Appendix G:

Lost River Temperature Modeling Scenarios

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G.1 Introduction

To support revision of the Lost River Temperature TMDL, EPA directed Tetra Tech to evaluate several shading scenarios using the existing Lost River Model, which was originally developed and applied to the Lost River TMDL (Appendix C of Kirk et al. 2010 TMDL document). An initial 30-percent shading scenario with a 30-percent reduction in solar radiation resulted in meeting the BBNC at most locations along the Lost River. An additional maximum shading scenario was identified that would implement additional variable shading situations to evaluate if the BBNC cool water species temperature criteria is met at all locations along the Lost River. The BBNC is interpreted by ODEQ to be 27.9 deg C as daily maximum temperature with 0.1 deg C allocated to reserve capacity. For this scenario, the maximum amount of shading possible that can be implemented along the Lost River for each of its Waterbodies was first determined and provided by ODEQ using available shade curves (developed by ODEQ). The site potential shading was incorporated into the Lost River Model to evaluate temperature compliance. Finally, an additional flow augmentation scenario was conducted (using the maximum shading scenario as a baseline) to ensure compliance at all locations. This memo describes the analyses performed to evaluate Lost River Modeled temperatures resulting from various shading and flow augmented regimes. First, it describes modeled existing temperatures along the Lost River, followed by the scenario that incorporates the maximum potential shading, and finally the augmented flow scenario (using the site potential shading model as the basis) to ensure that the daily maximum temperature criteria are met at all locations and at all times. Model results reveal that to meet criteria, both maximum shading and augmented flows will be required.

G.2 Lost River Model-Existing Conditions

The Lost River modeling framework is comprised of a series of CE-QUAL-W2 (W2) models. The Lost River model was developed for the year 1999. The Oregon portion of the Lost River model includes six out of the twelve waterbodies, with Waterbody #6 extending past the OR/CA border into CA up to Tule Lake (See Figure G-1).

During this analysis, Waterbodies #1 through #6 were run in sequence with output from one model transferred to another to generate hourly water temperatures at the Stateline. The models were run with the goal to evaluate the simulated hourly water temperatures at the OR/CA Stateline compared to the designated water temperature criteria of 27.9 deg C with the daily maximum temperature (DM).

The spatial extents of the waterbodies and boundary condition transfer from one waterbody to another is briefly discussed below.

Waterbody #1

Waterbody #1 extended from Malone Dam to Harpold Dam. Waterbody #1 was simulated independently, and the resulting dam discharge flow rate, as well as the simulated temperature (and water quality), at Harpold Dam were saved in separate files. These results were then read when simulating Waterbodies #2 through #4.

Waterbody #2 to #4

The following are the extents for waterbodies #2 to #4.

Waterbody #2 extends from Harpold Dam to Poe Valley Bridge

Waterbody #3 extends from Poe Valley Bridge to just upstream of Wilson Reservoir

Waterbody #4 extends before Wilson Reservoir to Wilson Dam.

Waterbodies #2 through #4 were run simultaneously as one piece with internal head boundaries provided between Waterbody #2 and #3 and between #3 and #4.

Waterbody #5

Waterbody #5 extends from Wilson Dam to Anderson Rose Dam. The upstream boundary for Waterbody #5 is based on the downstream weir-based boundary condition from Waterbody #4.

Waterbody #6

Waterbody #6 extends from Anderson Rose Dam to Lost River before Tule Lake. This waterbody crosses the OR/CA Stateline border (at model segment 205). The upstream boundary for Waterbody #6 received dam flow from Anderson Rose Dam (from Waterbody #5).

Multiple compliance points were evaluated throughout the system during the initial phase of modeling that was conducted as part of the original TMDL (Appendix C in Kirk et al. 2010) to ensure that water quality criteria were being met in critical locations. The stations that were used are as follows:

- Lost River at Gift Road (LRGR)
- Lost River at Keller Bridge (LRKB)
- Harpold Dam (LRHD)
- Lost River at Stevenson Park (LRSP)
- Lost River at Olene Gap (LROG)
- Lost River in Wilson Reservoir at Crystal Springs Road Bridge (LRWRC)
- Wilson Dam (LRWR)
- Lost River at Dehlinger Road (LRDR)
- Lost River at Hwy 39 n/w of Merrill (LR39)
- Anderson-Rose Dam (LRAR)
- Lost River at Stateline Road – OR/CA border (LRSR)

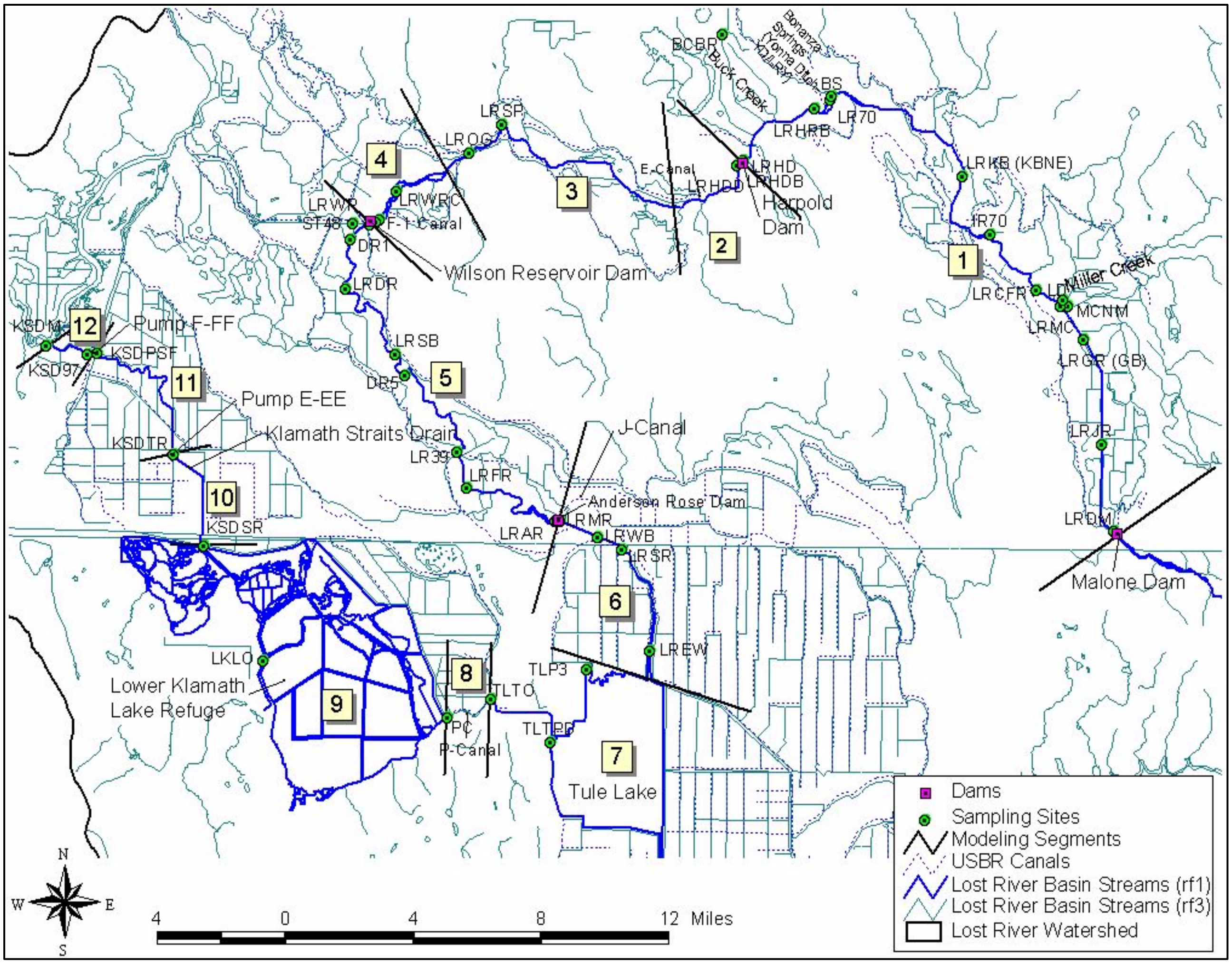


Figure G-1. Lost River Station Locations.

Simulated temperatures for the existing condition were evaluated and compared to the daily maximum temperature criteria of 27.9 deg C. The previous existing condition Lost River model output frequency was set to output at every five hours. For this analysis, the model was re-run sequentially to output temperatures at an hourly frequency for evaluation of the daily maximum value metric. The simulated daily maximum temperatures consistently exceeded the BBNC of 27.9 deg C at two locations – LRGR and LRSR, all other station locations met the criteria. Figure G-2 shows the temperature plot for the Stateline (LRSR), where the BBNC is exceeded typically from June through August with simulated temperatures as high as 38 deg C during July.

The excess thermal load was calculated using the flow and daily maximum values at the corresponding location. Loads exceeding the thermal loading capacity based on the 27.9 deg C criteria are presented as a function of flow at the Stateline (Figure G-3) and are also summarized based on the minimum and maximum values observed for all locations that did not meet the criteria (Table G-1). At the Stateline the excess loads were observed during flows ranging from 4.7 to 19 cfs and percent reductions ranged from 0.4 to 26 percent (Table G-1). The percent thermal load reductions needed to meet the criteria at the Stateline are shown below for the various flow rates, with darker colors indicating a higher percent reduction (Figure

G-4). In 1999, 12-percent of the days (42 days) required reductions in the thermal load to meet the loading capacity at the Stateline, whereas at the LRGR station 29-percent of the days (107 days) required reductions to the thermal load. In all cases as expected the largest percent reductions were required at the lower end of the observed flows (Figure G-3).

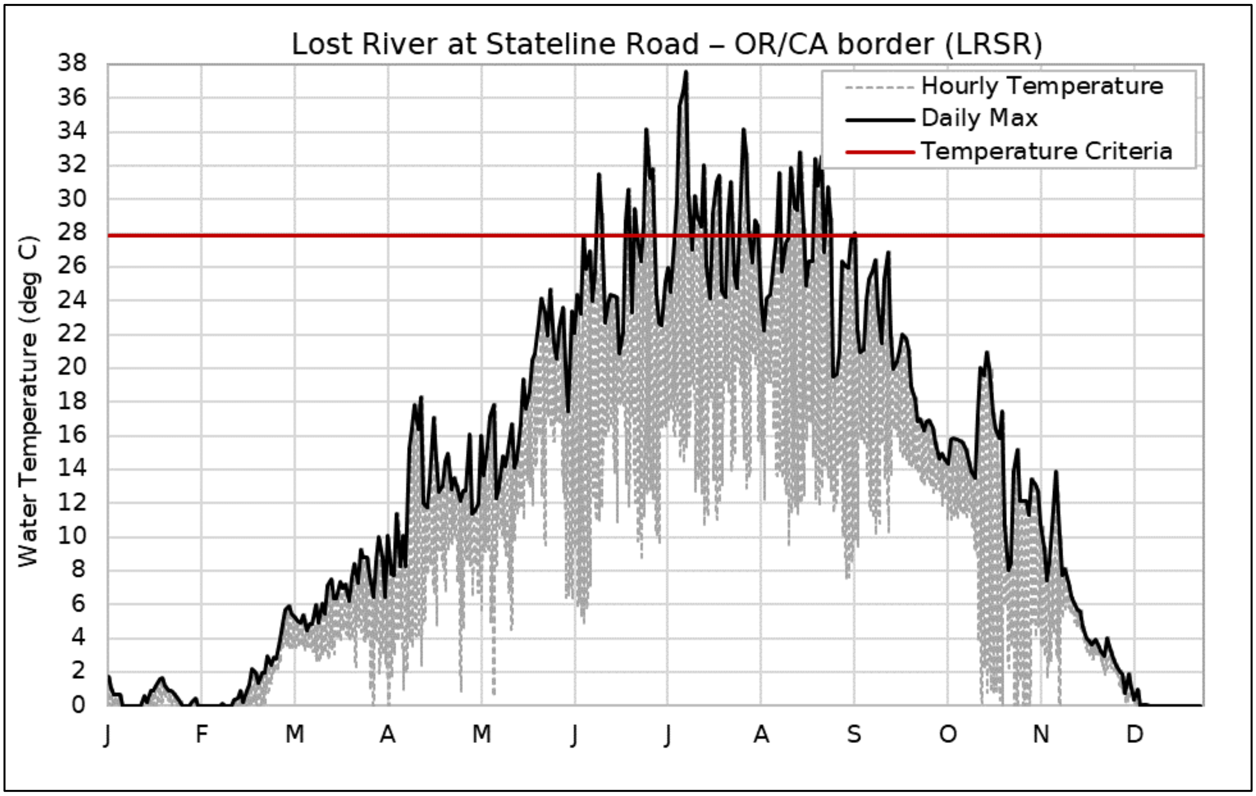


Figure G-2. Lost River temperature at Stateline (1999).

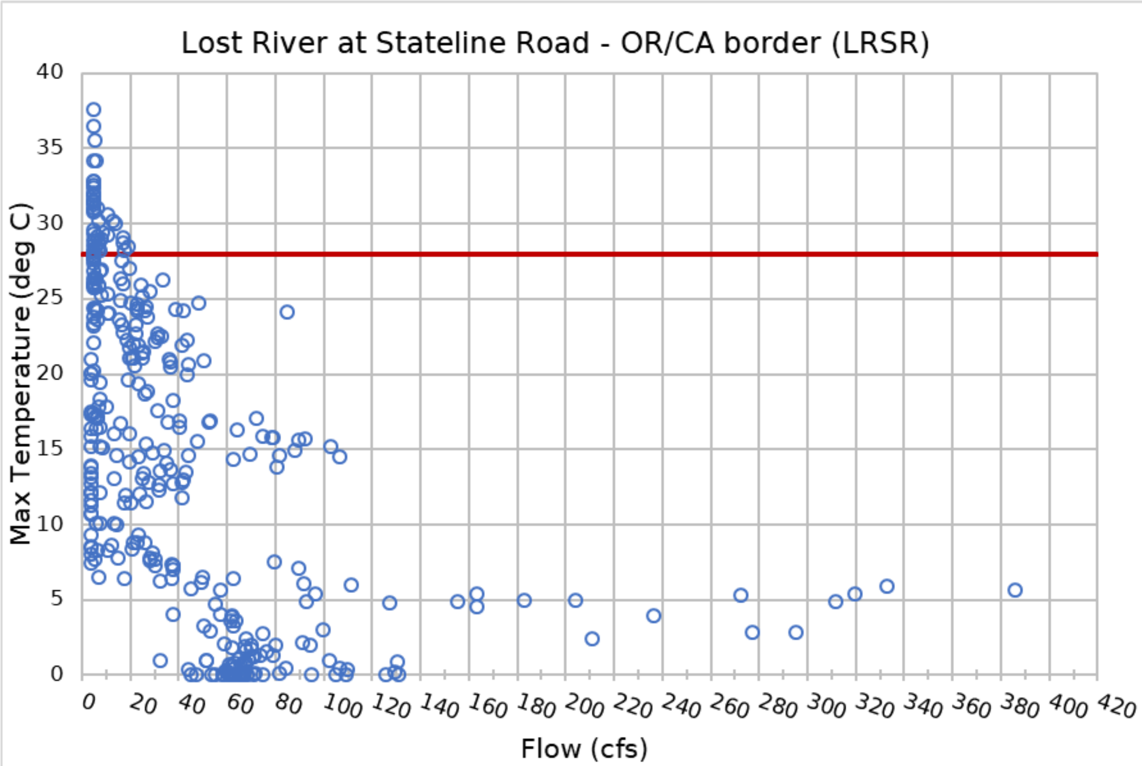


Figure G-3. Lost River temperature at Stateline – Daily Maximum temperatures and associated flows (1999).

Table G-1. Lost River summary of excess thermal load at locations not meeting criteria.

Statistic	Flows with Exceedances (cfs)	Observed DM Exceeding Criteria (°C)	Percent Reduction to Meet Criteria	Excess Heat Load (kcal/day)
Lost River at Gift Road (LRGR)				
Minimum	8.4	19.1	1.4%	9.15E+06
Maximum	10.1	39.47	24%	2.00E+08
Lost River at Stateline Road – OR/CA border (LRSR)				
Minimum	4.7	28.02	0.4%	1.38E+06
Maximum	19.0	37.61	26%	1.12E+08

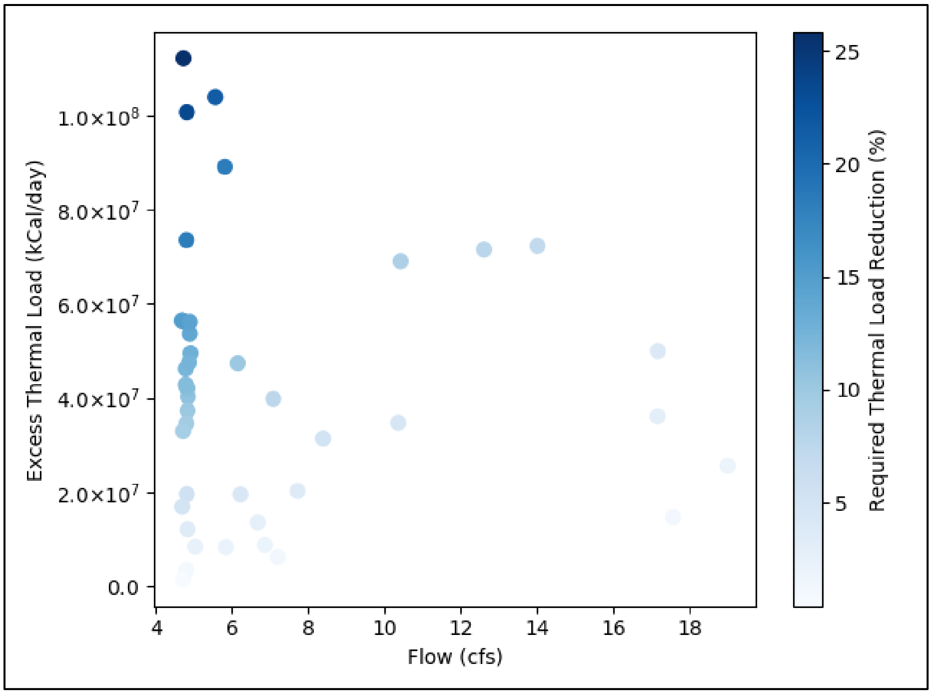


Figure G-4. Lost River excess thermal load and percent reductions by flow at Stateline(1999).

In addition to the time-series at the compliance locations, hourly water temperature time series were output at all the segments in the waterbodies (segments were typically approximately half a kilometer in length). The hourly results were then processed to calculate the daily maximum temperatures values at each of the segments. The maximum, mean, and minimum value of the daily maximum temperatures for the summer period taken from May through mid-September were then calculated for each of the segments in the waterbodies and plotted to evaluate the spatial distribution of the temperatures.

Section G8 shows the longitudinal plots for the existing condition during 1999. The longitudinal plots indicate that the upstream portion of Waterbody #1 has the highest exceedances of the daily maximum temperatures along the system from RKM 2 to RKM 12.5. During the irrigation period Malone Dam discharge into the Lost River is effectively negligible, the effects of which are seen in the high temperatures (the maximum of the DM being 39.5 deg C) up to around where Miller Creek enters Lost River. From here the temperature gets lower, which is possibly a reflection of the distributed flows entering the system. In addition, the conditions at the upstream end where the largest exceedances were observed, indicate a very open, flat, and wide channel. The excess temperature calculated as the difference between the maximum of the daily maximums (during the period from May through mid-September) and the criteria of 27.9 deg C can be as high as 11.48 deg C at RKM 11. The remaining Waterbodies 2, 3, 4 and 5 do not show any exceedance of the daily maximum criterion. Waterbody #6 showed exceedances of the daily maximum temperatures after around RKM 0.8 to Stateline (RKM 4.8). The excess temperature calculated as the difference between the maximum of the daily maximum and the criteria of 27.9 deg C can be as high as 9.88 deg C at RKM 3.8/Segment 9. These exceedances coincide during days when no flow is discharged from Anderson Rose Dam into Waterbody #6.

G.3 Lost River Restored Vegetation Shading Scenario

The impact of enhanced riparian vegetation on stream temperature was evaluated to determine if the temperature criteria at the Stateline and other locations could be met due to the resulting shading. The Lost River W2 model does not simulate the effects of riparian vegetation. The effects of riparian vegetation shading were accounted for by using a scaling factor for solar radiation intensity.

An initial shading scenario was configured with 30-percent shading and used as the basis for evaluation of the temperatures at the compliance points. The 30-percent reduction of the solar radiation value was configured in the model for all Waterbodies except in Wilson Reservoir to grossly represent increased riparian shading.

The 30-percent decrease in solar radiation was assumed to represent the maximum possible shading for the system and is most applicable to relatively narrow, riverine portions and narrow impoundments (as opposed to wide lakes such as Wilson where shading is not expected to have any effect) (Appendix C in Kirk et al. 2010). The increased shade simulation does not explicitly consider vegetation height/density, the path of the sun or impact of variable shading over the course of the day, orientation or geometry of the Waterbody (i.e., width of the river/impoundment), or topographic shading impacts (found to be in insignificant for the Lost River) (Appendix C in Kirk et al. 2010). The 30-percent shading scenario showed an improvement in temperature conditions at several locations along the Lost River. Hence a refined shading scenario that included the maximum amount of shading possible based on site potential restored vegetation conditions was evaluated.

The maximum amount of shading possible that can be implemented along the Lost River for each of its branches was first determined using the Heatsource model developed by DEQ. See Appendix A for the Lost River Heatsource model setup and configuration. The typical summertime average wetted width and aspect were extracted for each of the segments in the various waterbodies to assist in shade modeling. The summer time (7/15/1999) wetted widths and aspects are outlined in Section G.11. The restored vegetation shade values were calculated and provided by ODEQ (March 6, 2019 email communication *Lost_River_Restored_Veg_Scenario_for_W2 2019.03.05.xlsx*) to Tt (Figure G-5). The summer time (7/15/1999) mean effective shade values by segment can also be found in Section G.12.

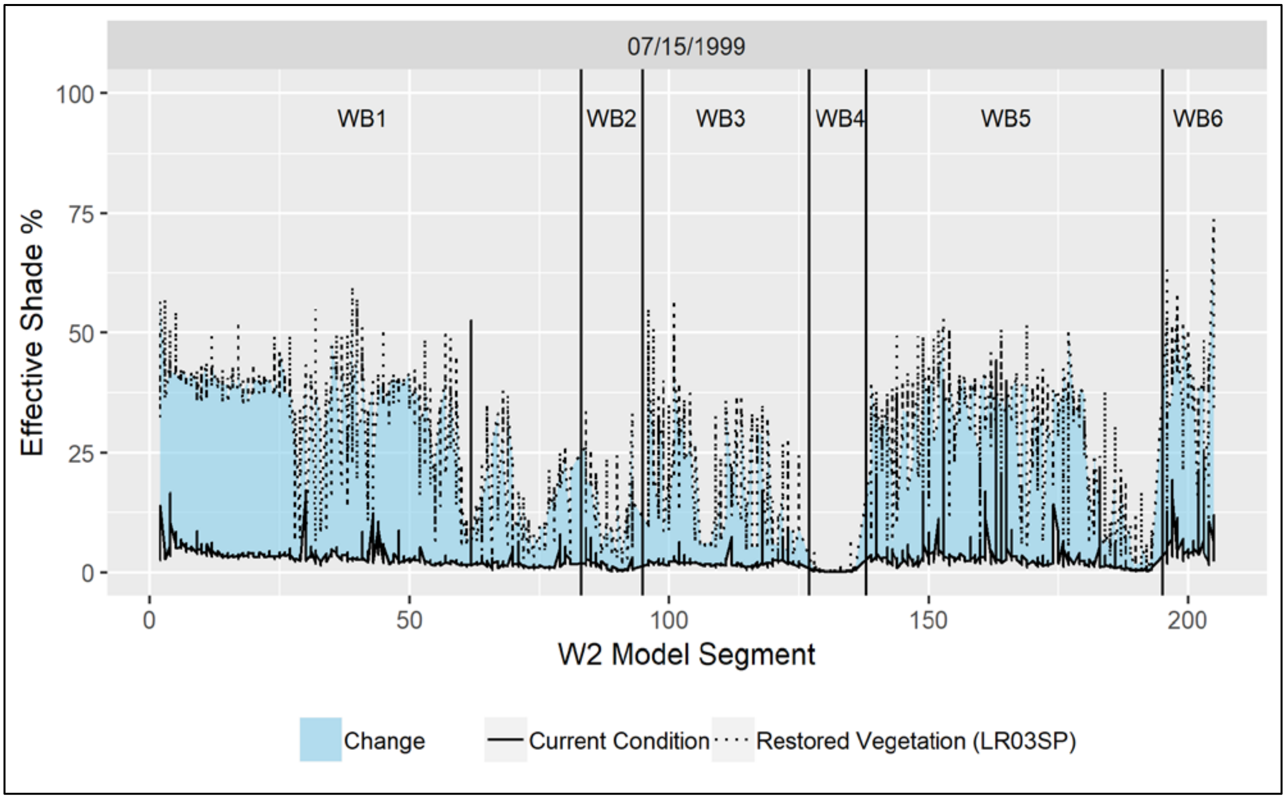


Figure G-5. Lost River – Effective shade due to restored vegetation (Source: ODEQ 3/6/2019).

The mean effective shade by waterbody in the restored vegetation scenario ranged from 0.5 to 37-percent along the Lost River modeling domain (Table G-2). However, the shade across the various individual segments can vary from 0.2 to 50-percent.

Table G-2. Summer time Mean Effective Shade for Restored Vegetation Condition in the Lost River.

		Mean Effective Shade %	
Date	**W2 Waterbody**	**Current**	**Restored Vegetation**
7/15/1999	1	3.1	29.9
7/15/1999	2	1.3	12.3
7/15/1999	3	2.0	19.7
7/15/1999	4	0.3	0.5
7/15/1999	5	3.0	26.9
7/15/1999	6	6.0	37.2

The model was run sequentially to output temperatures at an hourly frequency for evaluation of the daily maximum. Simulated temperatures at the Stateline for the restored vegetation shading scenario were evaluated and compared to the daily maximum temperature of 27.9 deg C (with 0.1 deg C for Reserve Capacity). The daily maximum temperatures cannot meet the criteria at

Stateline, with exceedances occurring during July and August (Table G-3). Figure G-6 shows the temperature plot for the Stateline for the restored vegetation shading scenario. Figure G-7 shows the daily maximum temperatures along with their associated flows at Stateline. In addition, the daily maximum temperatures at LRGR are also not met (Figure G-8 and Table G-3). The temperature time-series at all the compliance locations for the shading scenario can be found in Section G.6.

In 1999, 1-percent of the days require reductions (5 days) to the thermal load to meet the loading capacity at the Stateline after applying restored vegetation shading values. At the Stateline, the daily maximum temperature can go as high as 31.92 deg C, with excess loads observed during flows ranging from 4.7 to 5.8 cfs and percent reductions ranging from 1.4 to 13 percent (Table G-3). Similarly, in 1999, at the LRGR location, 4-percent of the days require reductions (15 days) to the thermal load to meet the loading capacity after applying restored vegetation shading values. At LRGR, the daily maximum temperature can go as high as 32.61 deg C, with excess loads observed during flows ranging from 8.4 to 9.8 cfs and percent reductions ranging from 0.9 to 7 percent (Table G-3).

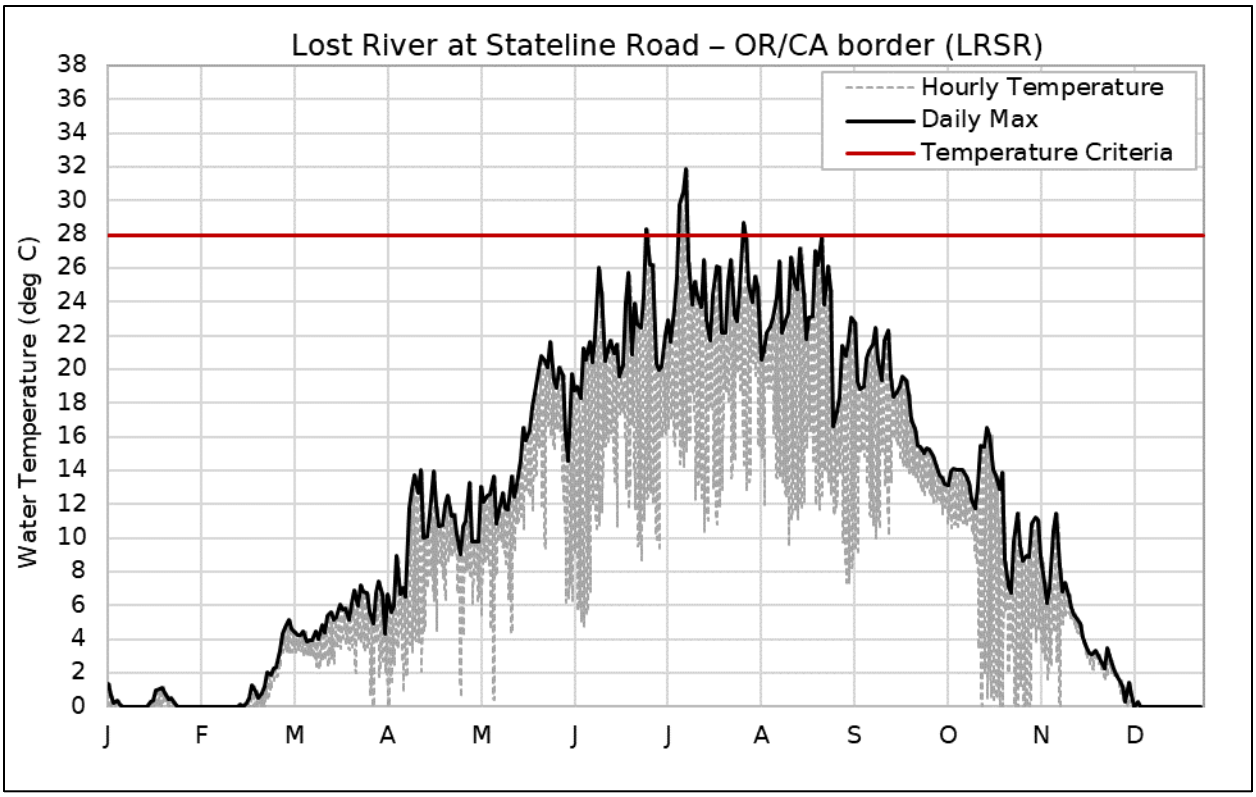


Figure G-6. Lost River temperature at Stateline – restored vegeration shading scenario (1999).

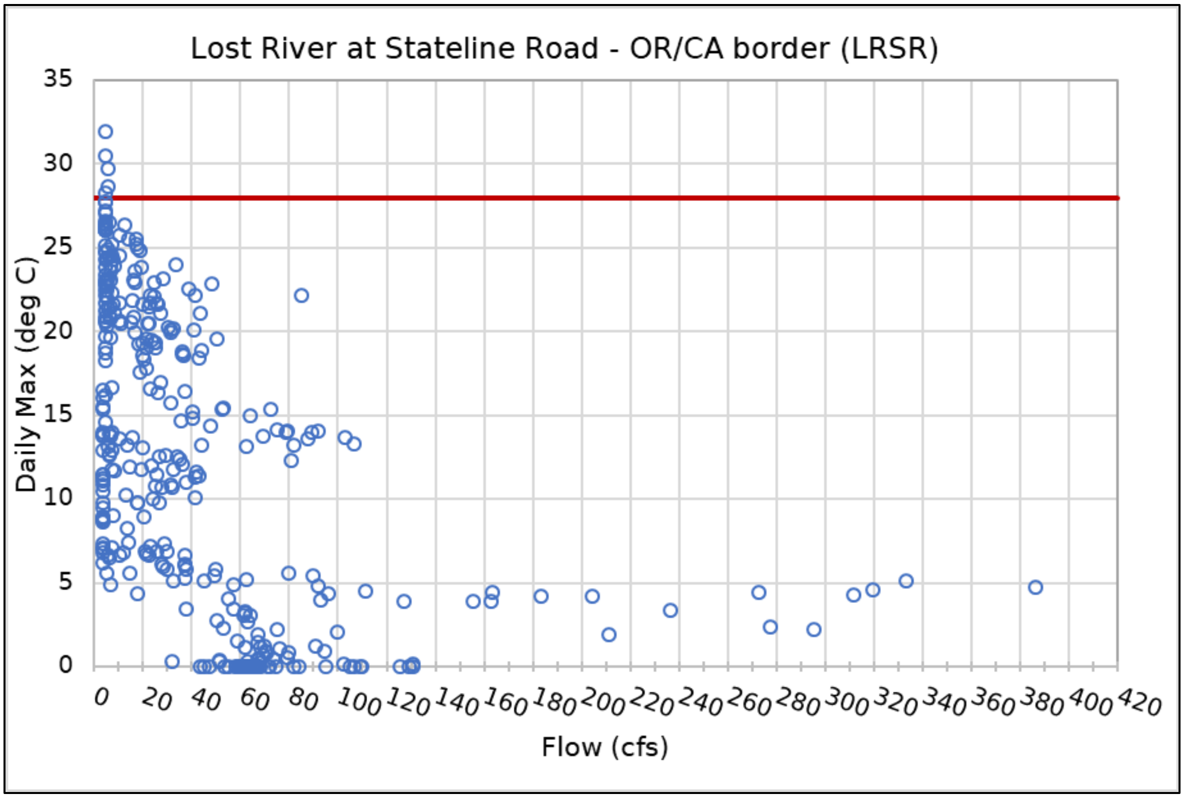


Figure G-7. Lost River temperature at Stateline restored vegeration shading scenario – Daily Max and associated flows (1999).

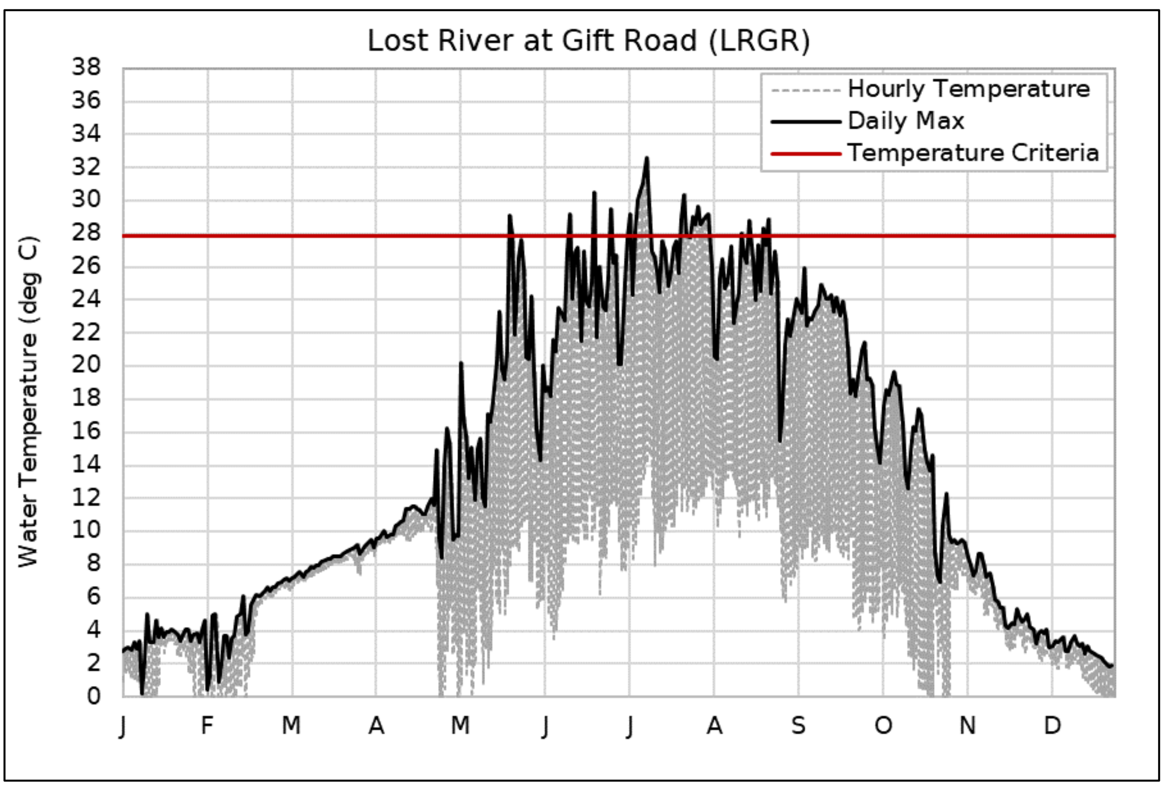


Figure G-8. Lost River temperature at LRGR– restored vegetation shading scenario (1999).

Table G-3. Lost River restored vegetation shading scenario summary.

Statistic	Flows with Exceedances (cfs)	Observed DM Exceeding Criteria (°C)	Percent Reduction to Meet Criteria	Excess Heat Load (kcal/day)
Lost River at Gift Road (LRGR)				
Minimum	8.4	24.47	0.9%	5.39E+06
Maximum	9.8	32.61	7%	4.25E+07
Lost River at Stateline Road – OR/CA border (LRSR)				
Minimum	4.7	28.3	1.4%	4.69E+06
Maximum	5.8	31.92	13%	4.65E+07

In addition to the time-series at the compliance locations, hourly water temperature time series were output at all the segments in the waterbodies (segments were typically approximately half a kilometer in length). The hourly results were then processed to calculate the daily maximum temperatures values at each of the segments. The maximum, mean, and minimum value of the daily maximum temperatures for the summer period taken from May through mid-September were then calculated for each of the segments in the waterbodies and then plotted to evaluate the spatial distribution of the temperatures.

Section G9 shows the longitudinal plots for the restored vegetation shading scenario. The longitudinal plots show that for Waterbody #1, the maximum of the daily maximum temperatures during the period from May through mid-September still exceeds the criteria from RKM 4 to RKM 12 (with a maximum daily maximum excess of 4.66 deg C at RKM 11.4/segment 25 in Waterbody #1). Note that the reach variable shading from RKM 4 to RKM 12 ranges from 37-percent to 43-percent. Conditions improve downstream of Gift Road after Miller Creek and nearing Harpold Dam (Section G.9), where the temperature criteria is met (most likely due to the influence of return flows to the system). In addition, the restored vegetation shading scenario does not meet the criteria at the CA/OR Stateline in Waterbody #6 (Section G.9). Waterbody #6 showed exceedances of the daily maximum temperatures after around RKM 1.5 to Stateline (RKM 4.8). The excess temperature calculated as the difference between the maximum of the daily maximum and the criteria of 27.9 deg C can be as high as 4.06 deg C at RKM 4.3/Segment 10 in Waterbody #6 (Section G.9).

G.4 Flow Augmentation Scenario

The restored vegetation scenario was able to meet the daily maximum at most locations along the Lost River except for portions in Waterbody #1 and Waterbody #6 (Section G.6 and Section G.9). The restored vegetation scenario model was used as the basis for evaluating the augmented flow scenarios. Both Waterbodies i.e. #1 and #6 show exceedances during the critical summer period when all water is diverted from upstream of the dam and no water flows from the Malone Dam or Anderson Rose Dam into the Lost River. As noted in the Lost River Modeling Report (2005), "the 1999 daily flow data downstream of Malone Dam (which forms the upstream boundary of Waterbody 1 from the BOR database were used to form the upstream inflow boundary condition. During the irrigation period Malone Dam discharge into the Lost River was effectively zero, except for dam leakage (which was represented in the model as 0.2 cms for the sake of model stability)" (

Figure G-9). The flows from Malone Dam can be as high as 38 cms during the non-irrigation season to 0.2 cms in the summer period from May through September when flows are withdrawn for irrigation purposes.

Flows were systematically increased during the summer period from May through September at Malone dam and the model was run to check if the daily maximum temperature criteria were met at all locations along Waterbody #1. Increasing the summer flow by adding 0.5 cms to 0.2 cms (7 cfs) (i.e. to 0.7 cms or 25 cfs) **(**Figure G-9**)** resulted in meeting the daily maximum temperature criteria at all locations in Waterbody #1.

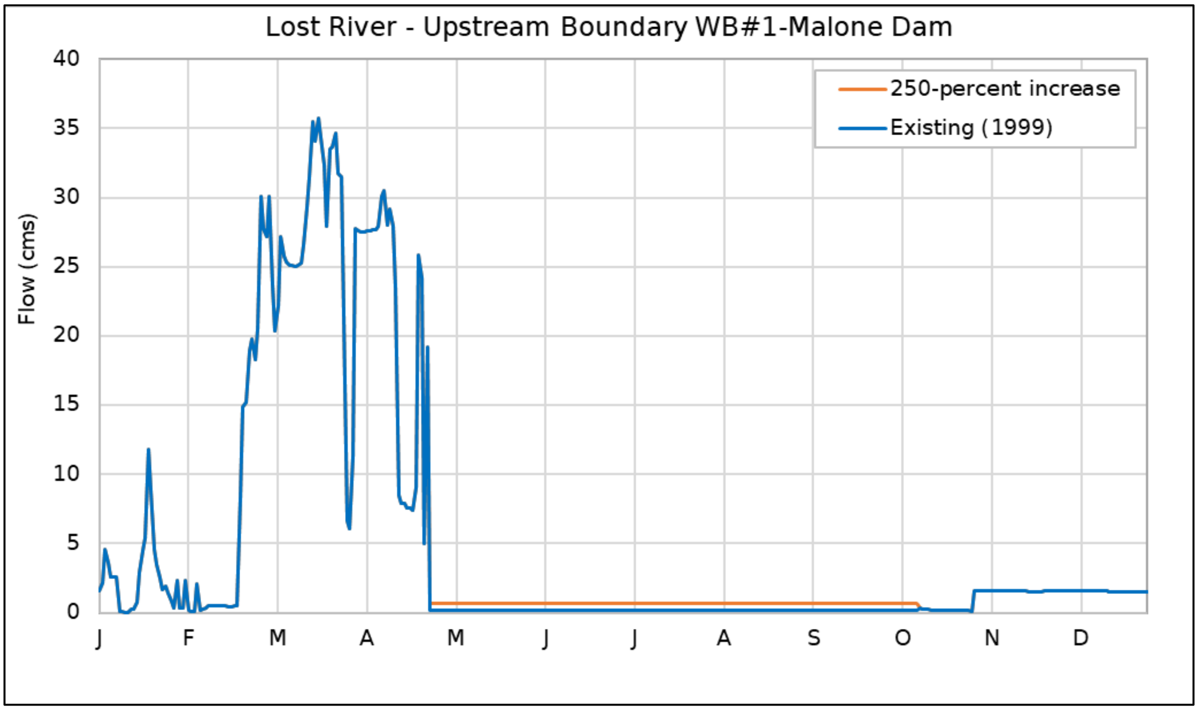


Figure G-9. Upstream boundary flows at Malone Dam.

The model was then run sequentially to output temperatures at an hourly frequency for evaluation of the daily maximum at Waterbodies 2, 3, 4, 5, and 6. The daily maximum temperatures were met along Waterbodies 2, 3, 4, and 5 except for Waterbody #6 including Stateline.

The outflow from Anderson Rose Dam forms the upstream boundary of Waterbody #6 **(**Figure G-10). The Anderson Rose Dam is located at the downstream boundary of Waterbody #5, which is configured as a spillway in the W2 model. In the W2 model a leakage term of 0.1 cms was used to account for leakage when water was below the dam crest in the spillway equation configuration. This essentially accounts for periods when no water is flowing from Anderson Rose Dam into Waterbody #6, and gives a downstream discharge attributed to dam leakage of 0.1 cms (this small amount of flow also ensures stability in Waterbody #6 when no flow is coming out of the reservoir during summer). The exceedances of the daily maximum temperature typically occurred when the outflow from Anderson Rose Dam was effectively zero or 0.1 cms. On the days when the predicted outflow from Anderson Rose dam was 0.1 cms, predicted outflows were increased incrementally and the predicted daily maximum temperatures were evaluated against the criteria for Waterbody #6 up to Stateline. Increasing the summer flow by adding 0.21 cms when the flow was 0.1 cms (3.5 cfs) (i.e. increased to 0.31 cms or 10.6 cfs) **(**Figure G-10) resulted in meeting the daily maximum temperature criteria at all locations in

Waterbody #6. Section G.7 shows the time series plots at all the compliance locations-including at the Stateline-meeting the daily maximum temperature criteria.

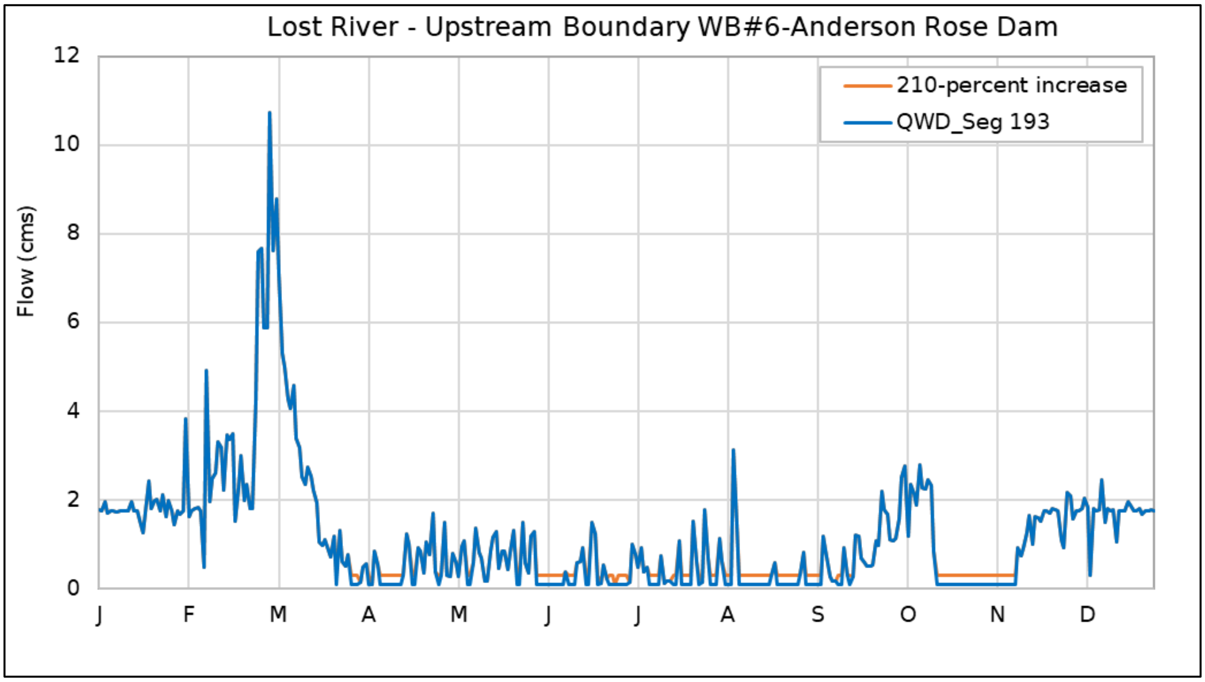
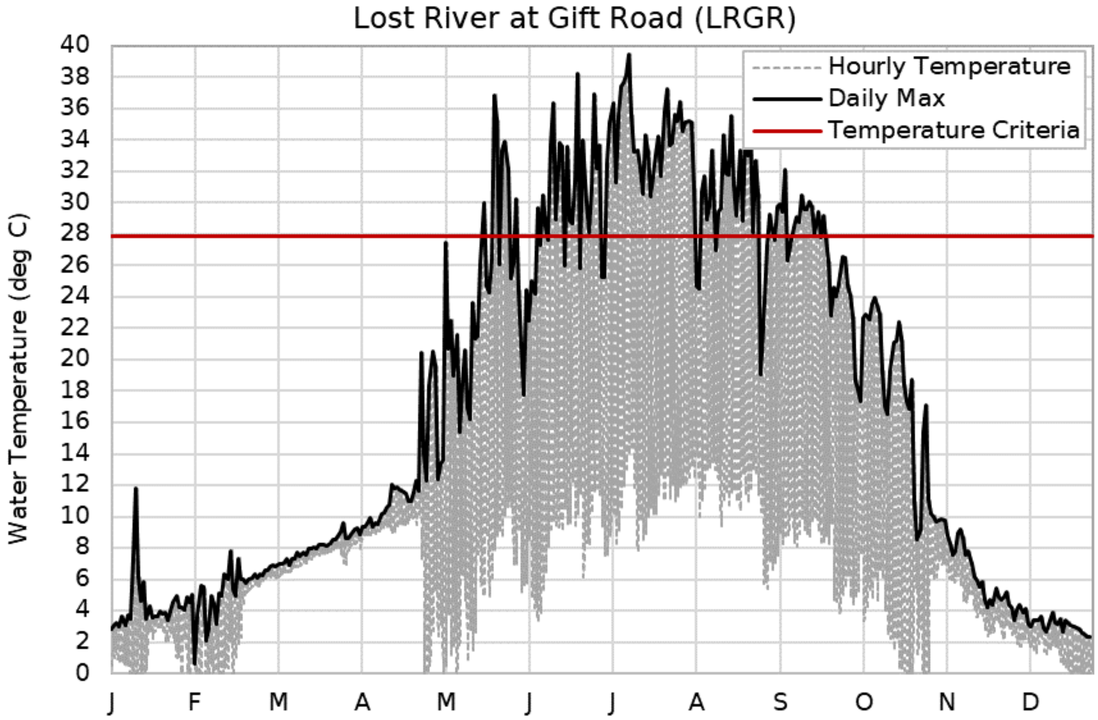


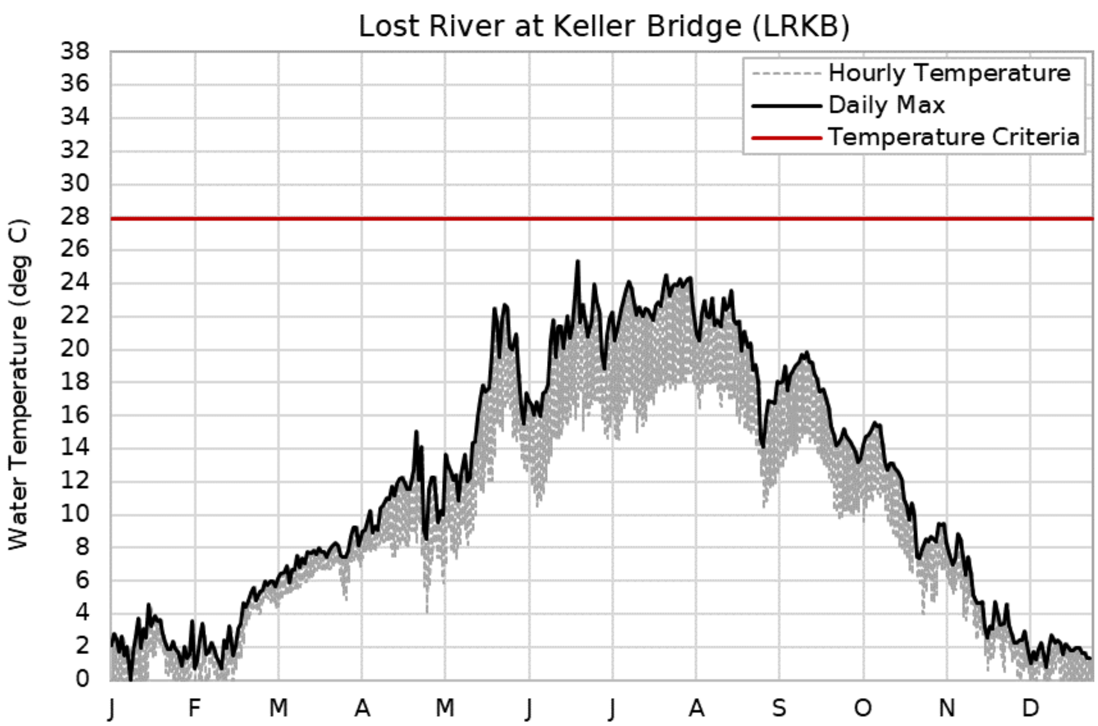
Figure G-10. Upstream boundary flows for Waterbody #6 coming out of Anderson Rose Dam.

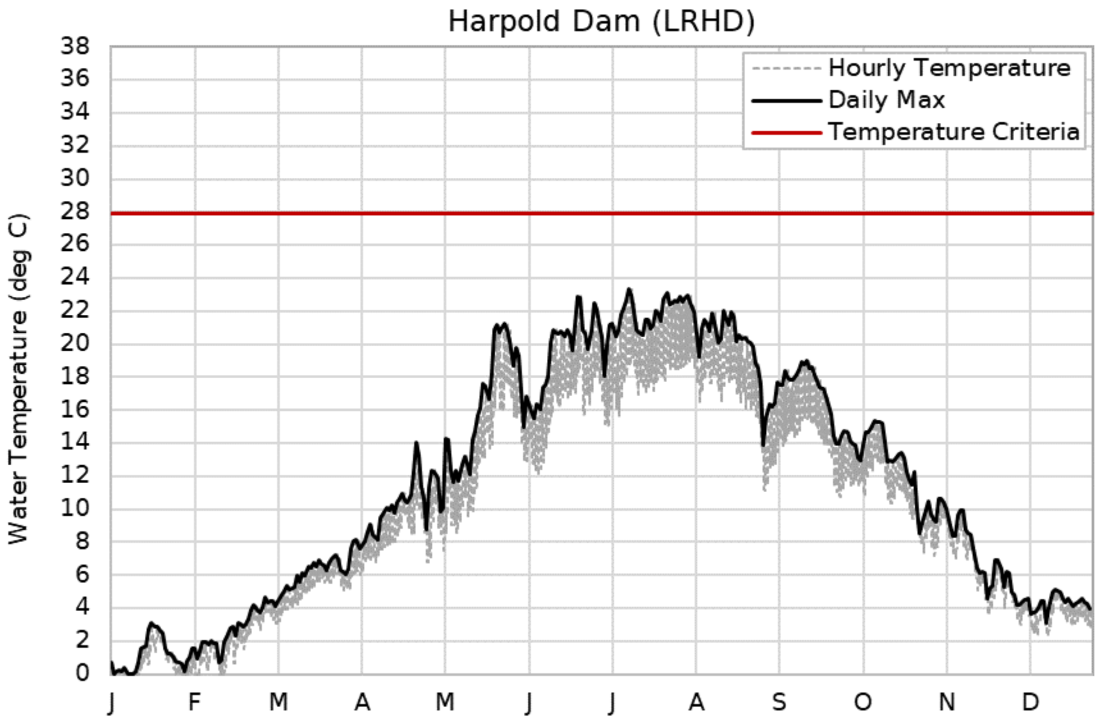
In addition to the time-series at the compliance locations, hourly water temperature time series were output at all the segments in the waterbodies (segments were typically approximately half a kilometer in length). The hourly results were then processed to calculate the daily maximum temperatures values at each of the segments. The maximum, mean, and minimum value of the daily maximum temperatures for the summer period taken from May through mid-September were then calculated for each of the segments in the waterbodies and then plotted to evaluate the spatial distribution of the temperatures. Section G.10 shows the longitudinal plots for the restored vegetation shading scenario with flow augmentation applied for Waterbodies #1 and #6. This scenario resulted in meeting the daily maximum criteria of 27.9 deg C at all waterbodies spatially and temporally.

G.5 Existing Condition Plots

Temperatures at TMDL compliance points (1999)






Harpold Dam (LRHD)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
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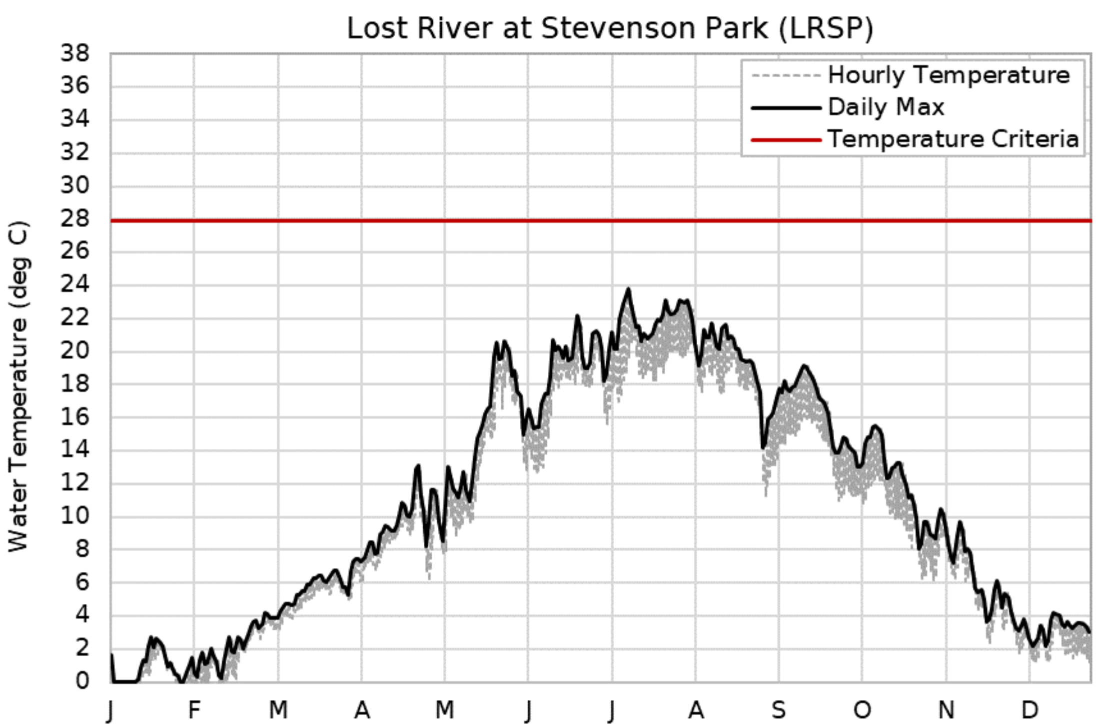
Lost River at Stevenson Park (LRSP)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
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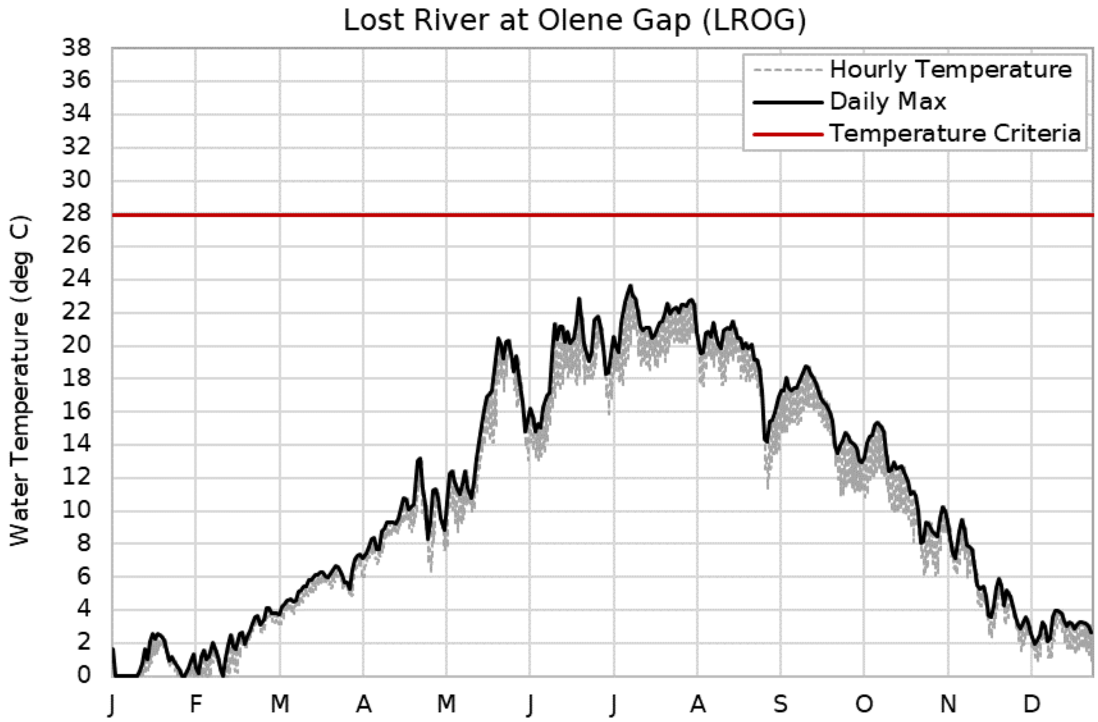
Lost River at Olene Gap (LROG)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
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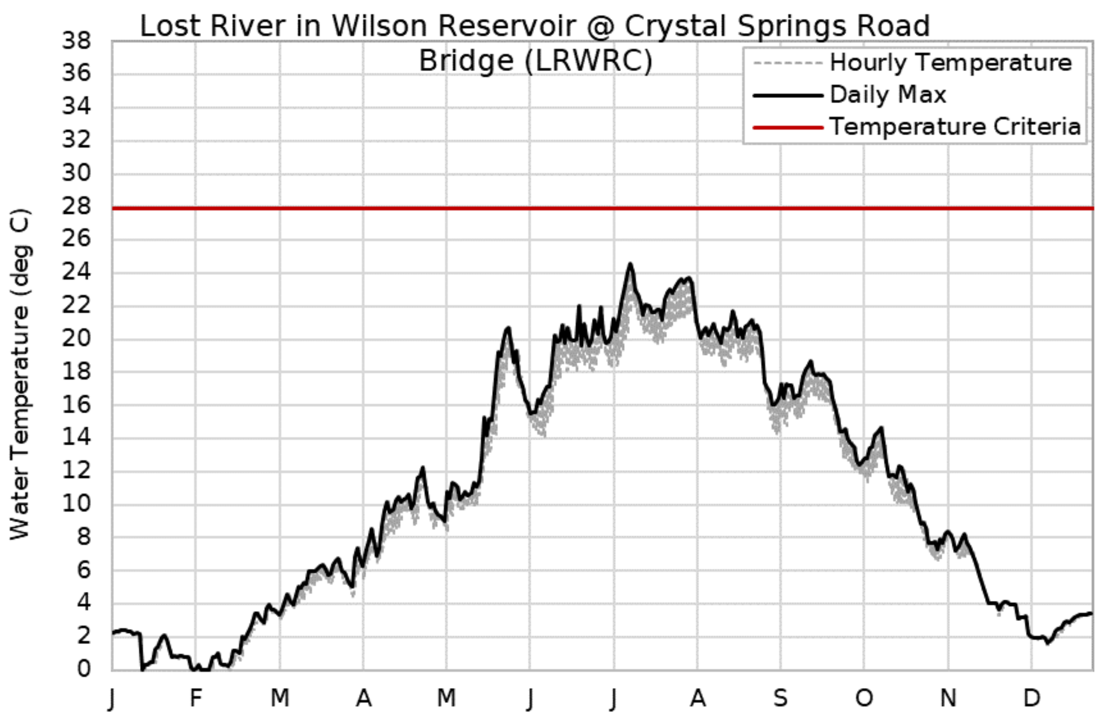
Lost River in Wilson Reservoir @ Crystal Springs Road Bridge (LRWRC)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
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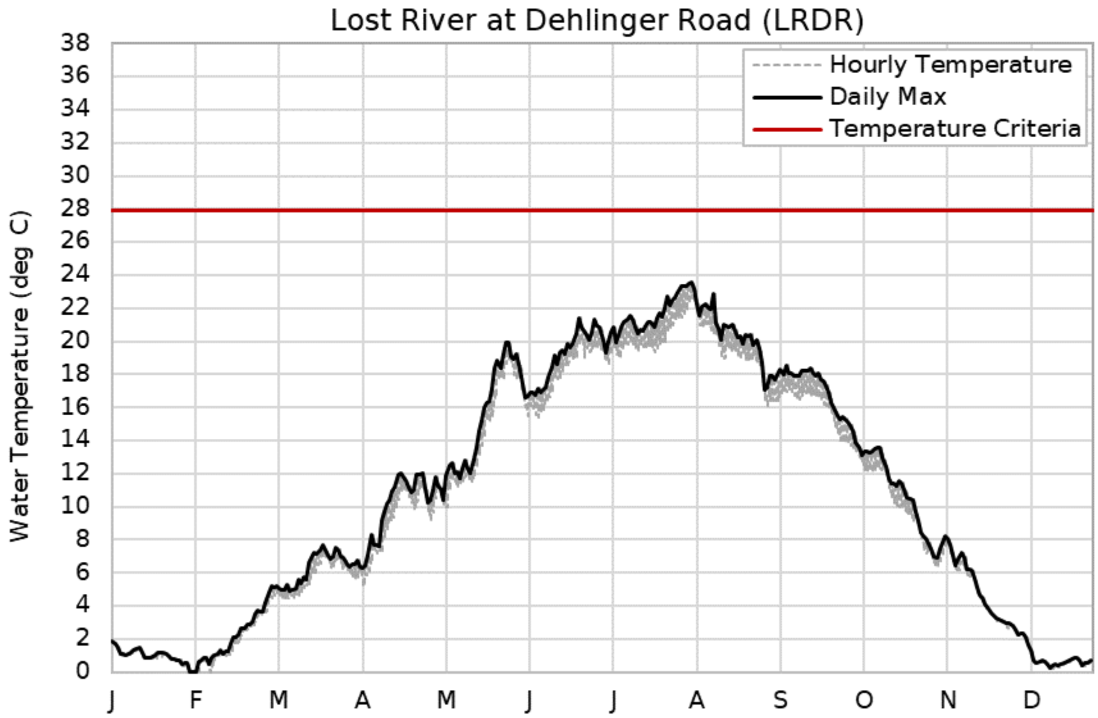
Lost River at Dehlinger Road (LRDR)
Hourly Temperature
Daily Max
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Water Temperature (deg C)
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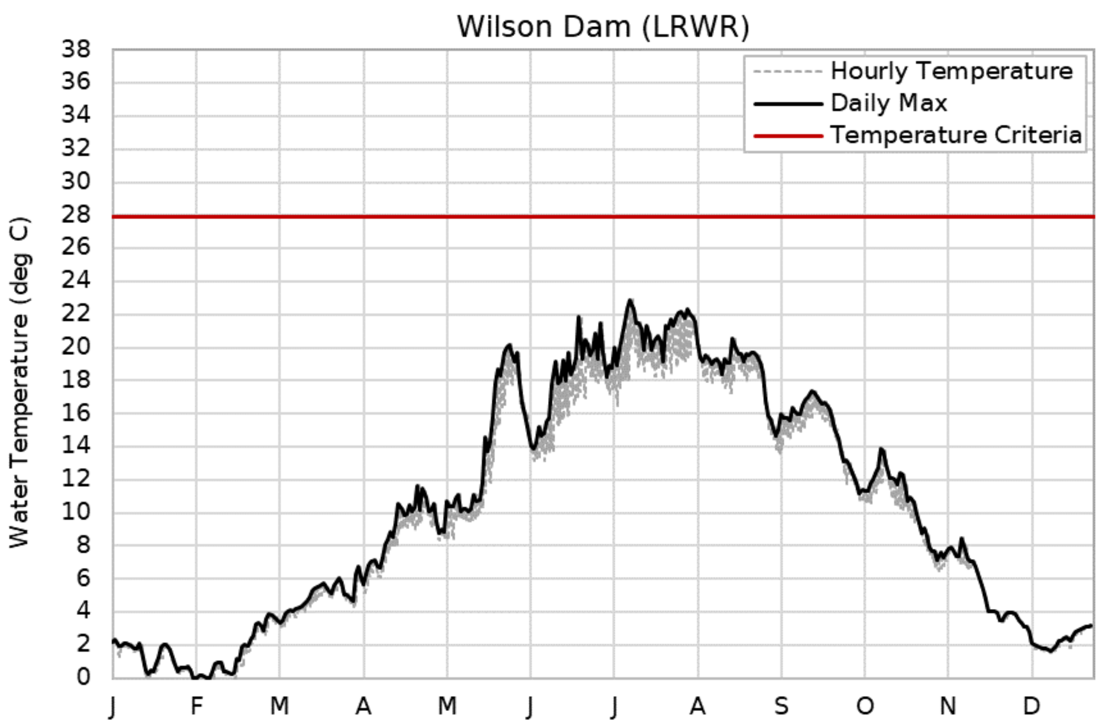
Wilson Dam (LRWR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
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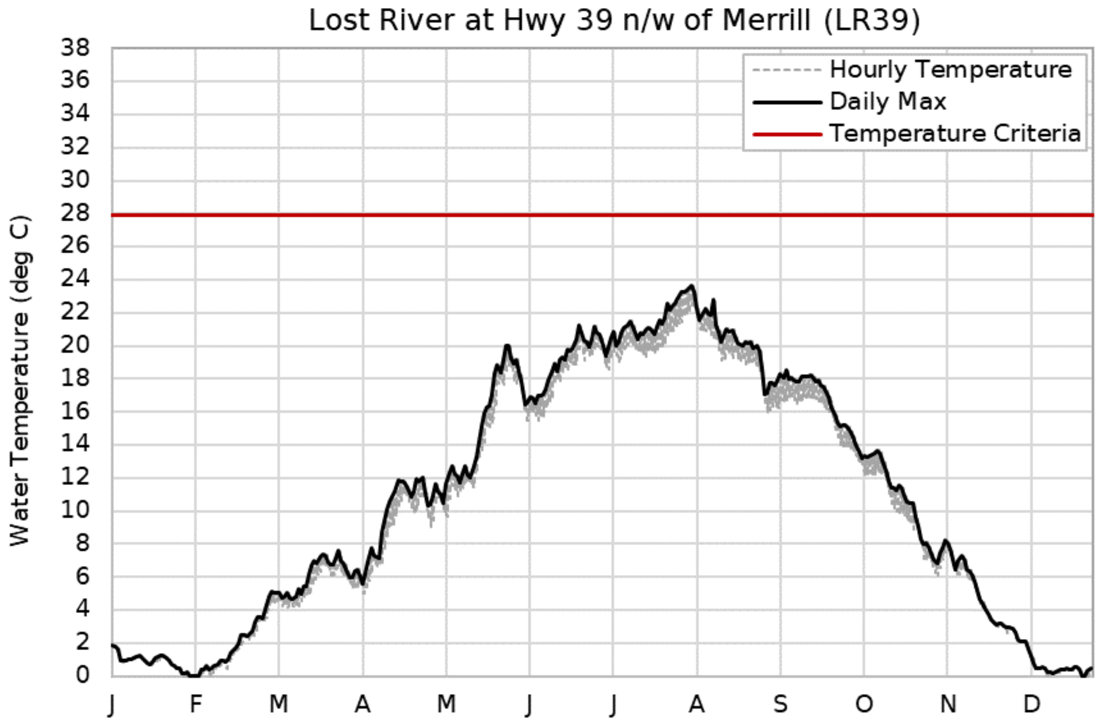
Lost River at Hwy 39 n/w of Merrill (LR39)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
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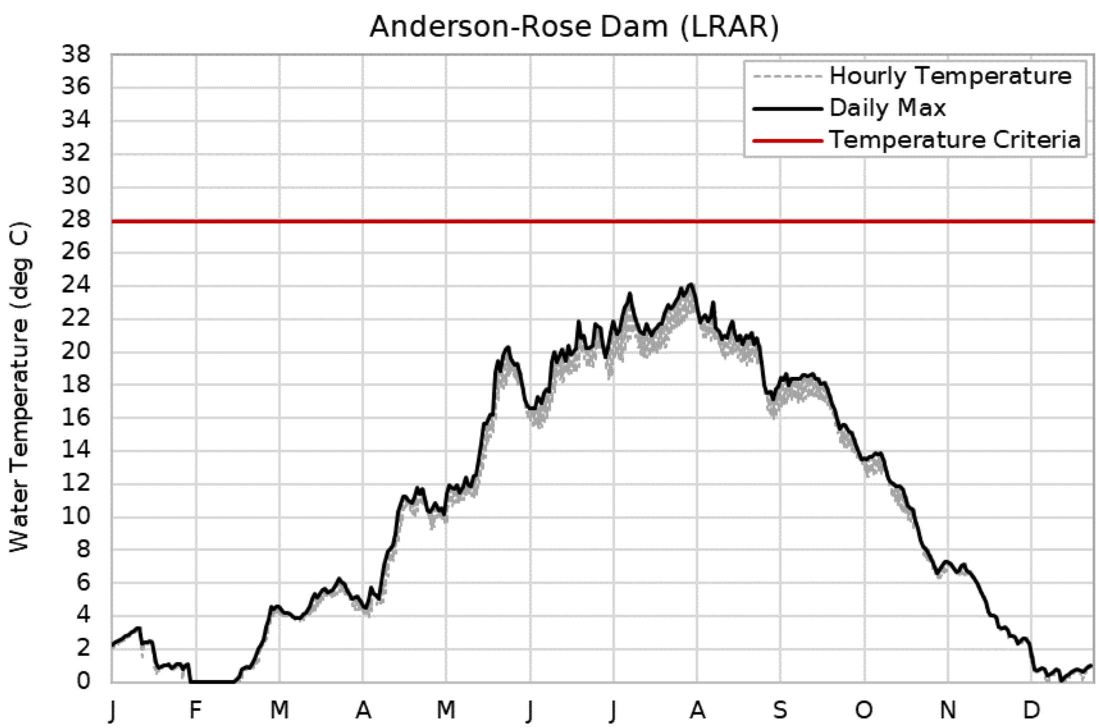
Anderson-Rose Dam (LRAR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
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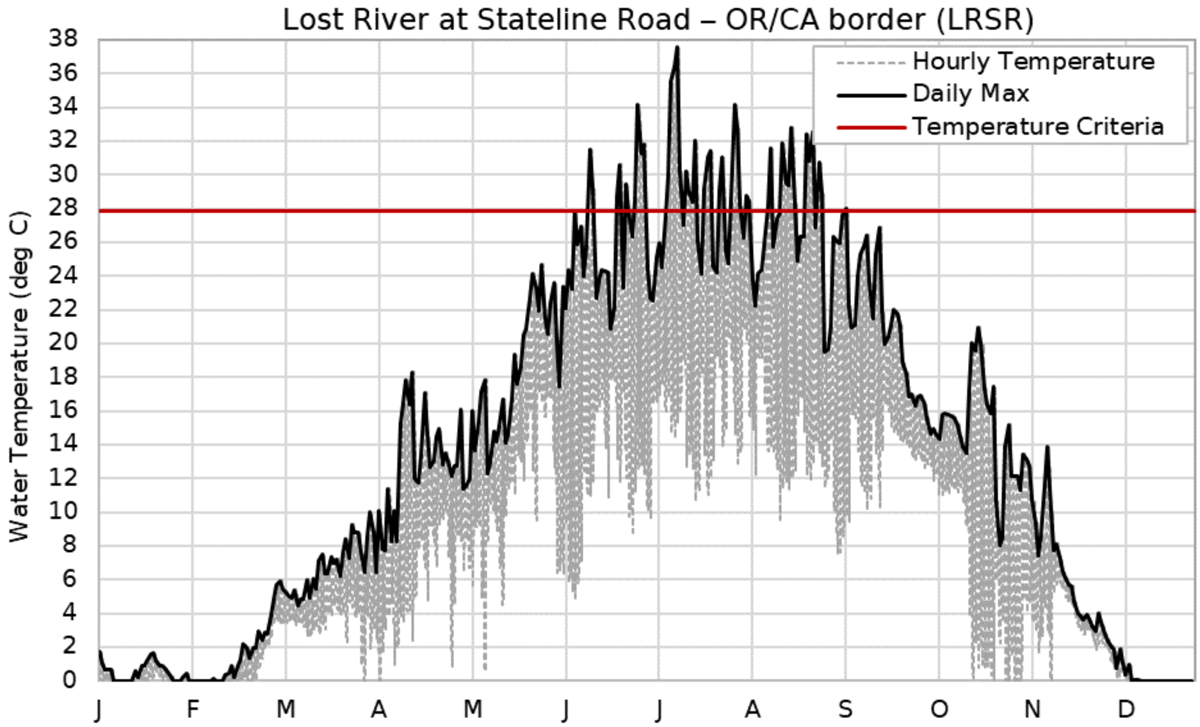
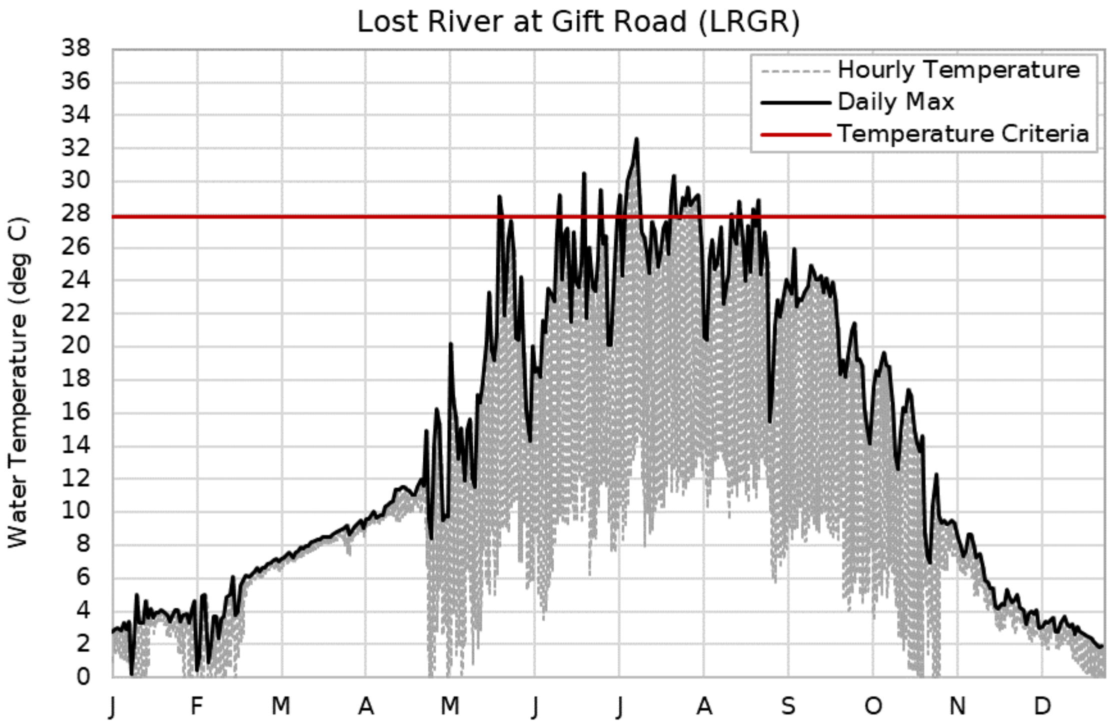
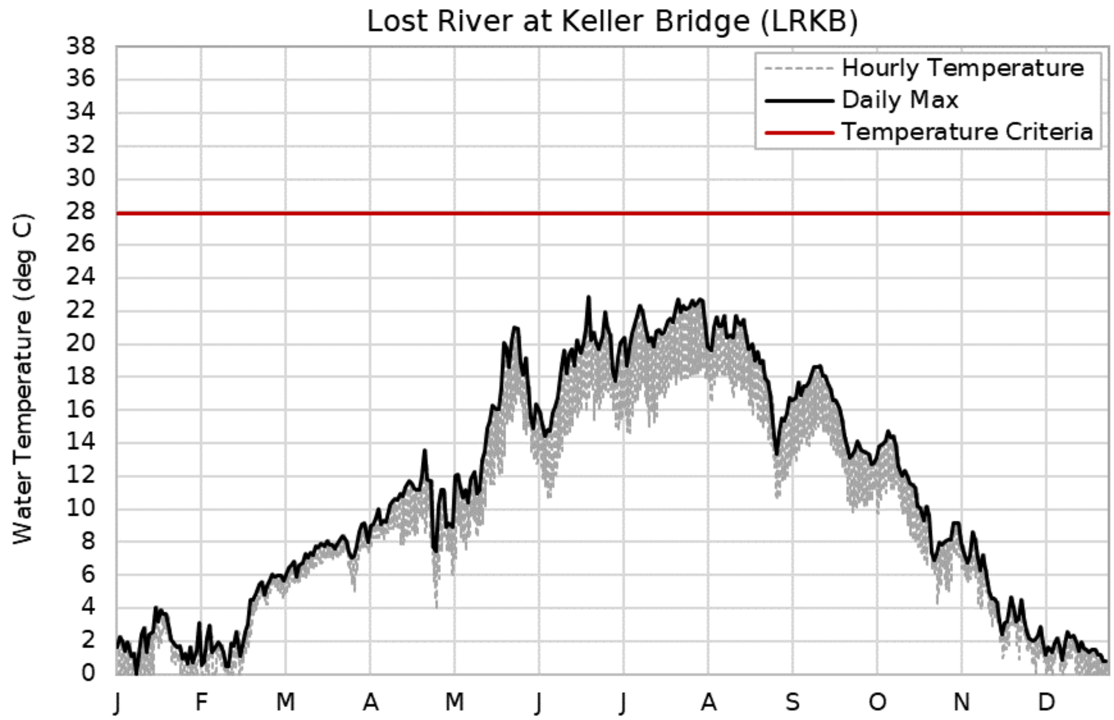
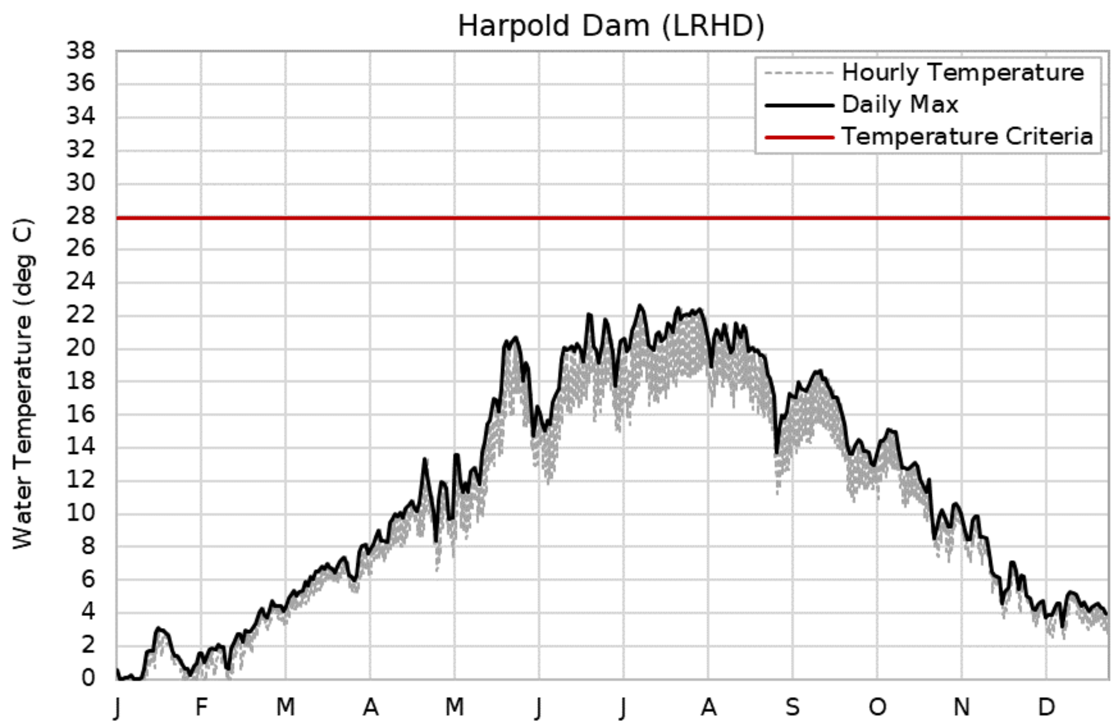

Lost River at Stateline Road – OR/CA border (LRSR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D

G.6 Restored Vegetation Shading Scenario Plots

Temperatures at TMDL Compliance Points




Lost River at Keller Bridge (LRKB)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D


Harpold Dam (LRHD)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
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J
F
M
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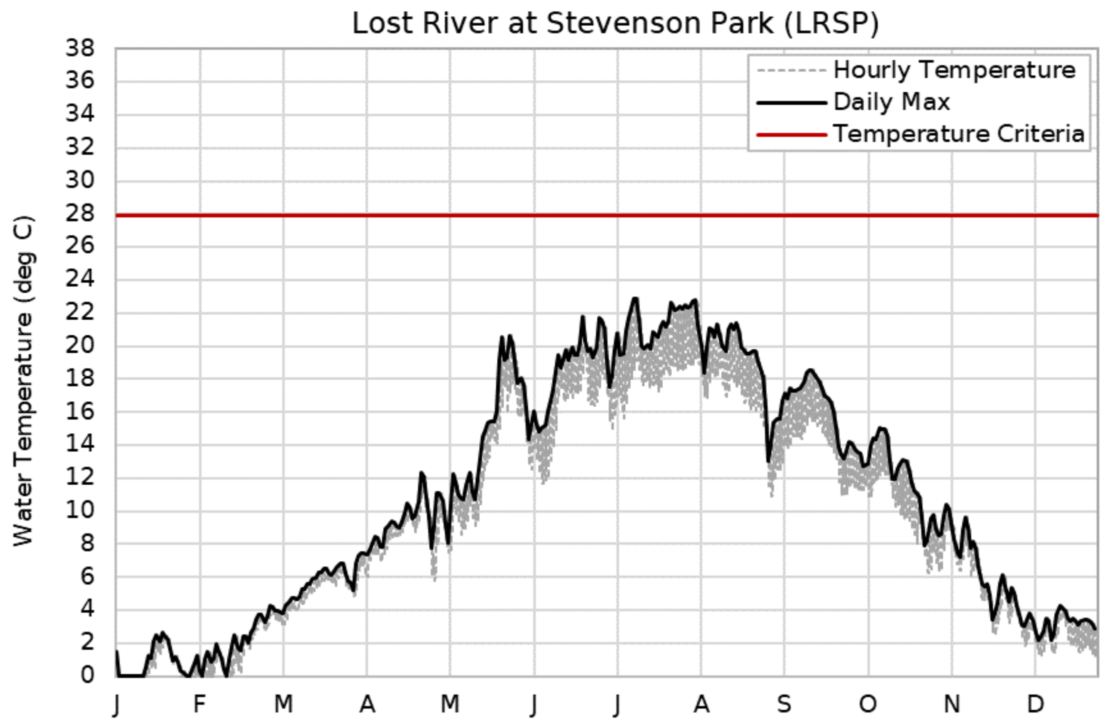
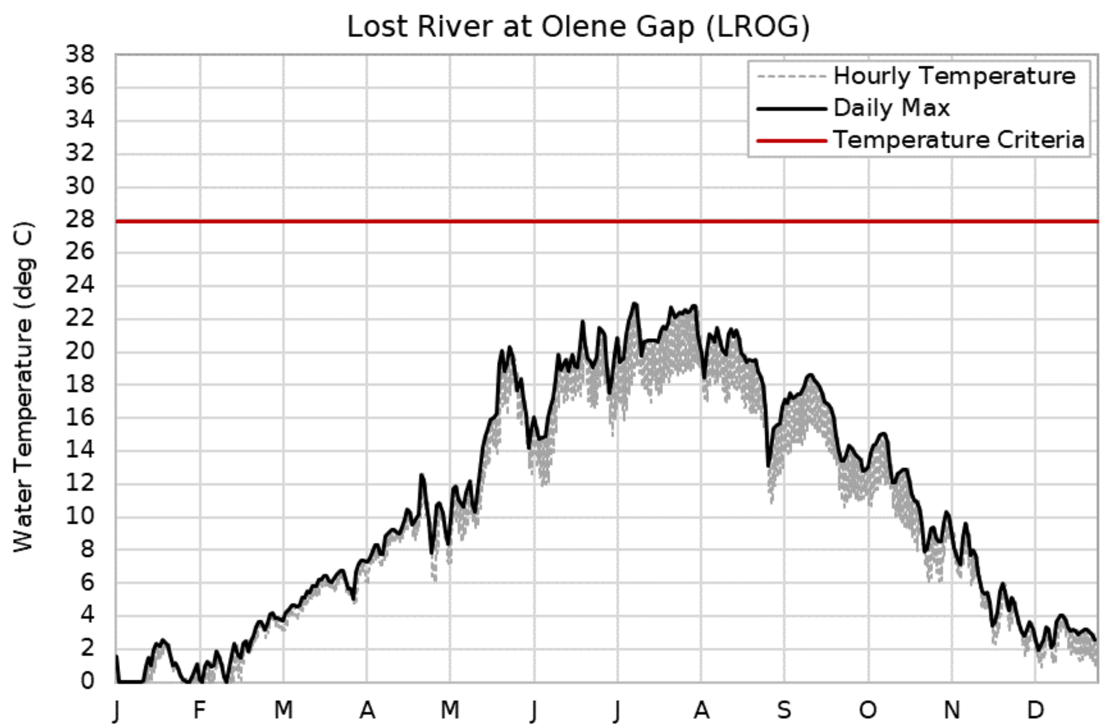
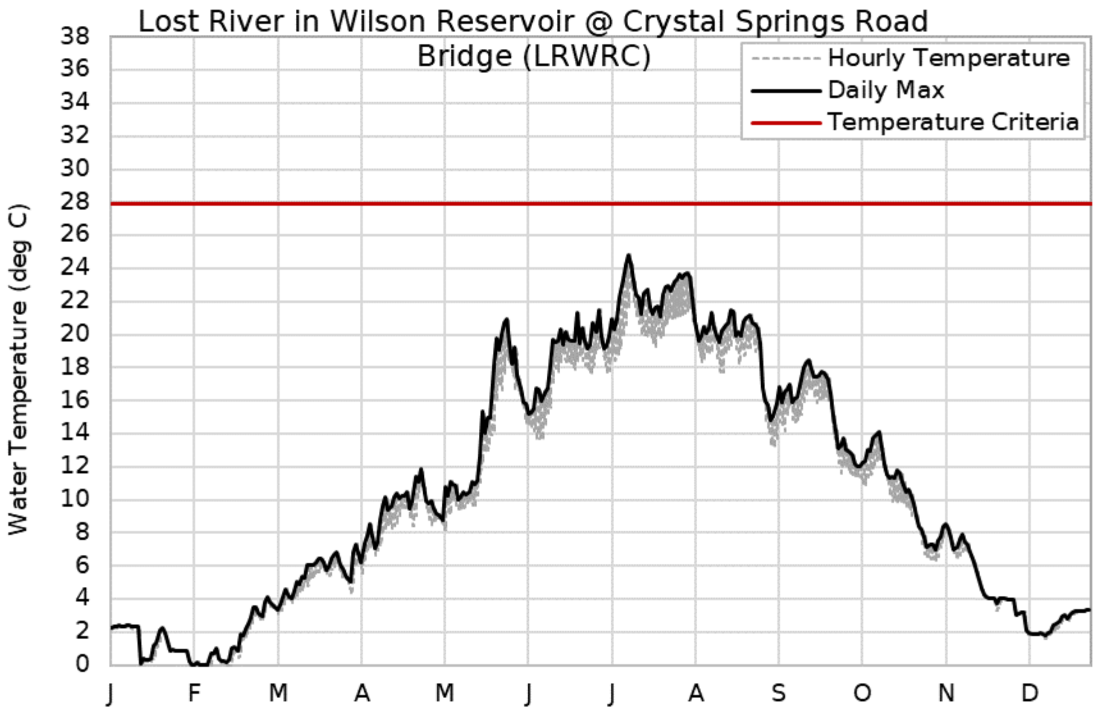
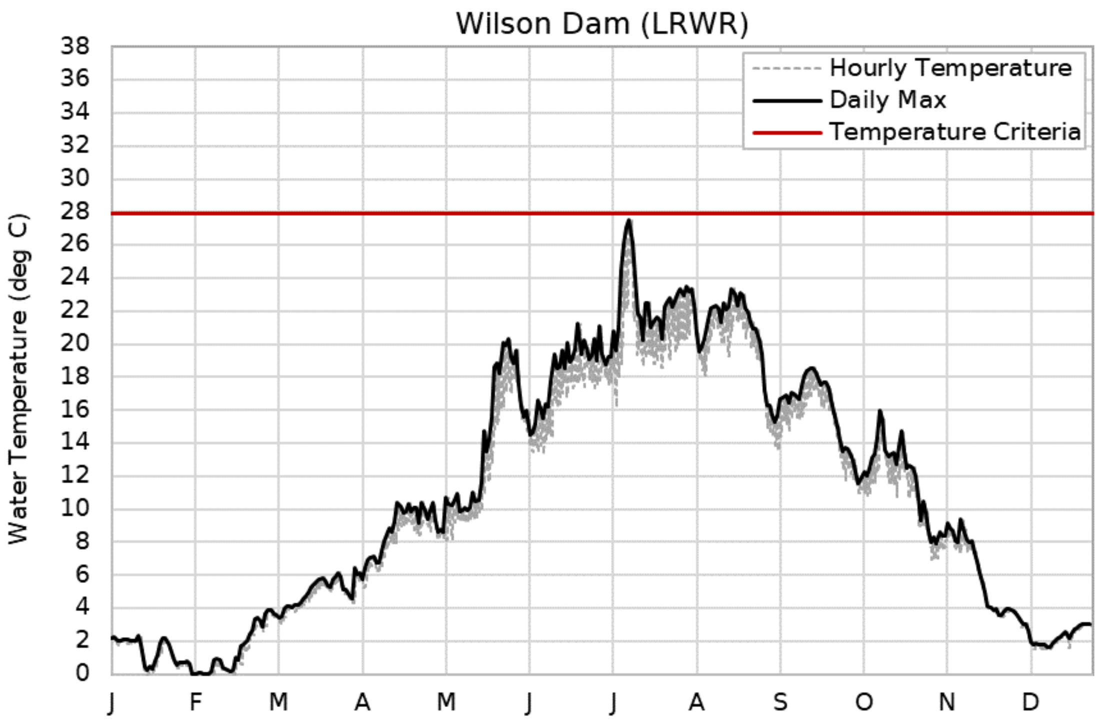
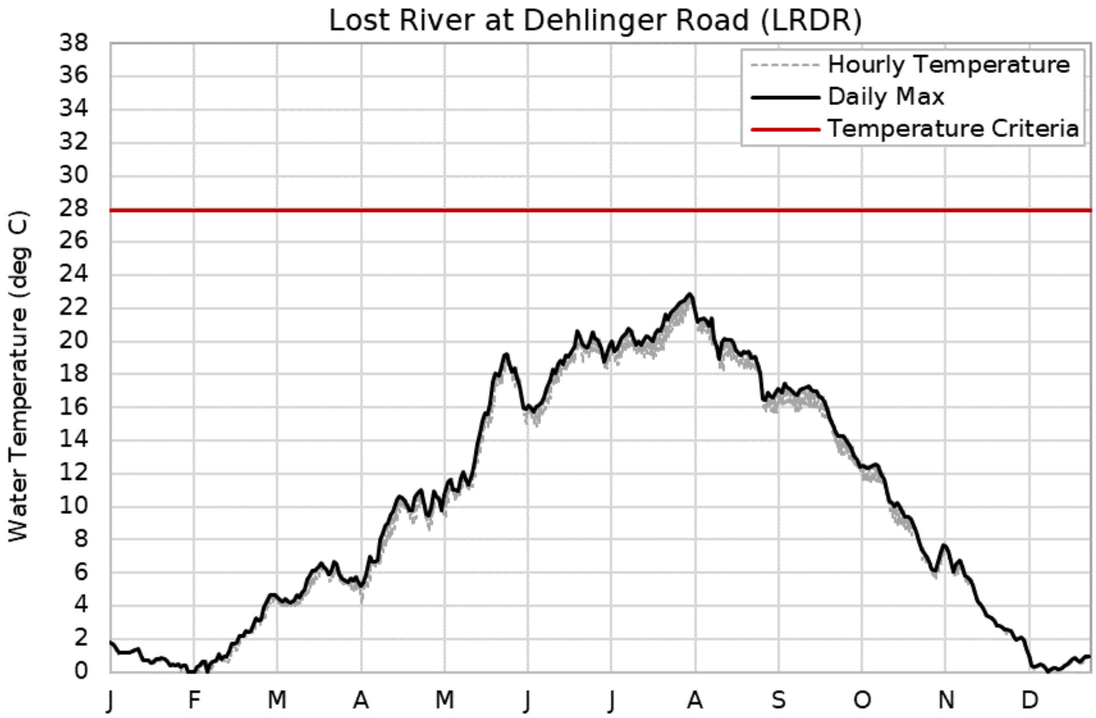
M
J
J
A
S
O
N
D


Lost River at Stevenson Park (LRSP)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D


Lost River at Olene Gap (LROG)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D


Lost River in Wilson Reservoir @ Crystal Springs Road Bridge (LRWRC)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D


Wilson Dam (LRWR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D


Lost River at Dehlinger Road (LRDR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
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J
F
M
A
M
J
J
A
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N
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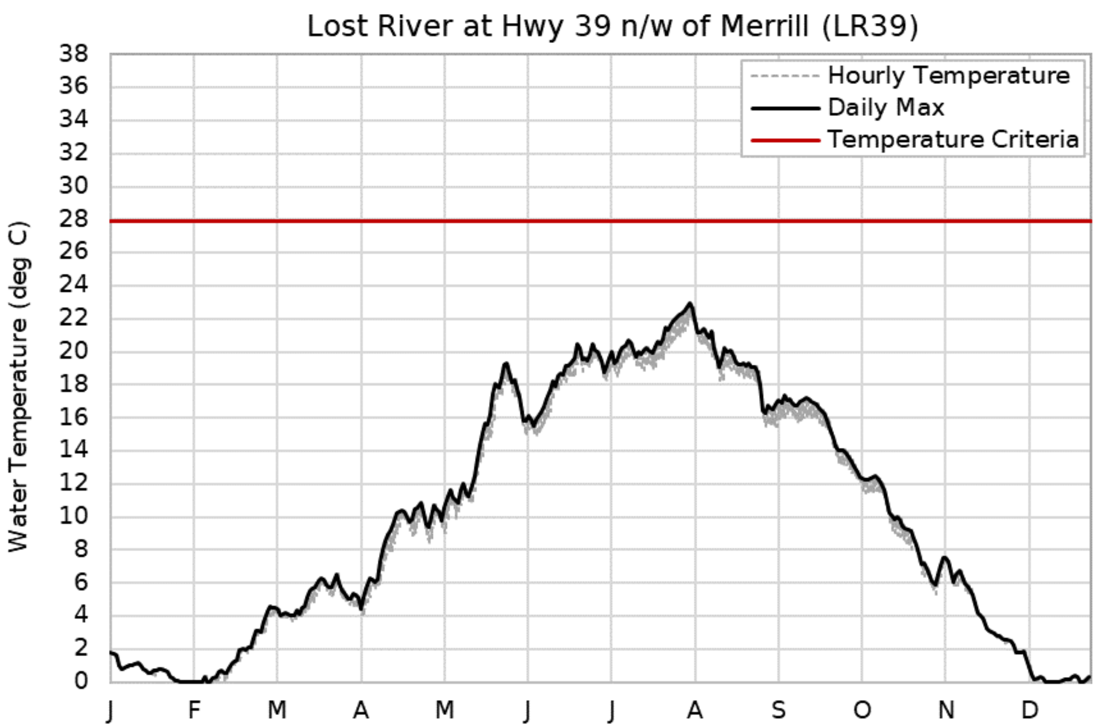
Lost River at Hwy 39 n/w of Merrill (LR39)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
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0
J
F
M
A
M
J
J
A
S
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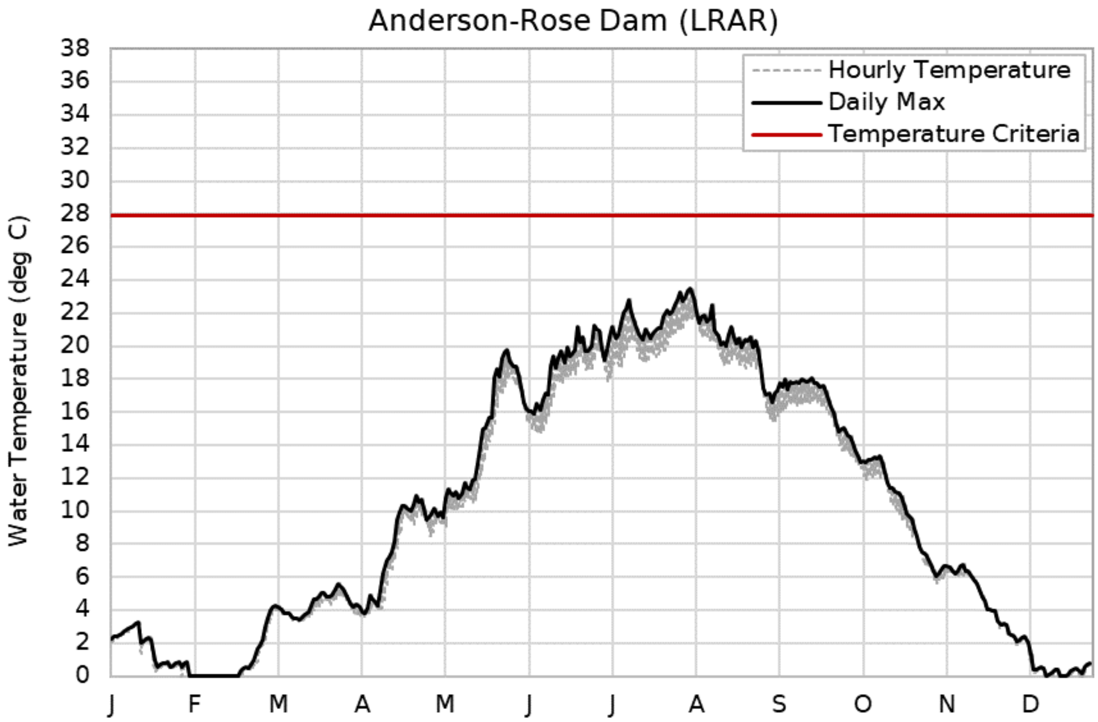
N
D


Anderson-Rose Dam (LRAR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
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8
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J
F
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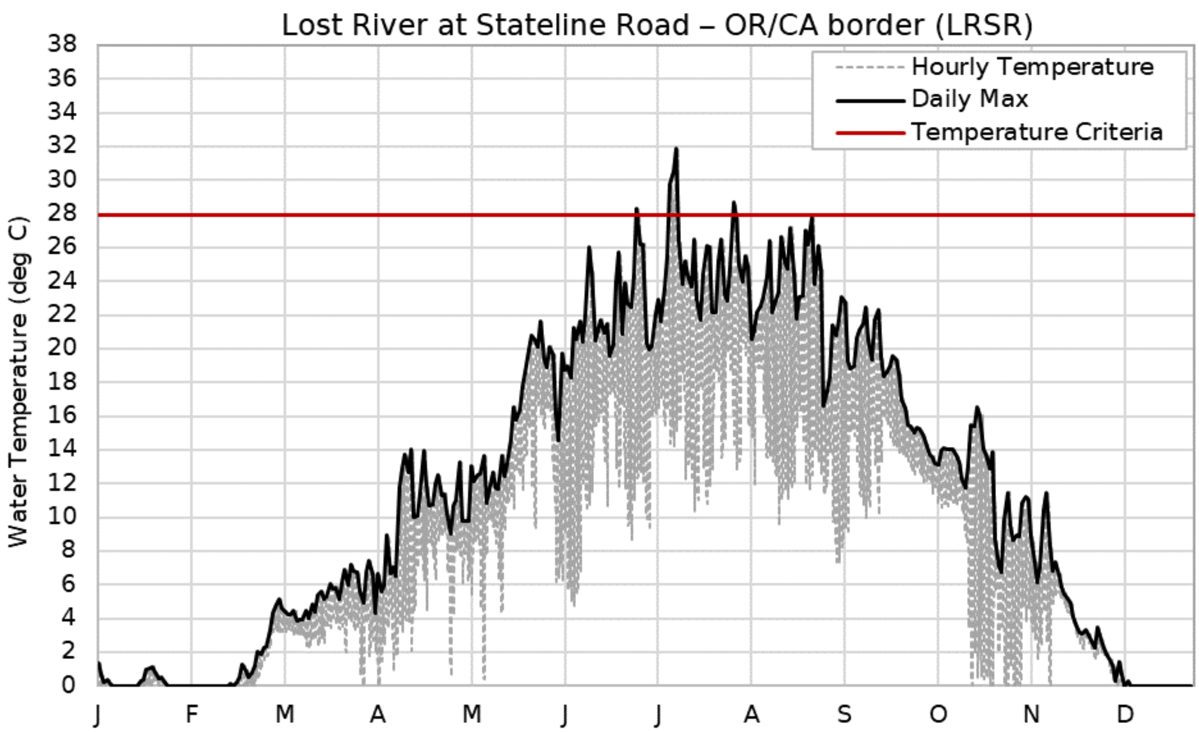
Lost River at Stateline Road – OR/CA border (LRSR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
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8
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4
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J
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M
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J
J
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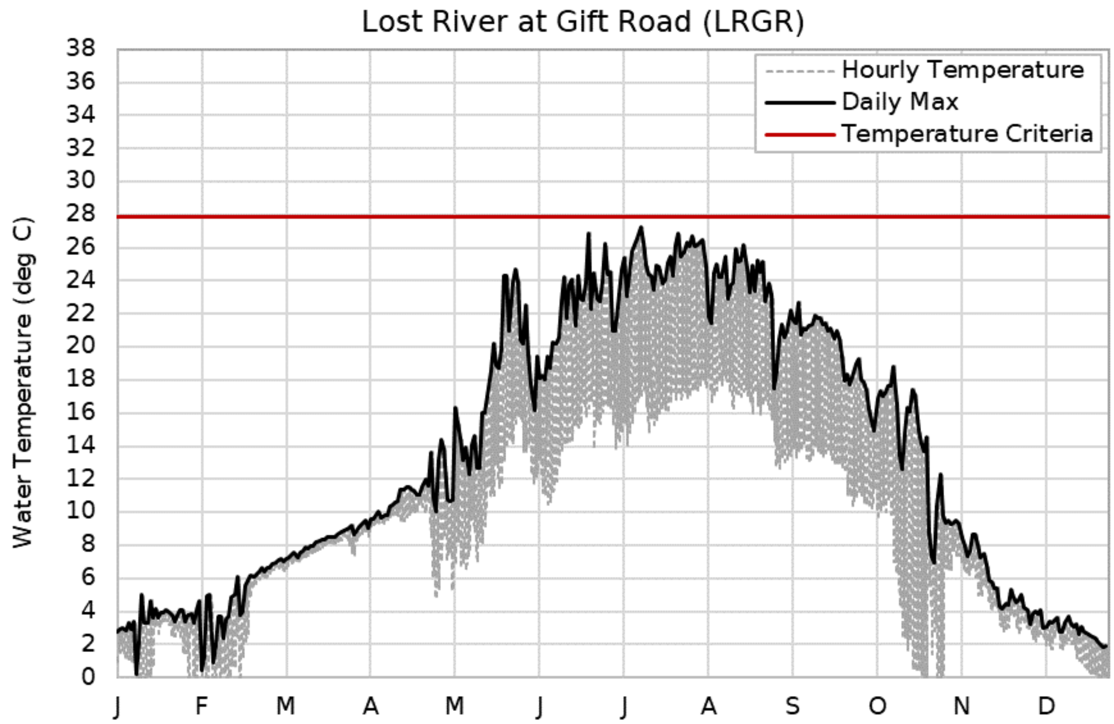
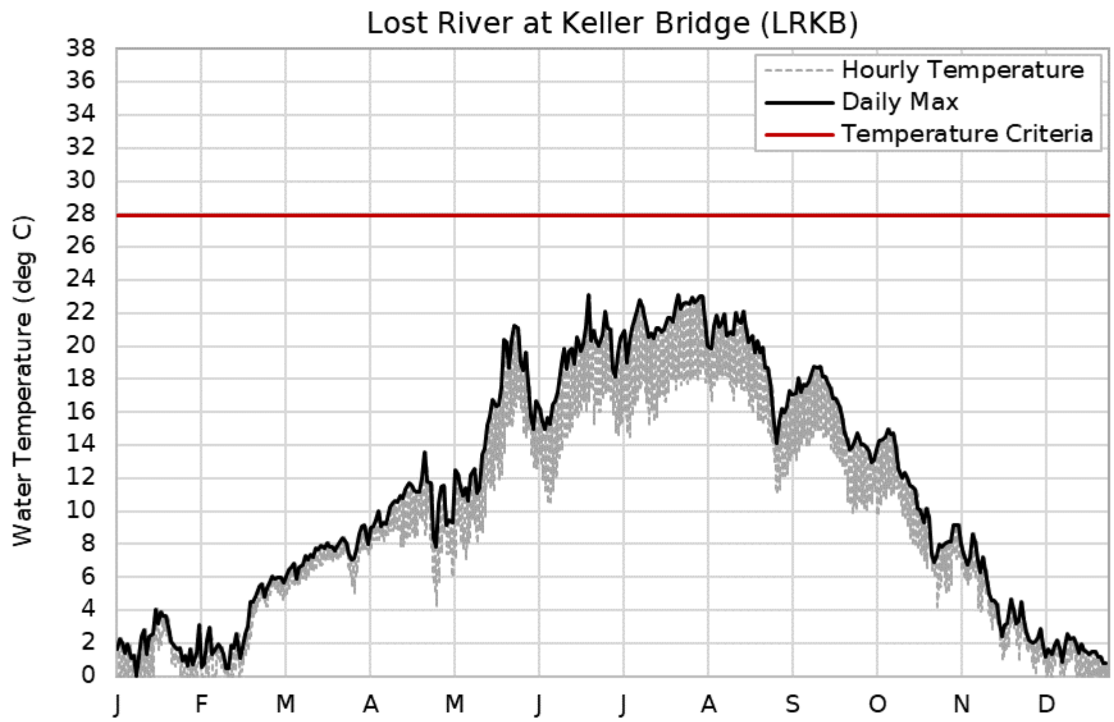
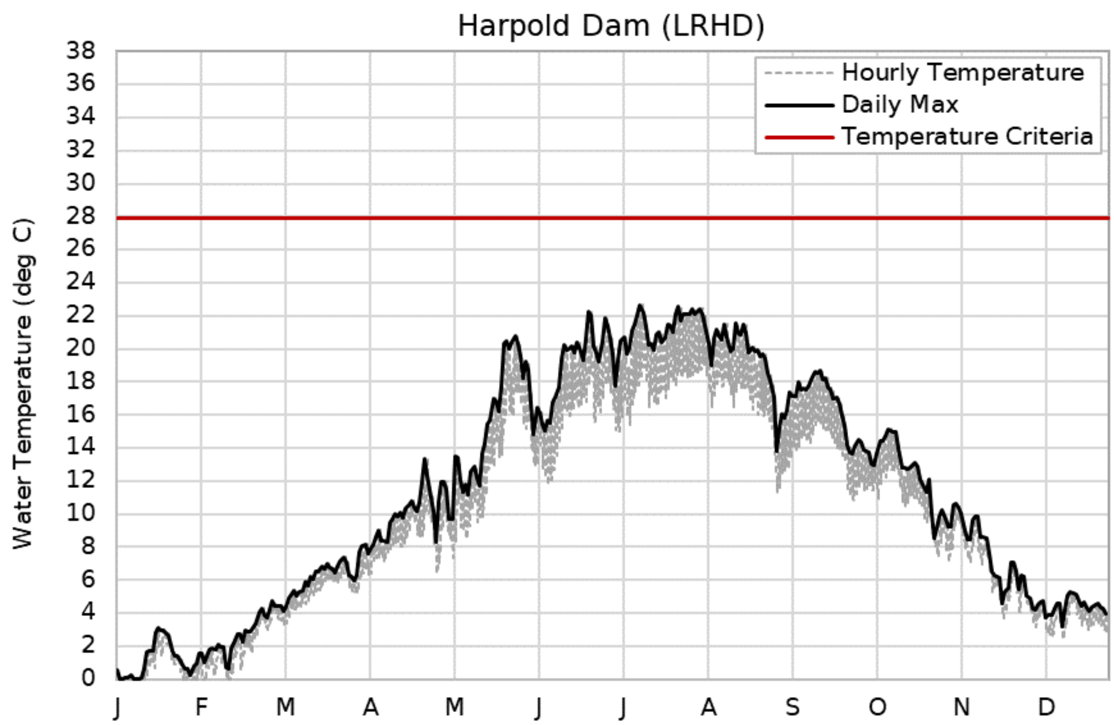
G.7 Restored Vegetation Shading + Augmented Flow Plots

Temperatures at TMDL compliance points




Lost River at Keller Bridge (LRKB)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D


Harpold Dam (LRHD)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
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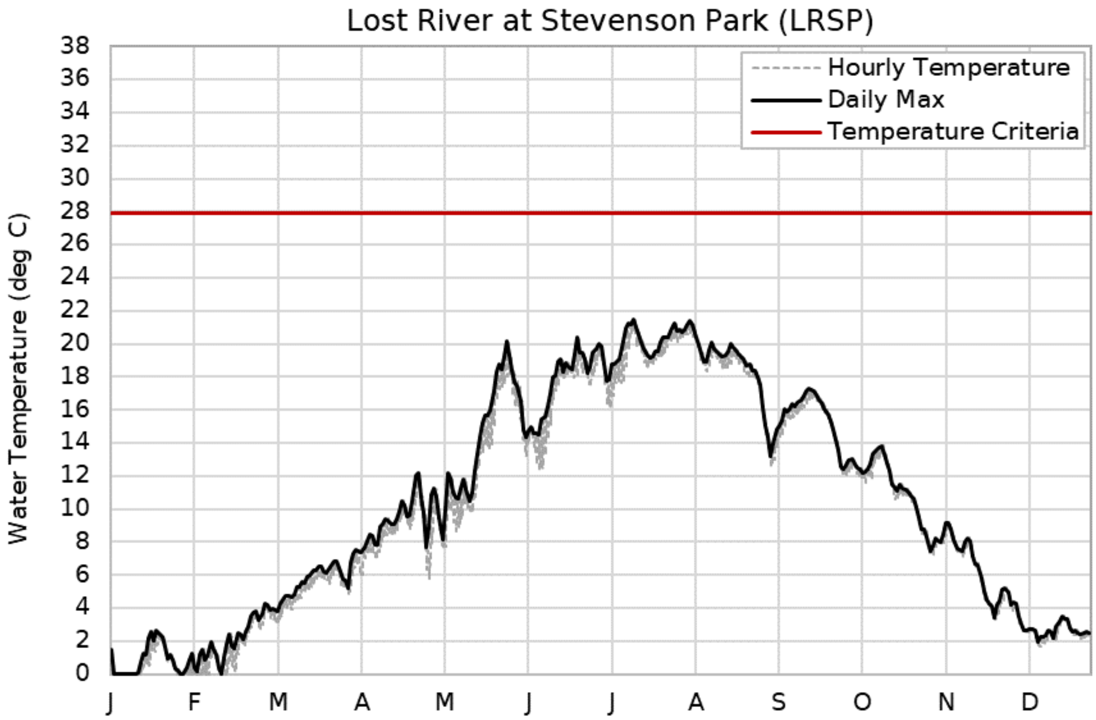
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J F M A M J J A S O N D


Lost River at Stevenson Park (LRSP)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
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N
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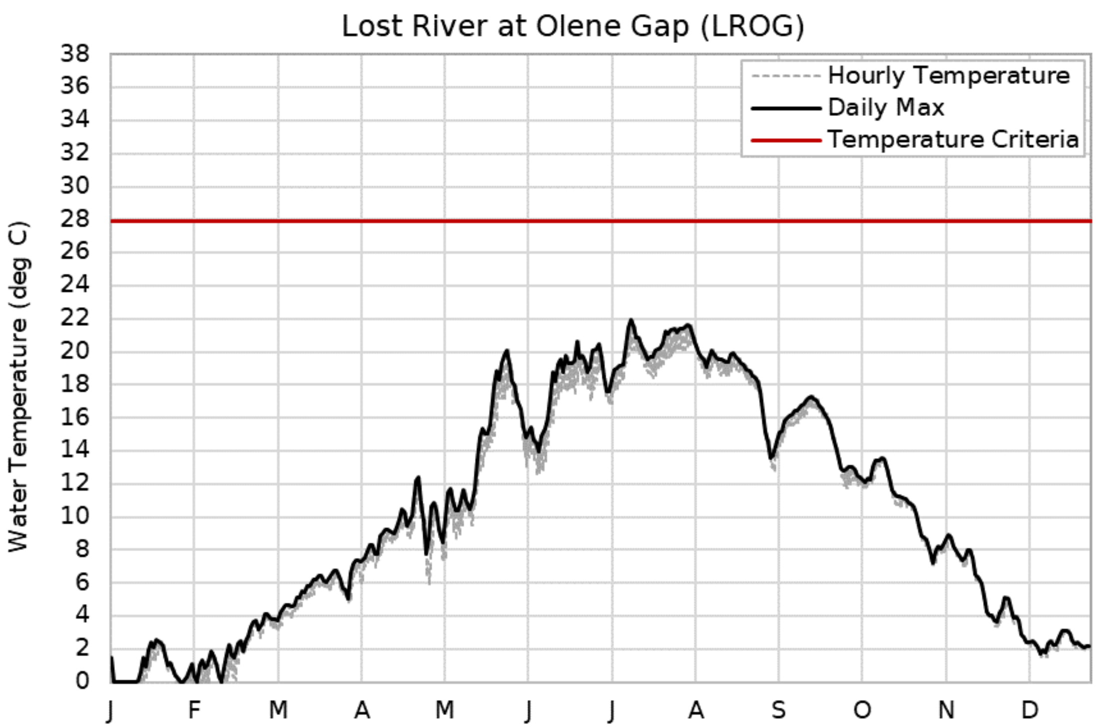
Lost River at Olene Gap (LROG)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
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8
6
4
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0
J
F
M
A
M
J
J
A
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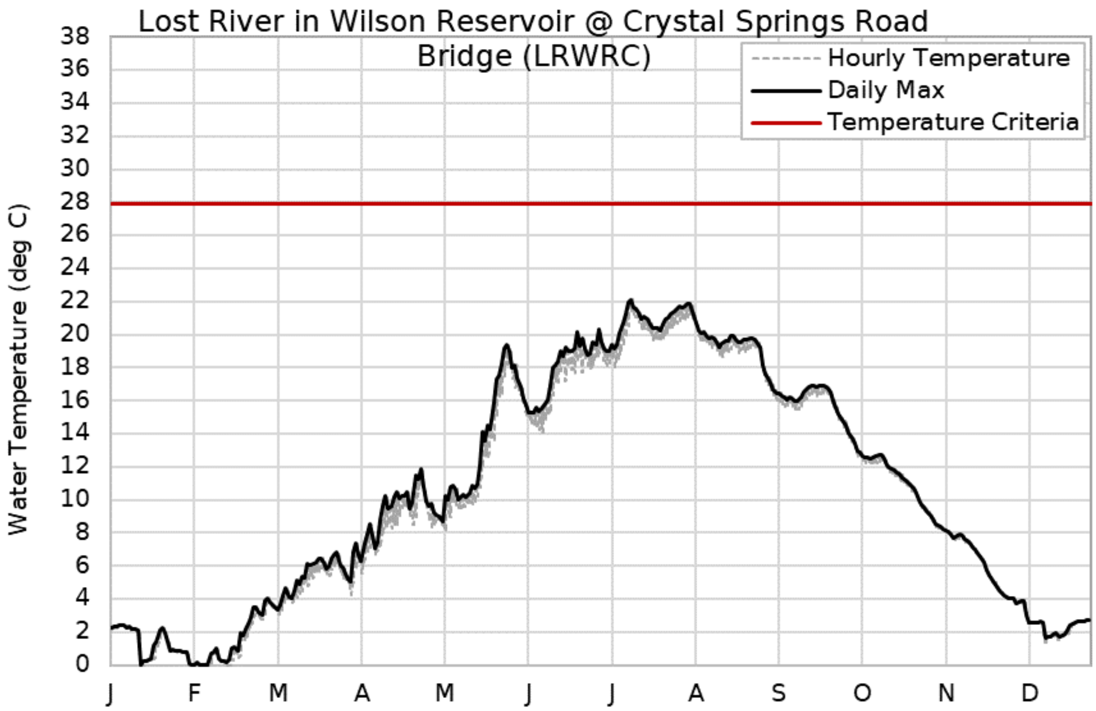
N
D


Lost River in Wilson Reservoir @ Crystal Springs Road Bridge (LRWRC)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
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8
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J
F
M
A
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J
A
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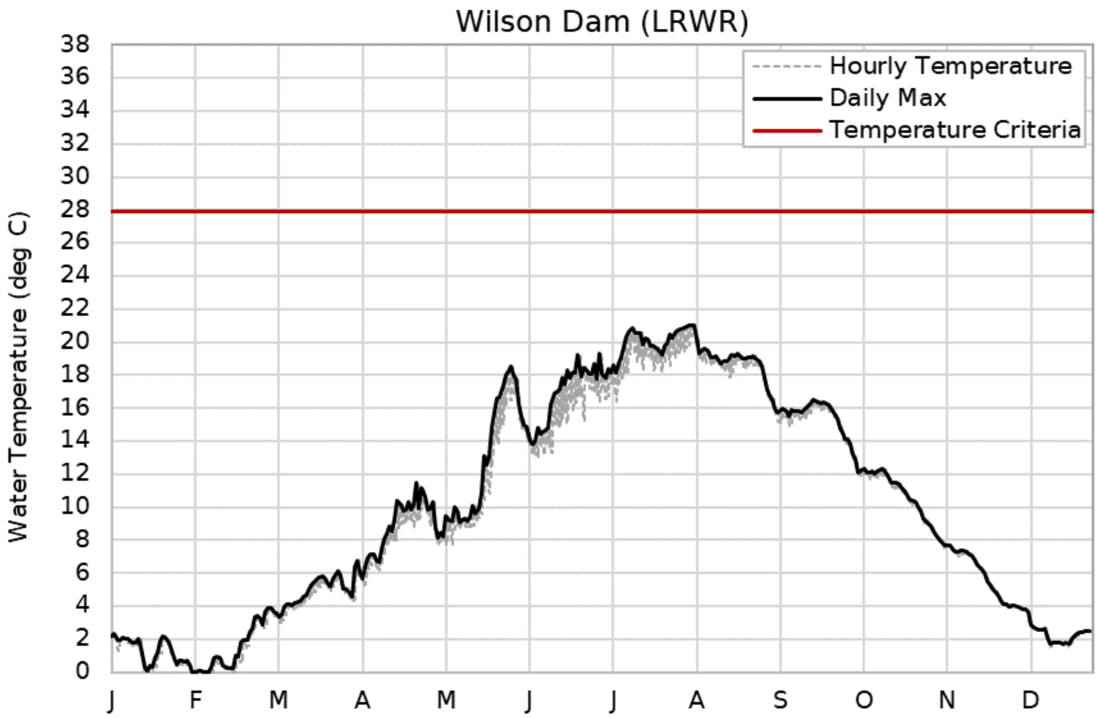
Wilson Dam (LRWR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
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N
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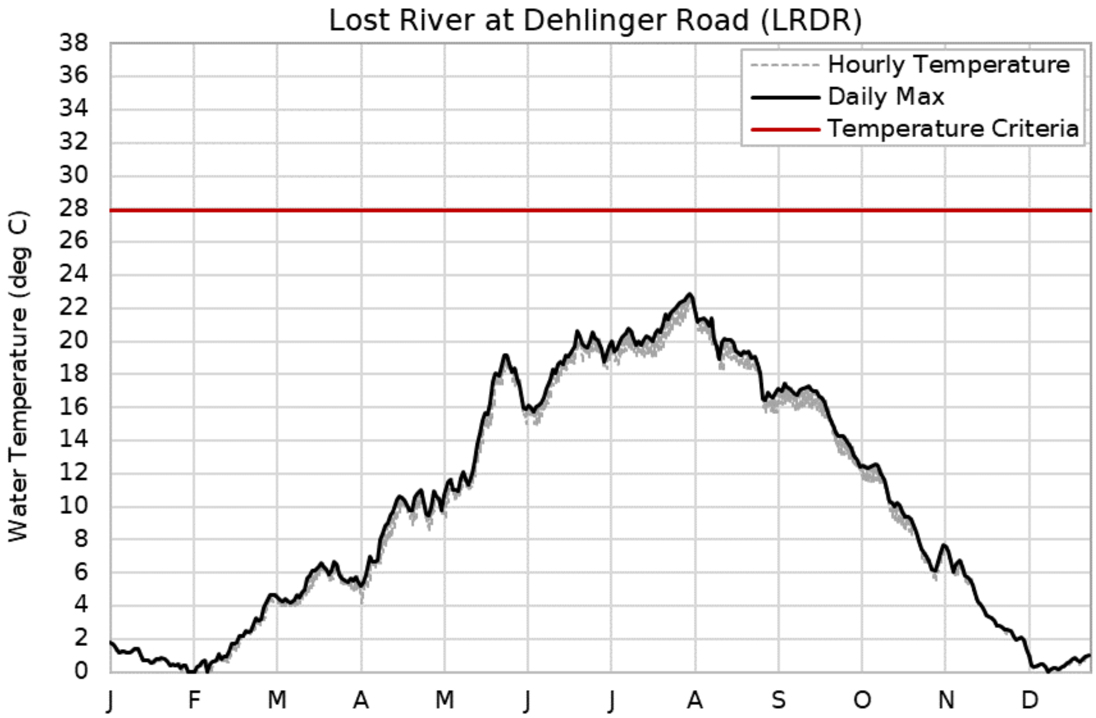
Lost River at Dehlinger Road (LRDR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
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O
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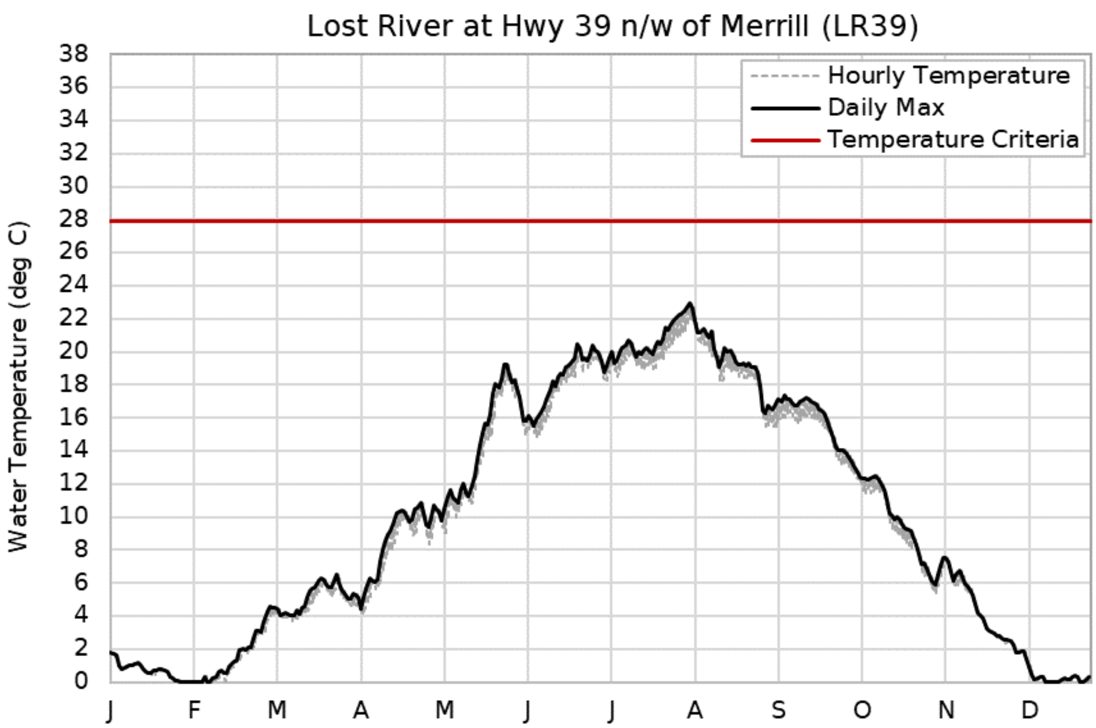
Lost River at Hwy 39 n/w of Merrill (LR39)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
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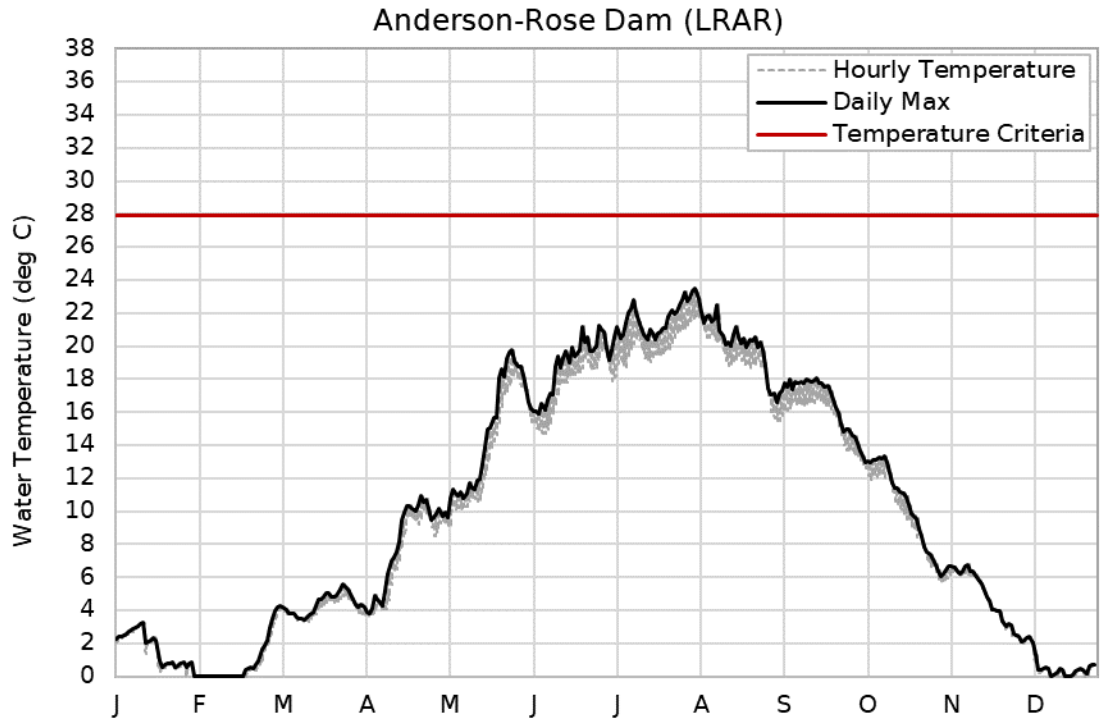
Anderson-Rose Dam (LRAR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
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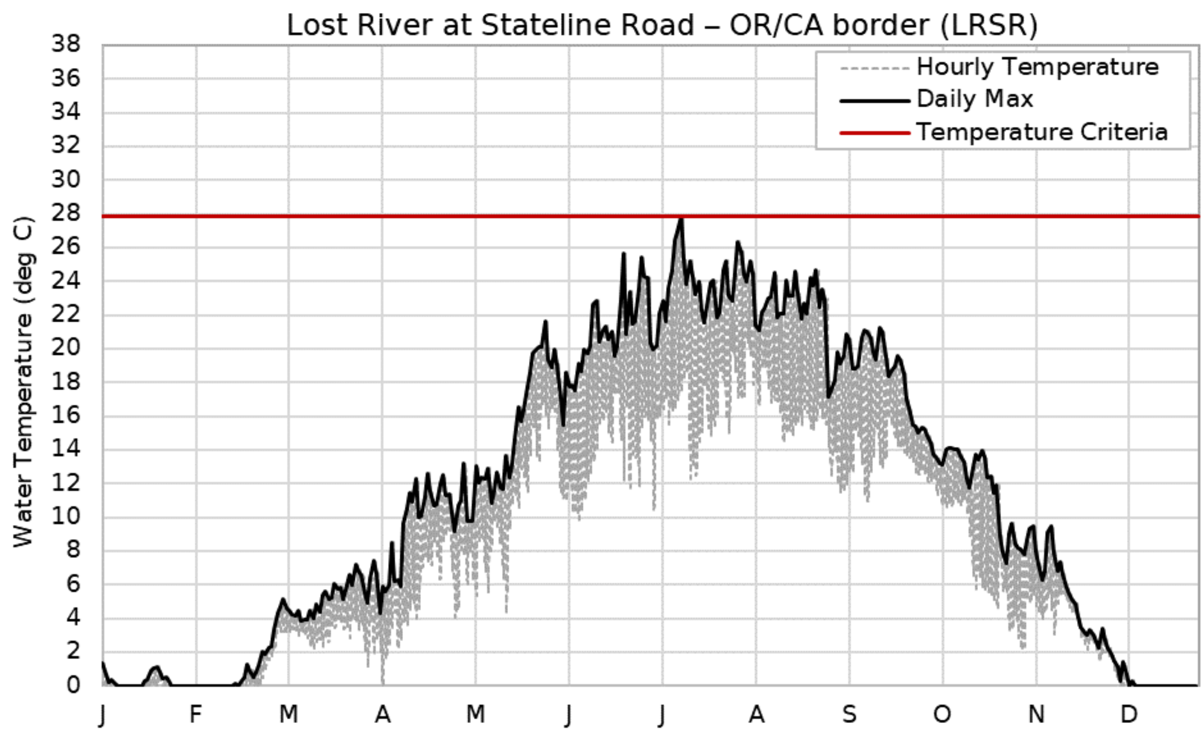
Lost River at Stateline Road – OR/CA border (LRSR)
Hourly Temperature
Daily Max
Temperature Criteria
Water Temperature (deg C)
38
36
34
32
30
28
26
24
22
20
18
16
14
12
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8
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J
F
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A
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J
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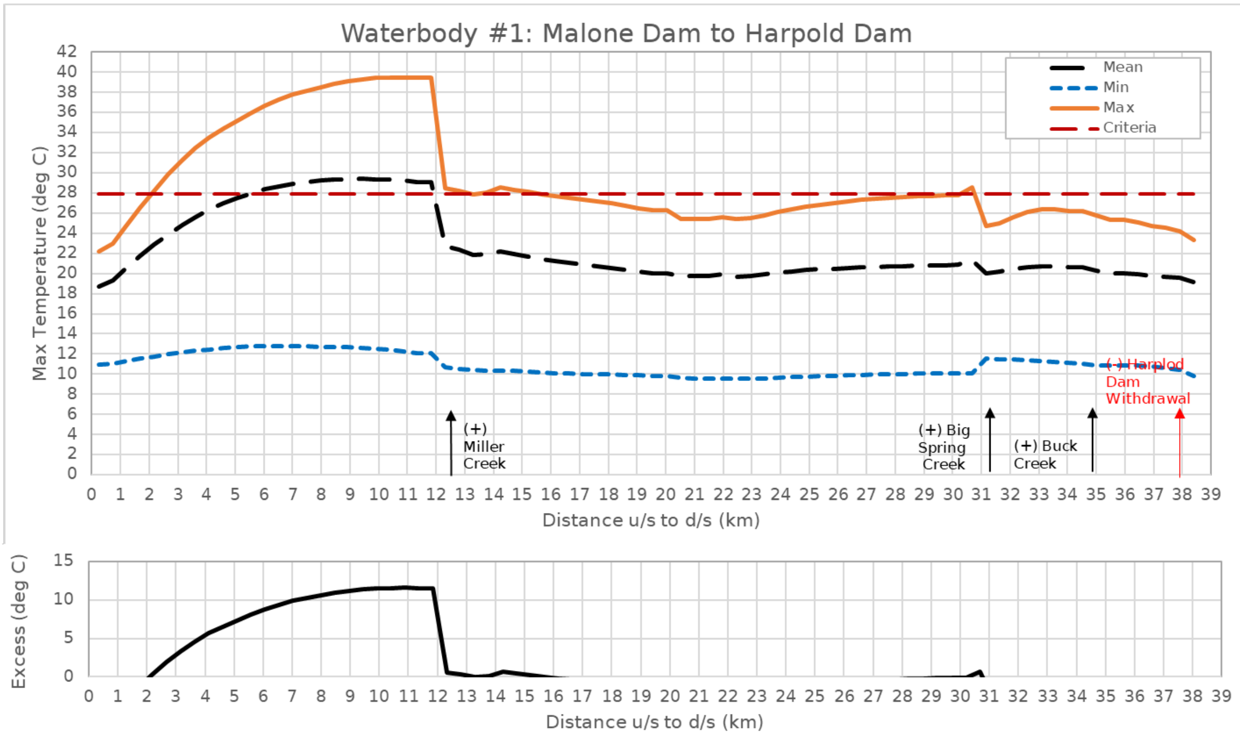
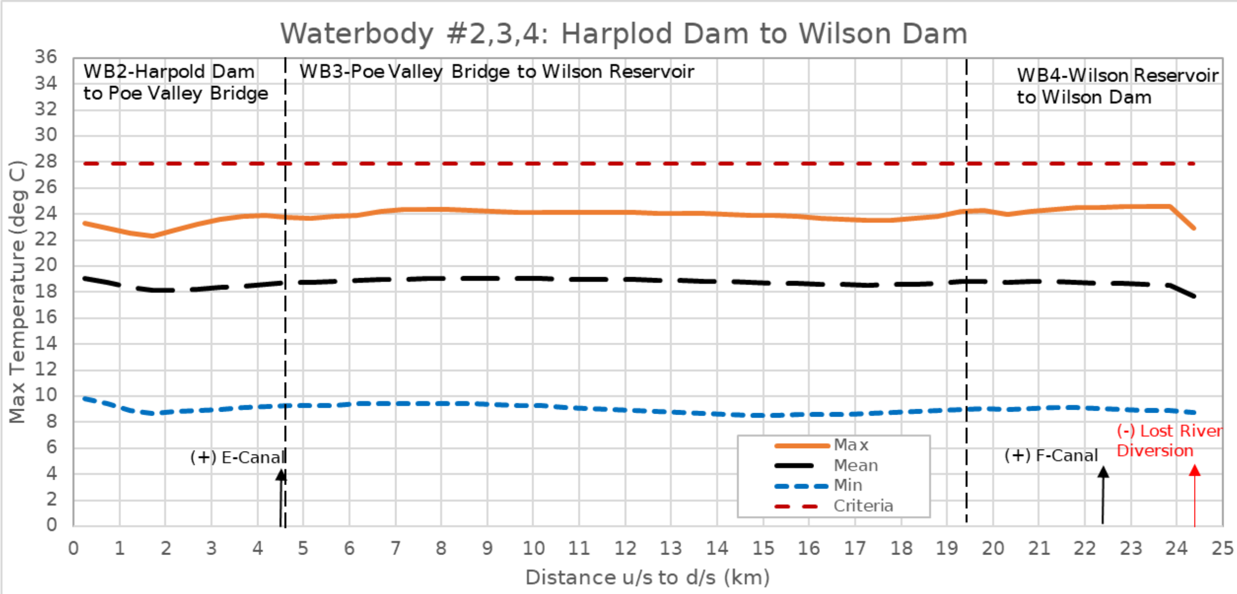
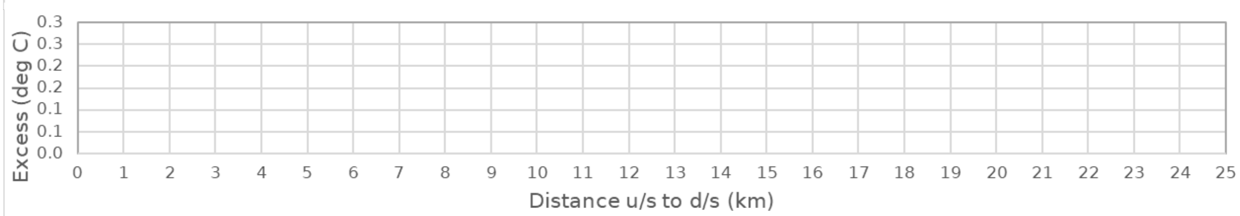
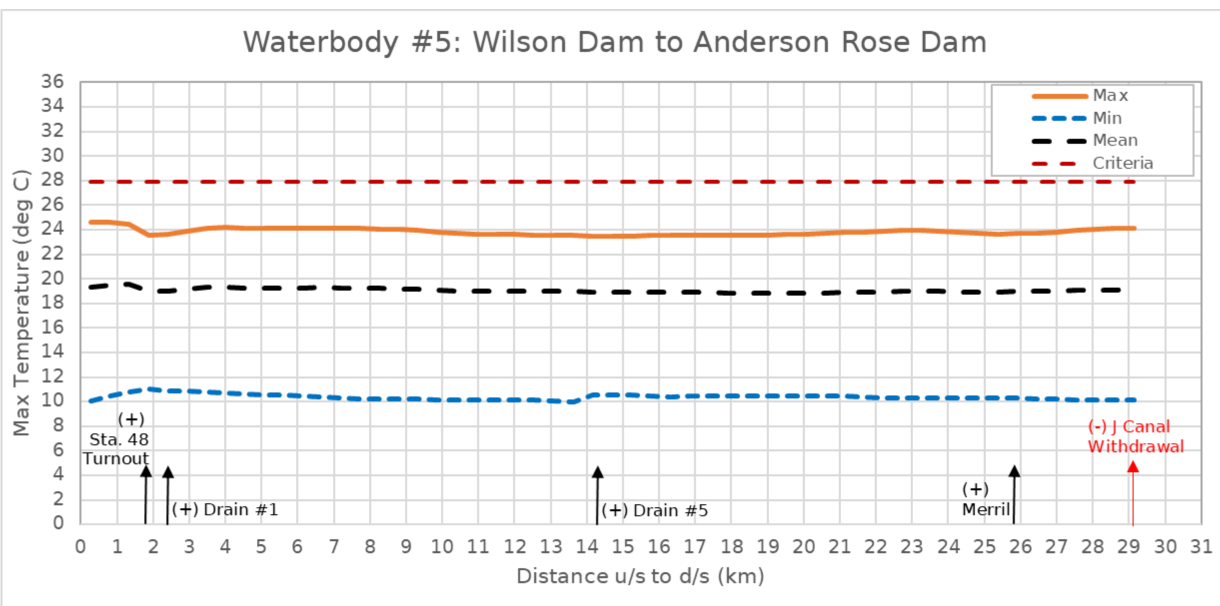
G.8 Existing Condition Longitudinal Plots

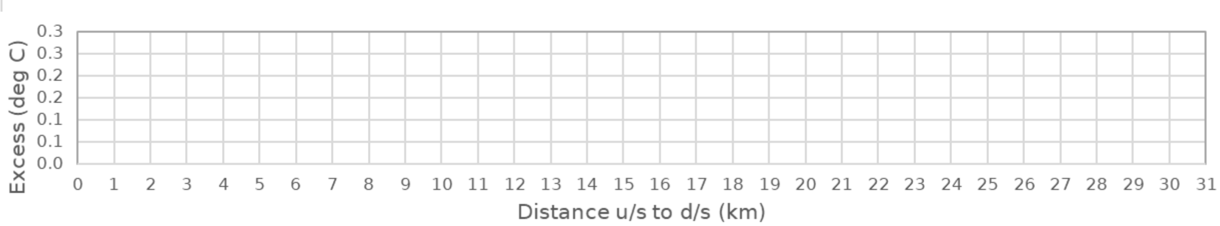
(May 1 to September 15)

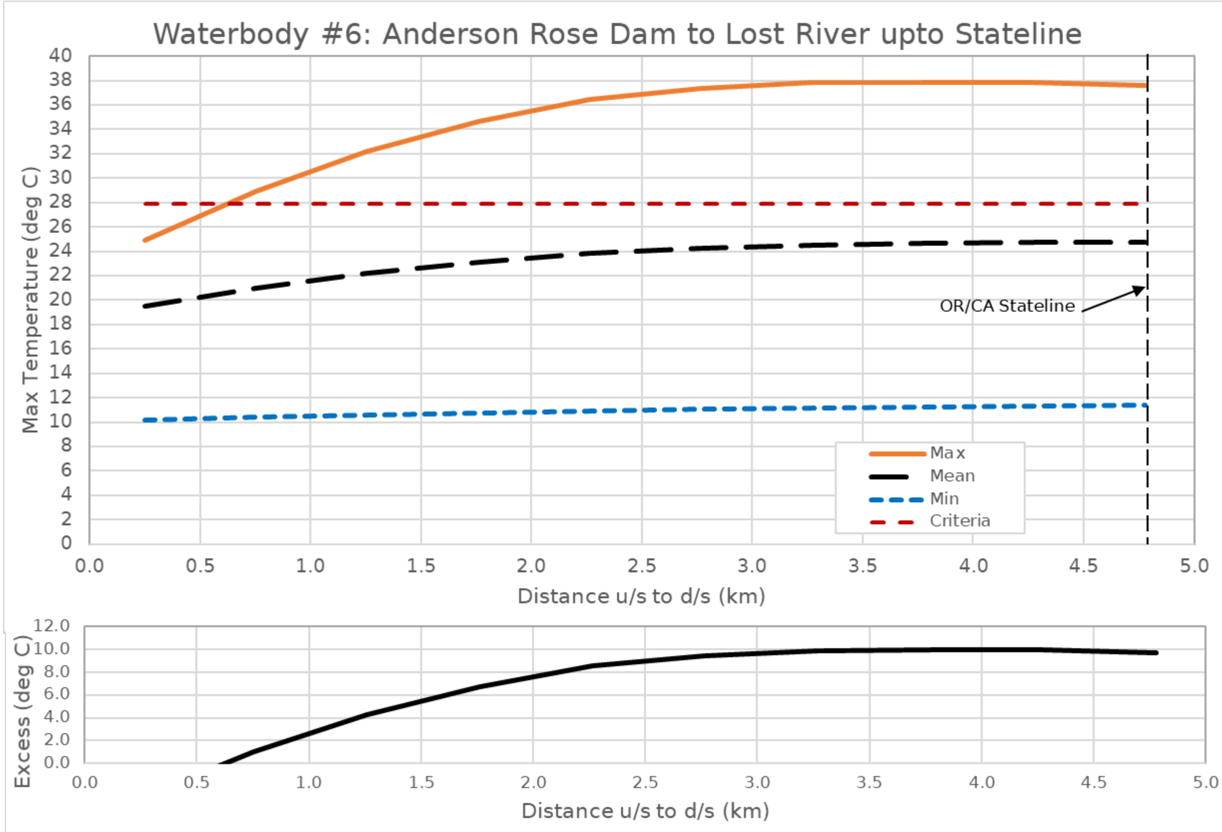



Waterbody #2,3,4: Harplod Dam to Wilson Dam
WB2-Harpold Dam to Poe Valley Bridge
WB3-Poe Valley Bridge to Wilson Reservoir
WB4-Wilson Reservoir to Wilson Dam
(+) E-Canal
(+) F-Canal
(-) Lost River Diversion
Max
Mean
Min
Criteria
Max Temperature (deg C)
Distance u/s to d/s (km)


Excess (deg C)
Distance u/s to d/s (km)

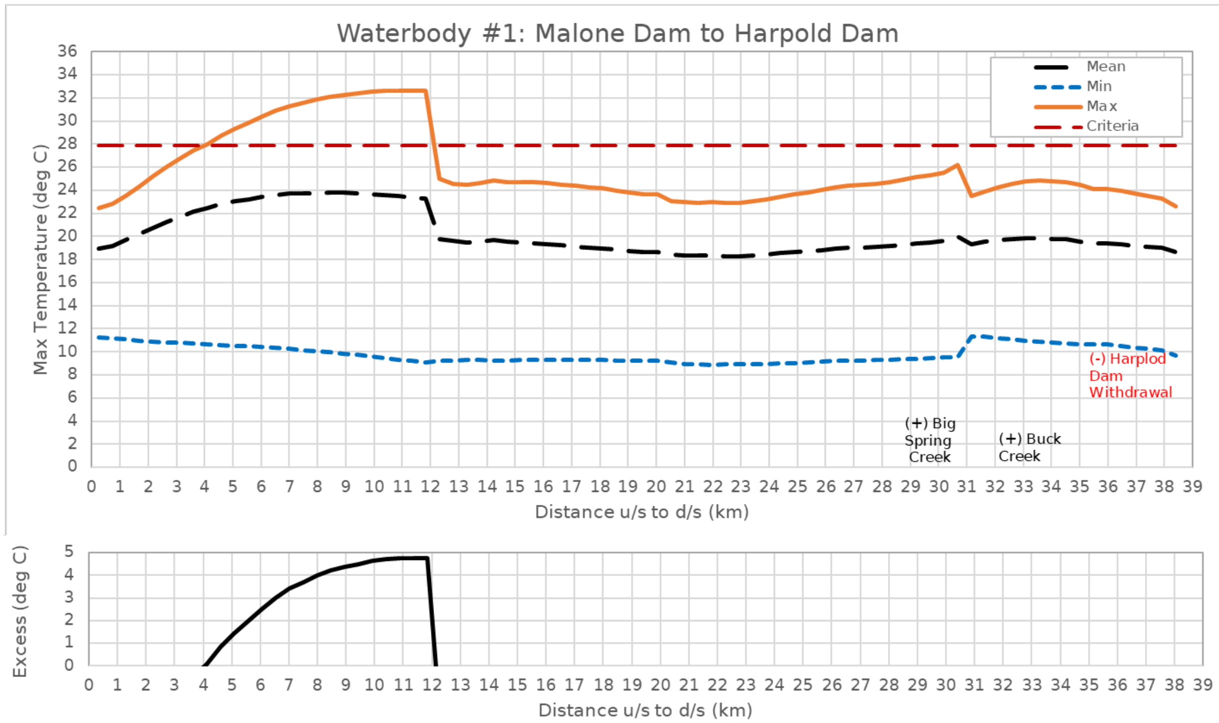

Waterbody #5: Wilson Dam to Anderson Rose Dam
Max
Min
Mean
Criteria
(+) Sta. 48 Turnout
(+) Drain #1
(+) Drain #5
(+) Merril
(-) J Canal Withdrawal
Max Temperature (deg C)
Distance u/s to d/s (km)

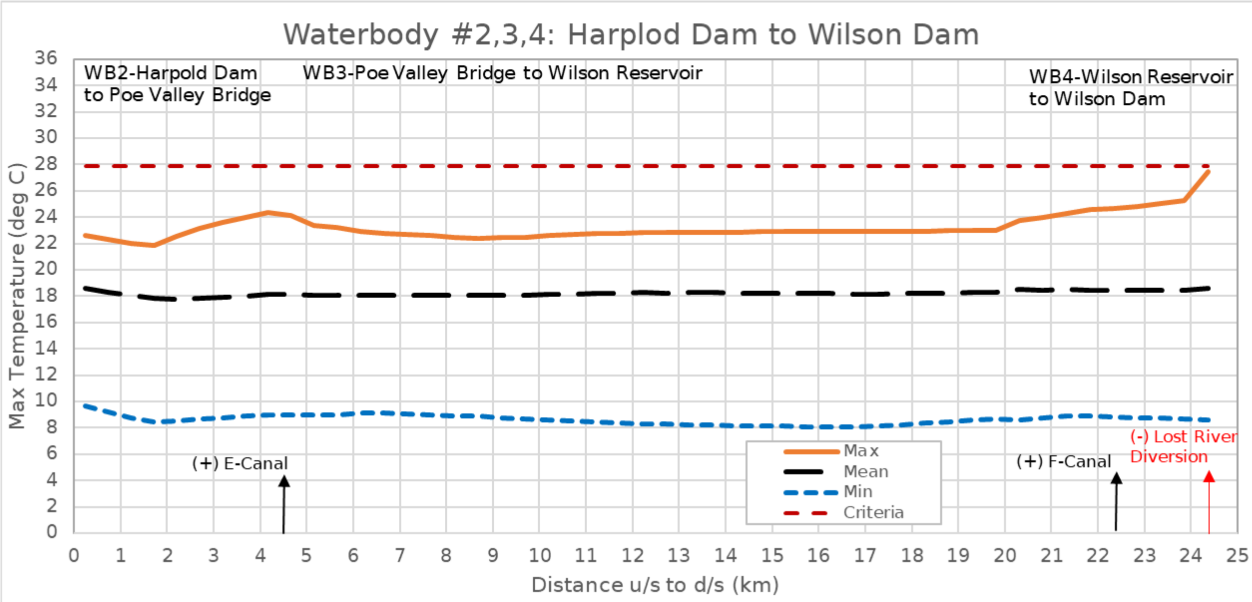

Excess (deg C)
Distance u/s to d/s (km)

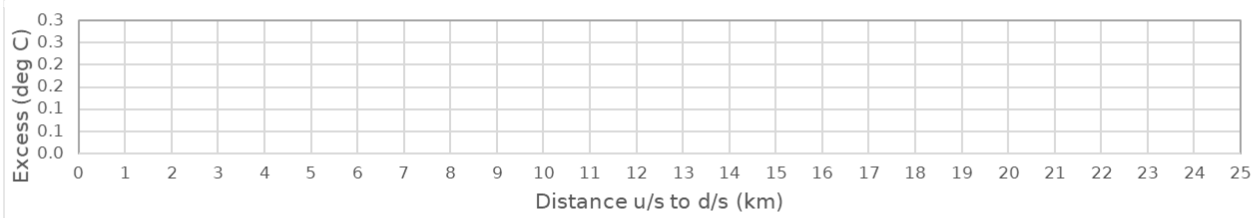

Waterbody #6: Anderson Rose Dam to Lost River upto Stateline
Max Temperature (deg C)
Distance u/s to d/s (km)
OR/CA Stateline
Max
Mean
Min
Criteria
Excess (deg C)
Distance u/s to d/s (km)

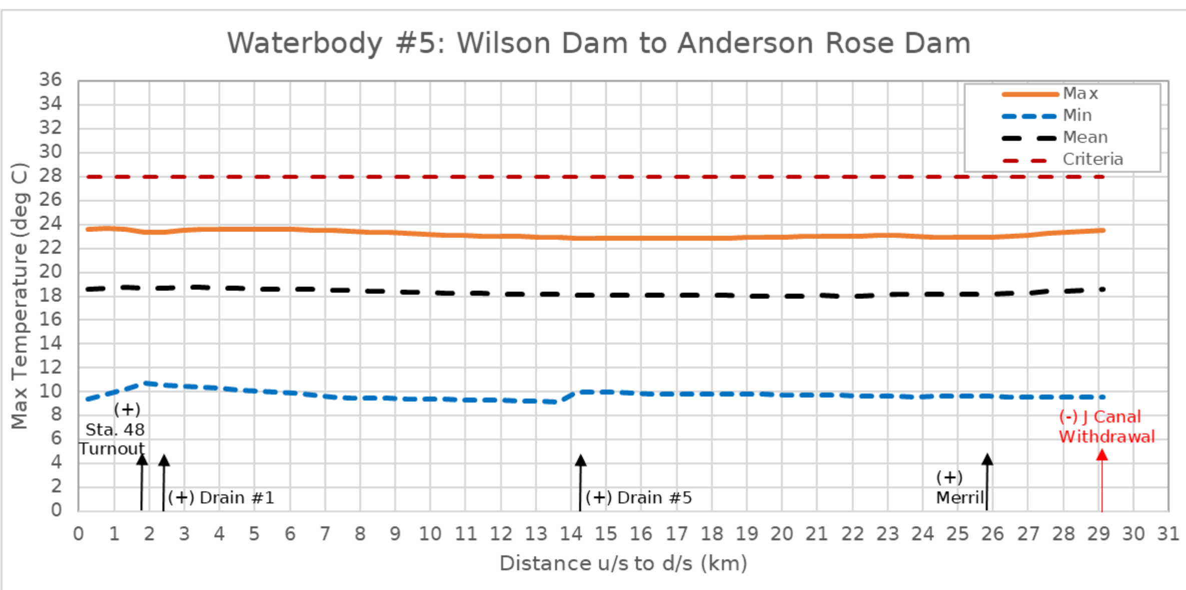
G.9 Restored Vegetation Shading Scenario Longitudinal Plots

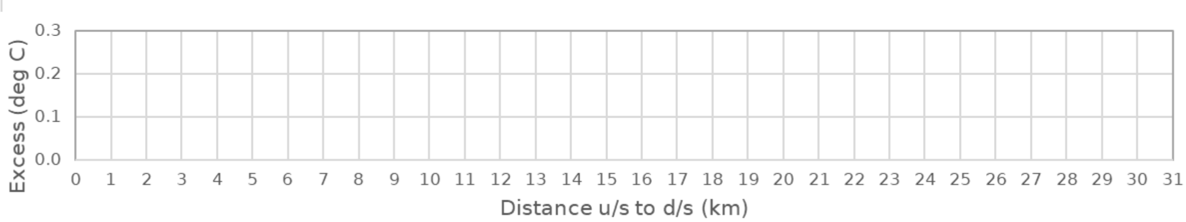
(May 1 to September 15)

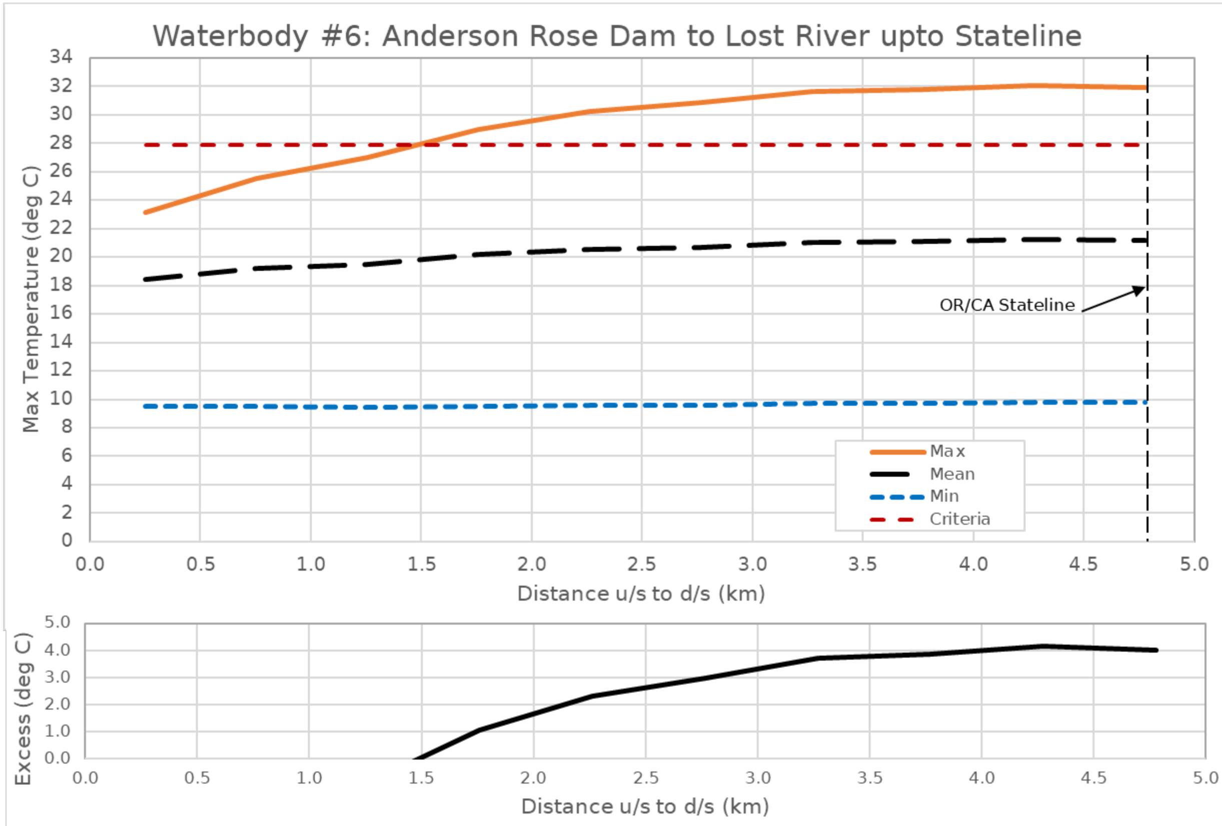



Waterbody #2,3,4: Harplod Dam to Wilson Dam
WB2-Harpold Dam to Poe Valley Bridge
WB3-Poe Valley Bridge to Wilson Reservoir
WB4-Wilson Reservoir to Wilson Dam
Max Temperature (deg C)
(+) E-Canal
(+) F-Canal
(-) Lost River Diversion
Max
Mean
Min
Criteria
Distance u/s to d/s (km)


Excess (deg C)
Distance u/s to d/s (km)

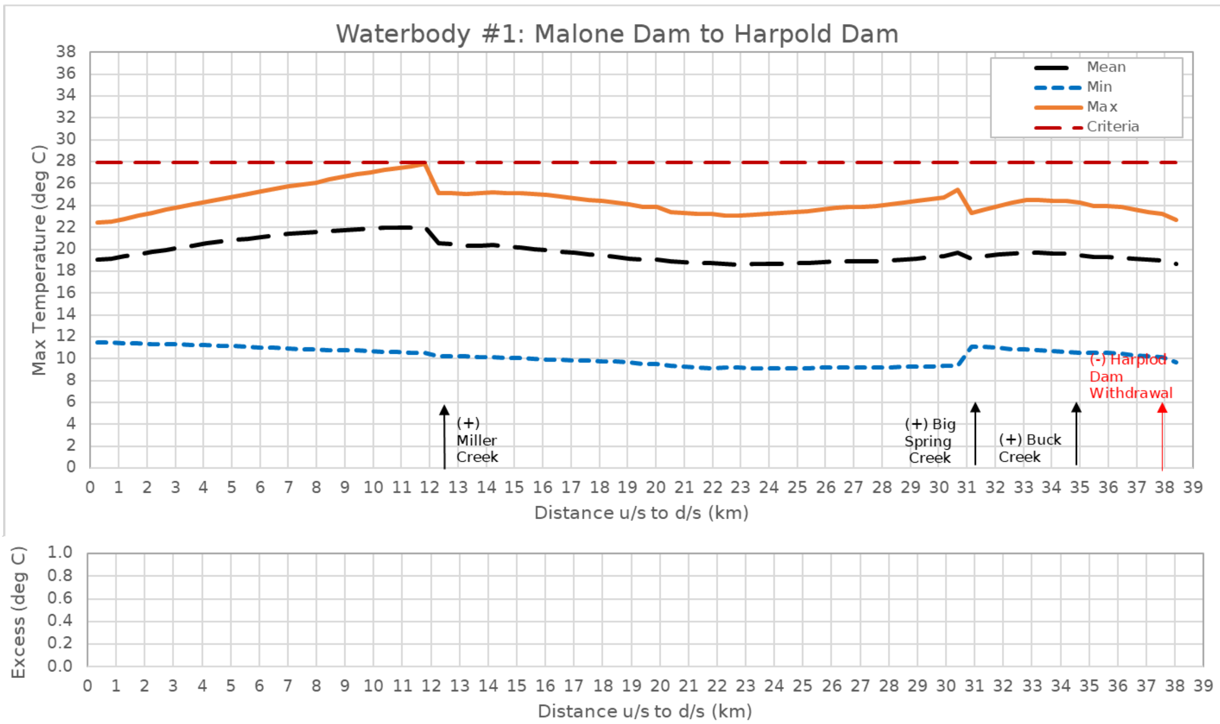

Waterbody #5: Wilson Dam to Anderson Rose Dam
Max Temperature (deg C)
Max
Min
Mean
Criteria
(+) Sta. 48 Turnout
(+) Drain #1
(+) Drain #5
(+) Merril
(-) J Canal Withdrawal
Distance u/s to d/s (km)

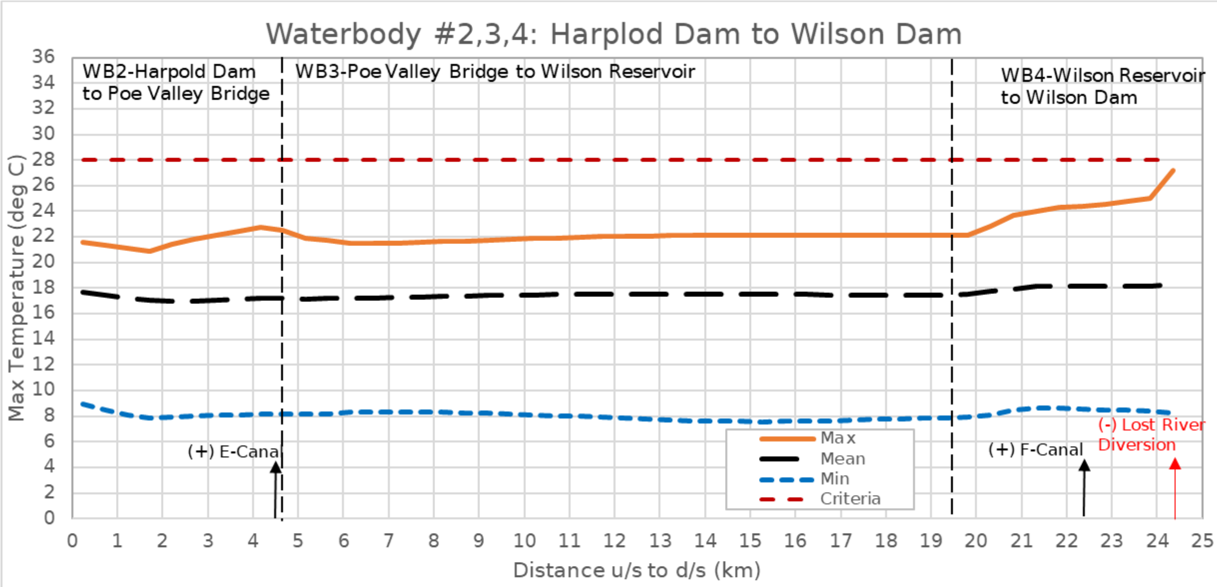

Excess (deg C)
Distance u/s to d/s (km)

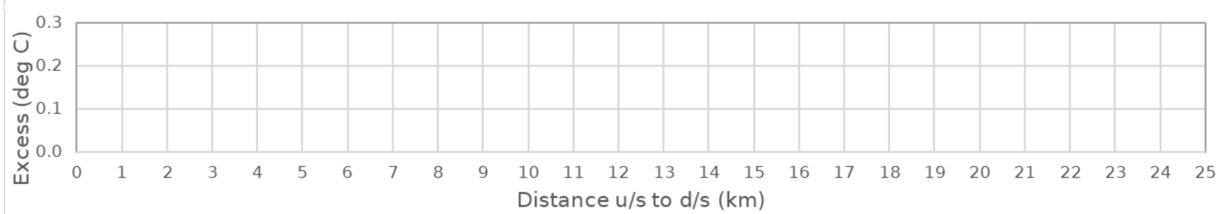

Waterbody #6: Anderson Rose Dam to Lost River upto Stateline
Max Temperature (deg C)
Distance u/s to d/s (km)
OR/CA Stateline
Max
Mean
Min
Criteria
Excess (deg C)
Distance u/s to d/s (km)

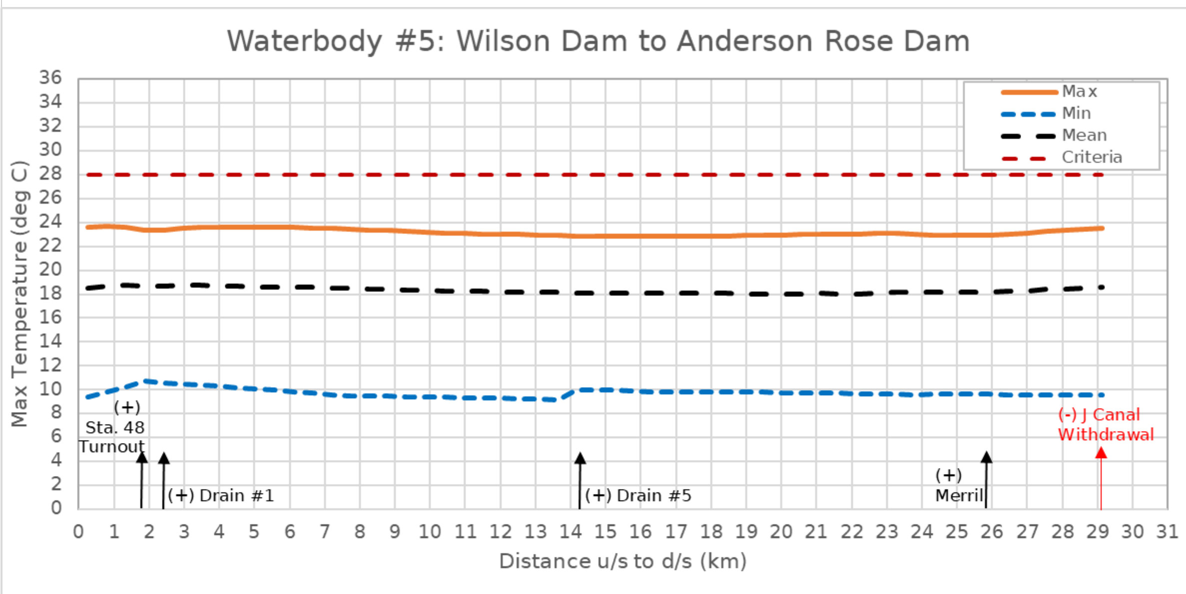
G.10 Shading + Augmented Flow Longitudinal Plots

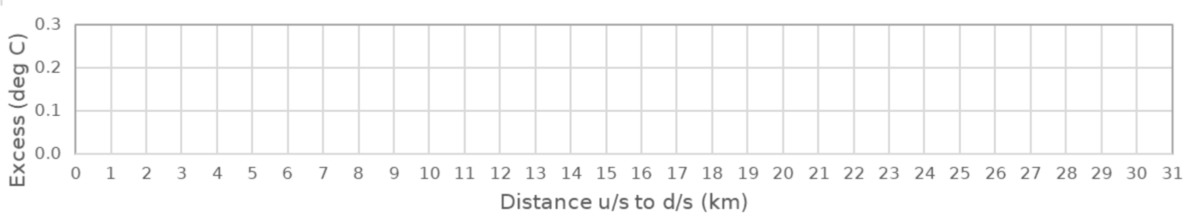
Restored Vegetation Shading Scenario + Augmented Flow (May 1 to September 15)

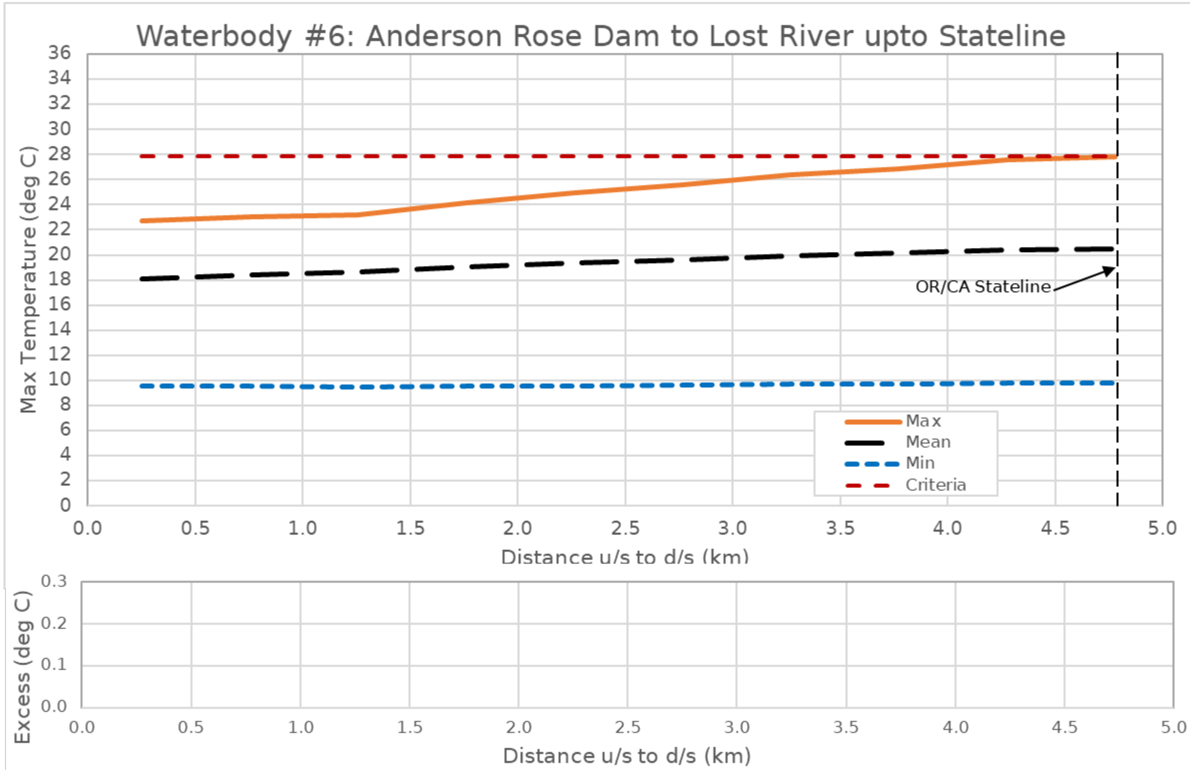



Waterbody #2,3,4: Harplod Dam to Wilson Dam
WB2-Harpold Dam to Poe Valley Bridge
WB3-Poe Valley Bridge to Wilson Reservoir
WB4-Wilson Reservoir to Wilson Dam
Max Temperature (deg C)
(+) E-Canal
(+) F-Canal
(-) Lost River Diversion
Max
Mean
Min
Criteria
Distance u/s to d/s (km)


Excess (deg C)
Distance u/s to d/s (km)


Waterbody #5: Wilson Dam to Anderson Rose Dam
Max
Min
Mean
Criteria
Max Temperature (deg C)
(+) Sta. 48 Turnout
(+) Drain #1
(+) Drain #5
(+) Merril
(-) J Canal Withdrawal
Distance u/s to d/s (km)


Excess (deg C)
Distance u/s to d/s (km)


Waterbody #6: Anderson Rose Dam to Lost River upto Stateline
Max Temperature (deg C)
Distance u/s to d/s (km)
OR/CA Stateline
Max
Mean
Min
Criteria
Excess (deg C)
Distance u/s to d/s (km)

G.11 Wetted Widths and Aspect by Segment/Waterbody

WB1				WB234				WB5				WB6			
RKM	Segment	Wetted Width	Aspect	RKM	Segment	Wetted Width	Aspect	RKM	Segment	Wetted Width	Aspect	RKM	Segment	Wetted Width	Aspect
0.2	2	3.0	NW	0.2	84	21.9	SW	0.3	139	28.9	SW	0.3	196	6	SE
0.7	3	4.0	NW	0.7	85	49.2	SW	0.8	140	30.5	SW	0.8	197	6	SE
1.2	4	6.0	NW	1.2	86	40.3	SW	1.3	141	32.1	SW	1.3	198	6	SE
1.7	5	6.0	NW	1.7	87	35.4	SW	1.9	142	33.1	SW	1.8	199	6	SE
2.2	6	6.0	NW	2.2	88	32.0	SW	2.4	143	31.1	SW	2.3	200	6	SE
2.7	7	6.0	NW	2.7	89	28.6	SW	2.9	144	29.2	SW	2.8	201	6	SE
3.1	8	6.0	NW	3.2	90	25.1	SW	3.5	145	27.2	SW	3.3	202	6	SE
3.6	9	6.0	NW	3.7	91	21.4	SW	4.0	146	23.0	SW	3.8	203	6	NE
4.1	10	6.0	NW	4.2	92	17.4	SW	4.5	147	17.2	SW	4.3	204	6	NE
4.6	11	6.0	NW	4.7	93	13.1	NW	5.1	148	9.4	SW	4.8	205	6	NE
5.1	12	6.0	NW	5.1	96	12.9	NW	5.6	149	16.2	SW				
5.6	13	6.0	NW	5.7	97	14.3	NW	6.1	150	21.7	SW				
6.0	14	6.0	NW	6.2	98	15.3	NW	6.7	151	23.0	SW				
6.5	15	6.0	NW	6.7	99	16.0	NW	6.9	152	22.4	SW				
7.0	16	6.0	NW	7.2	100	16.6	NW	7.2	153	21.7	SW				
7.5	17	6.0	NW	7.7	101	17.0	NW	7.5	154	21.0	SW				
8.0	18	6.0	NW	8.2	102	17.4	NW	7.8	155	20.3	SW				
8.5	19	6.0	NW	8.7	103	17.7	NW	8.0	156	19.6	SW				
8.9	20	6.0	NW	9.2	104	18.0	NW	8.3	157	18.8	SW				
9.4	21	6.0	NW	9.7	105	18.3	NW	8.6	158	18.0	SW				
9.9	22	6.0	NW	10.2	106	18.6	NW	8.8	159	17.2	SW				
10.4	23	6.0	NW	10.7	107	18.9	NW	9.1	160	17.0	SW				
10.9	24	6.0	NW	11.2	108	19.2	NW	9.4	161	17.6	SW				
11.4	25	6.0	NW	11.7	109	19.6	NW	9.6	162	18.2	SW				
11.8	26	6.0	NW	12.2	110	19.9	NW	9.9	163	18.7	SW				
12.3	27	6.0	NW	12.7	111	20.2	NW	10.2	164	19.2	SW				
12.8	28	6.0	NW	13.2	112	20.5	NW	10.4	165	19.7	SW				
13.3	29	6.0	NW	13.7	113	20.8	NW	10.7	166	20.1	SW				
13.8	30	6.0	NW	14.2	114	21.1	NW	11.0	167	20.6	SE				
14.2	31	6.0	NW	14.8	115	21.5	NW	11.2	168	21.0	SE				
14.7	32	6.0	NW	15.3	116	21.8	NW	11.5	169	21.4	SE				
15.2	33	6.0	NW	15.8	117	22.1	NW	11.8	170	20.6	SE				
15.7	34	6.0	NW	16.3	118	22.4	NW	12.0	171	19.7	SE				
16.2	35	6.0	NW	16.8	119	25.4	NW	12.3	172	18.7	SE				
16.7	36	6.0	NW	17.3	120	31.0	NW	12.6	173	17.7	SE				
17.1	37	6.0	NW	17.8	121	31.0	NW	12.8	174	16.6	SE				
17.6	38	6.0	NW	18.3	122	30.4	SW	13.1	175	15.3	SE				
18.1	39	6.0	NW	18.8	123	29.8	SW	13.4	176	16.9	SE				
18.6	40	6.0	NW	19.3	124	29.2	SW	13.6	177	20.4	SE				
19.1	41	6.0	NW	19.8	125	28.5	SW	13.9	178	23.8	SE				
19.6	42	6.0	NW	20.3	128	66.2	SW	14.2	179	27.0	SE				
20.0	43	6.0	NW	20.8	129	117.7	SW	14.4	180	30.2	SE				
20.5	44	20.7	NE	21.3	130	188.0	SW	14.7	181	33.4	SE				
21.0	45	22.9	NE	21.8	131	242.2	SW	15.0	182	32.2	SE				
21.5	46	23.0	NE	22.3	132	247.0	SW	15.2	183	30.8	SE				
22.0	47	23.0	NE	22.8	133	230.8	SW	15.5	184	29.3	SE				
22.5	48	2.0	NW	23.3	134	200.2	SW	15.8	185	27.5	SE				
22.9	49	22.8	NW	23.9	135	169.5	SW	16.0	186	33.2	SE				
23.4	50	22.7	NW	24.4	136	138.8	SW	16.3	187	38.9	SE				
23.9	51	22.5	NW					16.6	188	44.4	SE				
24.4	52	22.2	NW					16.8	189	55.8	SE				
24.9	53	21.9	NW					17.1	190	73.0	SE				
25.4	54	18.6	NW					17.4	191	79.6	SE				
25.8	55	19.2	NW					17.6	192	79.1	SE				
26.3	56	19.9	NW					17.9	193	77.2	SE				
26.8	57	20.7	NW												
27.3	58	21.4	NW												
27.8	59	22.2	NW												
28.3	60	22.9	NW												
28.7	61	23.6	NW												
29.2	62	24.4	NW												
29.7	63	25.1	SW												
30.2	64	41.7	SW												
30.7	65	81.1	SW												
31.2	66	95.4	SW												
31.6	67	70.6	SW												
32.1	68	79.4	SW												
32.6	69	72.8	SW												
33.1	70	61.7	SW												
33.6	71	48.5	SW												
34.1	72	26.0	SW												
34.5	73	26.0	SW												
35.0	74	26.0	SW												
35.5	75	26.0	SW												
36.0	76	26.0	SW												
36.5	77	26.0	SW												
36.9	78	26.0	SW												
37.4	79	27.3	SW												
37.9	80	31.7	SW												
38.4	81	36.0	SW												

G.12 Restored Vegetation Shading by Segment/Waterbody

WB1			WB234			WB5			WB6		
RKM	Segment	Mean Effective Shade %	RKM	Segment	Mean Effective Shade %	RKM	Segment	Mean Effective Shade %	RKM	Segment	Mean Effective Shade %
0.2	2	41.3	0.2	84	21.5	0.3	139	18.5	0.3	196	37.4
0.7	3	41.6	0.7	85	20.8	0.8	140	23.1	0.8	197	44.8
1.2	4	43.4	1.2	86	18.5	1.3	141	27.9	1.3	198	50.4
1.7	5	43.5	1.7	87	4.4	1.9	142	28.4	1.8	199	29.7
2.2	6	41.0	2.2	88	11.9	2.4	143	28.9	2.3	200	39.9
2.7	7	40.3	2.7	89	6.4	2.9	144	30.5	2.8	201	39.1
3.1	8	40.7	3.2	90	11.9	3.5	145	36.5	3.3	202	28.5
3.6	9	38.7	3.7	91	3.0	4.0	146	32.1	3.8	203	35.4
4.1	10	39.6	4.2	92	9.0	4.5	147	35.2	4.3	204	27.3
4.6	11	39.9	4.7	93	15.1	5.1	148	32.7	4.8	205	40.2
5.1	12	42.3	5.1	96	26.3	5.6	149	36.3			
5.6	13	39.8	5.7	97	27.1	6.1	150	29.5			
6.0	14	38.6	6.2	98	23.9	6.7	151	40.0			
6.5	15	38.7	6.7	99	29.1	6.9	152	42.5			
7.0	16	40.9	7.2	100	25.6	7.2	153	30.8			
7.5	17	43.4	7.7	101	38.4	7.5	154	34.3			
8.0	18	37.0	8.2	102	29.0	7.8	155	27.2			
8.5	19	38.8	8.7	103	31.5	8.0	156	37.0			
8.9	20	39.5	9.2	104	31.5	8.3	157	38.6			
9.4	21	39.9	9.7	105	9.6	8.6	158	36.0			
9.9	22	39.7	10.2	106	6.0	8.8	159	36.9			
10.4	23	40.4	10.7	107	5.8	9.1	160	24.1			
10.9	24	40.2	11.2	108	5.7	9.4	161	34.8			
11.4	25	39.1	11.7	109	17.8	9.6	162	36.2			
11.8	26	39.6	12.2	110	13.9	9.9	163	34.6			
12.3	27	39.0	12.7	111	30.3	10.2	164	38.5			
12.8	28	16.6	13.2	112	16.8	10.4	165	38.5			
13.3	29	23.3	13.7	113	26.4	10.7	166	38.0			
13.8	30	29.4	14.2	114	27.0	11.0	167	37.6			
14.2	31	40.1	14.8	115	7.3	11.2	168	22.5			
14.7	32	31.1	15.3	116	24.8	11.5	169	24.3			
15.2	33	14.8	15.8	117	24.5	11.8	170	33.4			
15.7	34	27.2	16.3	118	30.1	12.0	171	27.6			
16.2	35	37.5	16.8	119	17.3	12.3	172	31.8			
16.7	36	42.1	17.3	120	9.9	12.6	173	34.1			
17.1	37	38.7	17.8	121	6.9	12.8	174	30.7			
17.6	38	33.5	18.3	122	14.2	13.1	175	31.5			
18.1	39	36.0	18.8	123	13.0	13.4	176	21.4			
18.6	40	42.8	19.3	124	4.8	13.6	177	31.2			
19.1	41	44.1	19.8	125	16.8	13.9	178	34.8			
19.6	42	21.6	20.3	128	1.7	14.2	179	34.5			
20.0	43	29.0	20.8	129	0.4	14.4	180	30.2			
20.5	44	38.0	21.3	130	0.2	14.7	181	10.3			
21.0	45	39.3	21.8	131	0.2	15.0	182	13.6			
21.5	46	36.3	22.3	132	0.2	15.2	183	13.1			
22.0	47	39.5	22.8	133	0.3	15.5	184	18.2			
22.5	48	39.0	23.3	134	0.2	15.8	185	5.9			
22.9	49	39.4	23.9	135	1.0	16.0	186	23.8			
23.4	50	36.7	24.4	136	0.8	16.3	187	11.2			
23.9	51	38.2				16.6	188	11.0			
24.4	52	30.3				16.8	189	4.5			
24.9	53	34.1				17.1	190	3.4			
25.4	54	30.0				17.4	191	6.5			
25.8	55	15.2				17.6	192	2.0			
26.3	56	23.4				17.9	193	4.6			
26.8	57	37.1									
27.3	58	37.9									
27.8	59	30.5									
28.3	60	10.7									
28.7	61	7.8									
29.2	62	8.3									
29.7	63	8.6									
30.2	64	14.3									
30.7	65	28.0									
31.2	66	8.2									
31.6	67	16.8									
32.1	68	32.8									
32.6	69	25.1									
33.1	70	12.5									
33.6	71	9.1									
34.1	72	9.4									
34.5	73	6.1									
35.0	74	4.2									
35.5	75	6.0									
36.0	76	6.4									
36.5	77	16.2									
36.9	78	13.7									
37.4	79	19.9									
37.9	80	23.9									
38.4	81	7.7									

G.13 References

Kirk, S., Turner, D., and Crown, J. 2010. Upper Klamath and Lost River subbasins total maximum daily load (TMDL) and water quality management plan (WQMP). Oregon Department of Environmental Quality, Bend, Oregon.