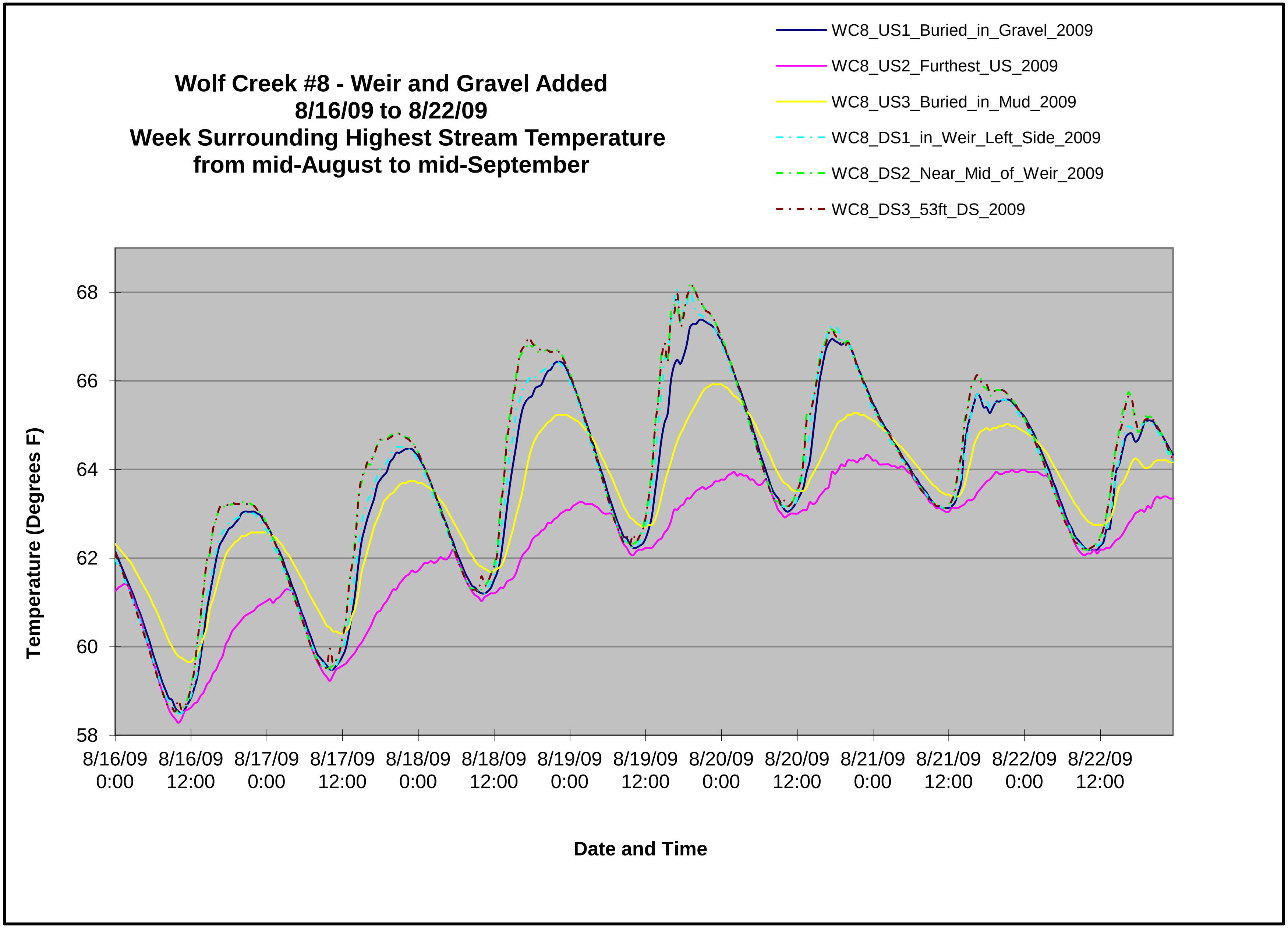
Site Name	Days > 60_8 F	Days > 64_4 F	Days > 68 F	Hours > 60_8 F	Hours > 64_4 F	Hours > 68 F	Warmest day of 7-day max Date	Maximum	Minimum
Wolf Creek #7 - Downstream of Entire Study Area - 2010	56	29	0	1040.0	275.5	0.0	08/14/10	67.6	63.0
WC #8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)	52	20	0	1014.0	157.0	0.0	08/14/10	66.1	63.3
WC #8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	54	29	0	999.0	278.5	0.0	08/14/10	67.6	62.9
WC #8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)	54	24	0	1042.5	192.5	0.0	08/14/10	66.5	63.3
WC #8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel	57	30	0	1062.0	289.0	0.0	08/14/10	67.7	63.0
WC #8 - Upstream #5 - 24' Upstream on Upstream Face of Gravel	55	28	0	1026.5	270.0	0.0	08/14/10	67.6	62.8
WC #8 - Upstream #6 - Buried 15" in Gravel Just US from Weir	53	18	0	1049.0	142.5	0.0	08/14/10	66.3	63.2
WC #8 - Upstream #7 - Buried 12" in Gravel - 12' Upstream, Midstream	46	7	0	928.0	35.0	0.0	08/14/10	64.8	63.0
WC #8 - Upstream # 8 - Buried in Mud - 44 ft. Upstream, Midstream	50	11	0	937.0	76.0	0.0	08/14/10	66.4	62.1
WC #8 - Downstream #1a - in Center of Weir	57	30	1	1073.0	296.0	1.0	08/14/10	67.8	63.0
WC #8 - Downstream #2 - Near Middle of Weir - Downstream of Gravel Face	56	30	1	1059.0	290.5	1.0	08/14/10	67.8	62.9
WC #8 - Downstream #3 - 53' Downstream on Right Side (Facing US)	56	30	1	1072.5	303.0	0.5	08/14/10	67.8	63.0
WC #9 - Upstream #1a - 107 ft. Upstream	49	24	0	837.5	185.5	0.0	07/25/10	67.8	62.1
WC9 - Upstream #2a - Mid Weir Just Upstream	54	29	2	1013.5	280.0	5.0	07/25/10	68.4	62.7
WC #9 - Upstream #3a - Right Side of Weir (Facing US)	53	27	1	933.5	247.5	2.0	08/14/10	67.9	62.6
WC #9 - Downstream #1 - in Left Side of Weir (Facing US)	52	26	1	948.0	246.5	1.5	07/25/10	68.1	62.6
WC #9 - Downstream #2 - 21 ft. Downstream - Mid Stream	53	28	2	988.0	272.5	4.0	07/25/10	68.3	62.7
WC #9 - Downstream #3 - in Right Side of Weir (Facing US)	53	26	1	970.0	257.0	2.0	07/25/10	68.3	62.6
WC #10 - Upstream #1 - Face of Gravel, 26' from MidWeir- Left Side (Facing US) - 20	57	31	1	1040.0	272.0	2.5	07/25/10	68.5	62.5
WC #10 - Upstream #2 - 115 ft. Upstream - 2010	56	31	2	1015.5	272.0	4.5	07/25/10	68.6	62.4
WC #10 - Upstream #3 - above Weir in Gravel Leading Edge - Rt Bank (Facing US) -	59	30	1	1085.5	291.5	3.0	07/25/10	68.6	62.7
WC #10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US) - 201(	57	32	2	1053.0	280.0	5.0	07/25/10	68.4	62.6
WC #10 - Downstream #2 - Downstream near Middle of Weir - 2010	59	33	2	1089.5	302.0	7.0	07/25/10	68.6	62.7
WC #10 - Downstream #3 - 30 ft. DS from Lower Weir in Boulder Cluster - 2010	58	31	1	1073.5	288.0	3.0	07/25/10	68.5	62.7
WC #12 - Upstream #1a - 30 ft. Upstream at Gravel Face Left Side (Facing US) - 201	55	28	1	981.0	236.5	1.5	07/25/10	68.2	62.1
WC #12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream - 2010	57	33	2	1022.0	267.5	6.5	07/25/10	68.6	62.1
WC #12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US) - 2010	56	33	2	995.5	254.5	5.0	07/25/10	68.5	62.1
WC #12 - Downstream #1a - Far Left Side of Weir (Facing US) - 2010	44	22	1	782.5	139.0	3.0	07/25/10	68.5	62.4
WC #12 - Downstream #2a - 32 ft. Downstream - 2010	57	33	2	1024.0	266.5	6.0	07/25/10	68.6	62.4
WC #12 - Downstream #3 - Right Side of Main Weir (Facing US) - 2010	57	32	2	1024.5	263.5	6.0	07/25/10	68.6	62.1
WC7 - Downstream of Entire Study Area	57	21	1	1017.5	189.0	5.0	08/25/11	68.4	65.1
WC8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)	55	13	0	1058.0	150.5	0.0	08/25/11	67.4	64.8
WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	58	21	1	1063.0	231.5	6.5	08/25/11	68.4	65.1
WC8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)	53	6	0	1028.5	80.5	0.0	08/25/11	65.9	64.3
WC8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel	56	15	0	1039.0	164.0	0.0	08/25/11	67.5	64.8
WC8 - Upstream #5 - 27' Upstream on Upstream Face of Gravel	58	19	0	1090.0	208.5	0.0	08/25/11	67.8	65.1
WC8 - Upstream #6 - Buried 14" in Gravel Just Upstream from Weir	56	15	0	1095.0	164.0	0.0	08/25/11	67.1	64.7
WC8 - Upstream #7a - Buried 12" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)	57	15	0	1092.5	174.0	0.0	08/25/11	67.5	65.0
WC8 - Upstream #8a - Buried in 5" MudNearBank-43' US fromWeirAtLeftEdge (Face	48	4	0	886.5	35.5	0.0	08/27/11	64.8	63.9
WC8 - Downstream #1a - in Center of Weir	57	20	1	1079.0	216.0	5.0	08/25/11	68.2	65.1
WC8 - Downstream #2a - To Right of Middle of Weir - Downstream of Gravel Face	59	22	1	1082.5	238.0	6.5	08/25/11	68.3	65.1
WC8 - Downstream #3a - 53' Downstream on Right of MidStream (Facing US)	60	24	2	1110.0	260.5	12.5	08/25/11	68.6	65.2
WC9 - Upstream #1a - 107 ft. Upstream	56	22	2	1069.0	228.5	8.0	08/25/11	68.7	65.1
WC9 - Upstream #2a - Mid Weir Just Upstream	57	23	2	1078.0	225.0	6.5	08/25/11	68.6	65.0
WC9 - Upstream #3b - 1ft US Rt Side of Weir (FaceUS) - logger exposed to sun notic	55	21	1	1066.0	210.0	4.0	08/25/11	68.4	64.9
WC9 - Upstream #4 - MidWeir Just Upstream - Buried 2" in Sand	57	25	2	1107.0	248.5	9.5	08/25/11	68.7	65.2
WC9 - Downstream #1a - in Left Side of Weir (Facing US)	57	24	2	1104.0	245.0	8.0	08/25/11	68.7	65.1
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream	56	22	1	1082.5	218.5	3.5	08/25/11	68.3	65.0
WC9 - Downstream #3 - in Right Side of Weir (Facing US)	57	25	2	1106.5	247.5	8.5	08/25/11	68.7	65.1

Appendix E: Wolf Creek Summary Data 2007-2012

Site Name	Start Date	Stop date	Seasonal Maximun		Seasonal Minimum		Seasonal Max ΔT		7-Day averages			
			Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	Δ T
WC10 - Upstream #1a - Face of Gravel - 26ft from MidWeir	07/21/11	09/26/11	08/25/11	68.7	09/18/11	54.6	07/23/11	5.8	08/25/11	67.1	63.2	3.9
WC10 - Upstream #2a - 115 ft. Upstream	07/21/11	09/26/11	08/25/11	68.8	09/18/11	54.6	07/23/11	5.8	08/25/11	67.2	63.3	3.9
WC10 - Upstream #3a - above Weir in Gravel Leading Edge - Rt Side (Facing US)	07/21/11	09/26/11	08/25/11	68.8	09/18/11	54.7	07/23/11	5.8	08/25/11	67.2	63.2	3.9
WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)	07/21/11	09/26/11	08/25/11	68.6	09/18/11	54.6	07/23/11	5.7	08/25/11	67.0	63.3	3.7
WC10 - Downstream #2 - Downstream near Middle of Weir	07/21/11	09/26/11	08/25/11	68.9	09/18/11	54.5	07/23/11	5.8	08/25/11	67.2	63.3	4.0
WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster	07/21/11	09/26/11	08/25/11	68.9	09/17/11	54.8	07/23/11	5.7	08/25/11	67.3	63.4	3.9
WC10 - Downstream #4 - Downstream near Far Right Side of Weir (Facing US)	07/21/11	09/26/11	08/25/11	68.2	09/18/11	54.5	07/23/11	5.8	08/25/11	66.8	63.3	3.5
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)	07/13/11	09/26/11	08/25/11	68.2	09/17/11	54.6	07/14/11	5.0	08/25/11	66.7	63.3	3.4
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream	07/13/11	09/26/11	08/25/11	67.4	09/18/11	55.4	07/24/11	4.5	08/26/11	66.2	63.4	2.8
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)	07/13/11	09/26/11	08/25/11	68.7	09/18/11	54.3	07/23/11	6.1	08/25/11	67.1	63.0	4.1
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)	07/21/11	09/26/11	08/25/11	66.6	09/18/11	54.9	07/23/11	5.7	08/01/11	65.6	61.2	4.4
WC12 - Downstream #2a - 32 ft. Downstream	07/21/11	09/26/11	08/25/11	68.5	09/18/11	54.6	07/24/11	5.9	08/25/11	66.9	63.2	3.8
WC12 - Downstream #3 - Right Side of Main Weir (Facing US)	07/21/11	09/26/11	08/25/11	68.6	09/18/11	54.3	07/24/11	6.1	08/25/11	67.0	62.9	4.0
WC12 - Downstream #4 - near Mid Weir	07/21/11	09/26/11	08/25/11	68.6	09/18/11	55.4	07/23/11	5.9	08/25/11	67.1	63.3	3.7
WC7 - Downstream of Entire Study Area	07/11/12	09/20/12	08/16/12	69.7	09/12/12	53.4	07/11/12	5.0	08/15/12	68.3	64.4	3.9
WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	07/11/12	09/20/12	08/16/12	69.7	09/12/12	53.5	07/11/12	5.2	08/15/12	68.4	64.4	4.0
WC8 - Upstream #4a - 42' Upstream on Upstream Face of Gravel near Rt Side (FaceU	07/11/12	09/20/12	08/16/12	69.5	09/12/12	53.6	07/11/12	5.1	08/15/12	68.2	64.3	4.0
WC8 - Upstream #5a - 16' Upstream on Upstream Face of Gravel Midstream	07/11/12	09/20/12	08/16/12	69.3	09/12/12	53.6	07/19/12	4.5	08/16/12	68.2	64.8	3.4
WC8 - Upstream #6a - Buried 12" in Gravel Upstrm of Main Weir near RtBank (FaceUS)	07/11/12	09/20/12	08/16/12	68.7	09/12/12	54.4	07/11/12	4.5	08/16/12	67.6	64.8	2.9
WC8 - Upstream #7a - Buried 10" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)	07/11/12	09/20/12	08/16/12	69.7	09/12/12	53.5	07/11/12	5.3	08/15/12	68.4	64.4	4.0
WC8 - Upstream #8b - Buried in 5" Mud Upstrm fromWeir NearLeftBank (FaceUS) at Fc	07/11/12	09/20/12	08/16/12	66.3	09/12/12	53.4	09/13/12	3.6	08/16/12	65.2	63.0	2.2
WC8 - Downstream #1b - near Center of Weir (OUT OF WATER mid-Aug Discovered 8/	07/11/12	09/20/12	08/16/12	69.6	09/12/12	53.7	08/21/12	6.0	08/15/12	68.2	63.8	4.4
WC8 - Downstream #2b - To Right Side of Weir (Facing US)- Downstream of Gravel Fa	07/11/12	09/20/12	08/16/12	69.6	09/12/12	53.5	07/11/12	5.3	08/15/12	68.4	64.4	4.0
WC8 - Downstream #3b - 35 ft. Downstream MidStream (Facing US)	07/11/12	09/20/12	08/16/12	69.8	09/12/12	53.7	07/11/12	5.1	08/15/12	68.5	64.6	3.9
WC9 - Upstream #1a - 107 ft. Upstream	07/11/12	09/20/12	08/16/12	69.9	09/12/12	53.4	09/13/12	6.0	08/15/12	68.5	64.3	4.2
WC9 - US #2a - MidWeir Just Upstrm (OUT OF WATER/ON SURFACE SINCE MID-AUG	*07/11/12*	*09/20/12*	*08/25/12*	*90.5*	*08/25/12*	*49.3*	*08/25/12*	*41.2*	*08/24/12*	*86.8*	*54.5*	*32.3*
WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)	07/11/12	09/20/12	08/16/12	69.8	09/12/12	53.1	09/13/12	6.1	08/15/12	68.4	64.1	4.3
WC9 - Downstream #1a - in Left Side of Weir (Facing US)	07/12/12	09/20/12	08/16/12	69.5	09/12/12	55.6	07/19/12	5.2	08/16/12	68.2	65.1	3.1
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream	07/12/12	09/20/12	08/16/12	69.9	09/12/12	53.1	09/13/12	6.1	08/15/12	68.5	64.1	4.4
WC9 - Downstream #3a - in Right Side of Weir (Facing US)	07/12/12	09/20/12	08/16/12	70.0	09/12/12	53.3	09/13/12	6.1	08/15/12	68.6	64.3	4.3
WC10 - Upstream #1a - Upstream 26ft from MidWeir	07/12/12	09/20/12	08/16/12	70.1	09/12/12	53.6	07/19/12	6.0	08/15/12	68.6	64.3	4.3
WC10 - Upstream #2a - 115 ft. Upstream	07/12/12	09/20/12	08/16/12	70.0	09/12/12	53.8	07/19/12	5.7	08/15/12	68.6	64.4	4.2
WC10 - Upstream #3b - 3 ft. Upstream from Weir - MidWeir	07/12/12	09/20/12	08/16/12	69.9	09/12/12	53.4	09/13/12	6.2	08/15/12	68.5	64.3	4.2
WC10 - Downstream #1a - In Weir Left Side (Facing US)	07/12/12	09/20/12	08/16/12	69.5	09/12/12	54.6	07/19/12	5.9	08/15/12	68.0	64.4	3.5
WC10 - Downstream #2 - Downstream near Middle of Weir	07/12/12	09/20/12	08/16/12	70.3	09/12/12	53.3	09/13/12	6.4	08/15/12	68.8	64.2	4.6
WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster	07/12/12	09/20/12	08/16/12	70.0	09/12/12	53.9	07/19/12	6.0	08/15/12	68.5	64.5	4.1
WC10 - Downstream #4a - Downstream near Far Right Side of Weir (Facing US)	07/12/12	09/20/12	08/16/12	70.2	09/12/12	53.2	09/13/12	6.4	08/15/12	68.7	64.1	4.6
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)	07/12/12	09/20/12	08/16/12	67.3	09/12/12	53.0	07/19/12	6.4	08/06/12	65.5	62.7	2.8
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream	07/12/12	09/20/12	08/06/12	65.2	09/12/12	54.1	07/13/12	4.3	08/17/12	64.2	63.0	1.2
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)	07/12/12	09/20/12	08/16/12	69.5	09/12/12	53.3	07/19/12	5.5	08/15/12	68.0	63.9	4.2
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)	07/12/12	09/20/12	08/16/12	71.3	09/12/12	54.0	07/19/12	6.4	08/15/12	69.0	63.8	5.2
WC12 - Downstream #2a - 32 ft. Downstream	07/12/12	09/20/12	08/16/12	70.2	09/12/12	53.9	07/19/12	6.2	08/15/12	68.6	64.0	4.5
WC12 - Downstream #3a - Right Side of Main Weir (Facing US)	07/12/12	09/20/12	08/16/12	70.8	09/12/12	53.1	09/13/12	7.3	08/15/12	69.2	63.9	5.3
WC12 - Downstream #4 - near Mid Weir	07/12/12	09/20/12	08/16/12	71.0	09/12/12	53.2	09/13/12	7.0	08/15/12	69.2	63.9	5.3
WC8 - Air on Bank - on the Ground	07/11/12	09/20/12	08/15/12	79.7	09/12/12	45.1	08/14/12	21.3	08/14/12	76.4	58.4	18.0

Appendix E: Wolf Creek Summary Data 2007-2012

Site Name	Days > 60_8 F	Days > 64_4 F	Days > 68 F	Hours > 60_8 F	Hours > 64_4 F	Hours > 68 F	Warmest day of 7-da Date	Maximum
WC10 - Upstream #1a - Face of Gravel - 26ft from MidWeir	57	24	2	1095.0	239.5	9.5	08/25/11	68.7
WC10 - Upstream #2a - 115 ft. Upstream	57	25	2	1115.5	256.5	11.0	08/25/11	68.8
WC10 - Upstream #3a - above Weir in Gravel Leading Edge - Rt Side (Facing US)	57	24	2	1092.0	245.0	10.0	08/25/11	68.8
WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)	57	22	2	1085.0	227.0	8.0	08/25/11	68.6
WC10 - Downstream #2 - Downstream near Middle of Weir	57	26	3	1103.5	256.0	12.5	08/25/11	68.9
WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster	57	26	3	1111.0	263.5	13.0	08/25/11	68.9
WC10 - Downstream #4 - Downstream near Far Right Side of Weir (Facing US)	57	23	1	1079.0	235.0	3.0	08/25/11	68.2
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)	59	19	1	1060.5	196.5	2.5	08/25/11	68.2
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream	57	17	0	1063.0	152.5	0.0	08/25/11	67.4
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)	60	24	1	1070.5	223.0	8.0	08/25/11	68.7
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)	52	18	0	935.0	146.5	0.0	07/30/11	66.6
WC12 - Downstream #2a - 32 ft. Downstream	57	23	1	1062.0	217.5	7.5	08/25/11	68.5
WC12 - Downstream #3 - Right Side of Main Weir (Facing US)	57	23	1	1046.5	215.0	8.0	08/25/11	68.6
WC12 - Downstream #4 - near Mid Weir	56	24	1	1079.5	247.5	8.5	08/25/11	68.6
WC7 - Downstream of Entire Study Area	58	33	3	1116.5	394.0	31.5	08/16/12	69.7
WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb	58	34	4	1138.0	418.0	35.0	08/16/12	69.7
WC8 - Upstream #4a - 42' Upstream on Upstream Face of Gravel near Rt Side (Face	58	32	3	1104.5	385.0	32.5	08/16/12	69.5
WC8 - Upstream #5a - 16' Upstream on Upstream Face of Gravel Midstream	58	36	4	1159.5	394.5	32.0	08/16/12	69.3
WC8 - Upstream #6a - Buried 12" in Gravel Upstrm of Main Weir near RtBank (FaceU	58	27	3	1144.0	340.0	21.0	08/16/12	68.7
WC8 - Upstream #7a - Buried 10" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)	60	35	4	1140.5	424.0	36.0	08/16/12	69.7
WC8 - Upstream #8b - Buried in 5" Mud Upstrm from Weir NearLeftBank (FaceUS) at	42	6	0	848.5	59.5	0.0	08/16/12	66.3
WC8 - Downstream #1b - near Center of Weir (OUT OF WATER mid-Aug Discovered	59	34	3	1126.0	395.0	27.5	08/16/12	69.6
WC8 - Downstream #2b - To Right Side of Weir (Facing US)- Downstream of Gravel	59	34	3	1128.0	416.5	33.5	08/16/12	69.6
WC8 - Downstream #3b - 35 ft. Downstream MidStream (Facing US)	61	35	5	1172.5	442.0	42.5	08/16/12	69.8
WC9 - Upstream #1a - 107 ft. Upstream	66	36	5	1160.0	405.0	39.0	08/16/12	69.9
WC9 - US #2a - MidWeir Just Upstrm (OUT OF WATER/ON SURFACE SINCE MID-A	*66*	*41*	*15*	*1127.5*	*466.0*	*81.5*	*08/25/12*	*90.5*
WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)	65	36	5	1139.0	398.5	37.0	08/16/12	69.8
WC9 - Downstream #1a - in Left Side of Weir (Facing US)	54	31	4	1098.5	390.0	35.0	08/16/12	69.5
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream	65	35	5	1126.5	403.5	40.0	08/16/12	69.9
WC9 - Downstream #3a - in Right Side of Weir (Facing US)	65	35	6	1172.5	431.5	47.0	08/16/12	70.0
WC10 - Upstream #1a - Upstream 26ft from MidWeir	65	35	6	1120.5	400.5	38.5	08/16/12	70.1
WC10 - Upstream #2a - 115 ft. Upstream	65	35	7	1139.5	397.0	38.5	08/16/12	70.0
WC10 - Upstream #3b - 3 ft. Upstream from Weir - MidWeir	65	35	5	1132.5	391.0	33.5	08/16/12	69.9
WC10 - Downstream #1a - In Weir Left Side (Facing US)	56	33	3	1064.0	373.0	25.0	08/16/12	69.5
WC10 - Downstream #2 - Downstream near Middle of Weir	65	35	7	1135.0	411.5	49.5	08/16/12	70.3
WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster	65	35	6	1149.0	417.0	38.5	08/16/12	70.0
WC10 - Downstream #4a - Downstream near Far Right Side of Weir (Facing US)	65	35	7	1110.0	398.5	46.5	08/16/12	70.2
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)	48	23	0	927.5	180.0	0.0	08/05/12	66.9
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream	45	9	0	865.0	61.0	0.0	08/17/12	65.1
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)	58	32	3	994.5	313.0	20.5	08/16/12	69.5
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)	66	35	8	1074.0	371.5	44.5	08/16/12	71.3
WC12 - Downstream #2a - 32 ft. Downstream	61	34	6	1033.0	355.0	29.5	08/16/12	70.2
WC12 - Downstream #3a - Right Side of Main Weir (Facing US)	67	36	9	1090.0	387.5	53.0	08/16/12	70.8
WC12 - Downstream #4 - near Mid Weir	67	36	9	1105.5	402.0	56.0	08/16/12	71.0
WC8 - Air on Bank - on the Ground	71	64	41	851.0	488.5	213.0	08/15/12	79.7


Wolf Creek #8 - Weir and Gravel Added
8/16/09 to 8/22/09
Week Surrounding Highest Stream Temperature
from mid-August to mid-September
WC8_US1_Buried_in_Gravel_2009
WC8_US2_Furthest_US_2009
WC8_US3_Buried_in_Mud_2009
WC8_DS1_in_Weir_Left_Side_2009
WC8_DS2_Near_Mid_of_Weir_2009
WC8_DS3_53ft_DS_2009
Temperature (Degrees F)
68
66
64
62
60
58
8/16/09 0:00
8/16/09 12:00
8/17/09 0:00
8/17/09 12:00
8/18/09 0:00
8/18/09 12:00
8/19/09 0:00
8/19/09 12:00
8/20/09 0:00
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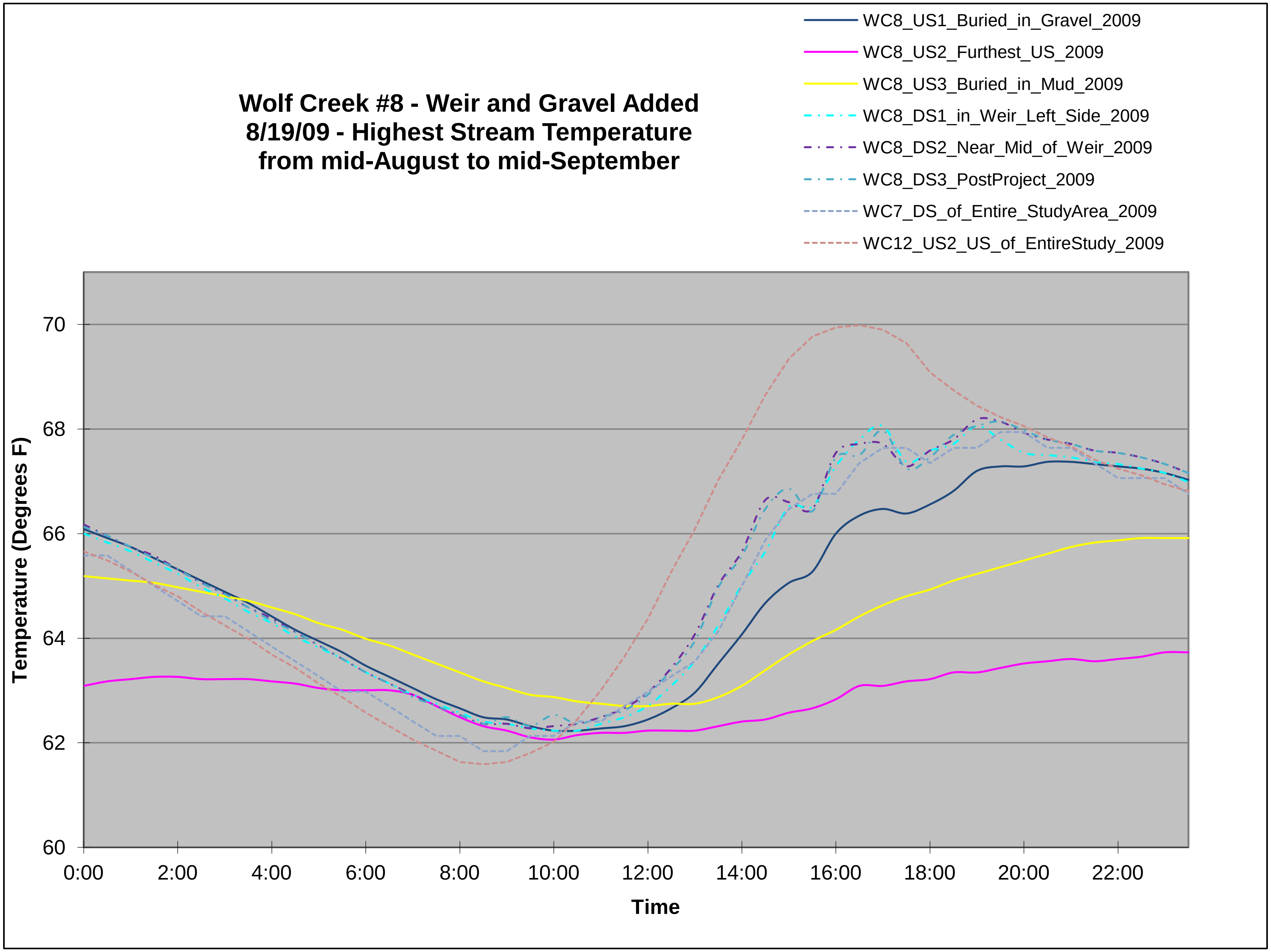
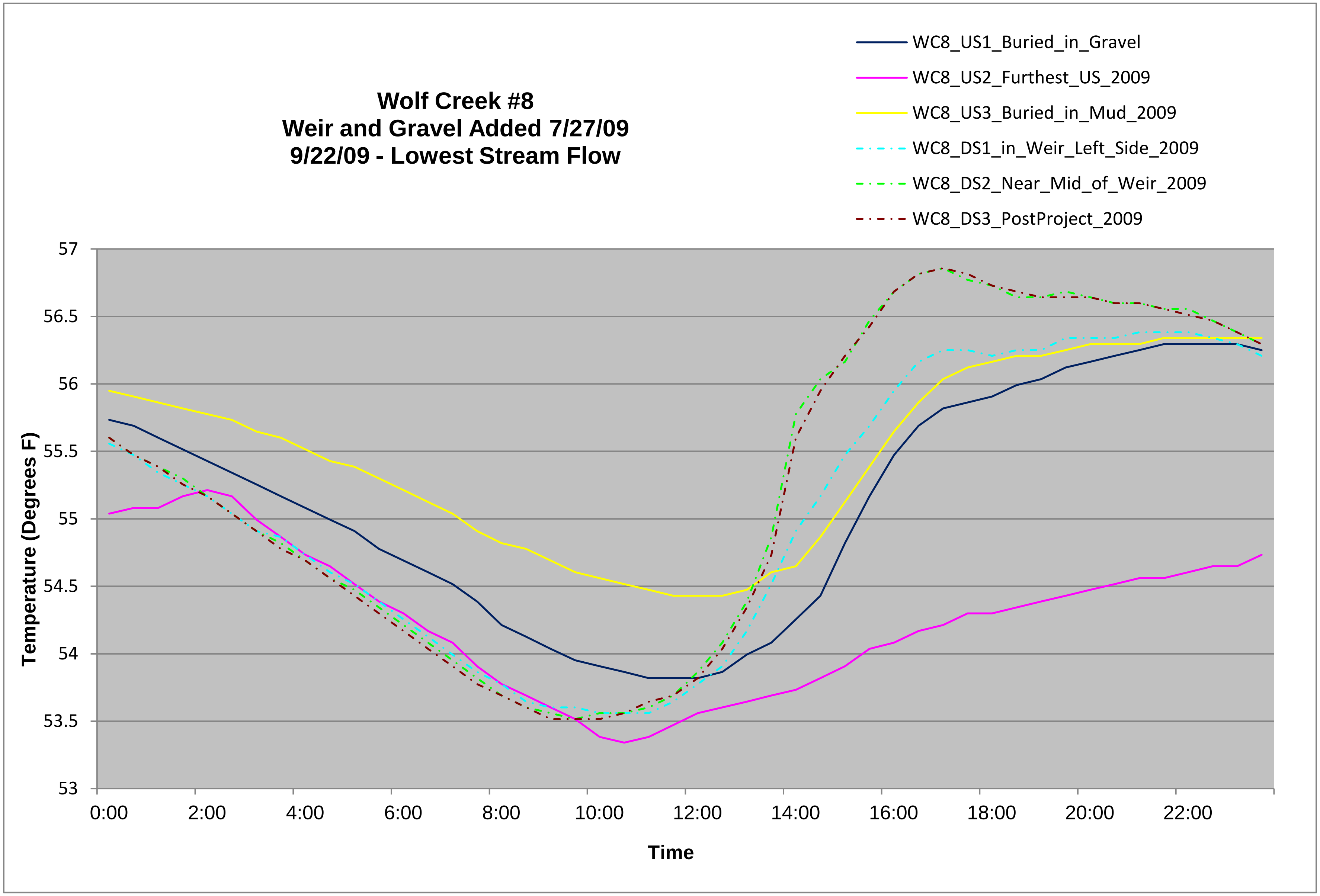
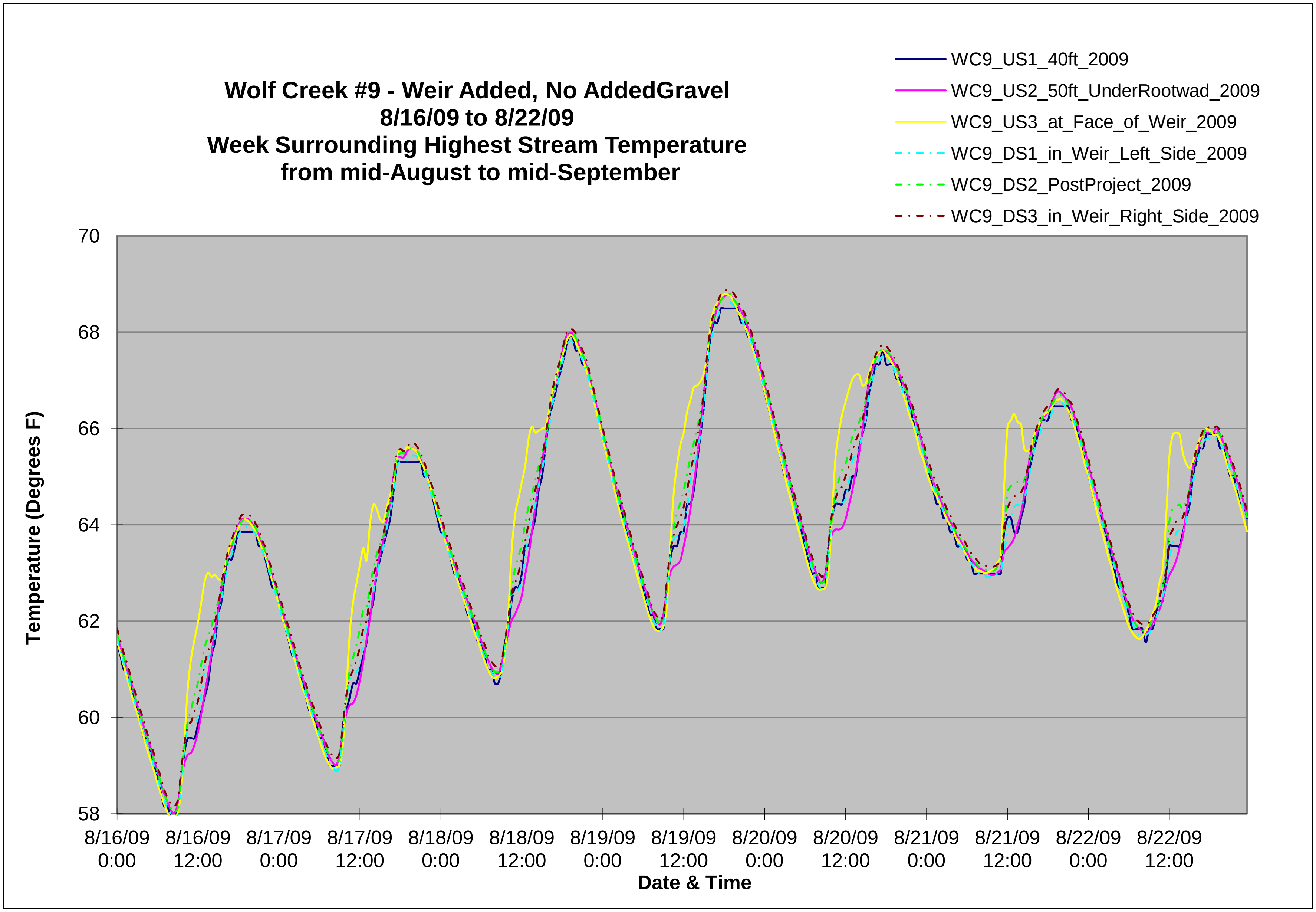
8/22/09 12:00
Date and Time


Wolf Creek #8 - Weir and Gravel Added
8/19/09 - Highest Stream Temperature
from mid-August to mid-September
WC8_US1_Buried_in_Gravel_2009
WC8_US2_Furthest_US_2009
WC8_US3_Buried_in_Mud_2009
WC8_DS1_in_Weir_Left_Side_2009
WC8_DS2_Near_Mid_of_Weir_2009
WC8_DS3_PostProject_2009
WC7_DS_of_Entire_StudyArea_2009
WC12_US2_US_of_EntireStudy_2009
Temperature (Degrees F)
70
68
66
64
62
60
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

Appendix F: 2009 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12





Wolf Creek #9 - Weir Added, No AddedGravel
8/16/09 to 8/22/09
Week Surrounding Highest Stream Temperature
from mid-August to mid-September
WC9_US1_40ft_2009
WC9_US2_50ft_UnderRootwad_2009
WC9_US3_at_Face_of_Weir_2009
WC9_DS1_in_Weir_Left_Side_2009
WC9_DS2_PostProject_2009
WC9_DS3_in_Weir_Right_Side_2009
Temperature (Degrees F)
70
68
66
64
62
60
58
8/16/09 0:00
8/16/09 12:00
8/17/09 0:00
8/17/09 12:00
8/18/09 0:00
8/18/09 12:00
8/19/09 0:00
8/19/09 12:00
8/20/09 0:00
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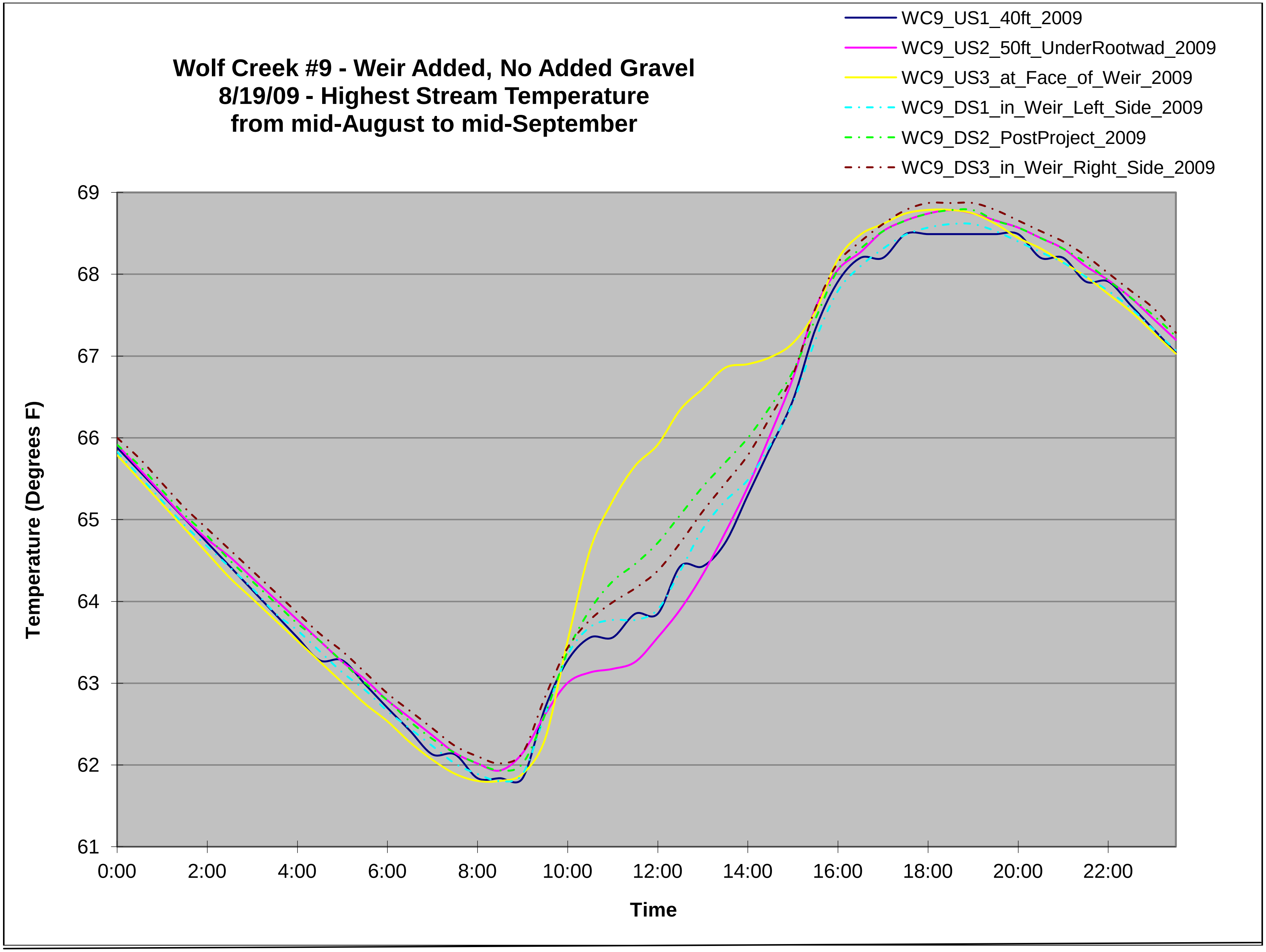
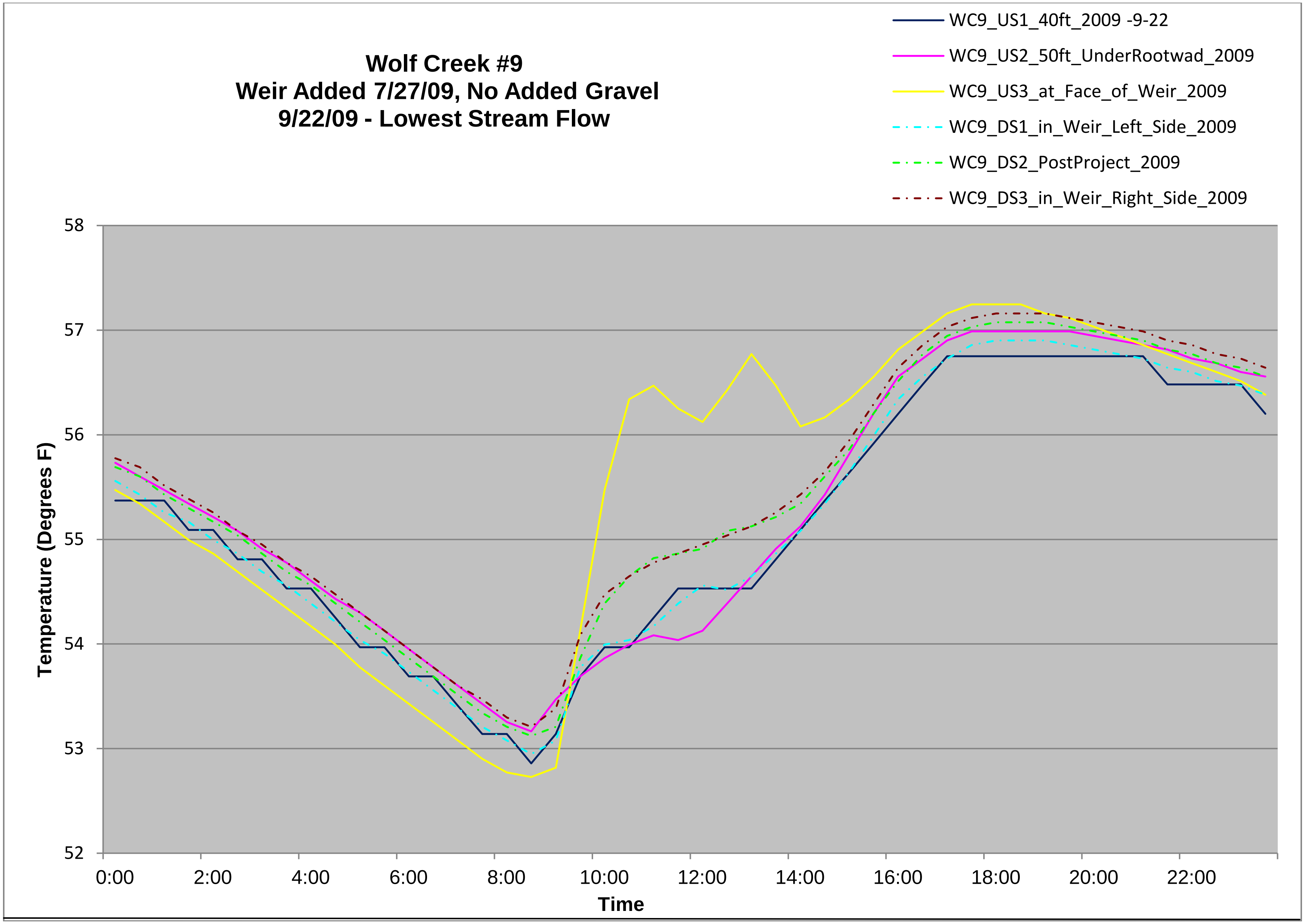
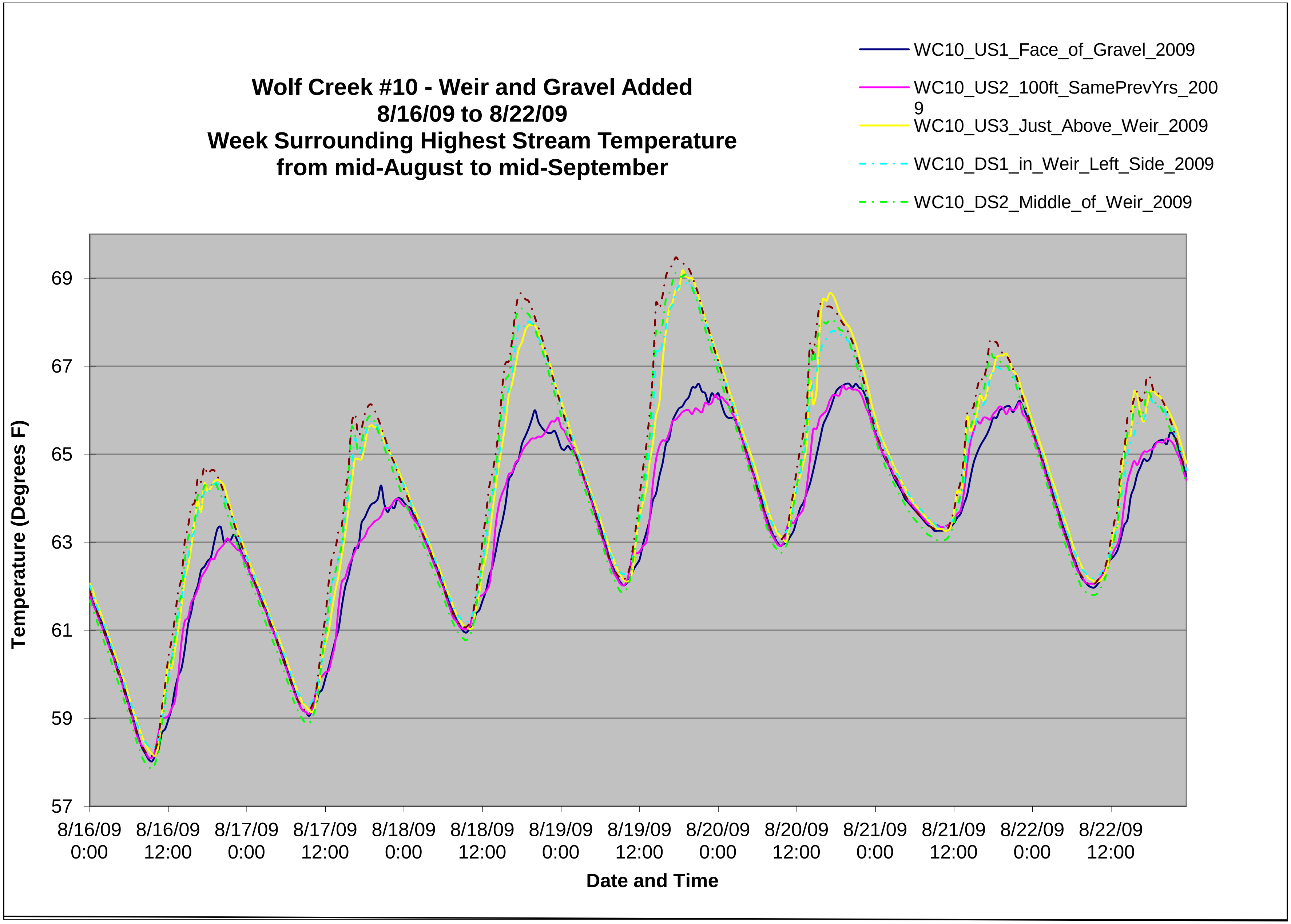
8/22/09 0:00
8/22/09 12:00
Date & Time


Wolf Creek #9 - Weir Added, No Added Gravel
8/19/09 - Highest Stream Temperature
from mid-August to mid-September
WC9_US1_40ft_2009
WC9_US2_50ft_UnderRootwad_2009
WC9_US3_at_Face_of_Weir_2009
WC9_DS1_in_Weir_Left_Side_2009
WC9_DS2_PostProject_2009
WC9_DS3_in_Weir_Right_Side_2009
Temperature (Degrees F)
69
68
67
66
65
64
63
62
61
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

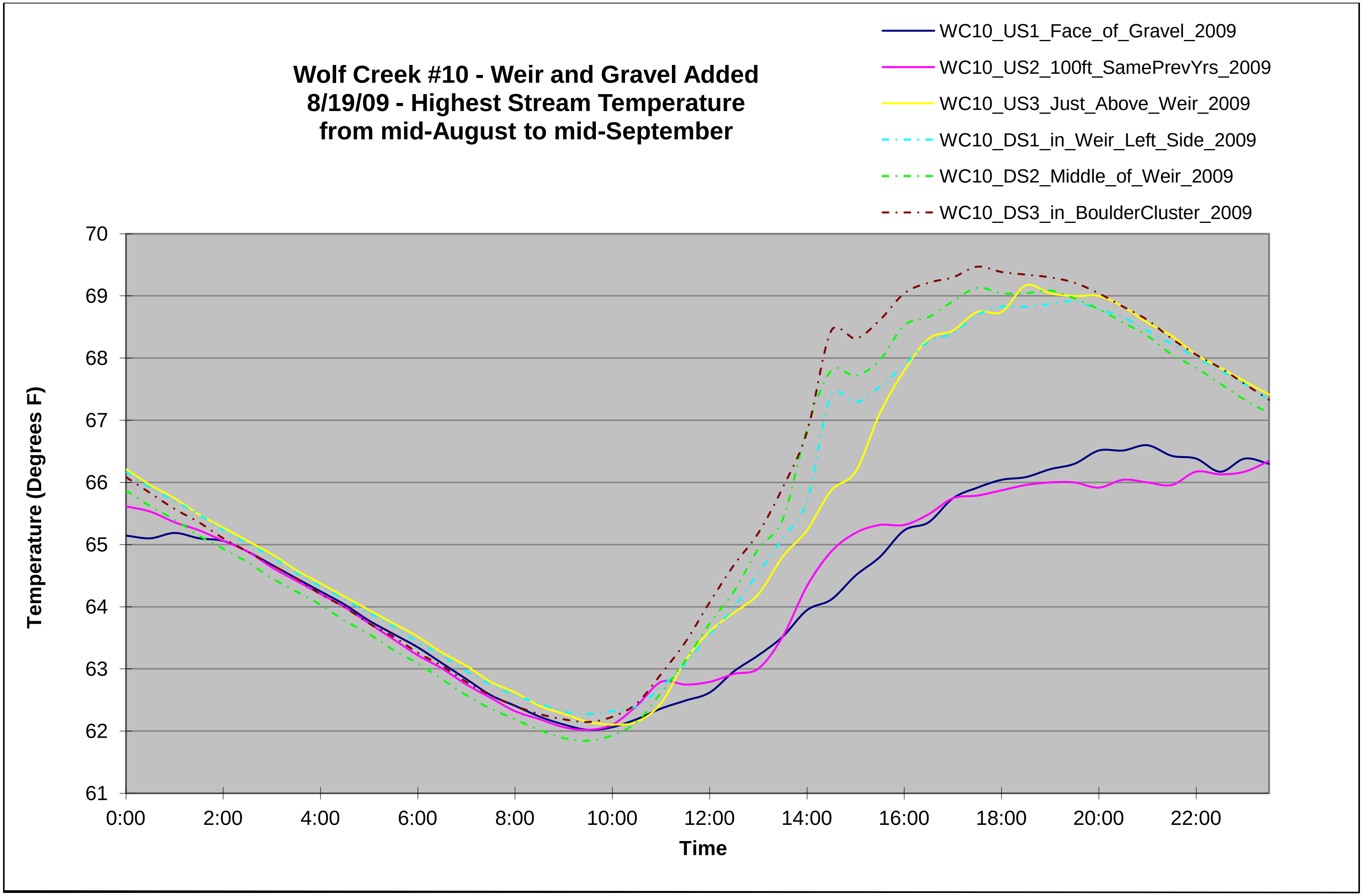
Appendix F: 2009 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12



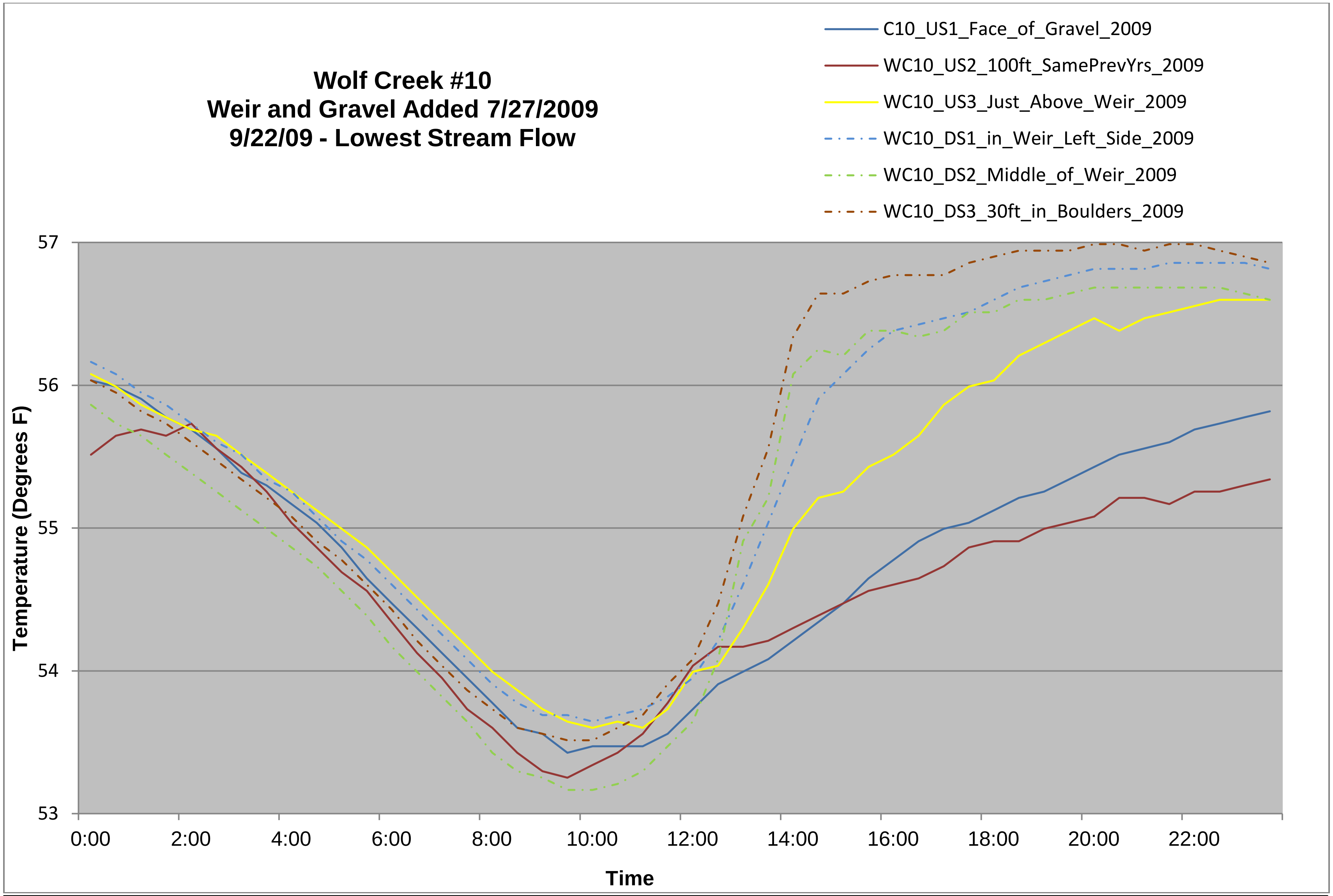
Appendix F: 2009 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

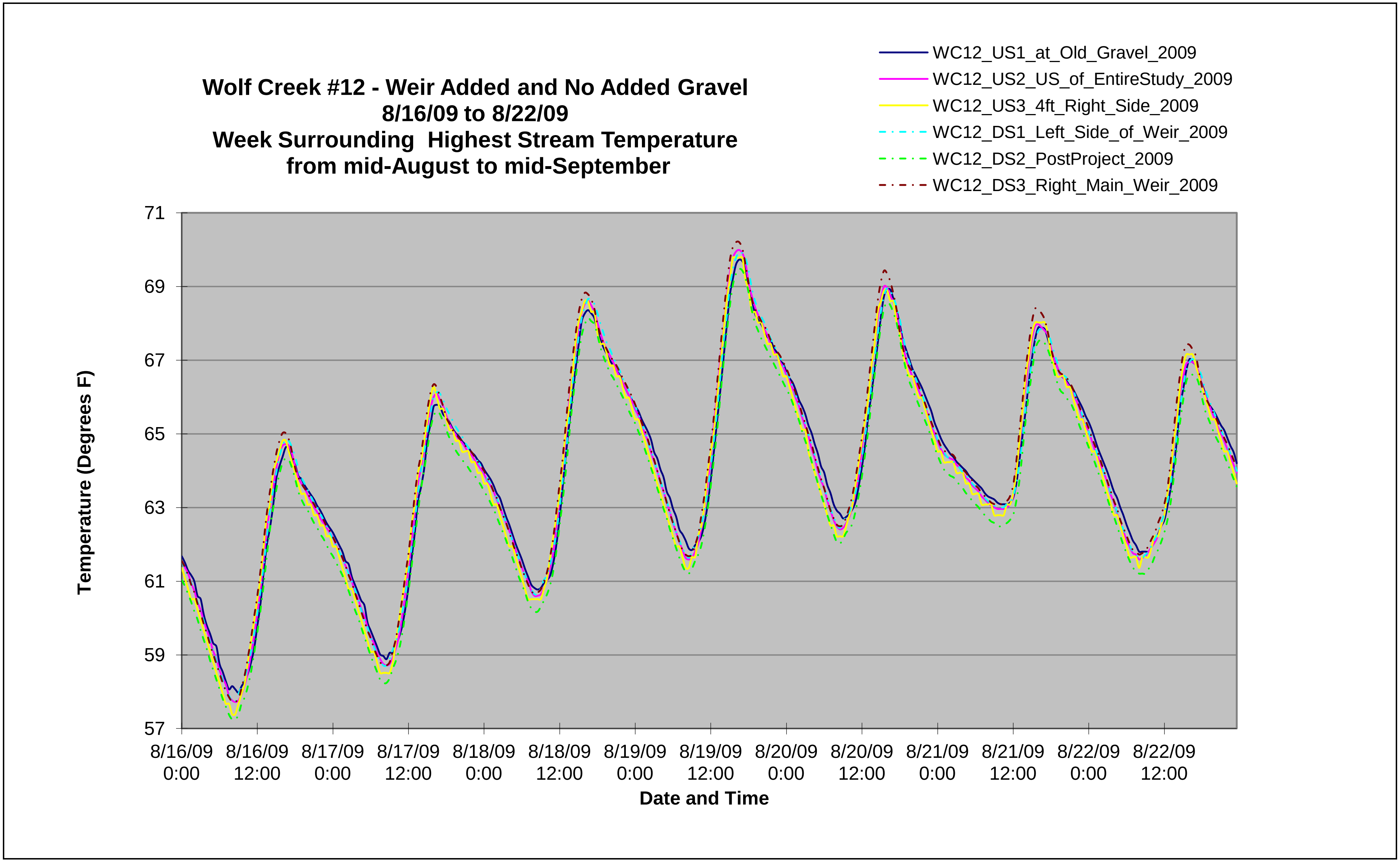


Appendix F: 2009 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

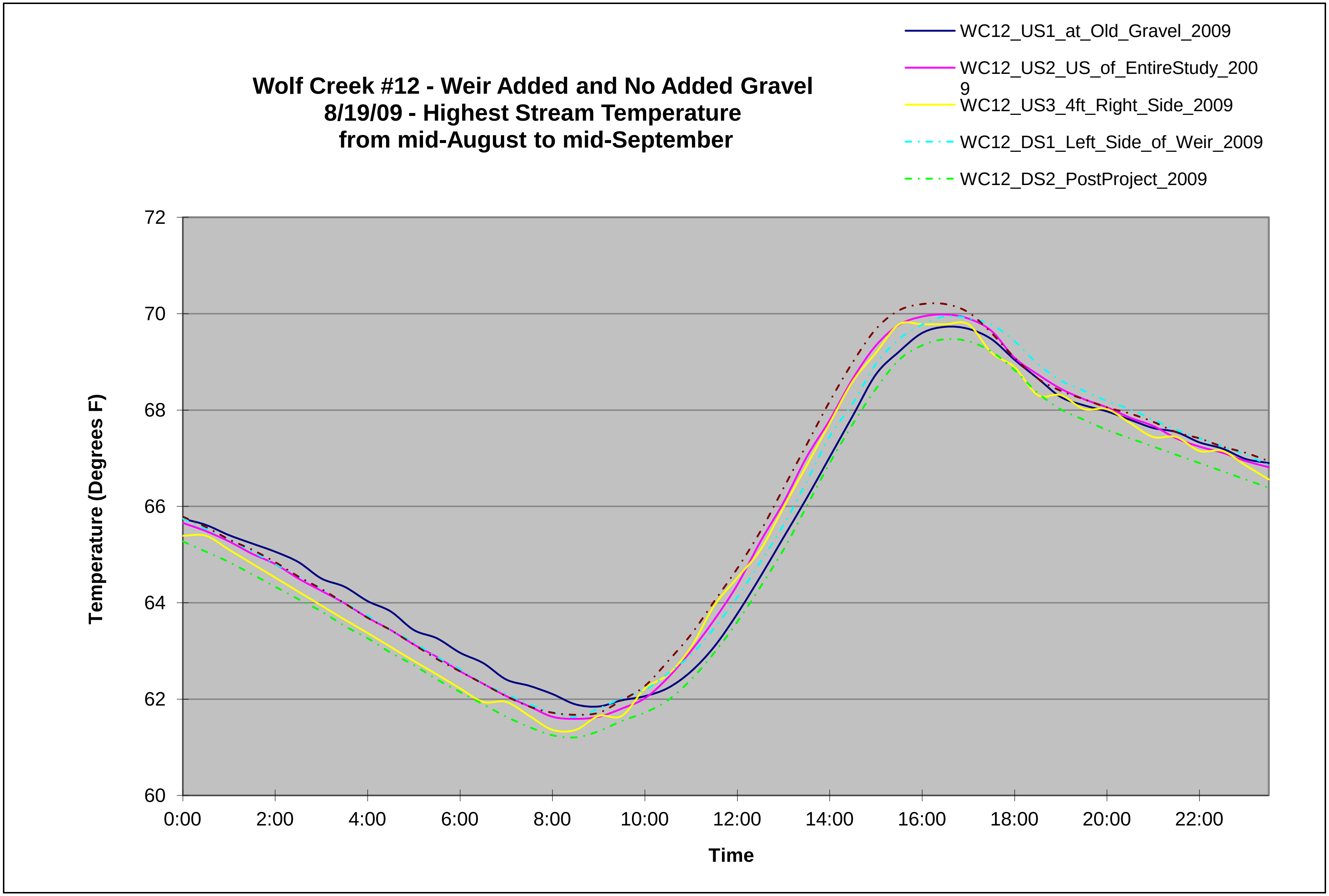


Appendix F: 2009 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

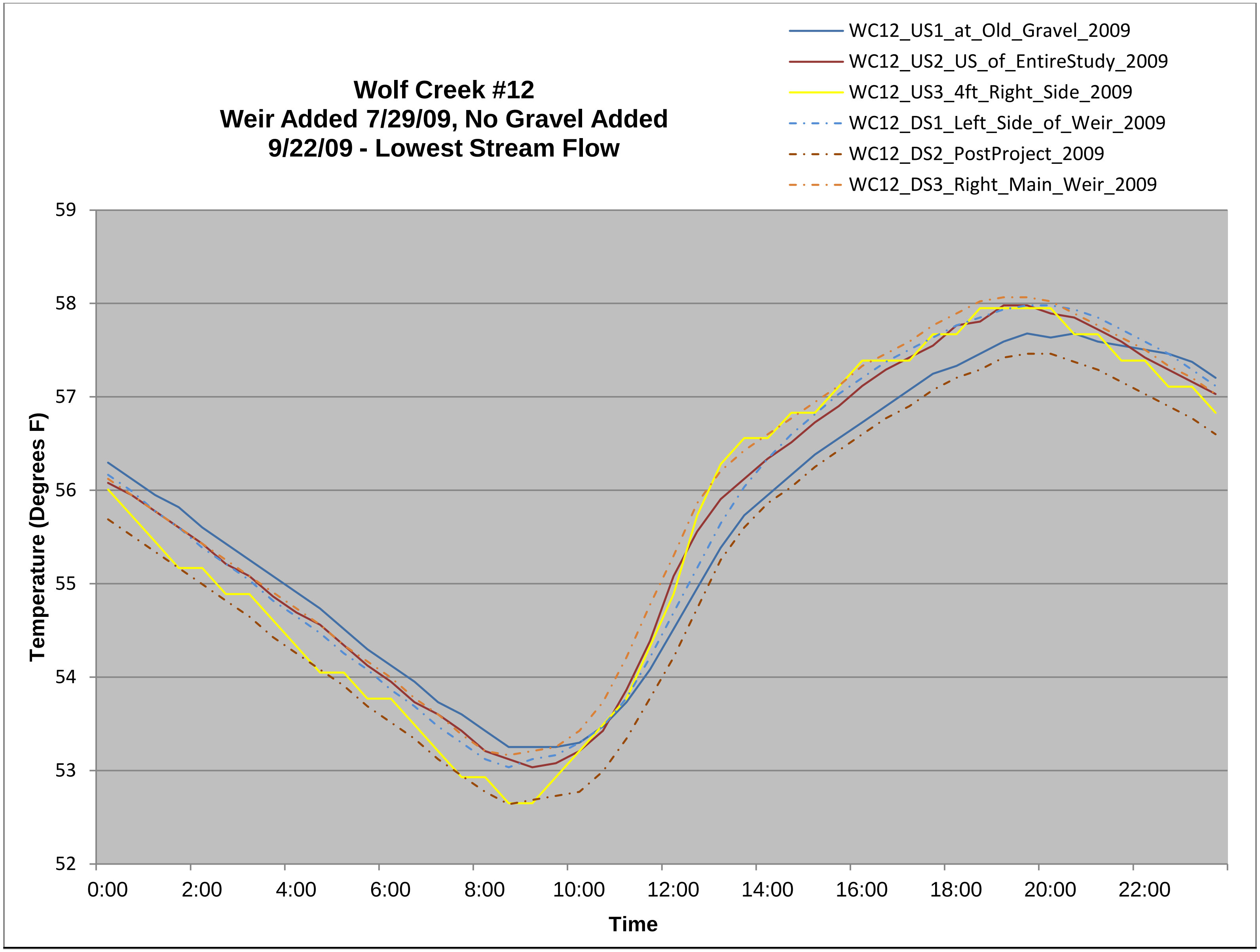



Wolf Creek #12 - Weir Added and No Added Gravel
8/16/09 to 8/22/09
Week Surrounding Highest Stream Temperature
from mid-August to mid-September
WC12_US1_at_Old_Gravel_2009
WC12_US2_US_of_EntireStudy_2009
WC12_US3_4ft_Right_Side_2009
WC12_DS1_Left_Side_of_Weir_2009
WC12_DS2_PostProject_2009
WC12_DS3_Right_Main_Weir_2009
Temperature (Degrees F)
71
69
67
65
63
61
59
57
8/16/09 0:00
8/16/09 12:00
8/17/09 0:00
8/17/09 12:00
8/18/09 0:00
8/18/09 12:00
8/19/09 0:00
8/19/09 12:00
8/20/09 0:00
8/20/09 12:00
8/21/09 0:00
8/21/09 12:00
8/22/09 0:00
8/22/09 12:00
Date and Time

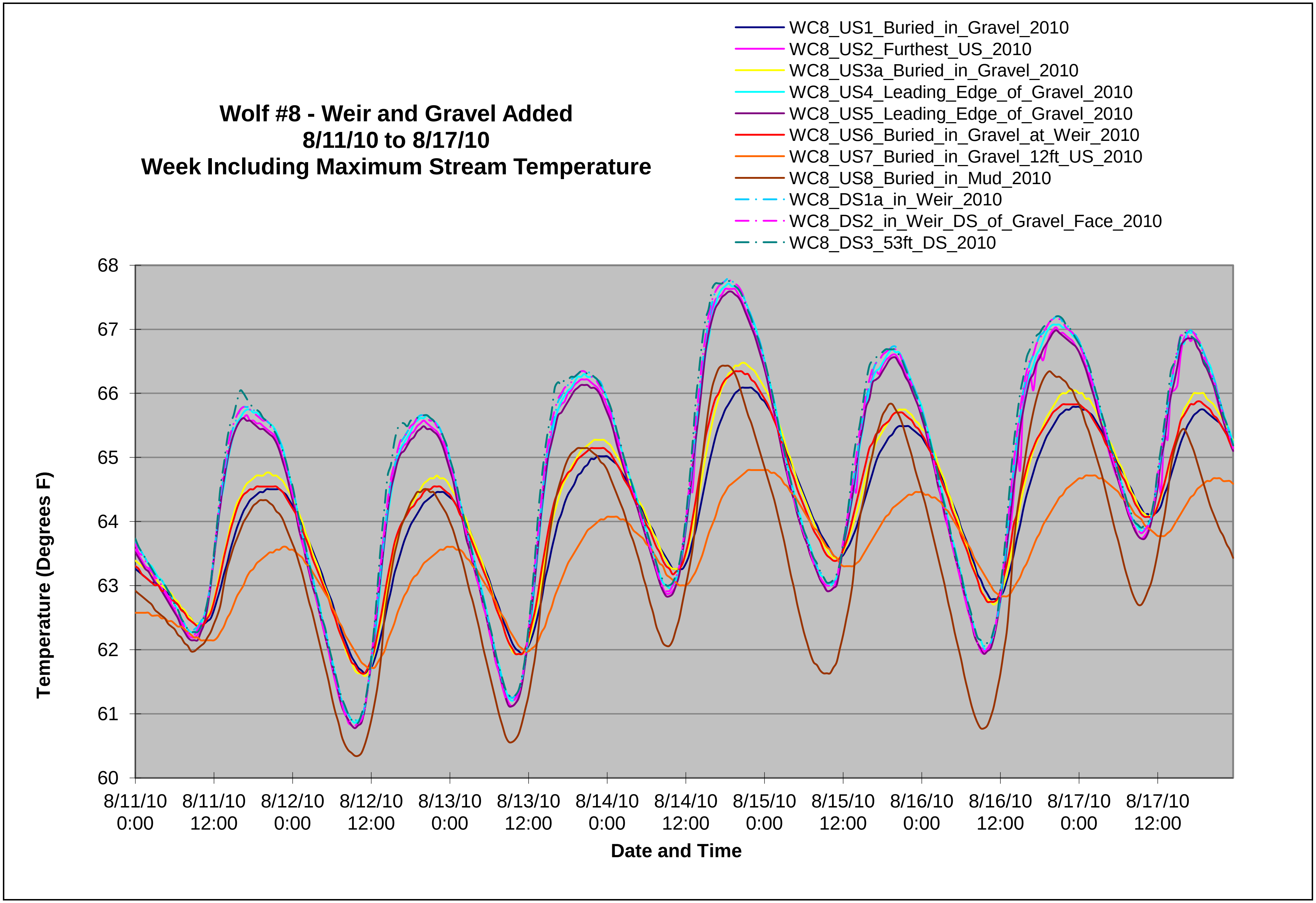
Appendix F: 2009 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12



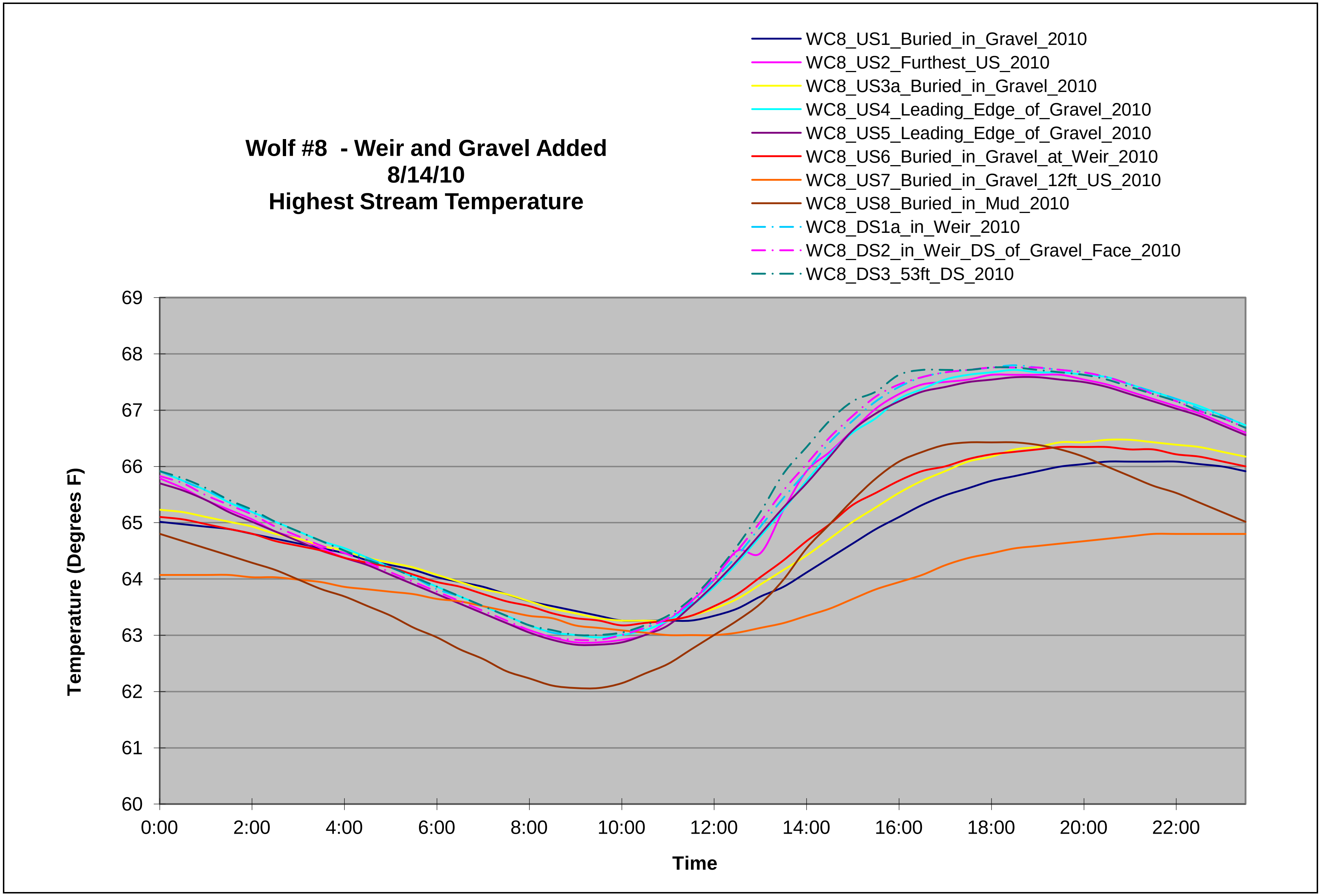
Appendix F: 2009 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

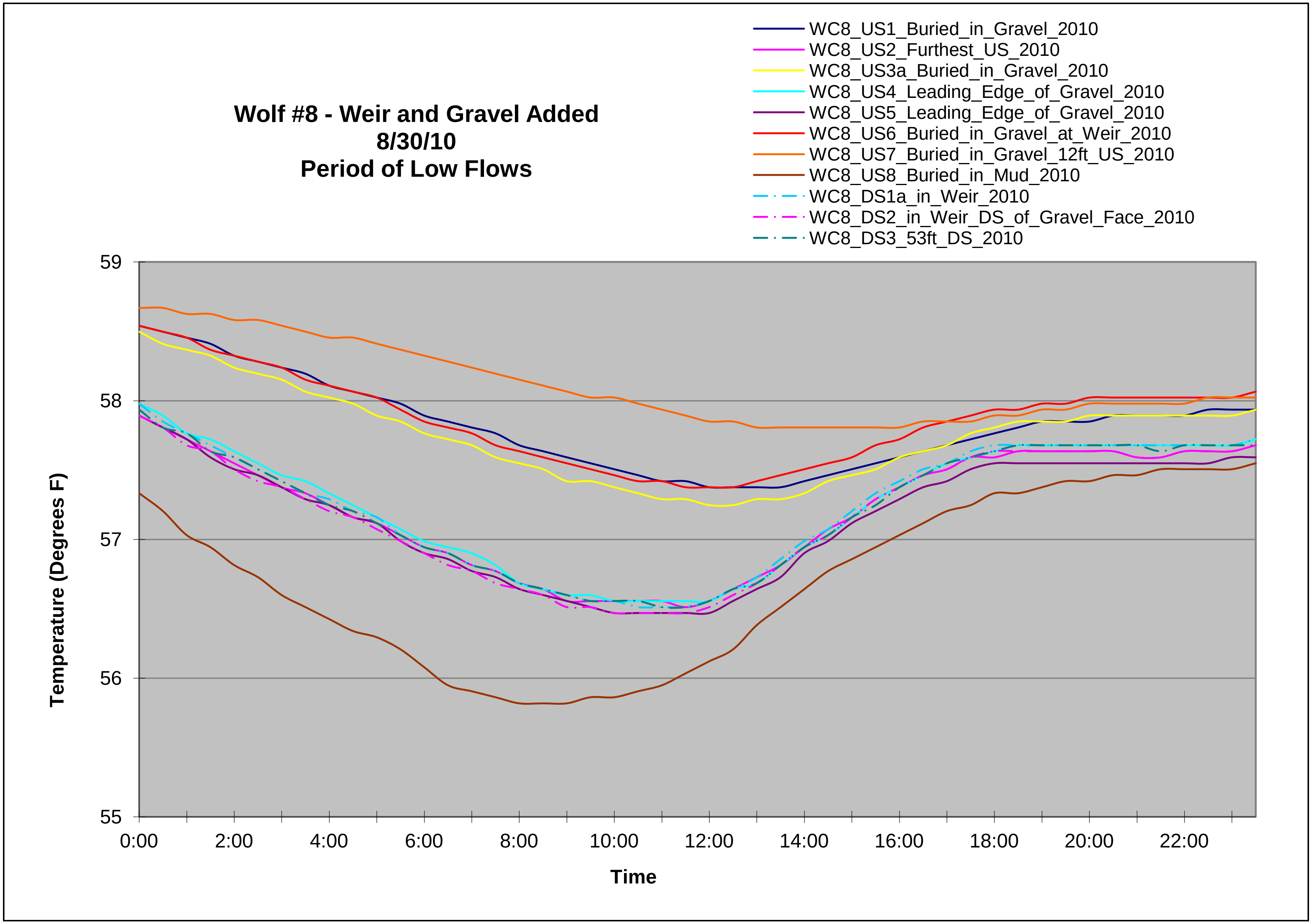


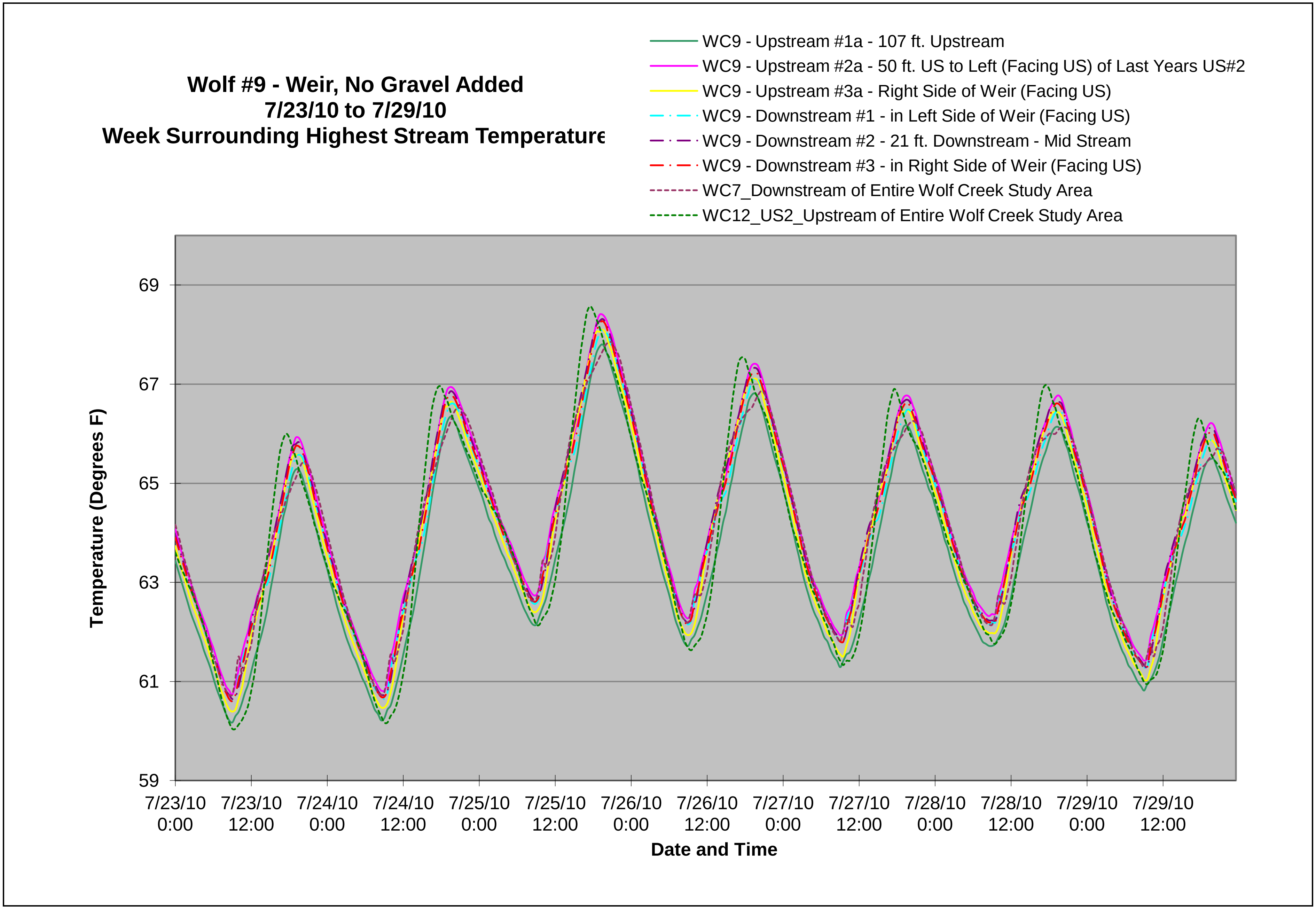
Appendix G: 2010 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12



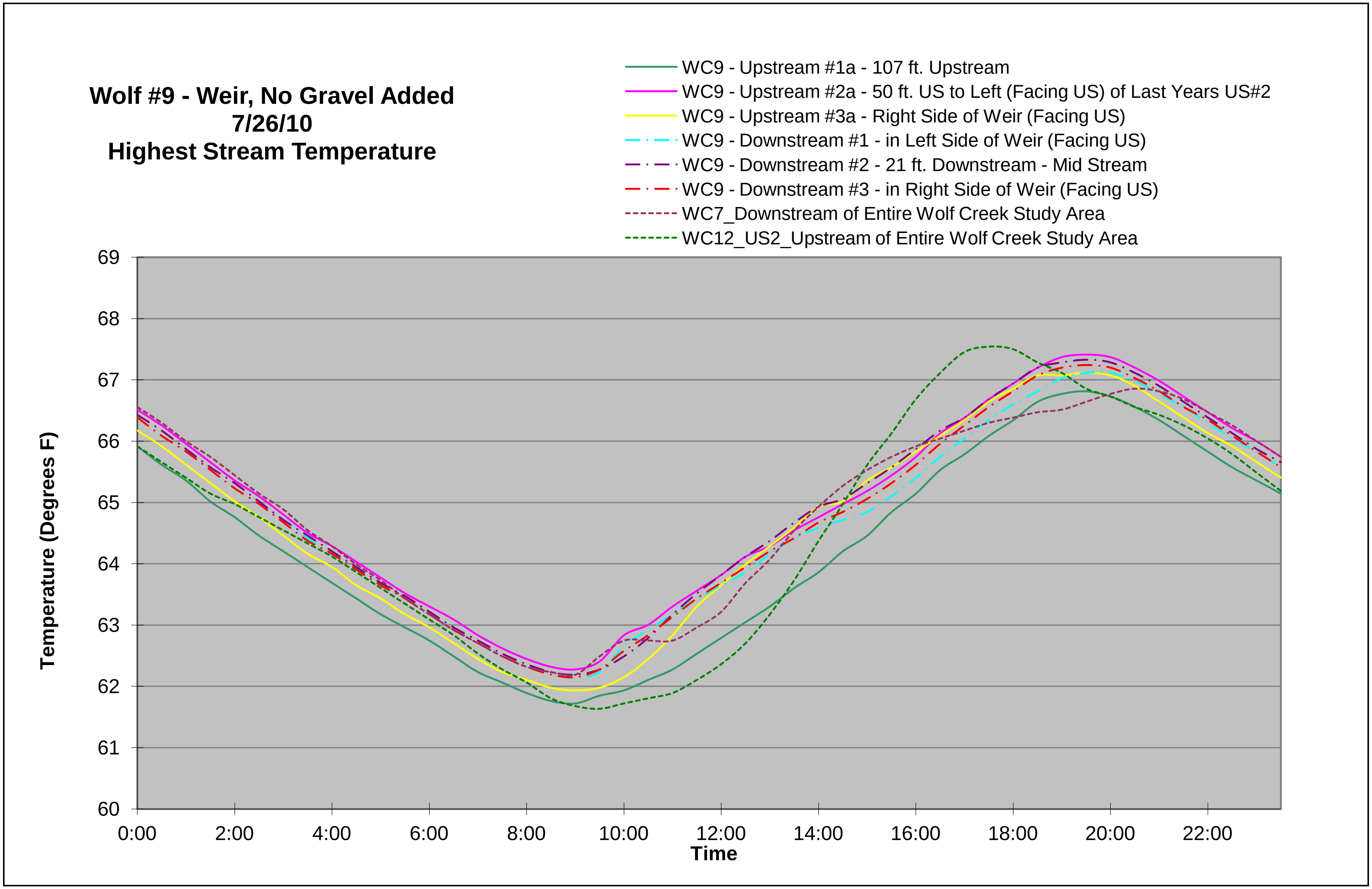
Appendix G: 2010 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

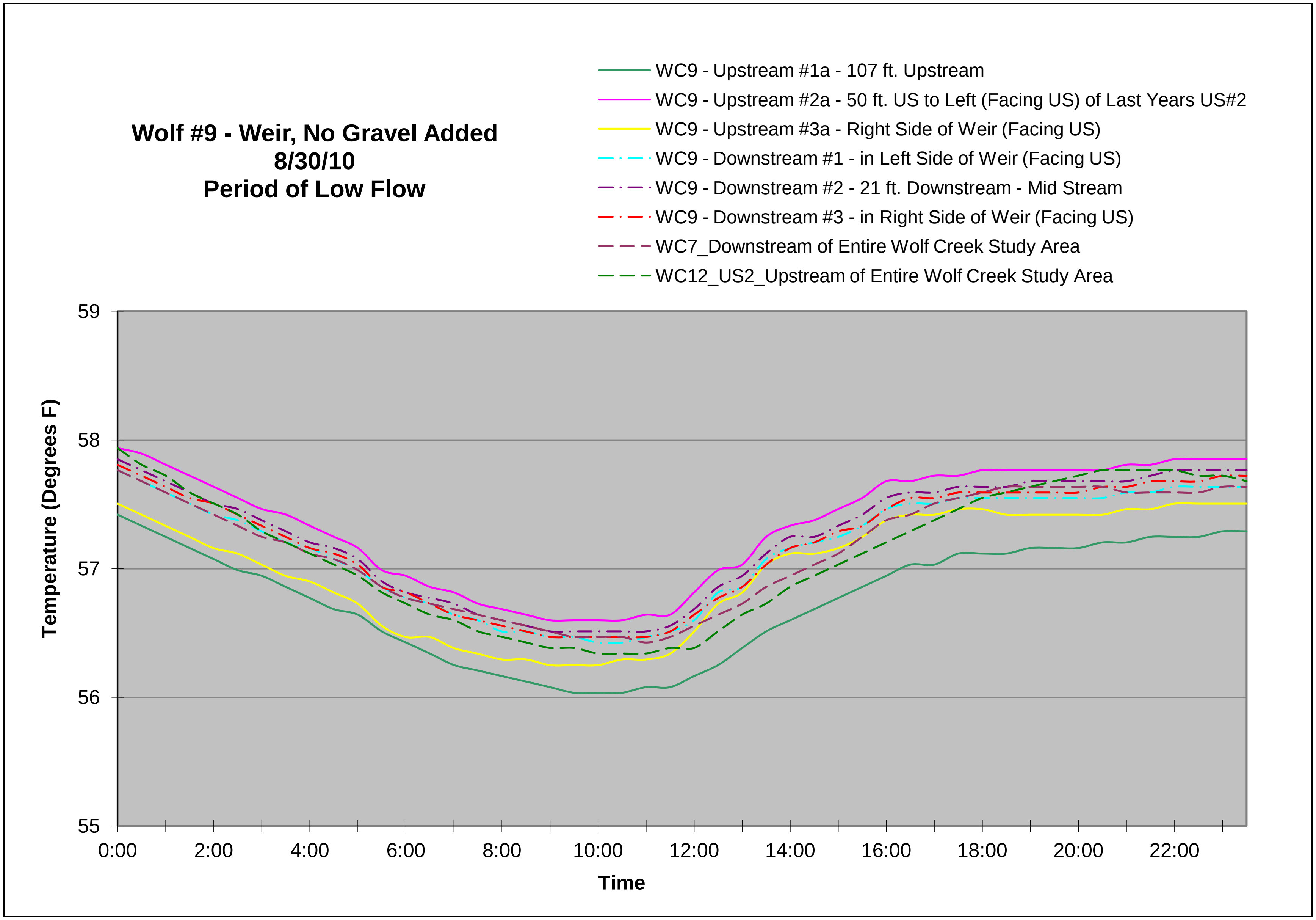



Wolf #8 - Weir and Gravel Added
8/30/10
Period of Low Flows
WC8_US1_Buried_in_Gravel_2010
WC8_US2_Furthest_US_2010
WC8_US3a_Buried_in_Gravel_2010
WC8_US4_Leading_Edge_of_Gravel_2010
WC8_US5_Leading_Edge_of_Gravel_2010
WC8_US6_Buried_in_Gravel_at_Weir_2010
WC8_US7_Buried_in_Gravel_12ft_US_2010
WC8_US8_Buried_in_Mud_2010
WC8_DS1a_in_Weir_2010
WC8_DS2_in_Weir_DS_of_Gravel_Face_2010
WC8_DS3_53ft_DS_2010
Temperature (Degrees F)
59
58
57
56
55
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

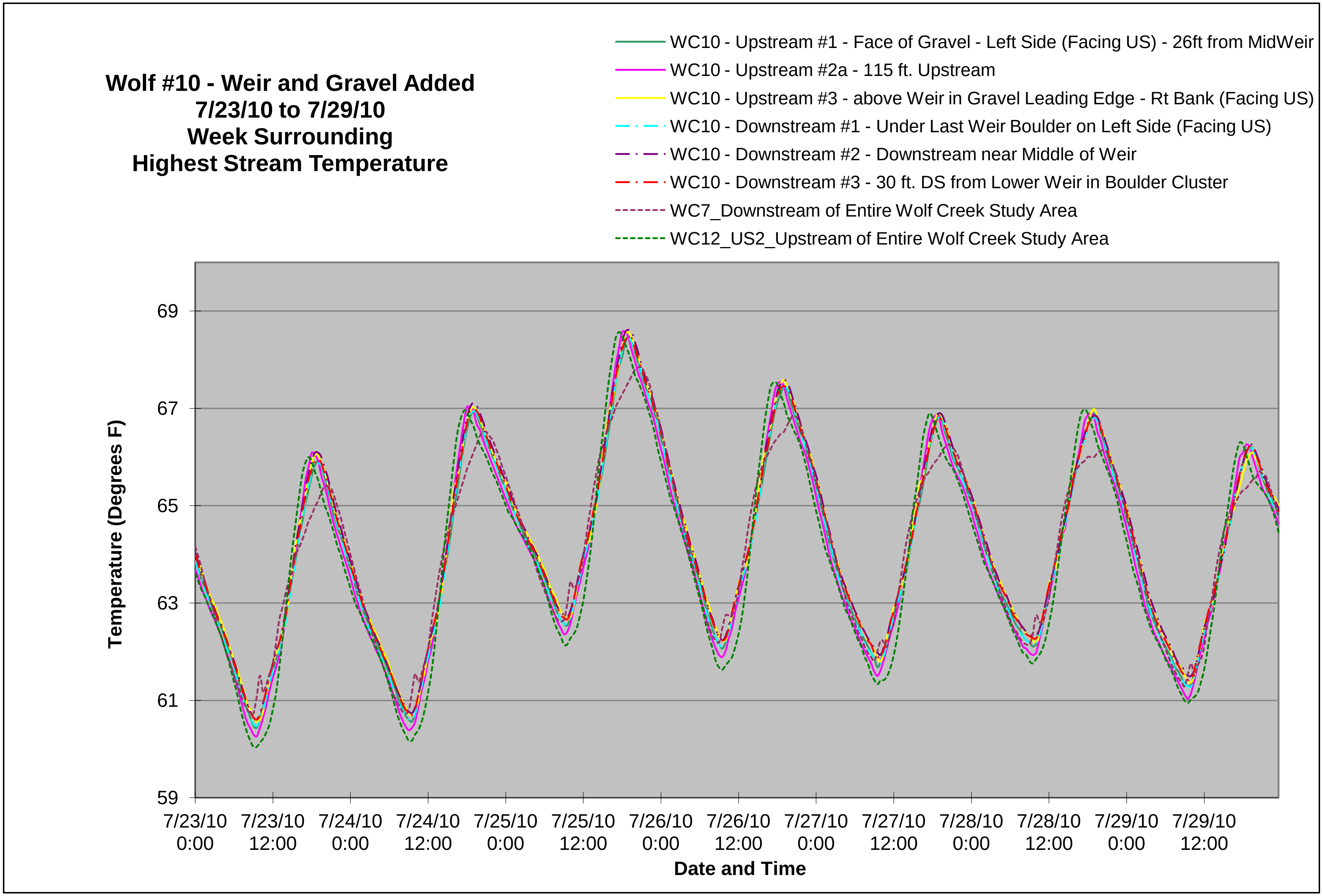

Wolf #9 - Weir, No Gravel Added
7/23/10 to 7/29/10
Week Surrounding Highest Stream Temperature
WC9 - Upstream #1a - 107 ft. Upstream
WC9 - Upstream #2a - 50 ft. US to Left (Facing US) of Last Years US#2
WC9 - Upstream #3a - Right Side of Weir (Facing US)
WC9 - Downstream #1 - in Left Side of Weir (Facing US)
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
WC9 - Downstream #3 - in Right Side of Weir (Facing US)
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
69
67
65
63
61
59
7/23/10 0:00
7/23/10 12:00
7/24/10 0:00
7/24/10 12:00
7/25/10 0:00
7/25/10 12:00
7/26/10 0:00
7/26/10 12:00
7/27/10 0:00
7/27/10 12:00
7/28/10 0:00
7/28/10 12:00
7/29/10 0:00
7/29/10 12:00
Date and Time

Appendix G: 2010 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

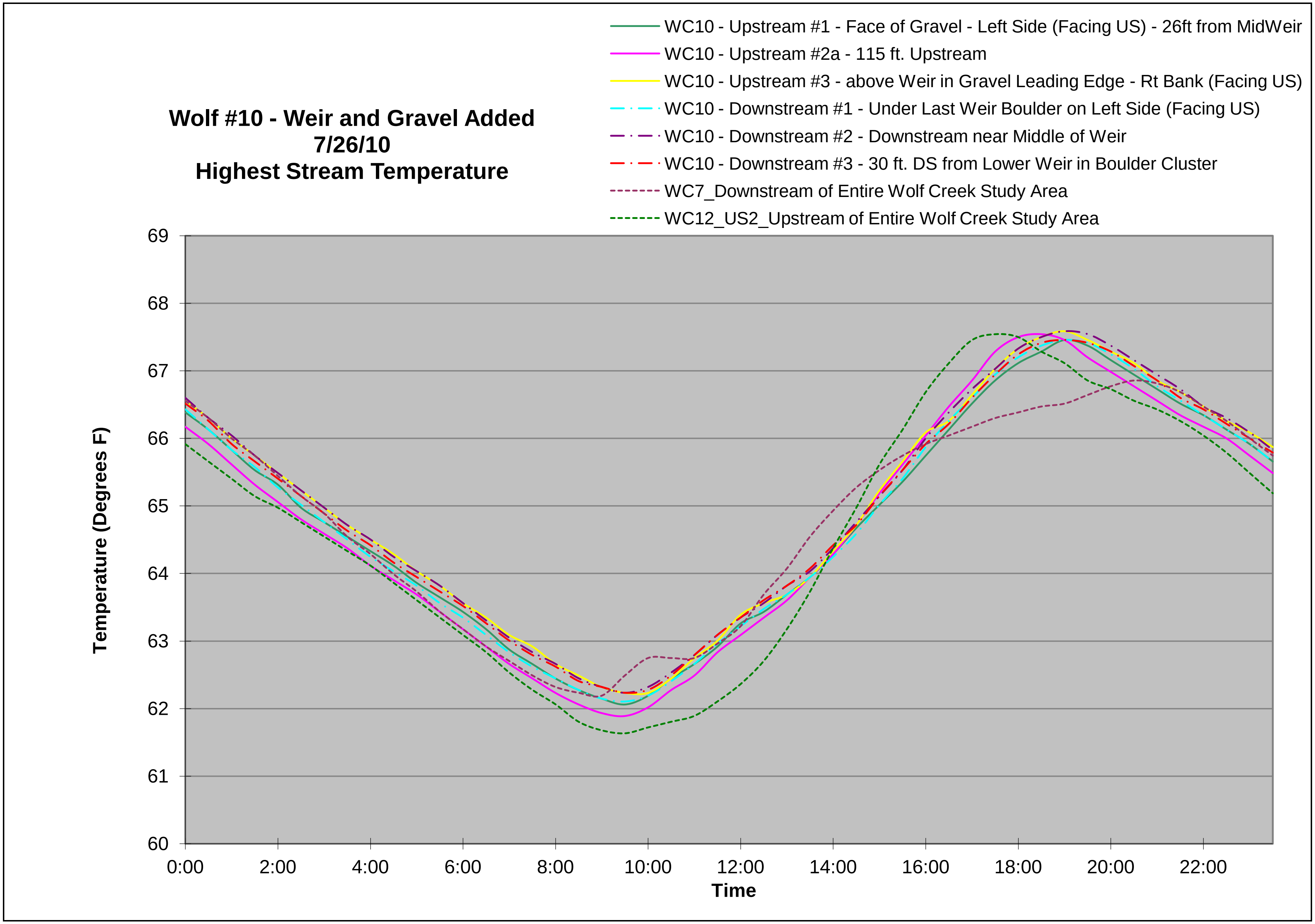


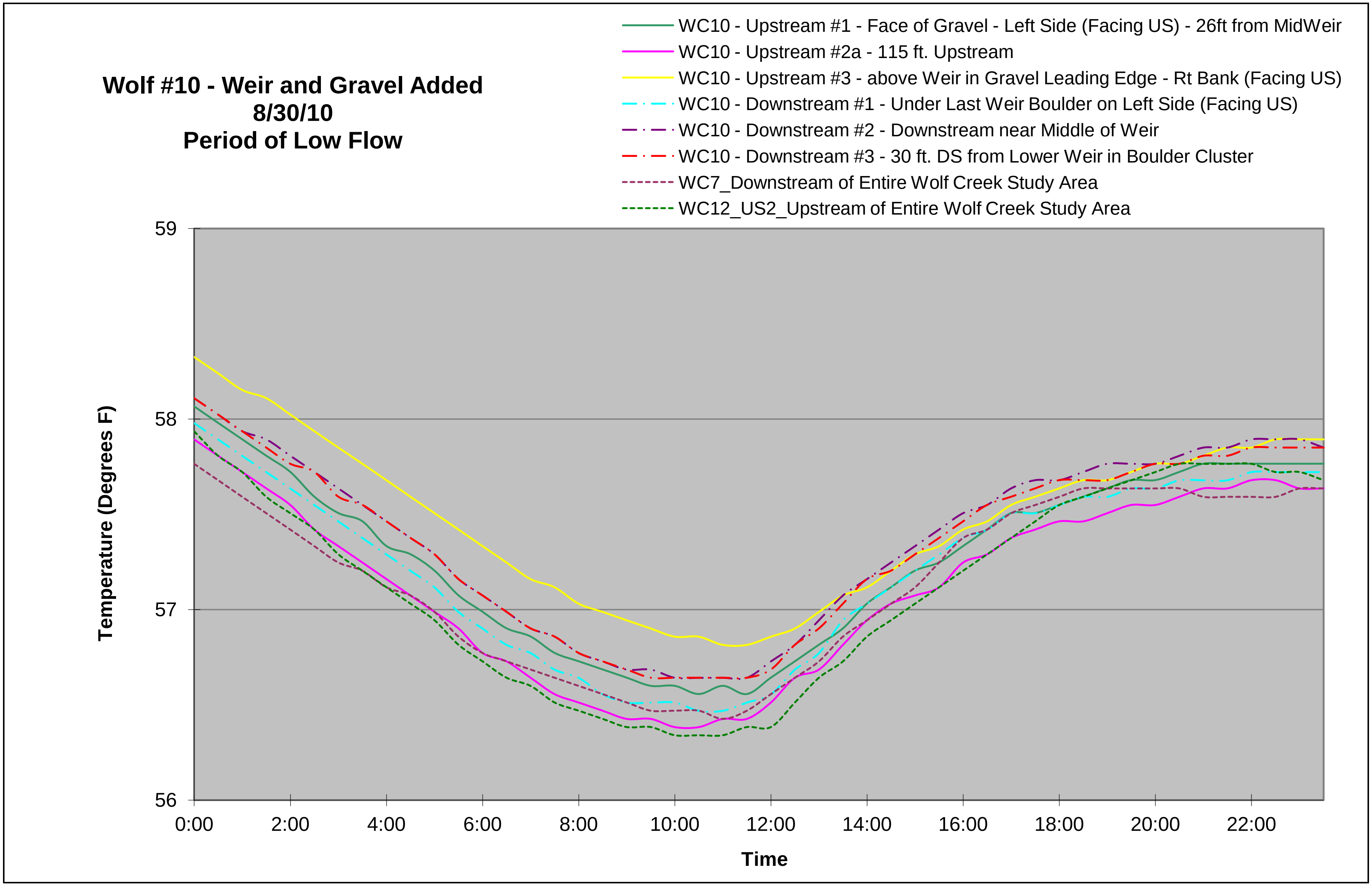


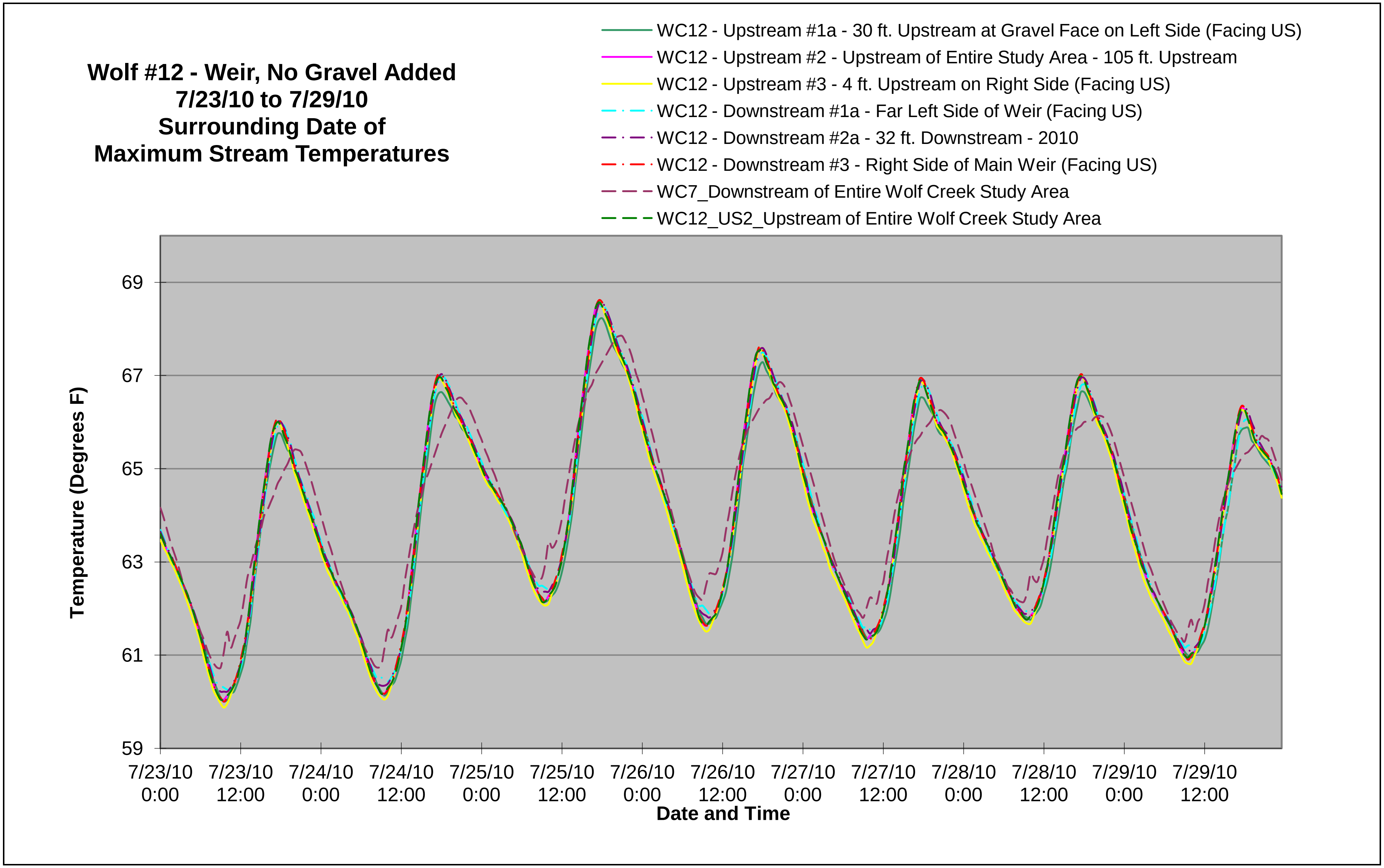
Wolf #9 - Weir, No Gravel Added
8/30/10
Period of Low Flow
WC9 - Upstream #1a - 107 ft. Upstream
WC9 - Upstream #2a - 50 ft. US to Left (Facing US) of Last Years US#2
WC9 - Upstream #3a - Right Side of Weir (Facing US)
WC9 - Downstream #1 - in Left Side of Weir (Facing US)
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
WC9 - Downstream #3 - in Right Side of Weir (Facing US)
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
59
58
57
56
55
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

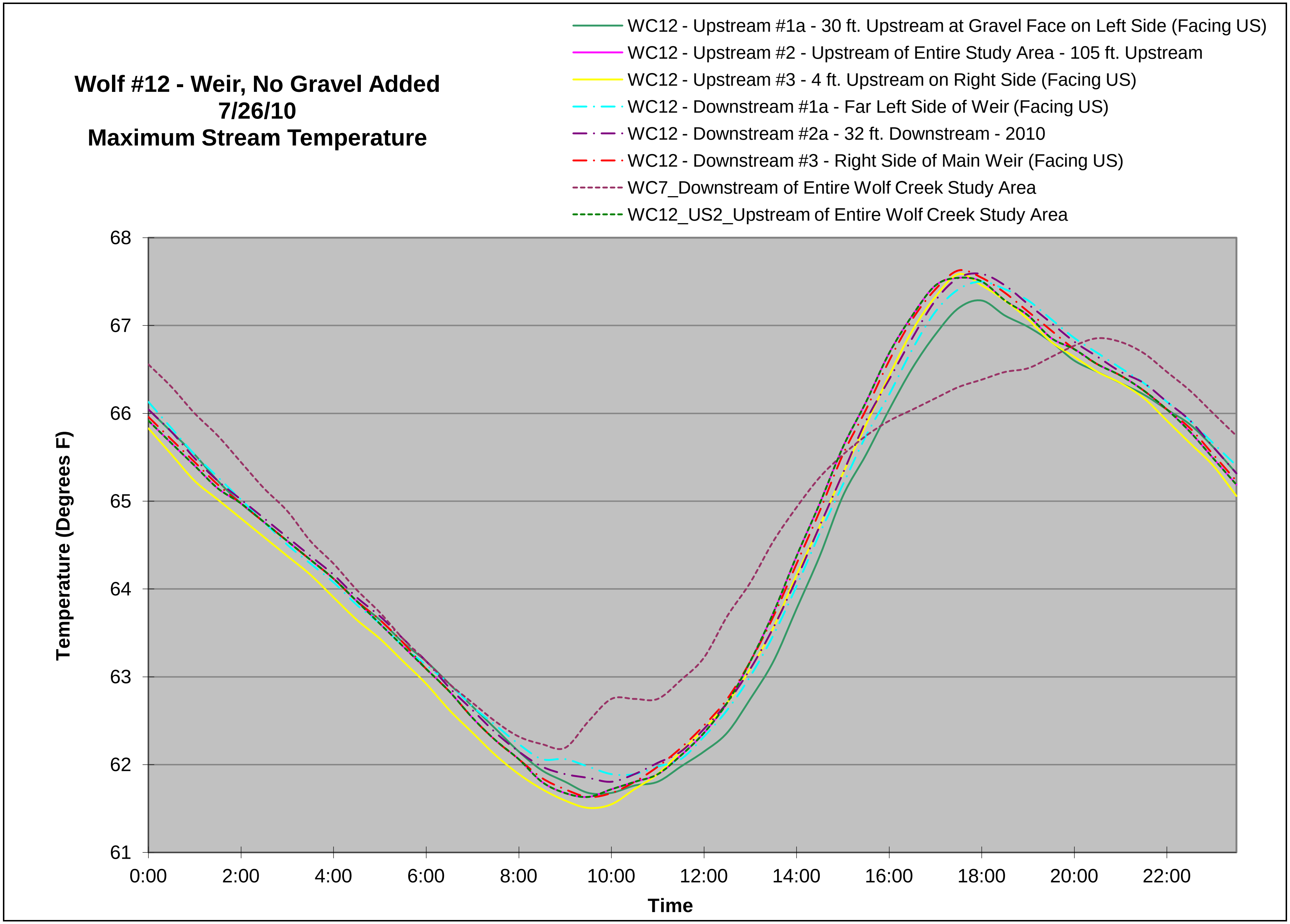


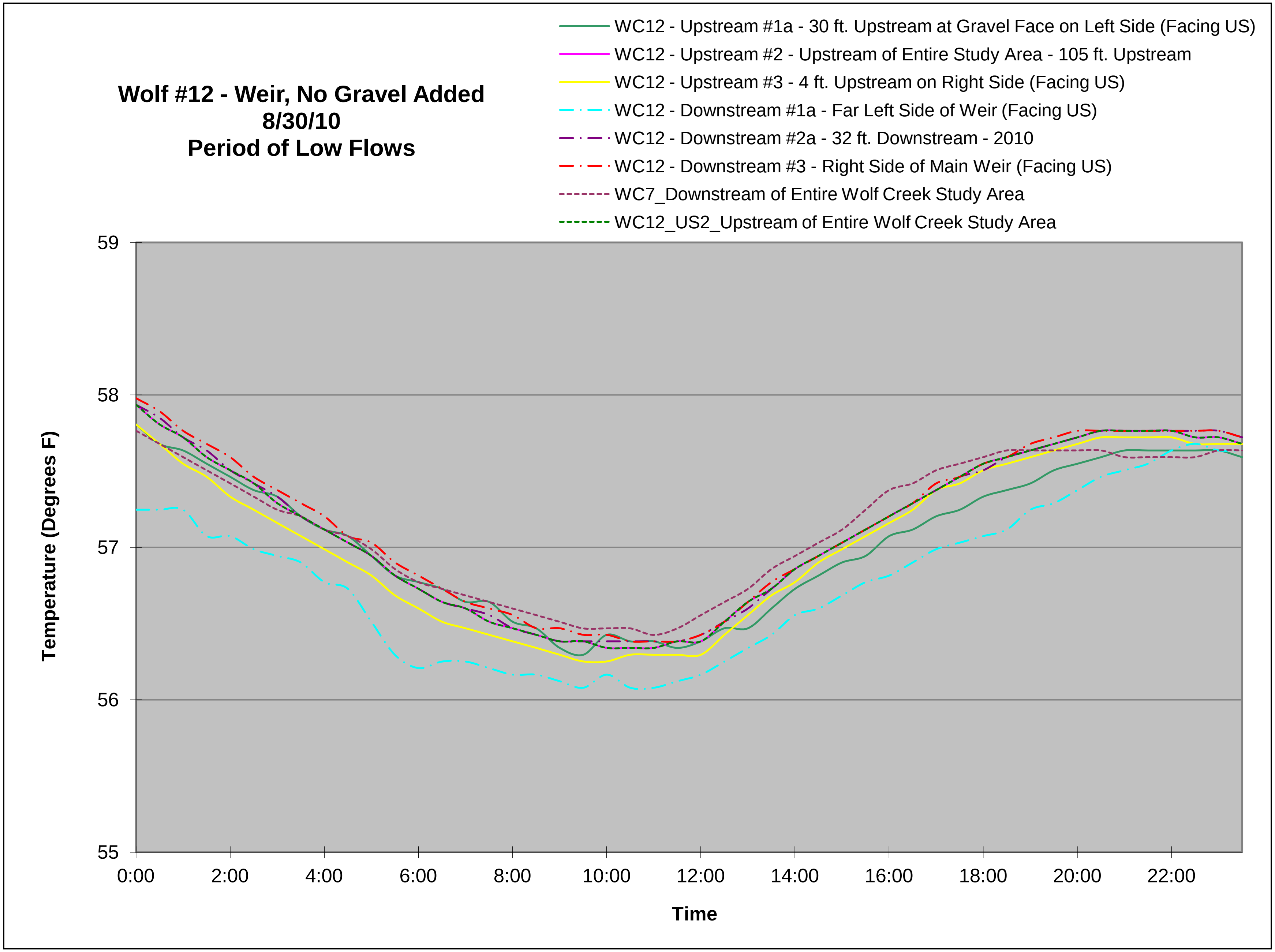
Wolf #10 - Weir and Gravel Added
7/23/10 to 7/29/10
Week Surrounding
Highest Stream Temperature
WC10 - Upstream #1 - Face of Gravel - Left Side (Facing US) - 26ft from MidWeir
WC10 - Upstream #2a - 115 ft. Upstream
WC10 - Upstream #3 - above Weir in Gravel Leading Edge - Rt Bank (Facing US)
WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)
WC10 - Downstream #2 - Downstream near Middle of Weir
WC10 - Downstream #3 - 30 ft. DS from Lower Weir in Boulder Cluster
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
69
67
65
63
61
59
7/23/10 0:00
7/23/10 12:00
7/24/10 0:00
7/24/10 12:00
7/25/10 0:00
7/25/10 12:00
7/26/10 0:00
7/26/10 12:00
7/27/10 0:00
7/27/10 12:00
7/28/10 0:00
7/28/10 12:00
7/29/10 0:00
7/29/10 12:00
Date and Time


Wolf #10 - Weir and Gravel Added
7/26/10
Highest Stream Temperature
WC10 - Upstream #1 - Face of Gravel - Left Side (Facing US) - 26ft from MidWeir
WC10 - Upstream #2a - 115 ft. Upstream
WC10 - Upstream #3 - above Weir in Gravel Leading Edge - Rt Bank (Facing US)
WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)
WC10 - Downstream #2 - Downstream near Middle of Weir
WC10 - Downstream #3 - 30 ft. DS from Lower Weir in Boulder Cluster
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
69
68
67
66
65
64
63
62
61
60
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

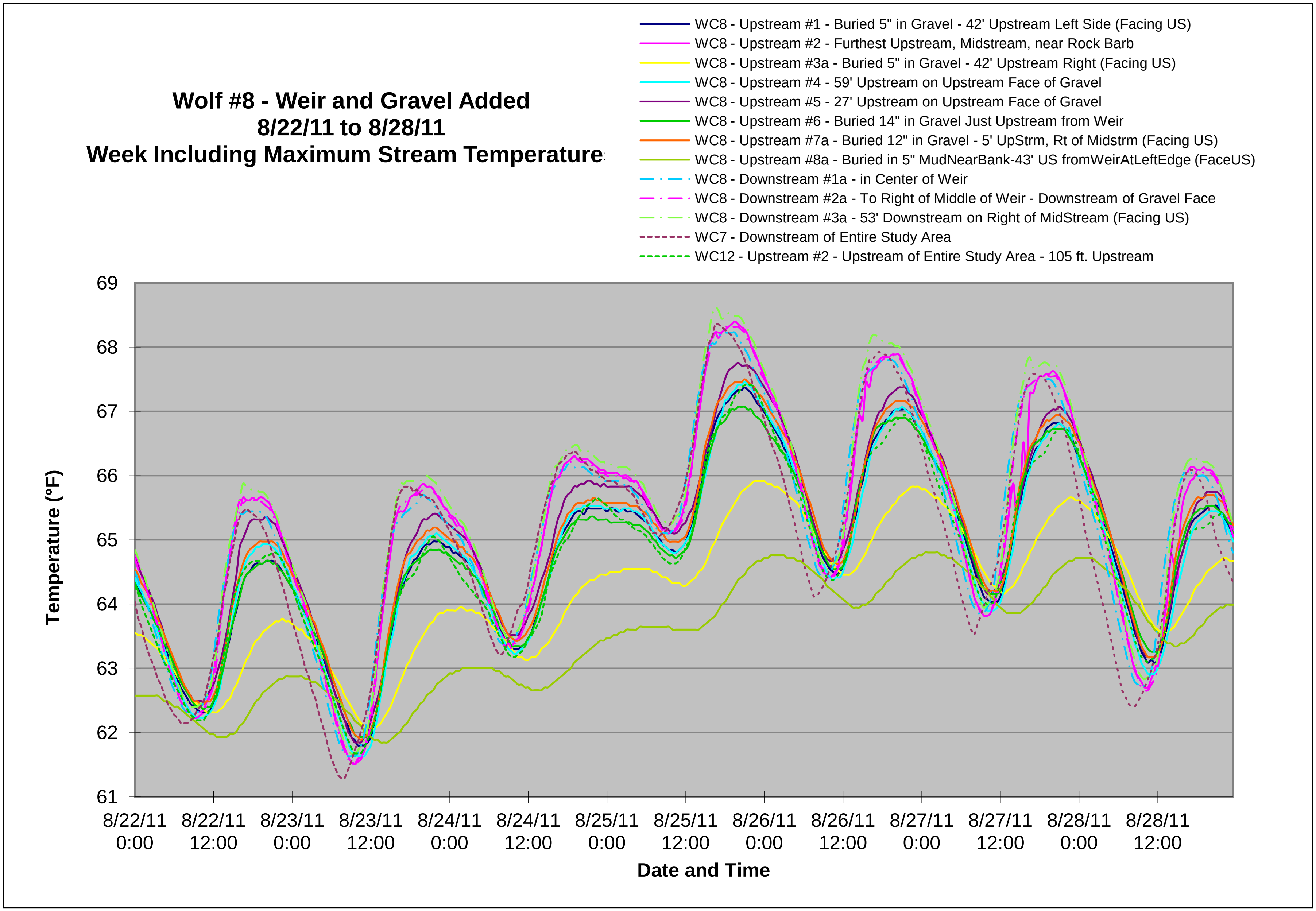

Wolf #10 - Weir and Gravel Added
8/30/10
Period of Low Flow
WC10 - Upstream #1 - Face of Gravel - Left Side (Facing US) - 26ft from MidWeir
WC10 - Upstream #2a - 115 ft. Upstream
WC10 - Upstream #3 - above Weir in Gravel Leading Edge - Rt Bank (Facing US)
WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)
WC10 - Downstream #2 - Downstream near Middle of Weir
WC10 - Downstream #3 - 30 ft. DS from Lower Weir in Boulder Cluster
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
59
58
57
56
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

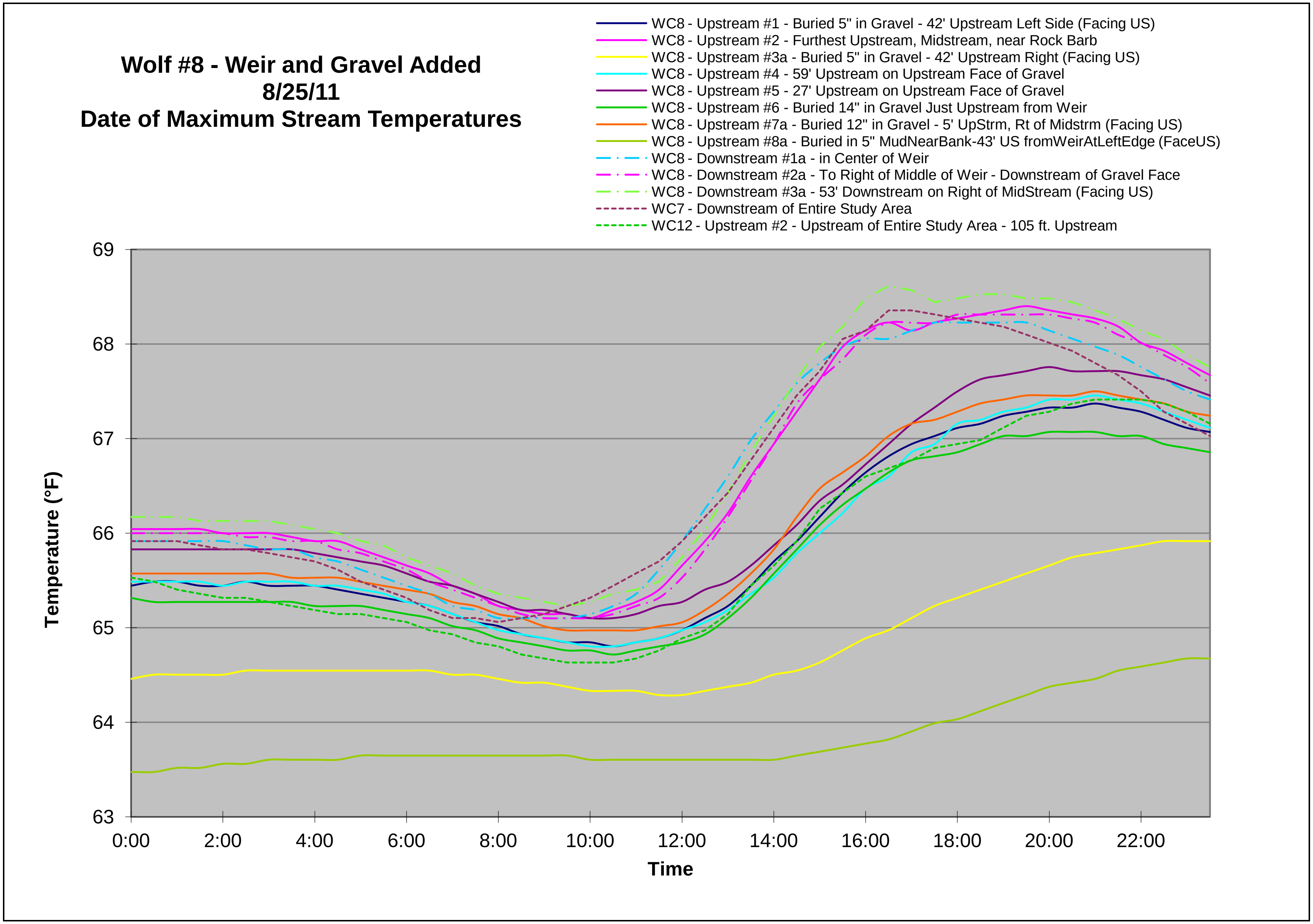

Wolf #12 - Weir, No Gravel Added
7/23/10 to 7/29/10
Surrounding Date of
Maximum Stream Temperatures
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
WC12 - Downstream #2a - 32 ft. Downstream - 2010
WC12 - Downstream #3 - Right Side of Main Weir (Facing US)
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
69
67
65
63
61
59
7/23/10 0:00
7/23/10 12:00
7/24/10 0:00
7/24/10 12:00
7/25/10 0:00
7/25/10 12:00
7/26/10 0:00
7/26/10 12:00
7/27/10 0:00
7/27/10 12:00
7/28/10 0:00
7/28/10 12:00
7/29/10 0:00
7/29/10 12:00
Date and Time

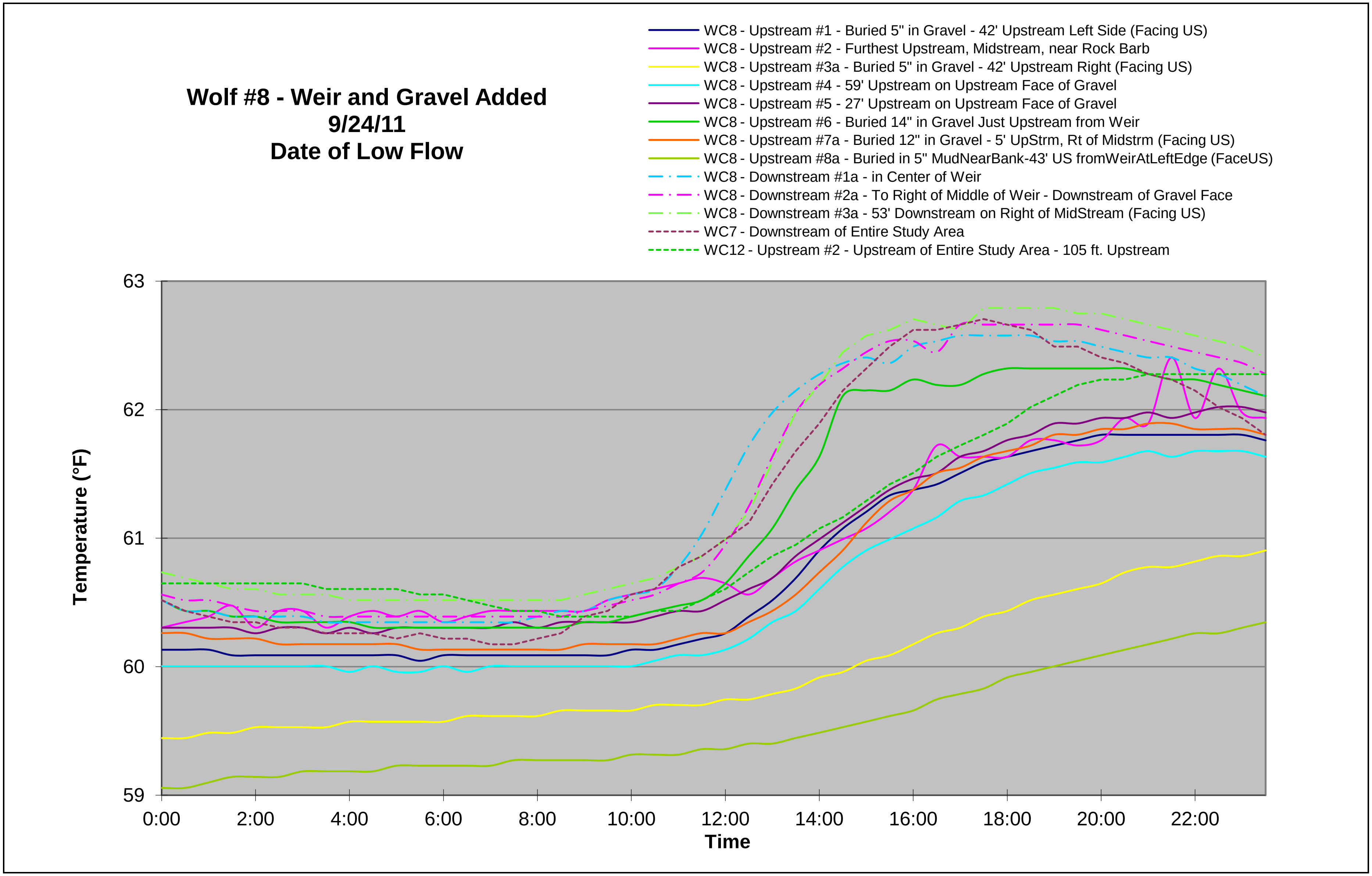

Wolf #12 - Weir, No Gravel Added
7/26/10
Maximum Stream Temperature
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
WC12 - Downstream #2a - 32 ft. Downstream - 2010
WC12 - Downstream #3 - Right Side of Main Weir (Facing US)
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
68
67
66
65
64
63
62
61
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

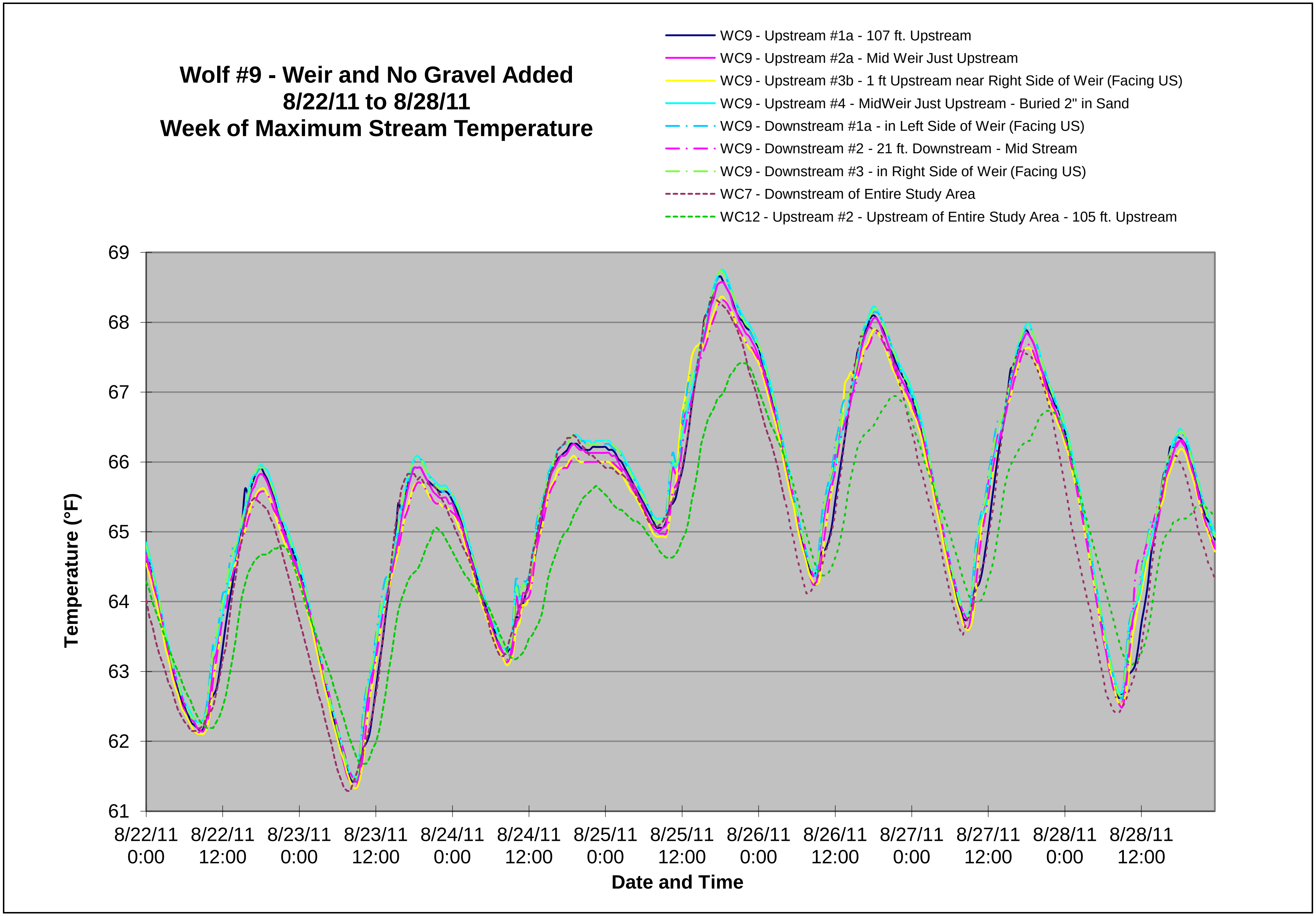

Wolf #12 - Weir, No Gravel Added
8/30/10
Period of Low Flows
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
WC12 - Downstream #2a - 32 ft. Downstream - 2010
WC12 - Downstream #3 - Right Side of Main Weir (Facing US)
WC7_Downstream of Entire Wolf Creek Study Area
WC12_US2_Upstream of Entire Wolf Creek Study Area
Temperature (Degrees F)
59
58
57
56
55
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

Appendix H: 2011 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12




Wolf #8 - Weir and Gravel Added
8/25/11
Date of Maximum Stream Temperatures
WC8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)
WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb
WC8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)
WC8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel
WC8 - Upstream #5 - 27' Upstream on Upstream Face of Gravel
WC8 - Upstream #6 - Buried 14" in Gravel Just Upstream from Weir
WC8 - Upstream #7a - Buried 12" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)
WC8 - Upstream #8a - Buried in 5" MudNearBank-43' US fromWeirAtLeftEdge (FaceUS)
WC8 - Downstream #1a - in Center of Weir
WC8 - Downstream #2a - To Right of Middle of Weir - Downstream of Gravel Face
WC8 - Downstream #3a - 53' Downstream on Right of MidStream (Facing US)
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
69
68
67
66
65
64
63
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time


Wolf #8 - Weir and Gravel Added
9/24/11
Date of Low Flow
WC8 - Upstream #1 - Buried 5" in Gravel - 42' Upstream Left Side (Facing US)
WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb
WC8 - Upstream #3a - Buried 5" in Gravel - 42' Upstream Right (Facing US)
WC8 - Upstream #4 - 59' Upstream on Upstream Face of Gravel
WC8 - Upstream #5 - 27' Upstream on Upstream Face of Gravel
WC8 - Upstream #6 - Buried 14" in Gravel Just Upstream from Weir
WC8 - Upstream #7a - Buried 12" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)
WC8 - Upstream #8a - Buried in 5" MudNearBank-43' US fromWeirAtLeftEdge (FaceUS)
WC8 - Downstream #1a - in Center of Weir
WC8 - Downstream #2a - To Right of Middle of Weir - Downstream of Gravel Face
WC8 - Downstream #3a - 53' Downstream on Right of MidStream (Facing US)
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
63
62
61
60
59
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time


Wolf #9 - Weir and No Gravel Added
8/22/11 to 8/28/11
Week of Maximum Stream Temperature
WC9 - Upstream #1a - 107 ft. Upstream
WC9 - Upstream #2a - Mid Weir Just Upstream
WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
WC9 - Upstream #4 - MidWeir Just Upstream - Buried 2" in Sand
WC9 - Downstream #1a - in Left Side of Weir (Facing US)
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
WC9 - Downstream #3 - in Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
69
68
67
66
65
64
63
62
61
8/22/11 0:00
8/22/11 12:00
8/23/11 0:00
8/23/11 12:00
8/24/11 0:00
8/24/11 12:00
8/25/11 0:00
8/25/11 12:00
8/26/11 0:00
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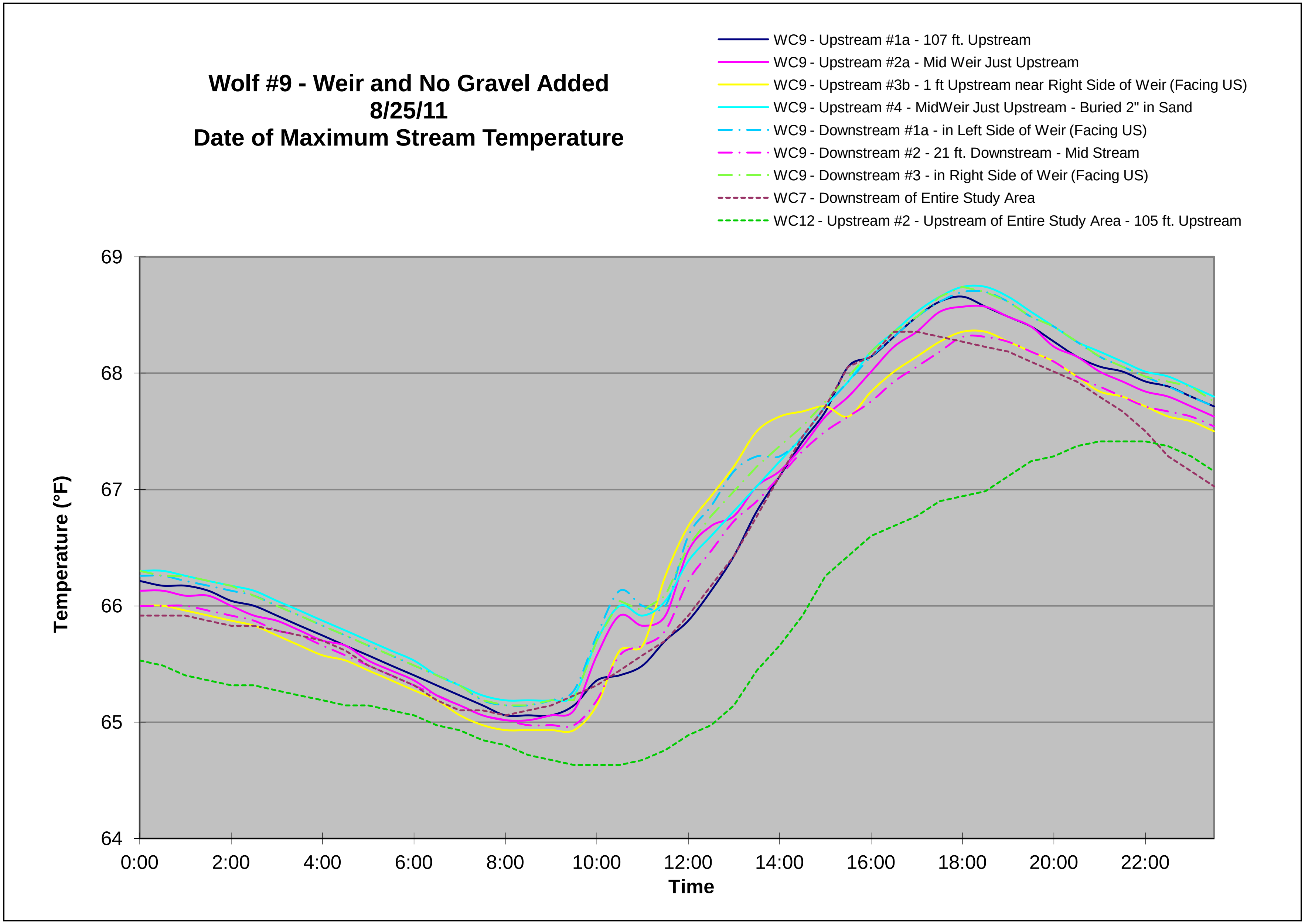
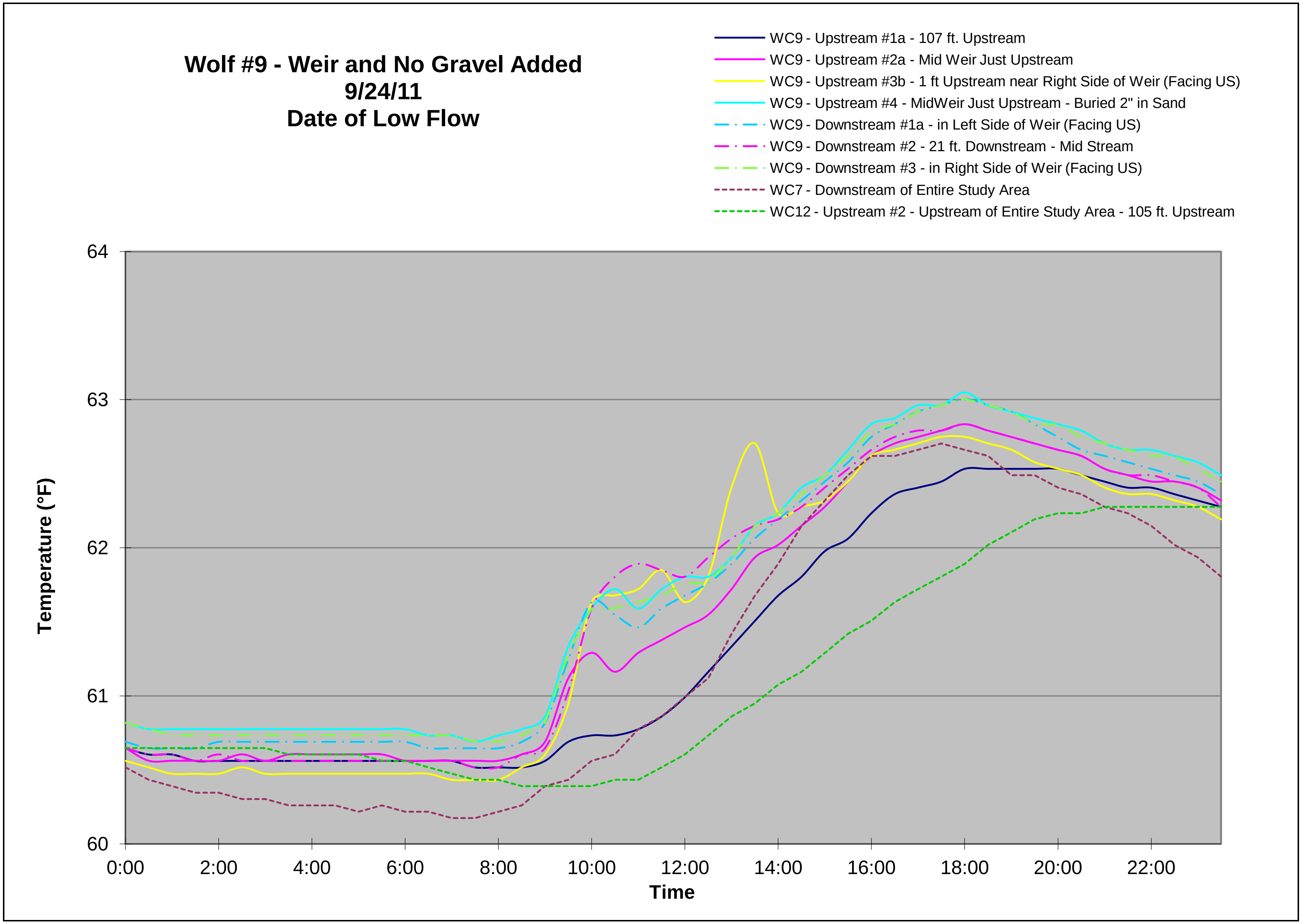
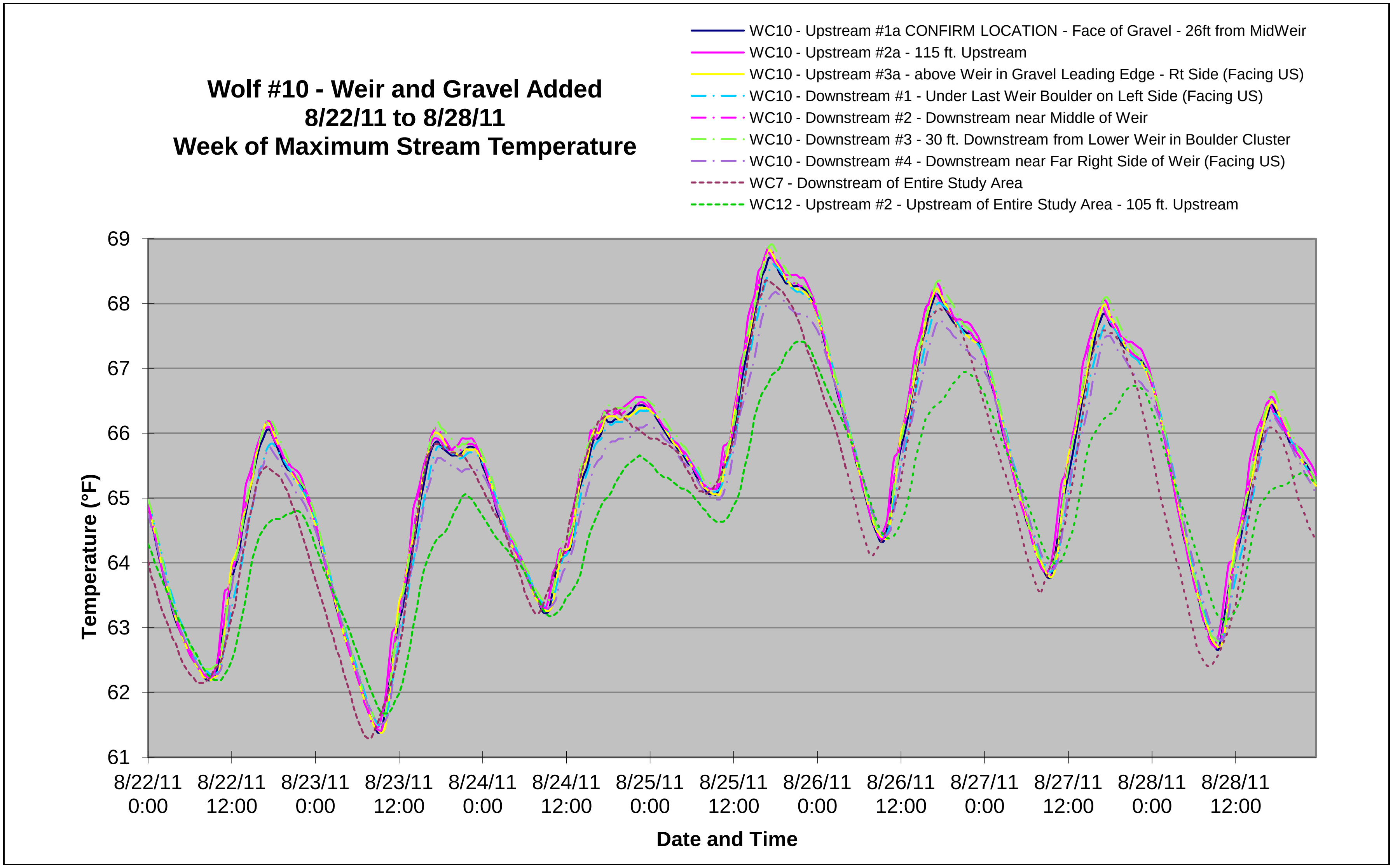
8/27/11 0:00
8/27/11 12:00
8/28/11 0:00
8/28/11 12:00
Date and Time

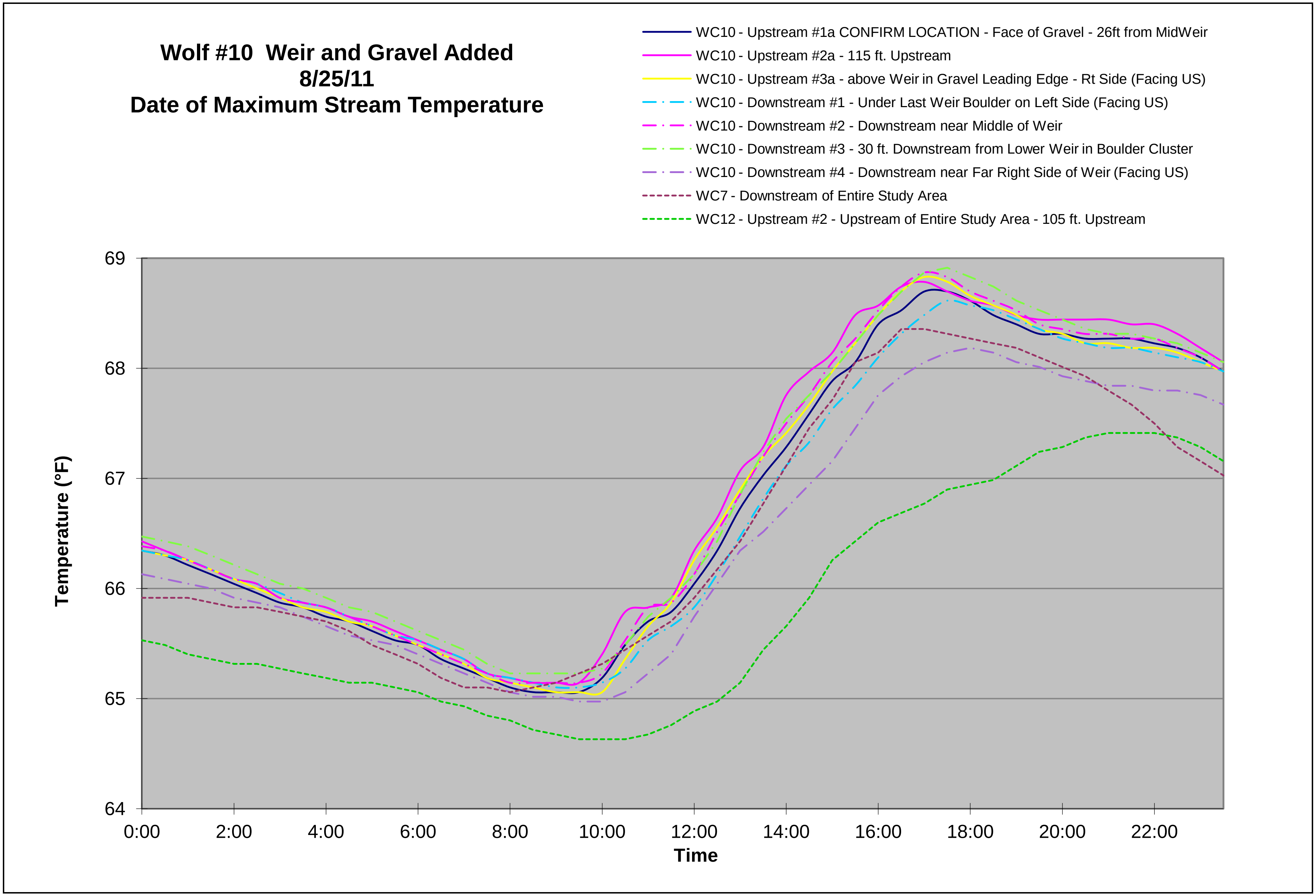

Wolf #9 - Weir and No Gravel Added
8/25/11
Date of Maximum Stream Temperature
WC9 - Upstream #1a - 107 ft. Upstream
WC9 - Upstream #2a - Mid Weir Just Upstream
WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
WC9 - Upstream #4 - MidWeir Just Upstream - Buried 2" in Sand
WC9 - Downstream #1a - in Left Side of Weir (Facing US)
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
WC9 - Downstream #3 - in Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
69
68
67
66
65
64
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

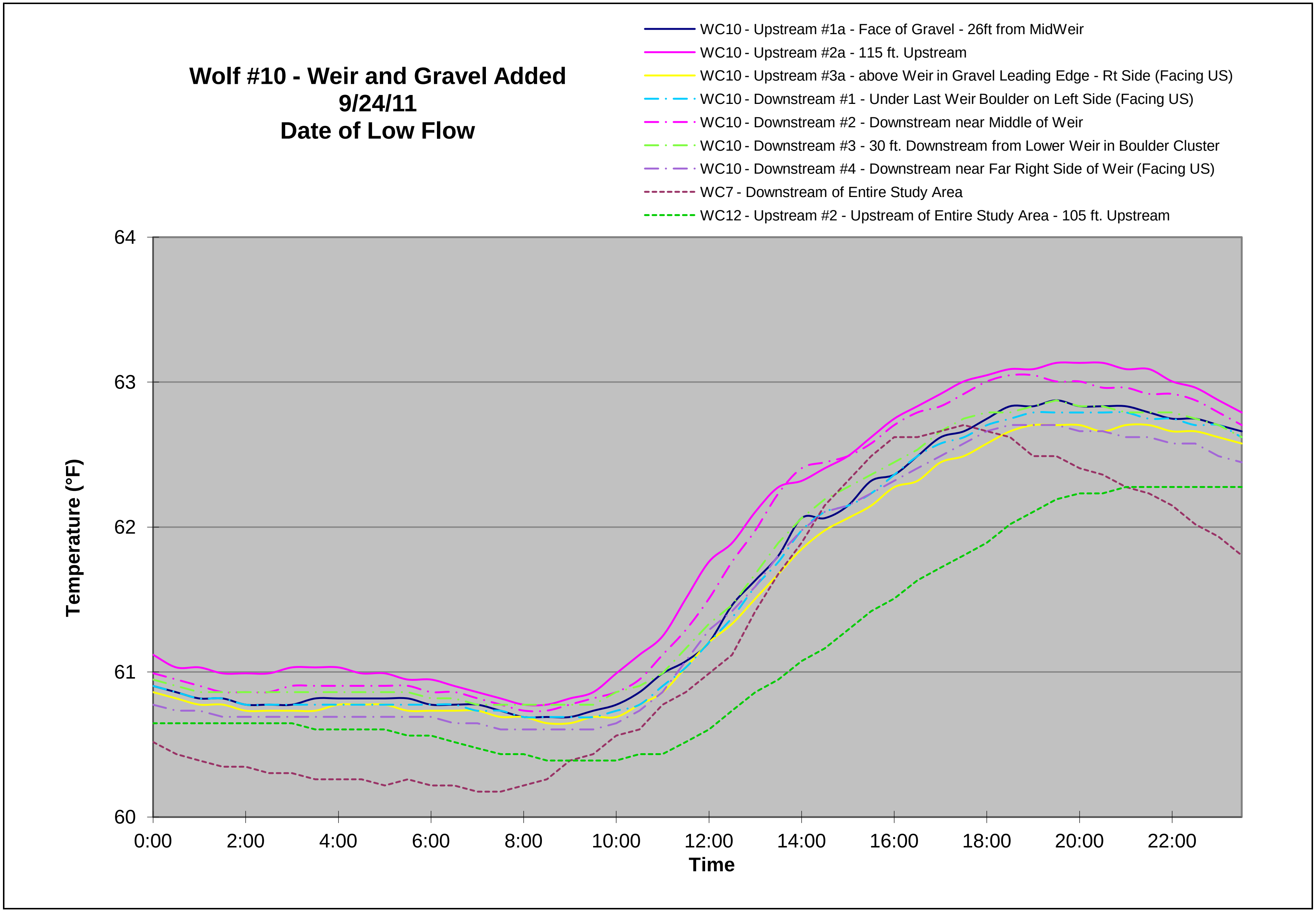

Wolf #9 - Weir and No Gravel Added
9/24/11
Date of Low Flow
WC9 - Upstream #1a - 107 ft. Upstream
WC9 - Upstream #2a - Mid Weir Just Upstream
WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
WC9 - Upstream #4 - MidWeir Just Upstream - Buried 2" in Sand
WC9 - Downstream #1a - in Left Side of Weir (Facing US)
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
WC9 - Downstream #3 - in Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
64
63
62
61
60
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

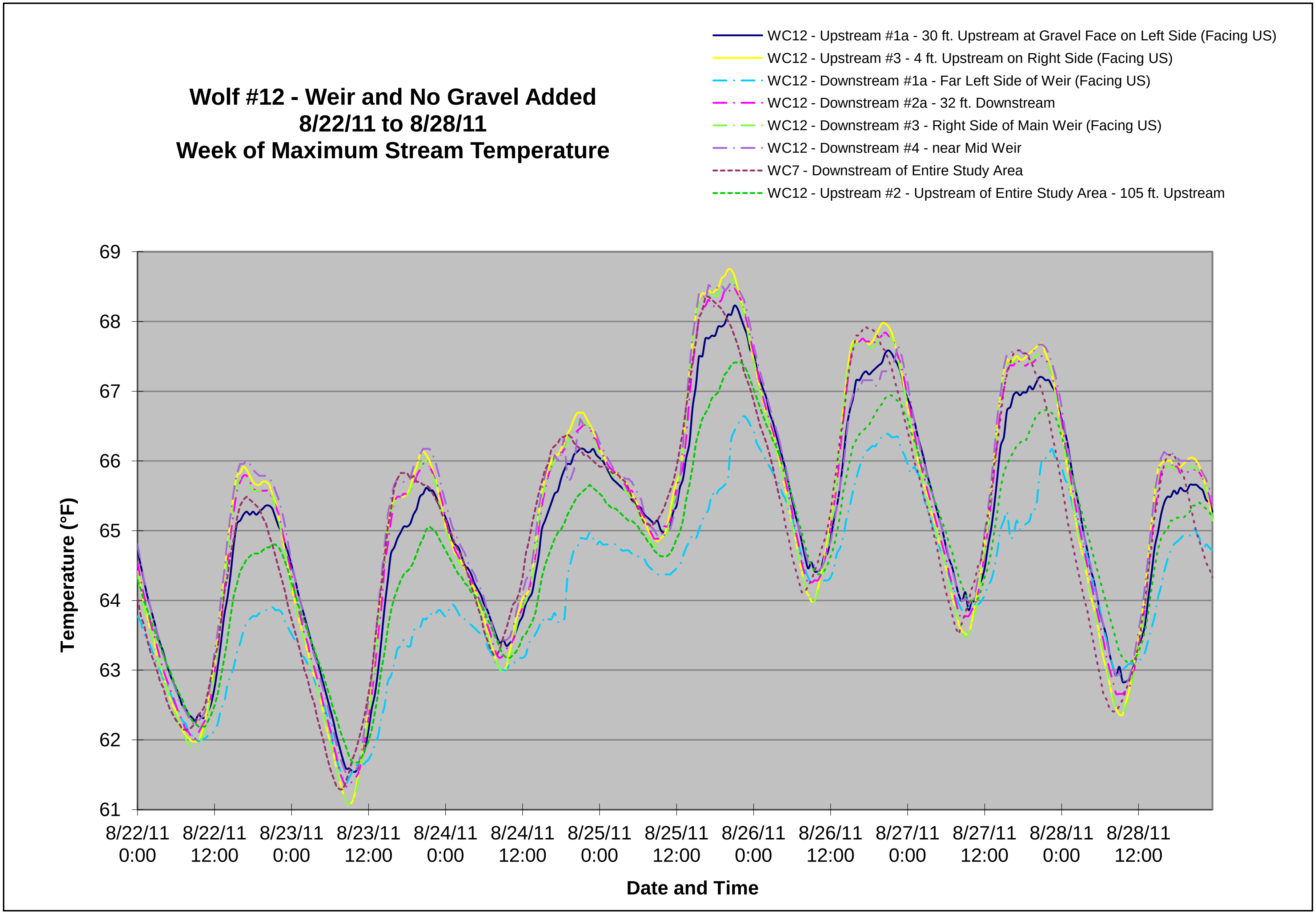


Wolf #10 - Weir and Gravel Added
8/22/11 to 8/28/11
Week of Maximum Stream Temperature
WC10 - Upstream #1a CONFIRM LOCATION - Face of Gravel - 26ft from MidWeir
WC10 - Upstream #2a - 115 ft. Upstream
WC10 - Upstream #3a - above Weir in Gravel Leading Edge - Rt Side (Facing US)
WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)
WC10 - Downstream #2 - Downstream near Middle of Weir
WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster
WC10 - Downstream #4 - Downstream near Far Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
69
68
67
66
65
64
63
62
61
8/22/11 0:00
8/22/11 12:00
8/23/11 0:00
8/23/11 12:00
8/24/11 0:00
8/24/11 12:00
8/25/11 0:00
8/25/11 12:00
8/26/11 0:00
8/26/11 12:00
8/27/11 0:00
8/27/11 12:00
8/28/11 0:00
8/28/11 12:00
Date and Time

Appendix H: 2011 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12




Wolf #10 - Weir and Gravel Added
9/24/11
Date of Low Flow
WC10 - Upstream #1a - Face of Gravel - 26ft from MidWeir
WC10 - Upstream #2a - 115 ft. Upstream
WC10 - Upstream #3a - above Weir in Gravel Leading Edge - Rt Side (Facing US)
WC10 - Downstream #1 - Under Last Weir Boulder on Left Side (Facing US)
WC10 - Downstream #2 - Downstream near Middle of Weir
WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster
WC10 - Downstream #4 - Downstream near Far Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
64
63
62
61
60
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time


Wolf #12 - Weir and No Gravel Added
8/22/11 to 8/28/11
Week of Maximum Stream Temperature
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
WC12 - Downstream #2a - 32 ft. Downstream
WC12 - Downstream #3 - Right Side of Main Weir (Facing US)
WC12 - Downstream #4 - near Mid Weir
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
69
68
67
66
65
64
63
62
61
8/22/11 0:00
8/22/11 12:00
8/23/11 0:00
8/23/11 12:00
8/24/11 0:00
8/24/11 12:00
8/25/11 0:00
8/25/11 12:00
8/26/11 0:00
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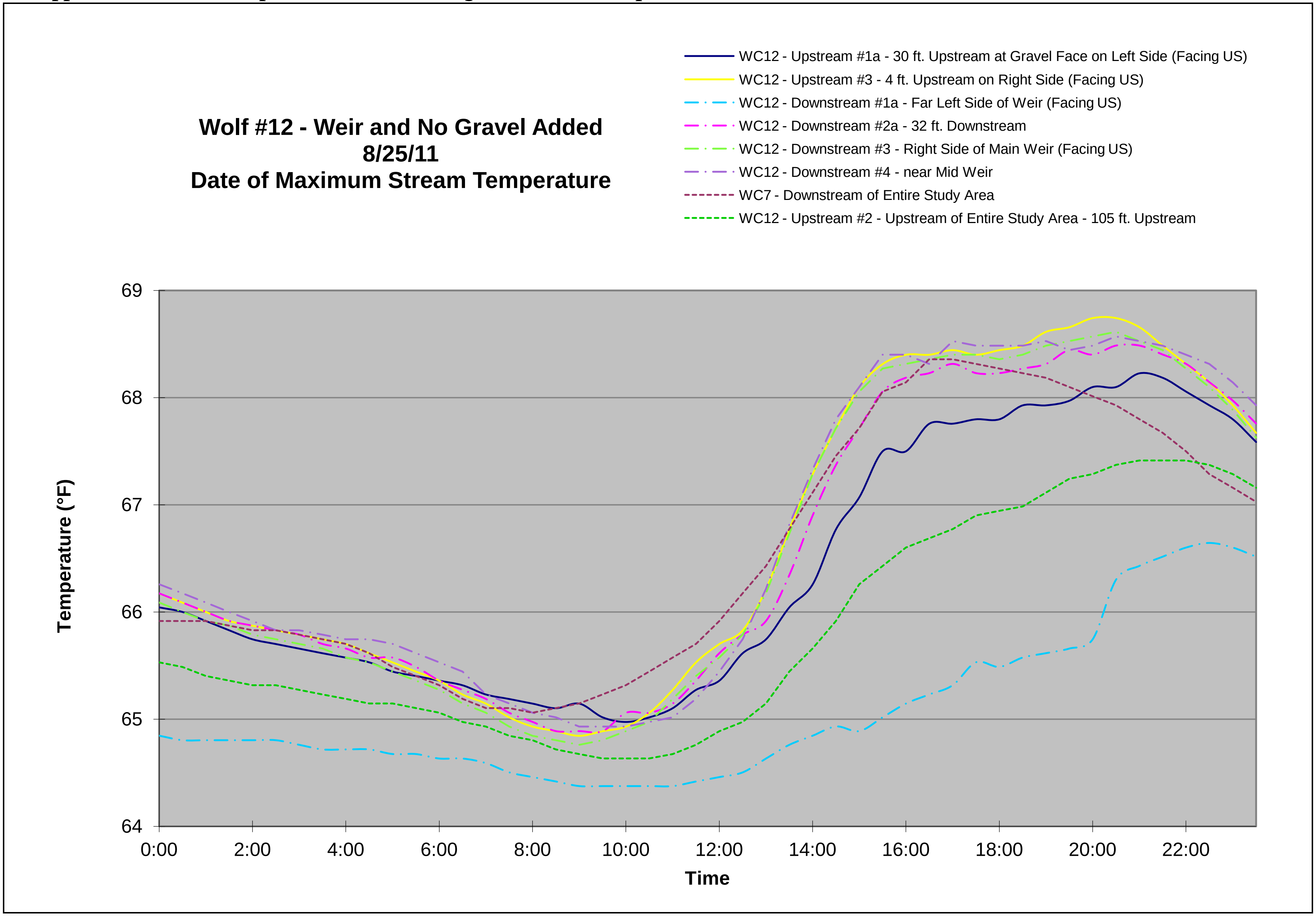
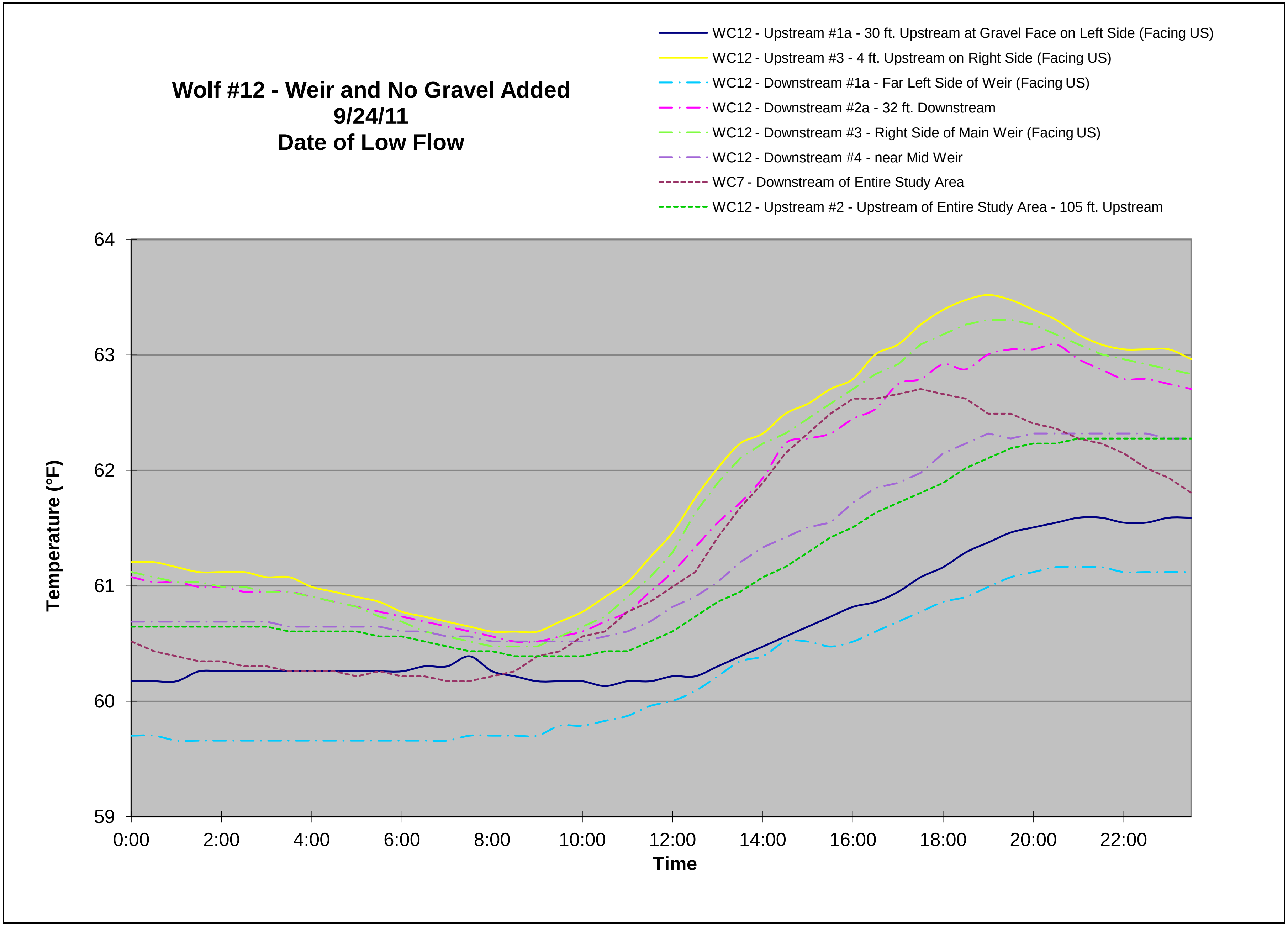
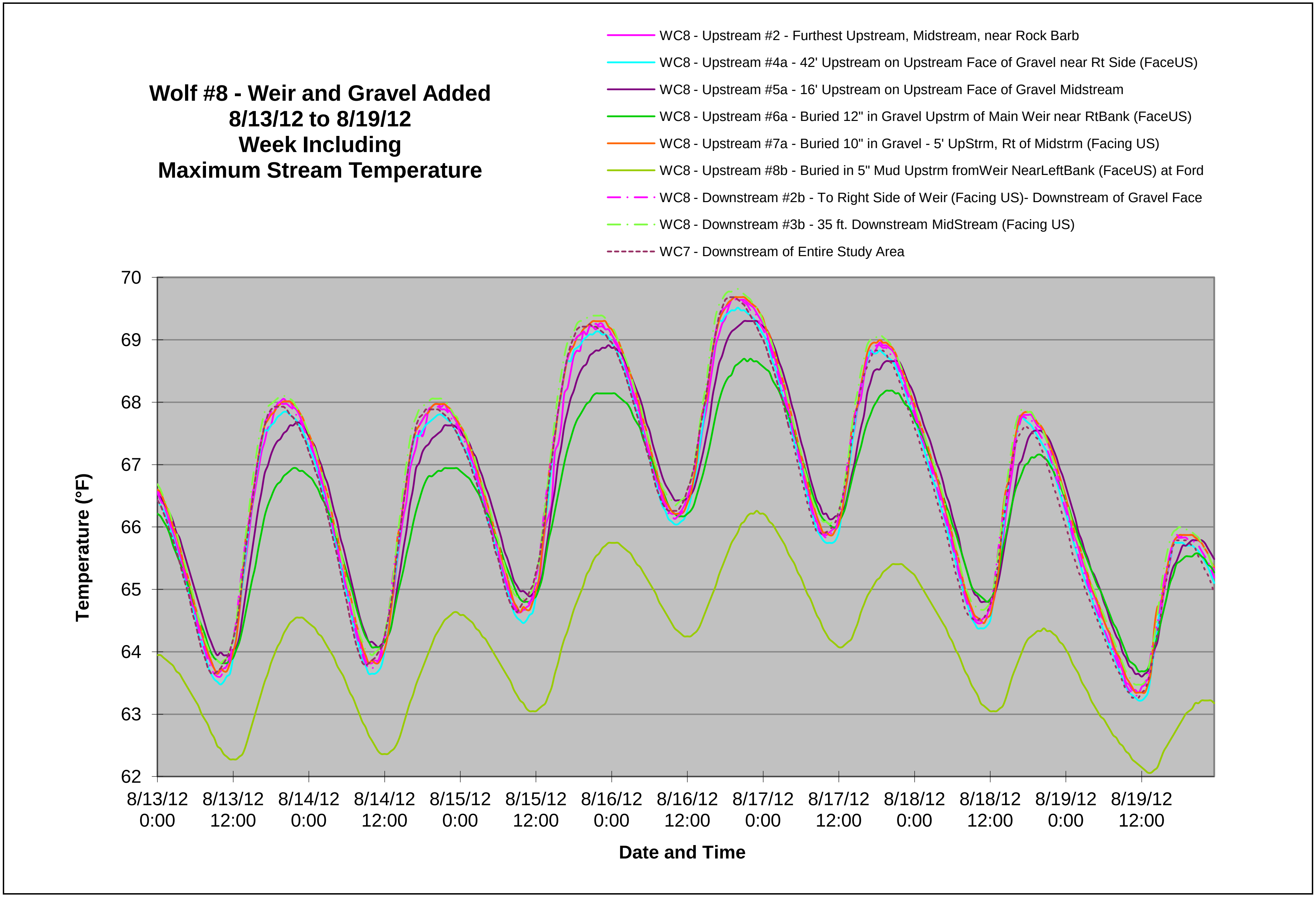
8/27/11 12:00
8/28/11 0:00
8/28/11 12:00
Date and Time

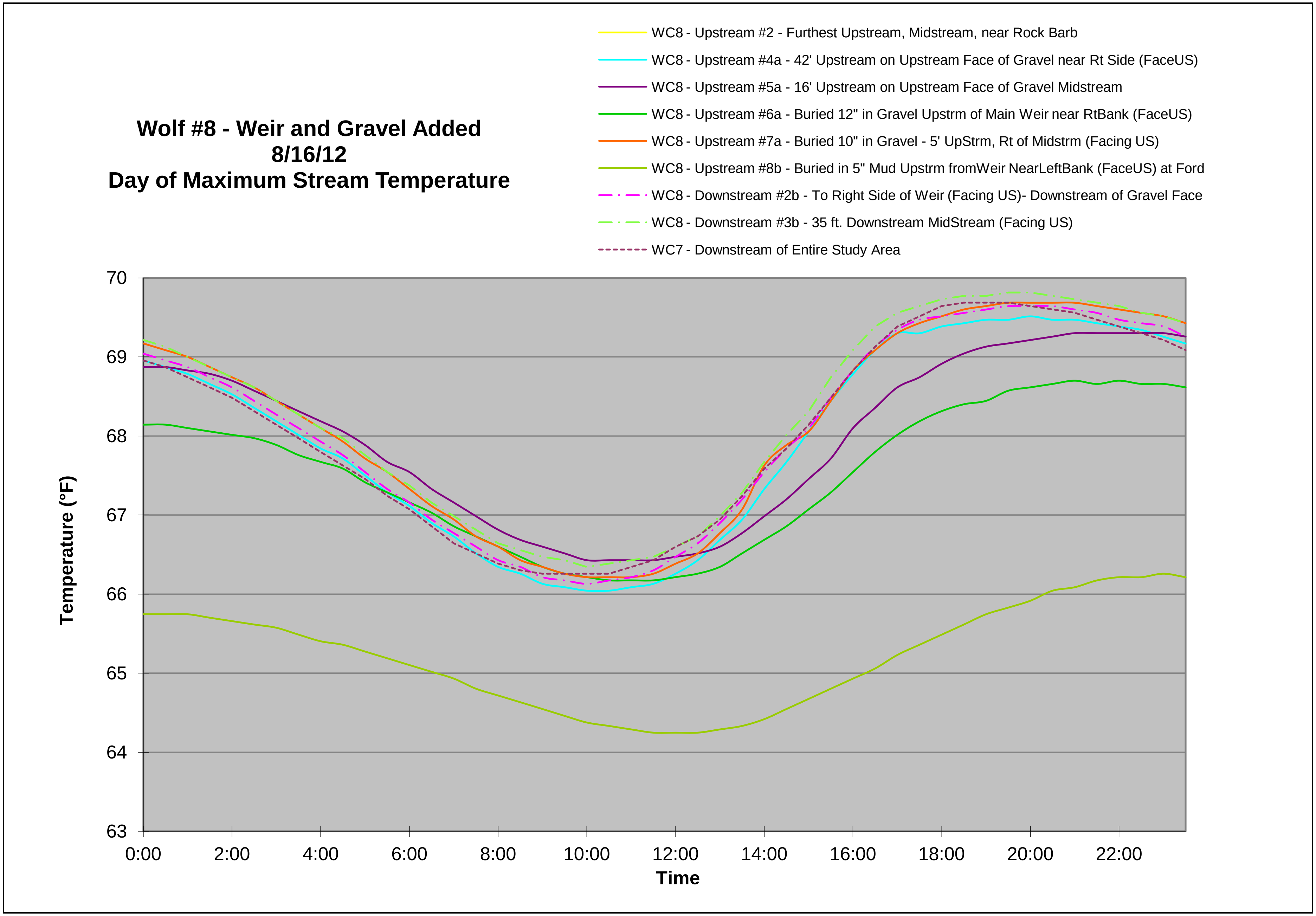

Wolf #12 - Weir and No Gravel Added
8/25/11
Date of Maximum Stream Temperature
WC12 - Upstream #1a - 30 ft. Upstream at Gravel Face on Left Side (Facing US)
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
WC12 - Downstream #2a - 32 ft. Downstream
WC12 - Downstream #3 - Right Side of Main Weir (Facing US)
WC12 - Downstream #4 - near Mid Weir
WC7 - Downstream of Entire Study Area
WC12 - Upstream #2 - Upstream of Entire Study Area - 105 ft. Upstream
Temperature (°F)
69
68
67
66
65
64
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

Appendix H: 2011 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12



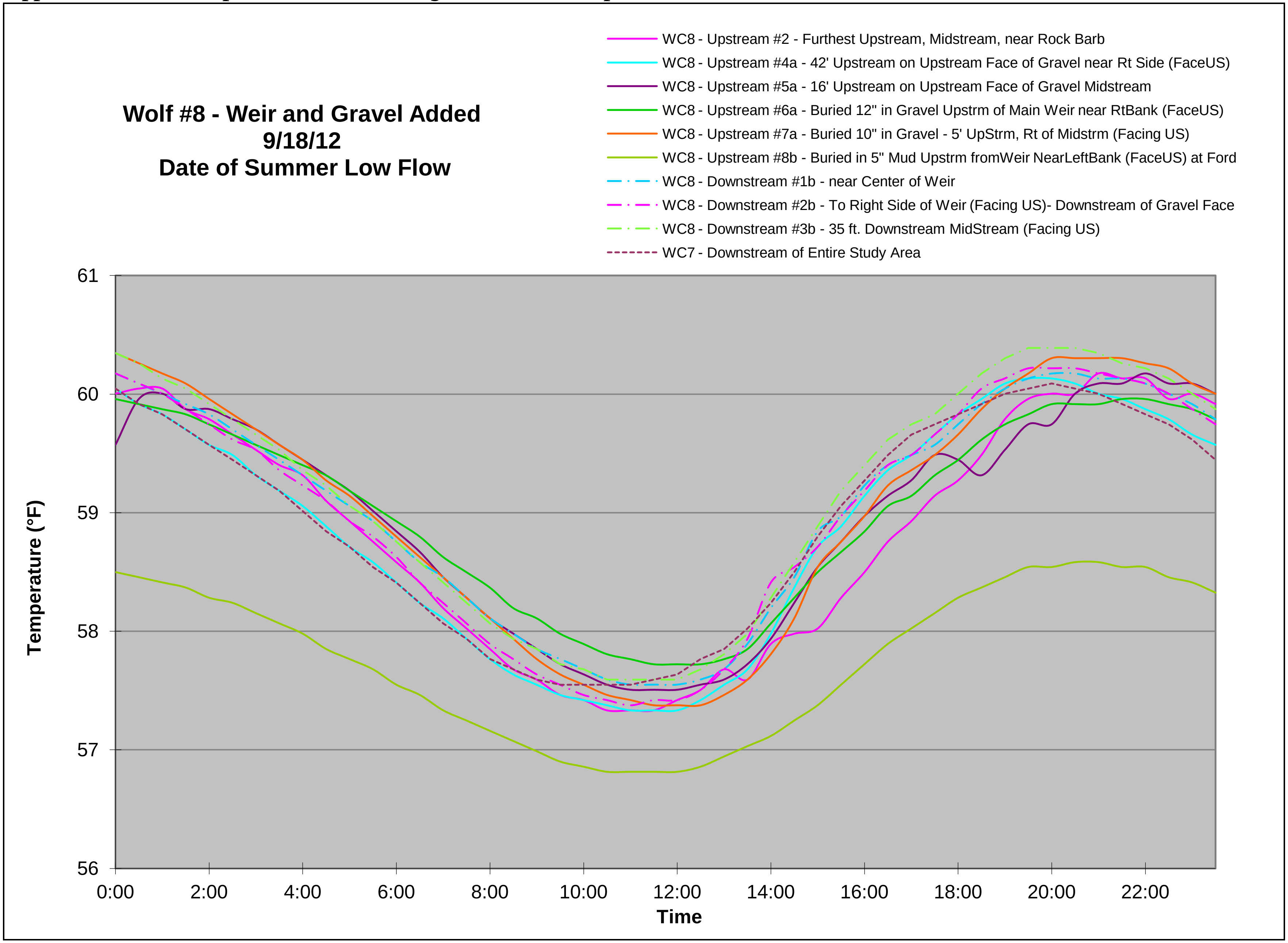
Appendix I: 2012 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

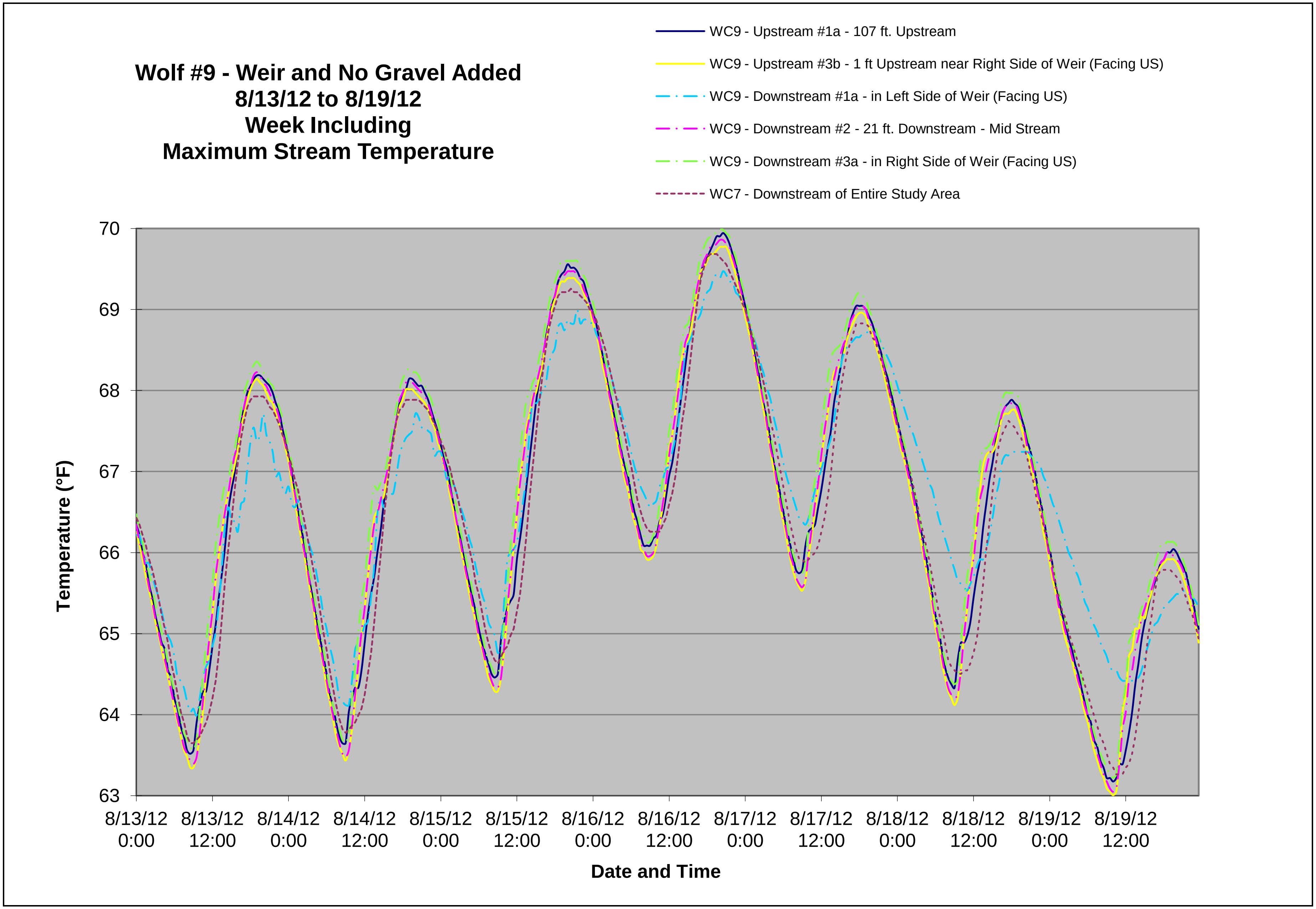




Wolf #8 - Weir and Gravel Added
8/16/12
Day of Maximum Stream Temperature
WC8 - Upstream #2 - Furthest Upstream, Midstream, near Rock Barb
WC8 - Upstream #4a - 42' Upstream on Upstream Face of Gravel near Rt Side (FaceUS)
WC8 - Upstream #5a - 16' Upstream on Upstream Face of Gravel Midstream
WC8 - Upstream #6a - Buried 12" in Gravel Upstrm of Main Weir near RtBank (FaceUS)
WC8 - Upstream #7a - Buried 10" in Gravel - 5' UpStrm, Rt of Midstrm (Facing US)
WC8 - Upstream #8b - Buried in 5" Mud Upstrm fromWeir NearLeftBank (FaceUS) at Ford
WC8 - Downstream #2b - To Right Side of Weir (Facing US)- Downstream of Gravel Face
WC8 - Downstream #3b - 35 ft. Downstream MidStream (Facing US)
WC7 - Downstream of Entire Study Area
Temperature (°F)
70
69
68
67
66
65
64
63
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

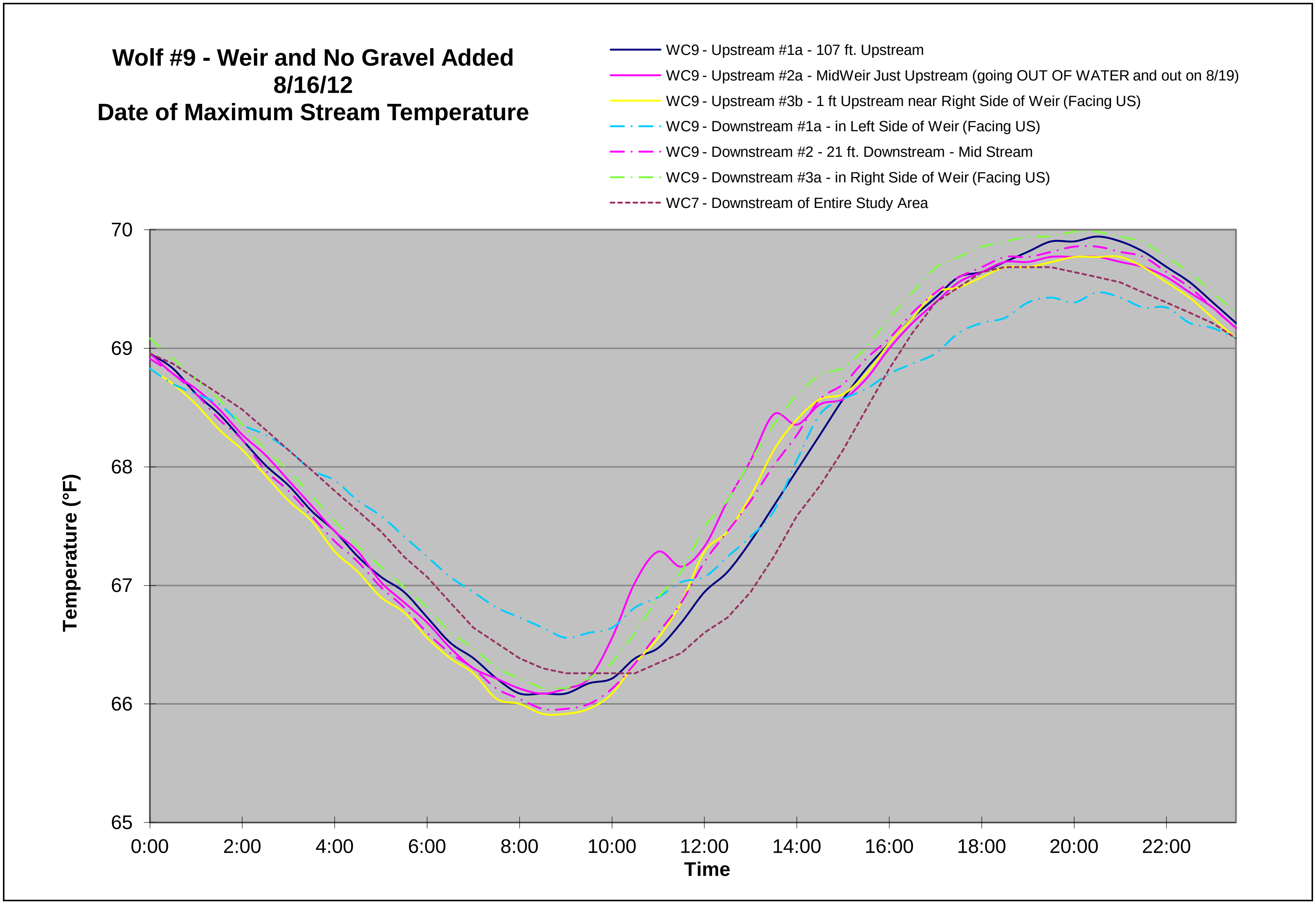
Appendix I: 2012 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

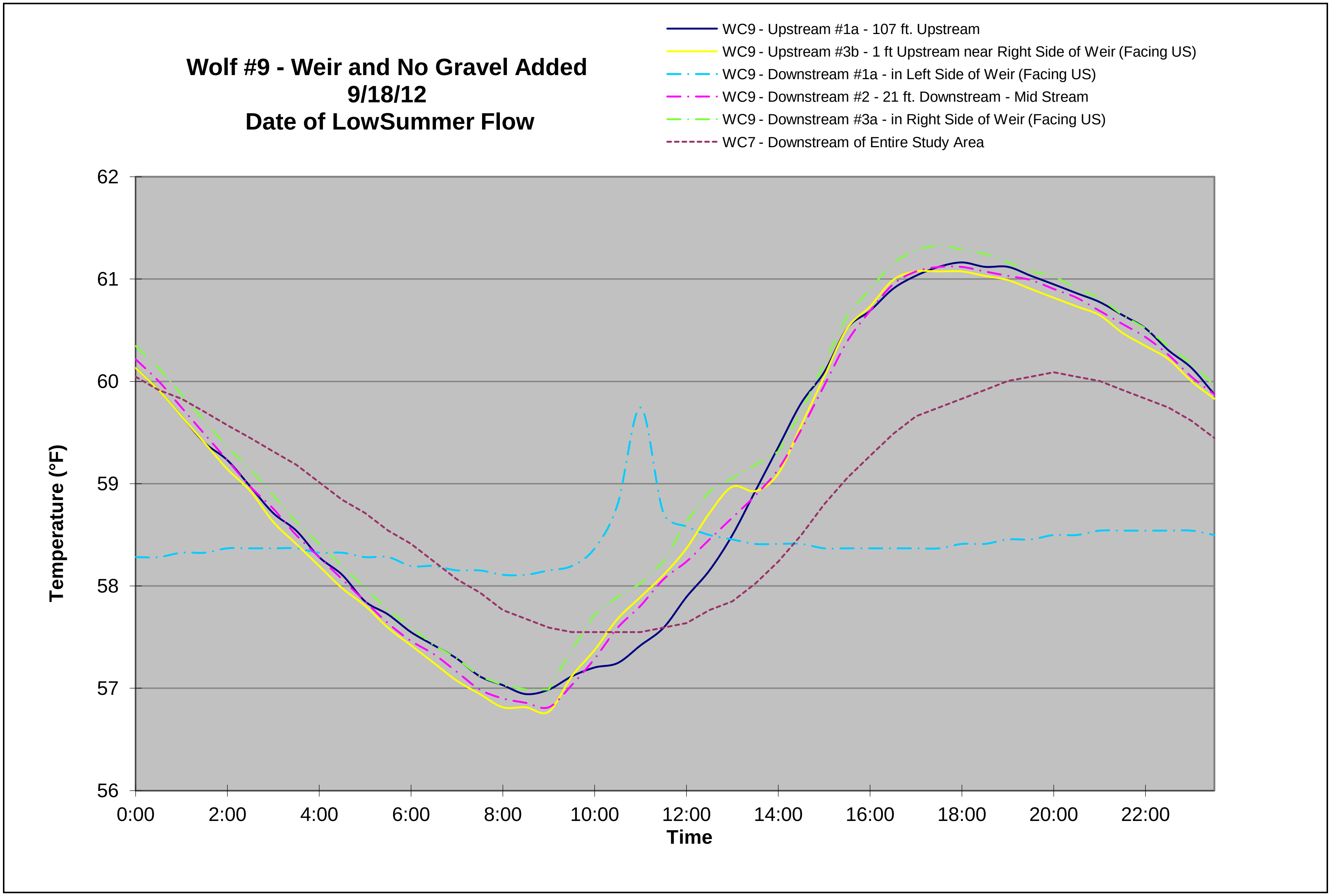




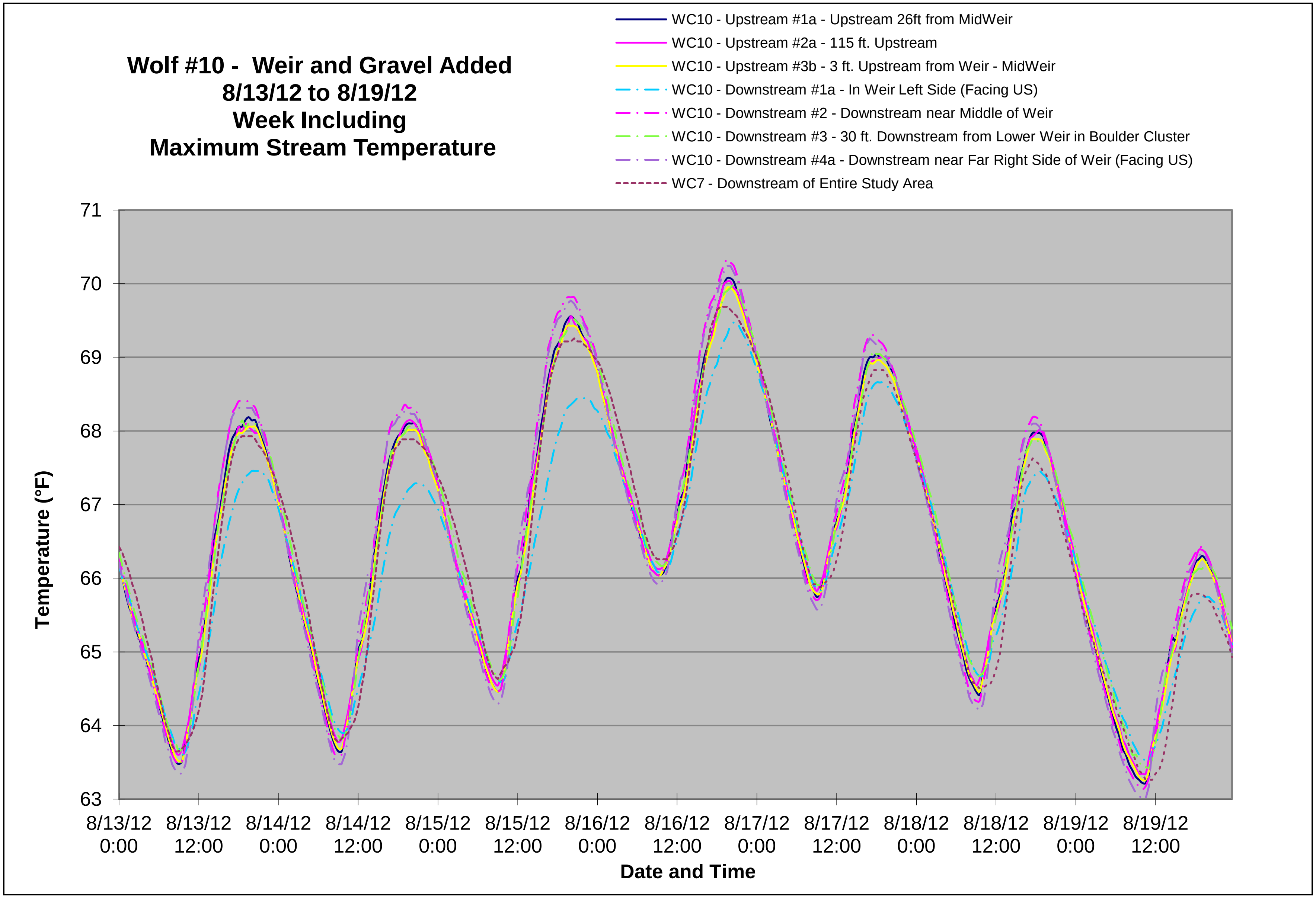
Wolf #9 - Weir and No Gravel Added
8/13/12 to 8/19/12
Week Including
Maximum Stream Temperature
WC9 - Upstream #1a - 107 ft. Upstream
WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
WC9 - Downstream #1a - in Left Side of Weir (Facing US)
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
WC9 - Downstream #3a - in Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
Temperature (°F)
70
69
68
67
66
65
64
63
8/13/12 0:00
8/13/12 12:00
8/14/12 0:00
8/14/12 12:00
8/15/12 0:00
8/15/12 12:00
8/16/12 0:00
8/16/12 12:00
8/17/12 0:00
8/17/12 12:00
8/18/12 0:00
8/18/12 12:00
8/19/12 0:00
8/19/12 12:00
Date and Time

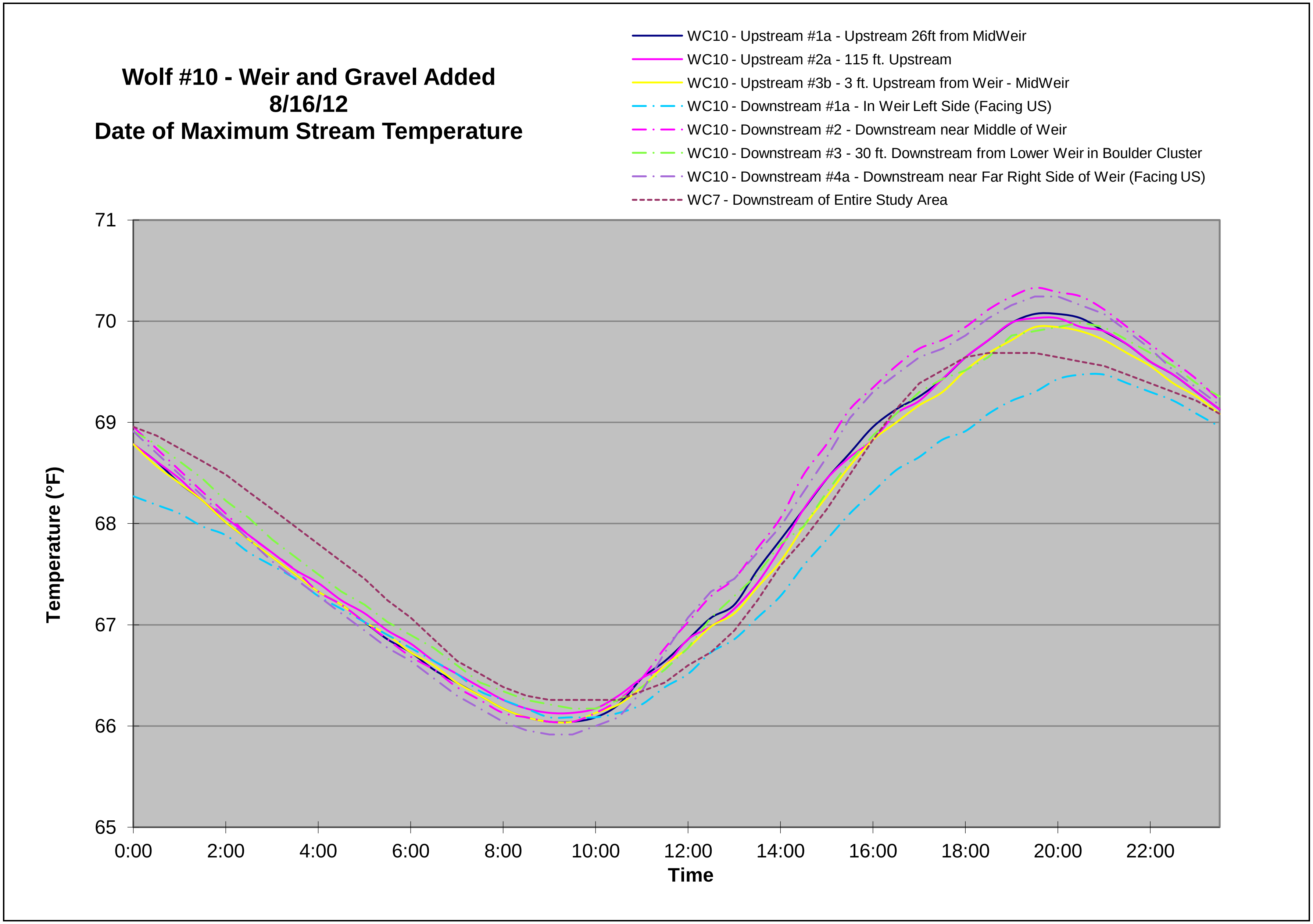
Appendix I: 2012 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12



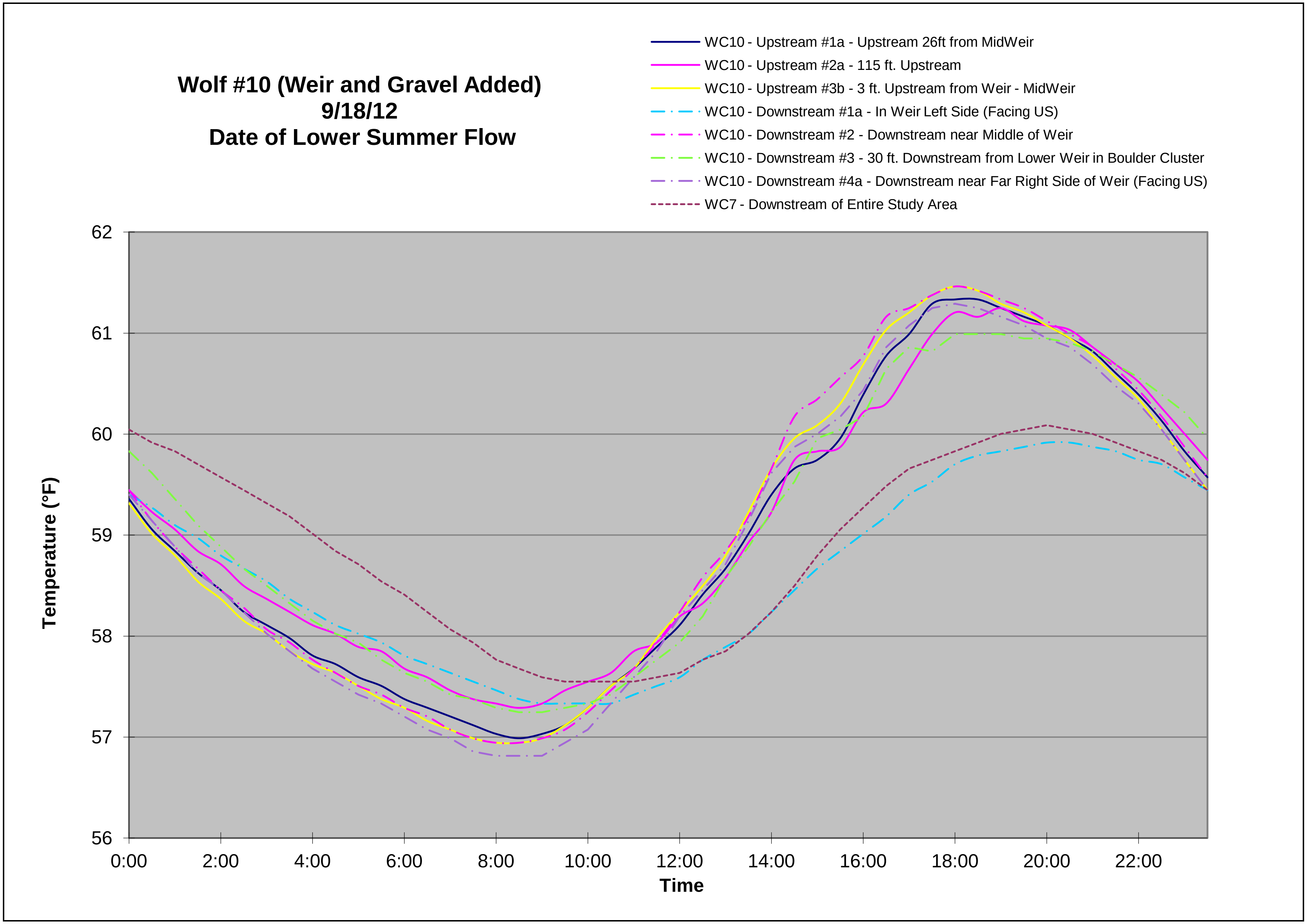

Wolf #9 - Weir and No Gravel Added
9/18/12
Date of LowSummer Flow
WC9 - Upstream #1a - 107 ft. Upstream
WC9 - Upstream #3b - 1 ft Upstream near Right Side of Weir (Facing US)
WC9 - Downstream #1a - in Left Side of Weir (Facing US)
WC9 - Downstream #2 - 21 ft. Downstream - Mid Stream
WC9 - Downstream #3a - in Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
Temperature (°F)
62
61
60
59
58
57
56
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

Appendix I: 2012 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

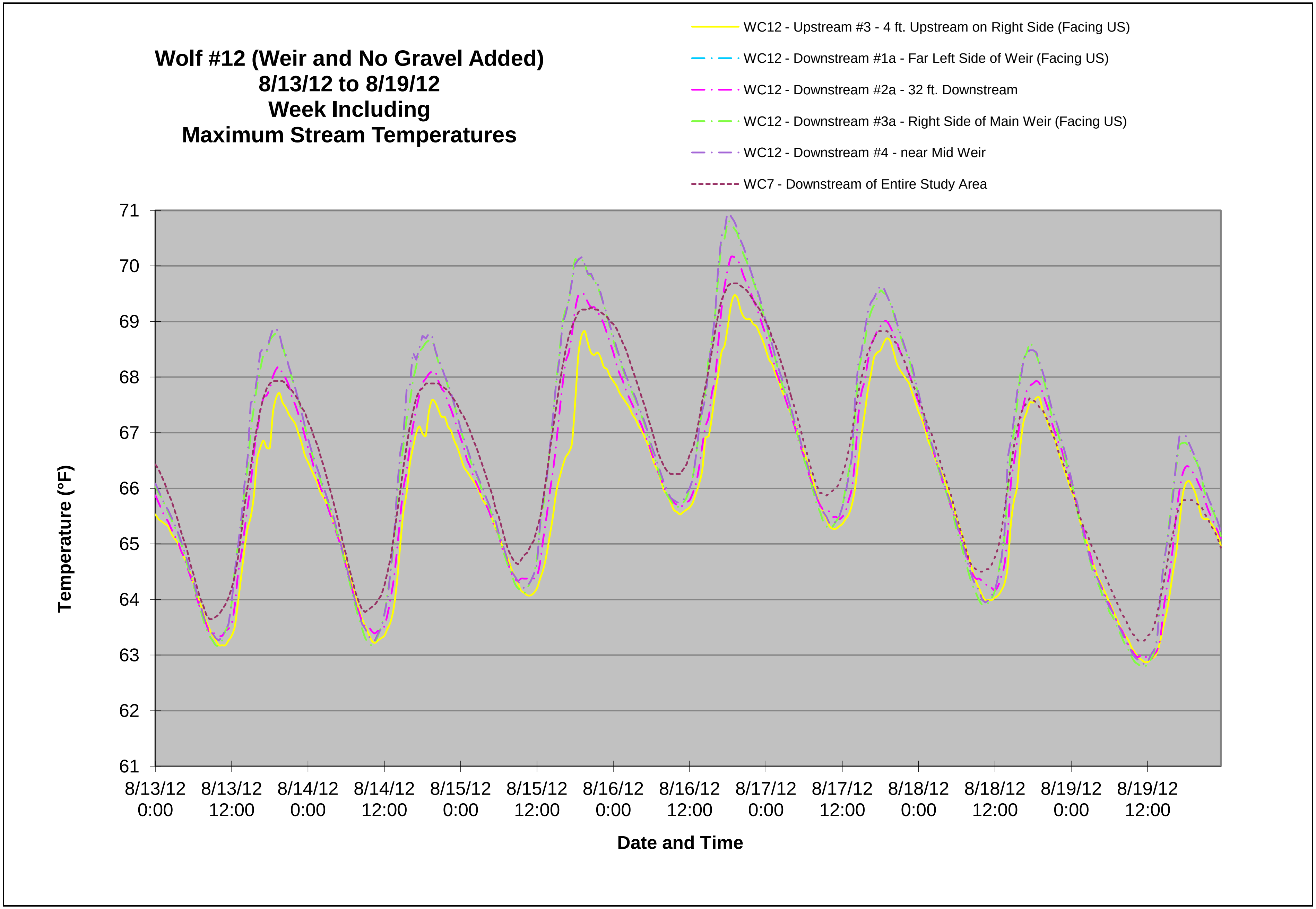



Wolf #10 - Weir and Gravel Added
8/16/12
Date of Maximum Stream Temperature
WC10 - Upstream #1a - Upstream 26ft from MidWeir
WC10 - Upstream #2a - 115 ft. Upstream
WC10 - Upstream #3b - 3 ft. Upstream from Weir - MidWeir
WC10 - Downstream #1a - In Weir Left Side (Facing US)
WC10 - Downstream #2 - Downstream near Middle of Weir
WC10 - Downstream #3 - 30 ft. Downstream from Lower Weir in Boulder Cluster
WC10 - Downstream #4a - Downstream near Far Right Side of Weir (Facing US)
WC7 - Downstream of Entire Study Area
Temperature (°F)
71
70
69
68
67
66
65
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

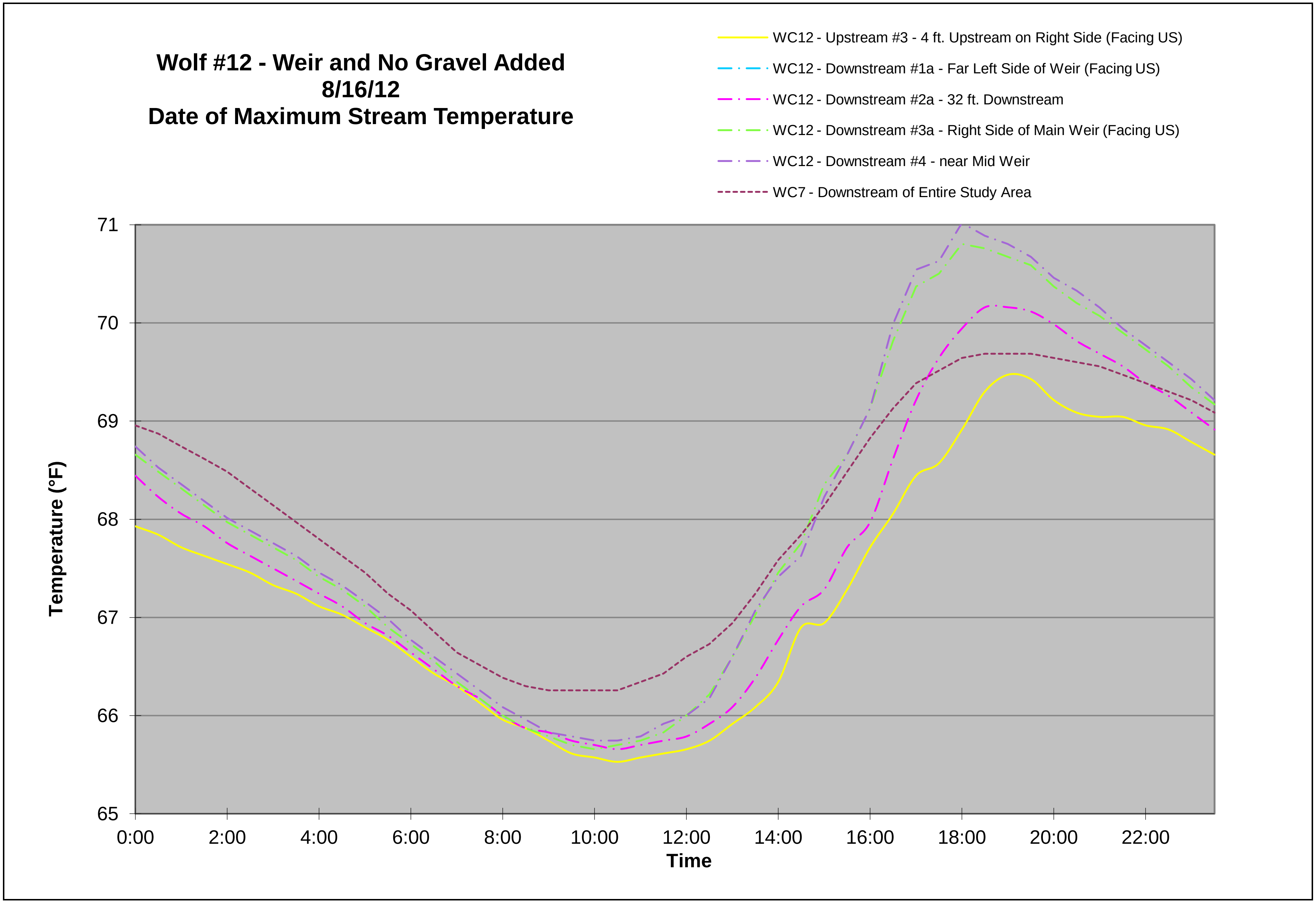
Appendix I: 2012 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12

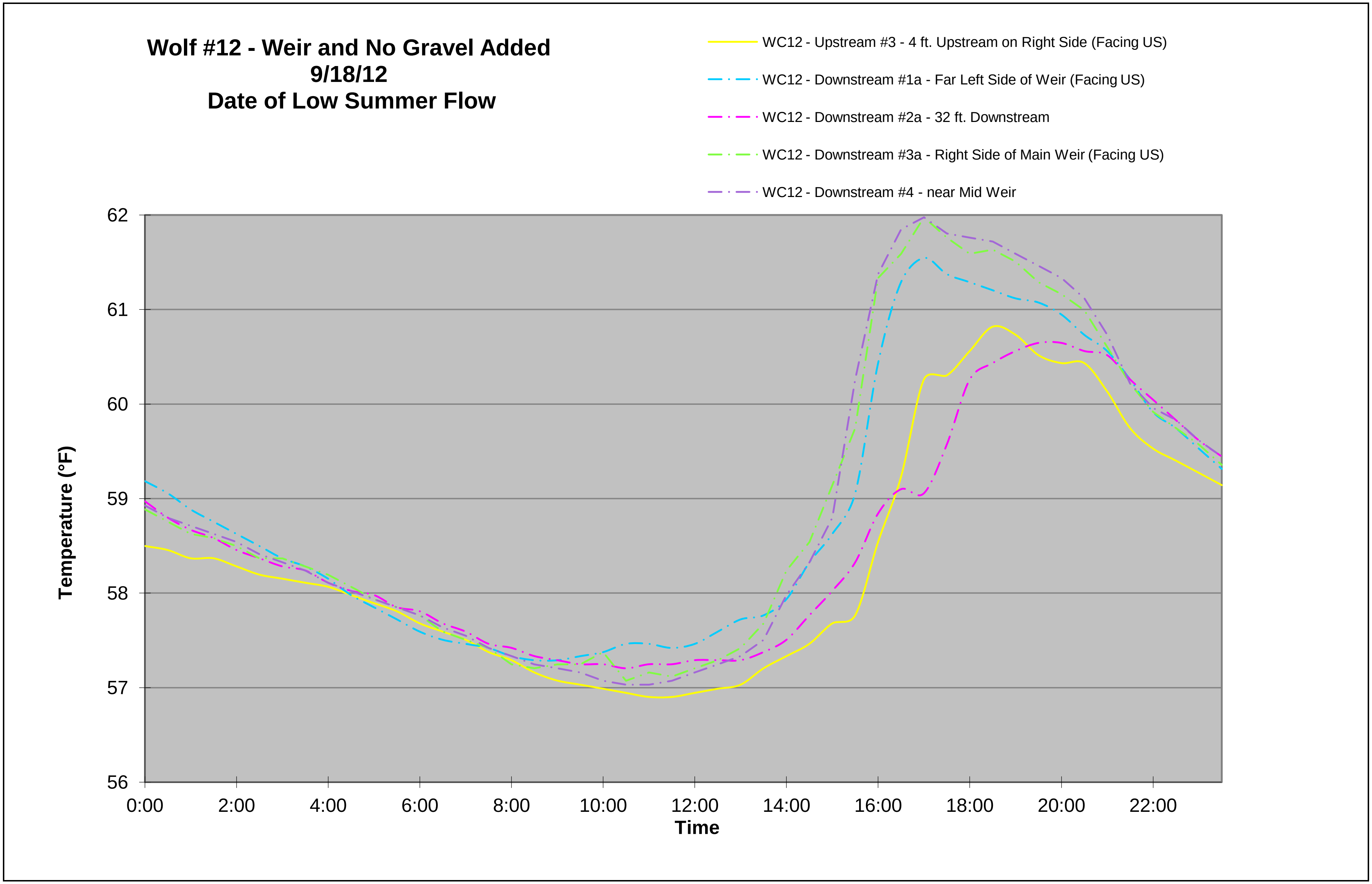


Appendix I: 2012 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12



Appendix I: 2012 Temperature Charts at Highest Stream Temperature and at Low Stream Flows, Weirs 8,9,10,12




Wolf #12 - Weir and No Gravel Added
9/18/12
Date of Low Summer Flow
WC12 - Upstream #3 - 4 ft. Upstream on Right Side (Facing US)
WC12 - Downstream #1a - Far Left Side of Weir (Facing US)
WC12 - Downstream #2a - 32 ft. Downstream
WC12 - Downstream #3a - Right Side of Main Weir (Facing US)
WC12 - Downstream #4 - near Mid Weir
Temperature (°F)
62
61
60
59
58
57
56
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
Time

Weir #8
Weir and Gravel Added

Photo 3:
7/6/2009
Proposed site
Weir #8
Looking downstream at weir

Photo 4:
Wier #8
8/7/09
Weir and gravel added
Mid-weir cross-section
Looking downstream
at weir

N43 26.084
W123 35.293
Weir Length 76’
Active Channel Width 49’
158 Boulders
100 cu.yd. 6’ minus unsorted, unwashed gravel

Appendix J: Weir Photos

Photo 5:
Weir #8
2nd upstream cross-section
8/25/09
122 feet upstream of weir face
Looking downstream

Photo 6:
Weir #8
2nd upstream cross-section
8/25/09
Looking upstream

Appendix J: Weir Photos

Photo 7:
Weir #8
Community public tour of Wolf Creek
8/11/09
At Weir #8

Photo 8:
Weir #8
3/31/2010
Following a major storm event

Photo 9:
Weir #8
With debris
accumulation
7/29/2010
Looking
downstream
at weir

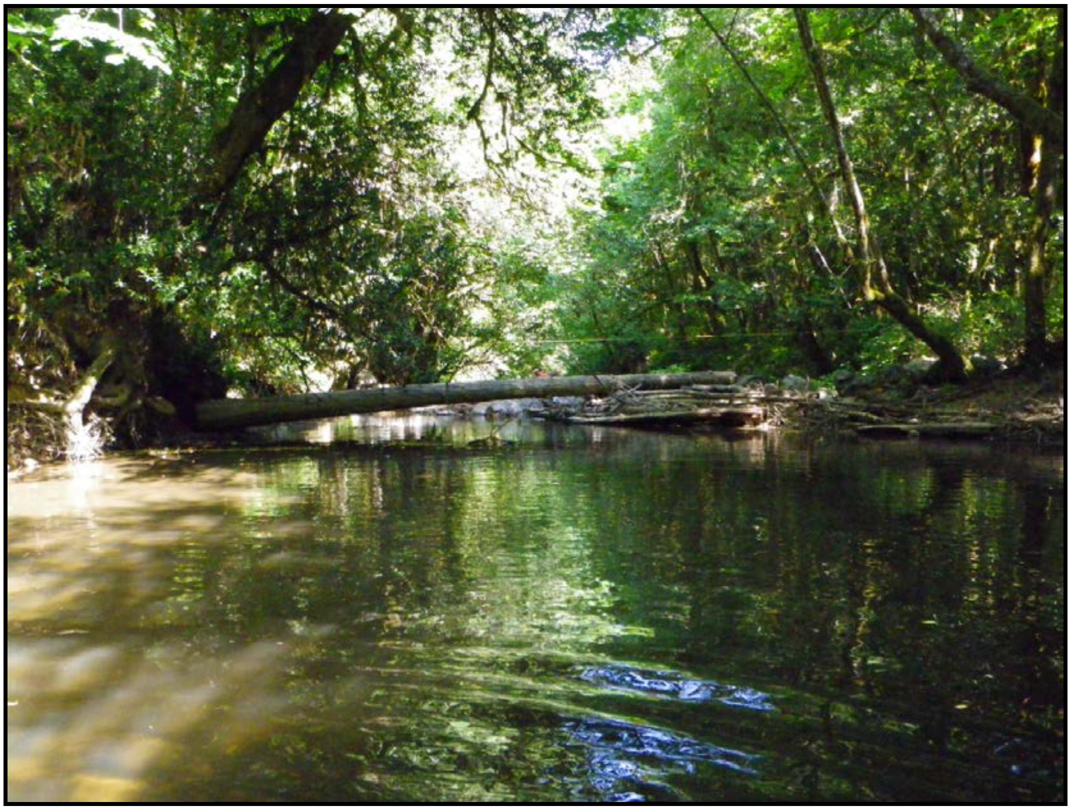


Photo #10:
Weir #8
More debris
accumulation
7/12/2011
Looking
downstream at
weir

Photo #11:
Weir #8 from downstream looking upstream 9/21/2012 Low flow conditions

Photo #12:
Weir #8 from upstream looking downstream 10/14/2012

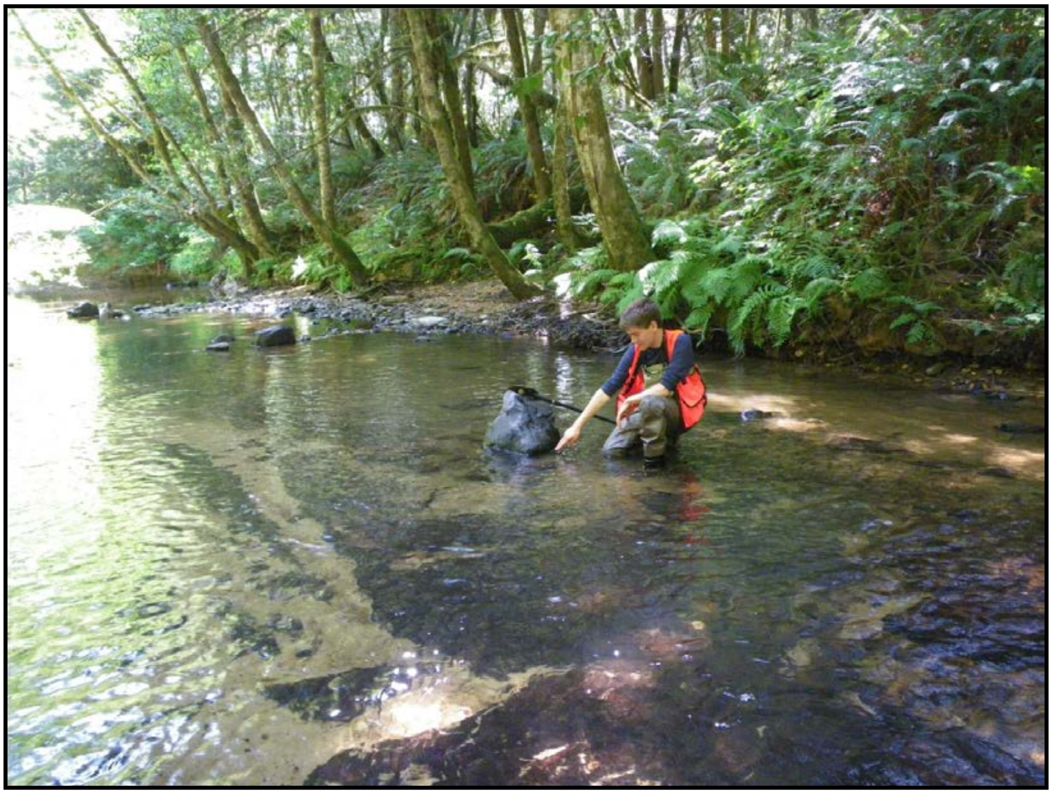


Photo #13: Furthest Downstream Temperature Logger Site Planned Weir #7 (never built) 466’ downstream of Weir #8 7/15/09 Looking downstream

Temperature Logger Sites Summer 2011
Upstream of Weir #8

Photo #14: Temperature Data Logger Sites 2011

Photo 15:

US 1 Buried 5" deep in gravel

Photo 16:

US2 Tied to small rock sitting on bottom under rock barb

Photo #17

US3a Buried 5" in gravel

Photo #18

US 4 59' upstream of weir face
On face of gravel edge
Not buried, covered with rock

Photo #19

US5 on face of gravel, not buried, covered with a rock

Photo #20

US 6 Buried 15” deep in gravel

Photo #21

US8a Buried 5" in mud

Temperature Logger Sites Summer 2011
Downstream of Weir #8
(Area photo from 2012, logs atop weir moved away winter 2011)

Photo #22

Photo #23

DS1a In notch between two boulders
downstream side of weir, mid weir
Tied to rock

Photo #24

DS2a downstream side of weir,
2/3 way across weir
Tied to rock

Photos – Weir #9
Weir only no gravel added

Photo # 25:
Weir #9
Looking upstream through proposed weir site
7/18/07

Photo #26:
7/2/09 prior to boulder placement boulders staged at right of photo
Looking upstream

Photo #27:
Weir #9
Upstream cross-section
nearest Weir #9
21 feet upstream of weir
8/25/09

N43 26.101
W123 35.437
Weir Length 69'
Active Channel Width
37'
154 Boulders
No gravel added

Photo #28
Weir #9
2nd Upstream cross-section
115 feet upstream of weir
9/16/09
Looking downstream at
weir

Photo #29: Weir #9 3/31/2010 after large storm event.

Photo #30: Weir #9 from downstream looking upstream 10/14/12

Photo #31:
Weir #9 from upstream looking downstream 10/14/12

Photos – Wier #10
Weir and Gravel Added

Photo #32:
Proposed site for Weir #10
on remains of old weir
7/18/07
Looking downstream

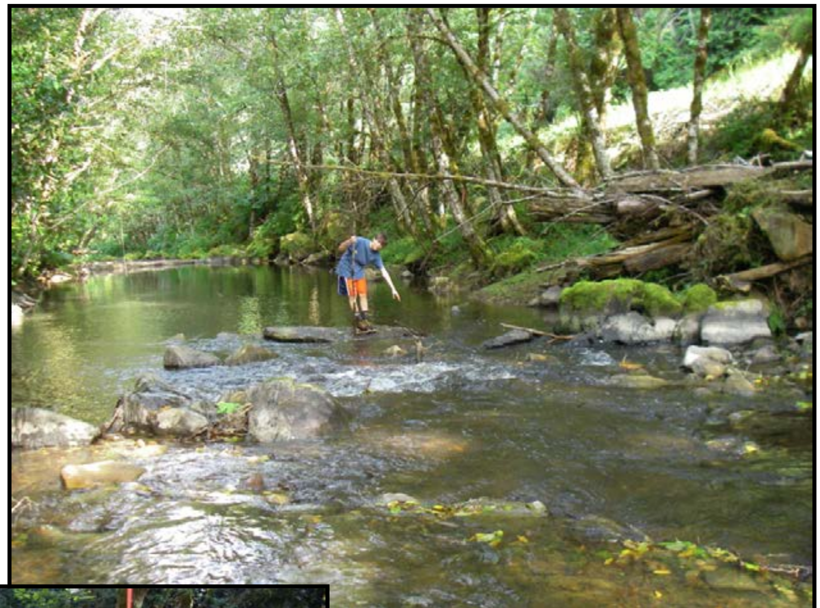


Photo #33:
7/27/09
Weir#10 and gravel placement day of construction
N43 26.117
W123 35.572
Weir Length 82’
Active Channel Width 34’
146 Boulders
100 cu.yd. - 6’minus unsorted unwashed gravel

Photo #34

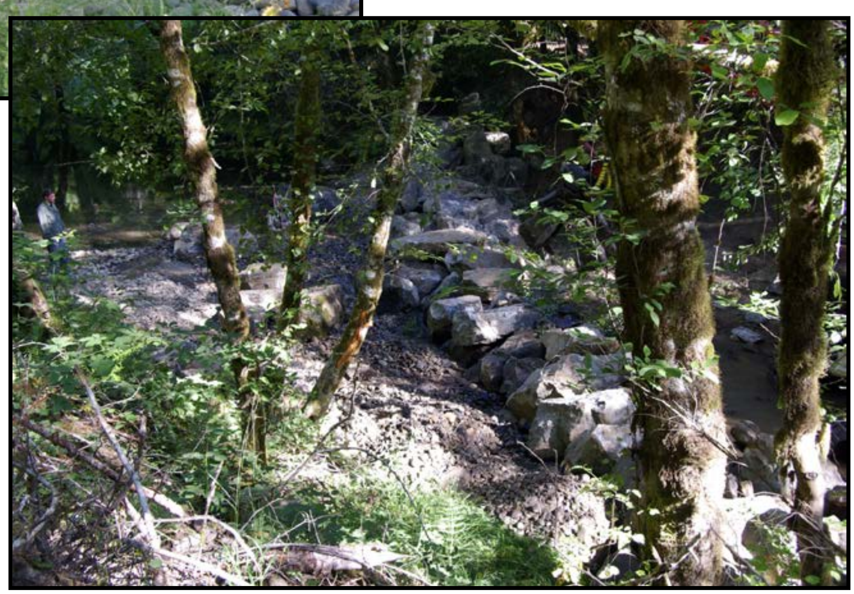


Photo #35:
8/13/09
Upstream Cross-section
nearest Weir #10
29 feet upstream

Photo #36:
2nd upstream cross-section
Weir #10
130 feet upstream

Photo #37: Winter flows 3/31/2010 after a major storm event.
Logs are sitting atop of Weir #10

Photo #38: Typical winter flow 3/20/2013 Weir #10

Appendix K: Weir Photos

Photo #39:
Weir #10 from downstream looking upstream
10/14/2012

Photo #40:
Weir #10 from upstream looking downstream
10/14/2012

Photos – Weir #12
Weir only no gravel added

Photo #41: Proposed site for Weir #12 7/2/09, Upstream looking downstream

Appendix M: Weir #12 Photos

Photo #42:
8/25/09
Upstream cross-section nearest Weir #12
29 feet upstream of weir face

N43 26.143
W123 35.686
Weir Length 70'
Active Channel Width 37'
140 Boulders
No gravel added

Photo #43:
2nd Upstream cross-section
Weir #12
10/1/09
113 feet upstream of weir face

Appendix M: Weir #12 Photos

Photo #44:
7/15/2010
Weir #12 with beaver additions

Photo #45:
Beaver burrow in bank upstsream of Weir #12
7/12/2010

Appendix M: Weir #12 Photos

Photo #46:
Downstream looking up at Weir #12
10/14/2012

Photo #47:
Upstream looking down at Weir #12
10/14/2012

Wolf Creek Restoration Effectiveness Monitoring – A Partnership Story

Jeffrey McEnroe[1], Dan Dammann[1], Scott Lightcap[1], Sandy Lyon[2], and Holly Truemper[3]

1-Bureau of Land Management – Roseburg, Oregon, 2- Partnership for the Umpqua Rivers, 3 – Oregon Department of Fish and Wildlife

Introduction:

Millions of dollars have been spent on aquatic restoration projects in the Pacific Northwest over the last several decades. However, evaluating the physical and biological effectiveness of these projects at large scales has proven to be problematic due to high costs and intensive labor needs.

Restoration partners in the Umpqua Basin recognized an opportunity to attempt a large scale restoration effectiveness monitoring project in Wolf Creek, a 23,000 acre 6th field sub-watershed in the Coast Range mountains of Southwestern Oregon. By working together in this effort, no single partner was over-burdened with the overall monitoring workload.

Objective:

Our objective was to accomplish large scale restoration effectiveness monitoring using a partnership approach in order to minimize the amount of staff time, effort, and funding required by any one group. In addition, due to an overall lack of regional effectiveness monitoring data, we wanted to devise a sampling regime that was both extensive, and intensive, and utilized rigorous peer-reviewed protocols.

Monitoring Methods Used:

BEFORE AFTER CONTROL IMPACT (BACI) design

- Coho spawning surveys (*ODFW Protocol*) in the full extent of coho distribution
- Coho juvenile standing crop surveys (*ODFW Protocol*) in treatment and control reaches
- Extensive Macroinvertebrate samples in treatment and control reaches
- Water temperature monitoring throughout the watershed
- Water temperature monitoring upstream and downstream of several individual structures
- Pre and post project photopoints using a rigorous, repeatable protocol
- Intensive habitat surveys in treatment and control reaches using an Engineering Total Station
- Use of AREMP crews to sample 21 parameters at 33 sites throughout the watershed at 5 year intervals

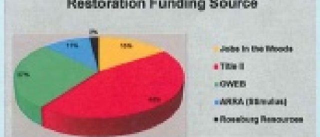
Wolf Creek Monitoring Summary

MONITORING TYPE	EXTENT	FREQUENCY	START YEAR	TIME OF YEAR	CREW
Coho Spawning Surveys	6th Field	Yearly	2006	November - January	BLM, ODFW, & PUR
Juvenile Coho Standing Crop Surveys	11 Reaches (1000 m)	Yearly	2007	August-September	BLM, ODFW, & PUR
USGS Stream Gage	7th Field (Little Wolf Creek)	Continuous	2007	Continuous	BLM and USGS
AREMP	6th Field (33 sites)	Every 3-5 years	2006	June - September	BLM (AREMP)
Intensive Longitudinal Survey and Mapping	4 Reaches (300 m) Little Wolf Creek	Every 3-5 years	2008	June - September	BLM (AREMP)
Water Temperature (Ambient Monitoring)	6th Field (7 sites)	Yearly	2002	June - October	BLM
Water Temperature (Restoration Monitoring)	4 Reaches (8 sites) Little Wolf Creek	Yearly	2007	June - October	PUR
Water Temperature (Restoration Monitoring)	Wolf Creek (6 sites)	Yearly	2008	June - October	PUR
Cross Section Surveys	Little Wolf and Wolf Creeks (22 sites)	Yearly	2008	Anytime	PUR
Photopoints	6th Field (20 sites)	2-3 times/year	2008	Anytime	BLM
Rain Gauge	7th Field (Little Wolf Creek)	Continuous	2007	Continuous	BLM
Winter Habitat Surveys	Miner Creek & Trib A	Every 3-5 years	2007	December - February	ODFW
Summer Habitat Surveys	Miner Creek	Every 3-5 years	2007	June - September	ODFW
Oregon Department of Water Resources Low Flow Measurements	Wolf Creek (1 site)	Yearly	2009	June-September	OWRD & PUR

Restoration Summary:

- Two years of restoration treatments on public and private industrial timber lands have resulted in the placement of over 700 logs and 6,000 boulders into roughly 9.5 miles of stream channel.
- 5 fish barrier culverts were removed and replaced with fish-friendly designs.
- Over $1 Million dollars spent on restoration actions from the sources listed below.

Restoration Funding Source

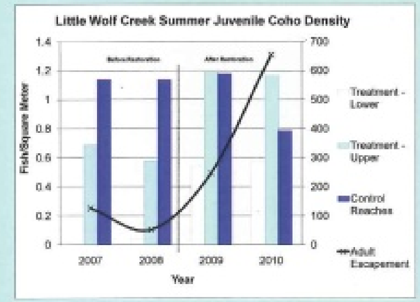


Total = $1,254,326

Examples of Preliminary Results:

Juvenile Coho Surveys

- Four 1,000 M reaches (2 treatment, 2 control) were snorkeled in Little Wolf Creek before and after restoration treatments were implemented.
- After the 1st year of restoration, coho density increased dramatically in treatment reaches while staying relatively stable in control reaches. After the 2nd year, treatment reaches remained higher, but control reaches declined.



Detailed Stream Channel Mapping in Little Wolf Creek:

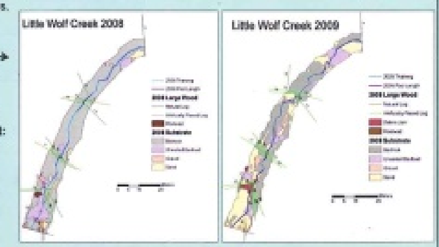
- Four 300 meter stream reaches (two treatment, one control high quality, and one control low quality) were mapped using an Engineering Total Station.
  - Treatment reaches = bedrock dominated with logs added in 2008
  - Control High = excellent habitat, lots of wood
  - Control Low = bedrock dominated with some wood
- Surveys were completed in 2008 immediately after wood placement, and repeated in 2009 to capture the effects from the first season of winter flows.

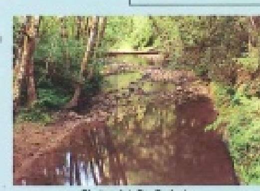
Sample of data from Treatment Reach 1

(what is shown is about 1/3 of the total reach)

One Year after the large wood project:

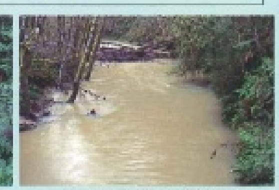
- Area of bedrock decreased 33%
- Area of gravel increased 240%
- Area of sand increased 445%
- Length of Thalweg increased 8%
- Length of Pools increased 38%





Photopoint: Pre-Project

Photopoint: Time 0 – just after placement



Photopoint: First Winter – High Flows

Acknowledgements:

We would like thank all our partners: Bob Kinyon, Terry Burleson, and the rest of the Partnership for Umpqua Rivers staff. Bill Cannaday, Dan Jenkins, and other ODFW staff. Chris Moyer and the AREMP crews. Jim Lee and the Douglas Soil and Water Conservation District. Roseburg Resources and Seneca Jones timber companies. Keith Karoglanian, Jake Winn, Jonas Parker, and Cory Sipher with the Roseburg BLM. The Roseburg BLM Resource Advisory Committee and the Oregon Watershed Enhancement Board.

Appendix O: Additional information about the project

A. Description and changes to the original proposal:

a. A few changes had to be made to the original proposal. The costs involved for materials in the restoration part of the grant had significantly increased from estimates. This required reducing the amount of funding available for the gravel addition. Instead of three augmented weirs and three control weirs only two weirs were augmented with gravel and two non-augmented weirs were used as controls.
b. A second change that was made from the original proposal was the location of the cross-sections. We wanted to be able to capture any native gravel accumulation over time and we felt that having two upstream cross-sections would provide a better opportunity of tracking where and how much deposition was accumulating. Therefore the downstream cross-sections were eliminated in favor of two upstream.
c. A beneficial addition was made to the monitoring when the local Watermaster offered to measure summer stream flows in Wolf Creek just downstream of our test reach, two times per month starting in 2009 and continuing in 2010, 2011 and 2012. This information has proven to be valuable in analysis of our results.

B. Where the data can be obtained:

The data can be obtained from Sandy Lyon, Monitoring Coordinator for the Partnership for the Umpqua Rivers. The raw temperature data will soon be sent to DEQ and will be made available in their LASAR Database.

C. Explanation of how the information collected is to be used to inform future actions:

The information gained from this study will be used to improve designs of future projects. The information obtained from this project is specific to this size watershed and flow conditions.

D. Accounting of Expenditures:

All expenditure accounting and match is included in the final report for *Wolf Creek Basin Restoration* 209-2021-6735.

E. Will data collected be used in any published report or shared with any other parties:

Some of the preliminary data has already been shared at several conferences, most notably at the 2010 OWEB Biennial Conference in Pendleton. The final report will be displayed on the PUR website. The results will be presented at a local monthly gathering of hydrologists in Roseburg called the Hydro Breakfast. The Roseburg District BLM produced an informational poster that is being shared at various professional and community events – see Appendix N. Many tours have already occurred and continue to occur due to the large scale, mult-partner success of the Wolf Creek Restoration Project.

F. Did the project achieve the larger objective it was designed to meet?

The project achieved the objectives it was designed to accomplish. Under the conditions that were monitored in Wolf Creek our data was of good quality and sufficient enough to answer the question proposed. Unfortunately the results were not what we might have hoped for, but we were able to accurately monitor the temperatures above and below the test weirs and the control weirs and to demonstrate changes to the bedload with the cross-sections and pebble counts.