Evaluation of Proposed Temperature Moderation Measure
FERC 2107 -- Poe Reach

3/9/2005

Methodology

Three years of actual temperature data (1999, 2000 and 2003) collected during the FERC 2107 re-licensing study were evaluated to characterize the typical temperature warming (DT) between Poe Dam and NFFR immediately above Poe Powerhouse when the corresponding stream temperature above Poe Powerhouse exceeded 20 ºC. SNTEMP model was then used to test the same environmental conditions (meteorology and starting temperatures) with a series of high flow releases, up to the proposed flow caps for each water year type. The simulated temperature data were evaluated using the flow action proposal based on a 2-day averaged triggering criterion.

Data Evaluation

Two DTs were calculated, one based on the hourly average temperatures (as proposed) and the other based on daily averaged values (for SNTEMP modeling purpose). The time series data were graphically displayed in Figure 1a-1c. During these three years, the instream flows ranged from 110 cfs to 140 cfs (due to a leakage condition currently exist at the Poe Dam). Inflow condition of all these three years falls into the Normal water year type. Additional unpublished data (2001, 2002 and 2004) were later supplemented in Figure 2a-2b to aid in comparison to other water year types (2001 is Critical Dry year, and 2002 is Dry year). There were no hourly averaged data for 2002 due to instrument memory limitation. The following summarizes the data evaluation:

1) DT based on hourly averaged temperatures generally varied from 3-5 ºC in the months of June and July. The DTs start decreasing in early August. Much of the larger DTs occurred in June-July period with few occasions during heat storms in the remainder of the summer months. The frequent occurrence of large DT in June-July is caused by the fact that the solar radiation peaks in this period (see Figure 3) while the starting temperatures at Poe Dam are at the lowest.
2) DT based on daily mean temperatures show a similar temporal trend to those on the hourly basis; however, the warming magnitude is less, ranged from 1.5 to 3 ºC in June-July, or about 1.5 ºC less than those on the hourly based values.
3) DT in Critical Dry and Dry years (2001 and 2002) show similar seasonal trend and the warming magnitude is about the same, if not less, compared to those of normal water year type. Model simulation for the normal water year type can conservatively be extended to assess the 'DT' temperature moderation effect for other water year types.
4) DT time series show a cyclic trend with a typical period about one week. Within a week, DT can swing up to 1.5 ºC. The effectiveness of the 'high flow release action' would be severely hampered by this temporal trend. For instance, giving a 25 cfs/day ramping rate, it would take four days to crank up 100 cfs and possibly another day to travel the high pulse flow to the

powerhouse 7.6 miles downstream; at which time Mother Nature would have already 'cooled' off the water temperature regardless the high flow release.

5) Heat loading of 1 ºC in Poe Reach (about 7.6 miles long) is equivalent to 0.13 ºC/mile. Heat loading from the lower Butte Creek in the nearby watershed with equivalent elevation range (520 feet to 2880 feet for lower Butte Creek while the elevation range for Poe is 1180 to 1360 feet) revealed a heat loading range of 0.4 to 0.7 ºC/mile for the river system, whereas the canal system (Hendricks/Toadtown Canal) has a much less heat loading, about 0.05 to 0.07 ºC/mile. The heating loading criterion for Poe Reach under consideration is much too close to a canal system than to a natural river system.

SNTEMP Model Simulation

The existing data evaluated temperature characteristics under the current flow conditions about 110 to 140 cfs. SNTEMP model is used to analyze the temperature conditions at higher flow releases. This model is developed by calibrating and testing with the same three years of data (1999, 2000 and 2003). The smallest time interval of SNTEMP is one day. For Poe Reach, PG&E employed a 2-day interval (because of travel time for the baseline condition at 50 cfs is about 2 days). Since no modeling is being developed to predict the 'hourly' averaged temperatures, we modified the 'temperature moderation' criteria from the 'hourly' basis to a 2-day averaged basis. The same data and model are tested for higher flow release schedules under consideration by the Poe Collaborative workgroup. The results of the various flow schedules on different water year types, including those corresponding to flow caps, are shown in Figures 4a-4c. The predicted results are then tested with the modified 'temperature moderation' criteria as following,

(a) if the 2-day averages water temperatures above Poe Powerhouse exceeding 20 ºC,
(b) if DT (also on 2-day averaged) exceeds 1 ºC

If both conditions are met, high flow action would then be triggered. The total number of days and their monthly occurrence distribution of such triggering events are tabulated in Table 1. The following is a summary of model simulation result:

1) Flow releases under 'Critical Dry' and 'Dry' water year type would trigger a total of 22 to 44 days each year of 'required action' among the studied 3 years.
2) Increase of flow under the 'Critical Dry' and 'Dry' water year to the flow cap (420 cfs for CD and 450 cfs for Dry) would not be adequate to completely moderate the temperature warming to meet the 1 ºC. Among the three years studied, there would still have 2 to 12 days that would not meet the specified 1 ºC DT based on the 2-day averaged values.
3) To evaluate the implication from criteria on the 'hourly' basis, one could shift the predicted DT time series upward by 1.5 ºC (based on Bullet 2 in the Data Evaluation section). The result of this shifting suggests one should speculate that a significant portion of the summer would subject to such high flow release condition. Such condition likely is going to occur frequently in the months of June and July.
4) Flow releases under 'Wet' and 'Normal' water year types would trigger a total of 10 to 40 days of 'required action' among the studied 3 years. Again, mostly occur in June-July.

5) Increase of flow under the 'Wet' and 'Normal' water year to the flow cap (500 cfs) would reduce the warming and moderate DT to meet 1 ºC criterion (2-day mean) for 1999, but not enough for the other two years. High flow release at 500 cfs would not meet the desired temperature warming at 1 ºC (2-day mean) for 6 days in June 2000 and 2 days in July 2003 during heat storms. If the prediction result is shifted upward by 1.5 ºC for consideration of 'hourly average' criterion, nearly the entire summer would be subject to high flow release condition.
6) SNTEMP model is accurate to 0.5 ºC at the 50% confidence level based on the three years of model testing.

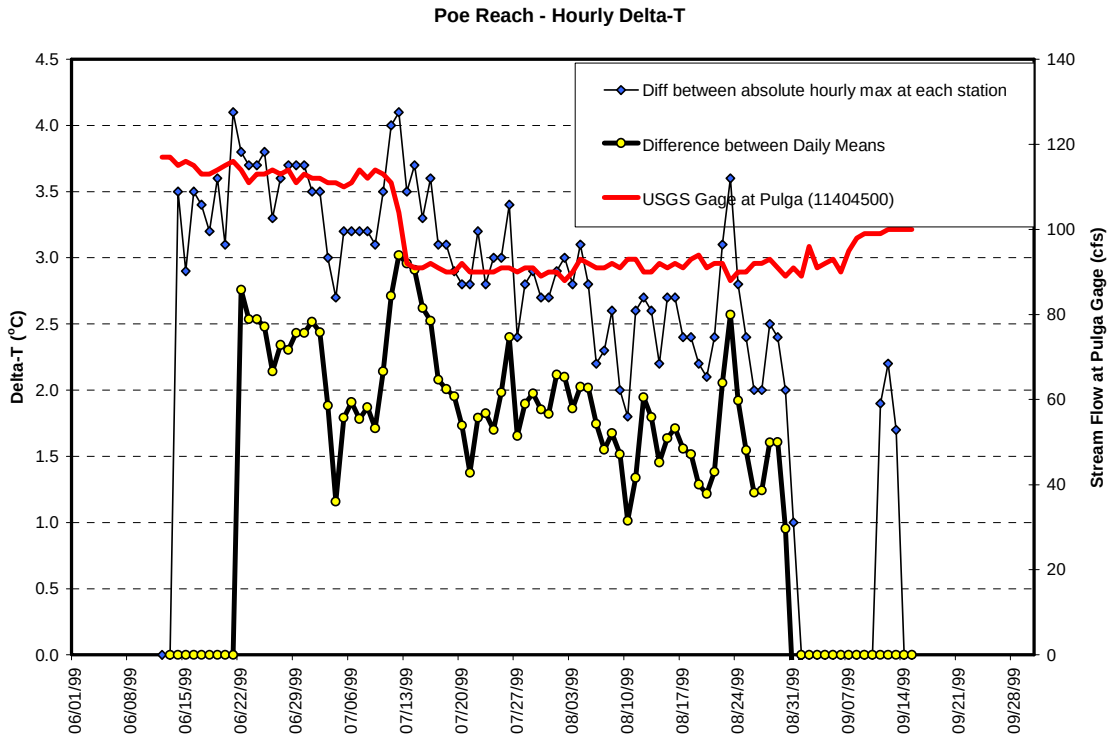

Figure 1a. Delta-T Time series for 1999

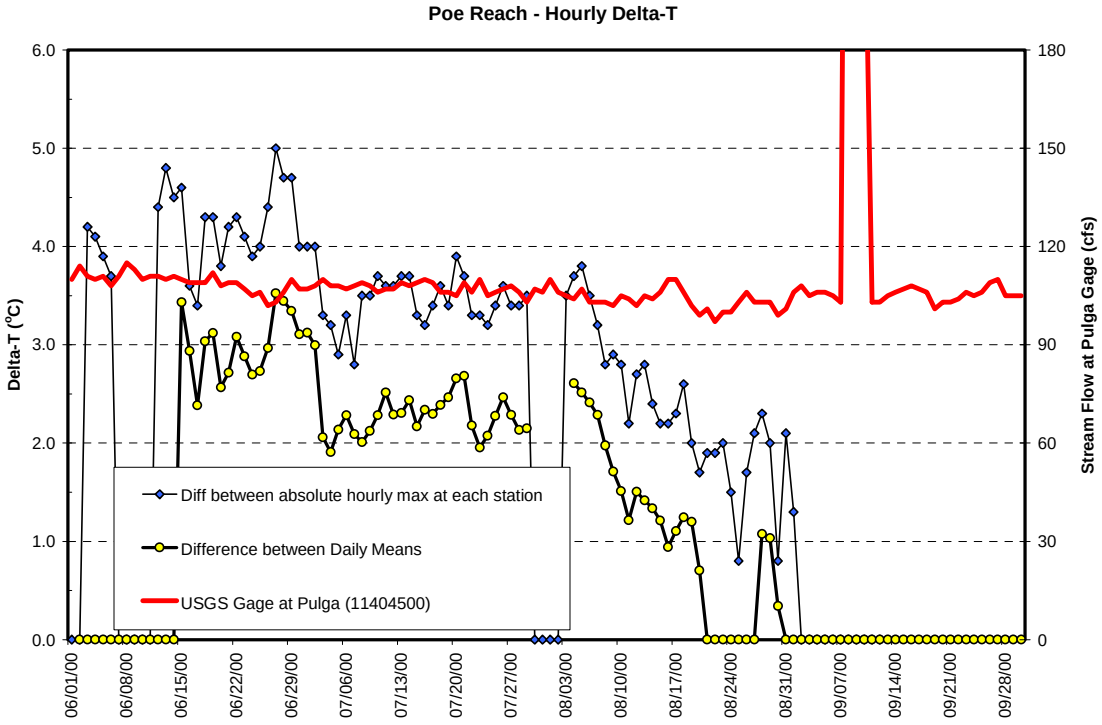

Figure 1b Delta-T Time Series for 2000

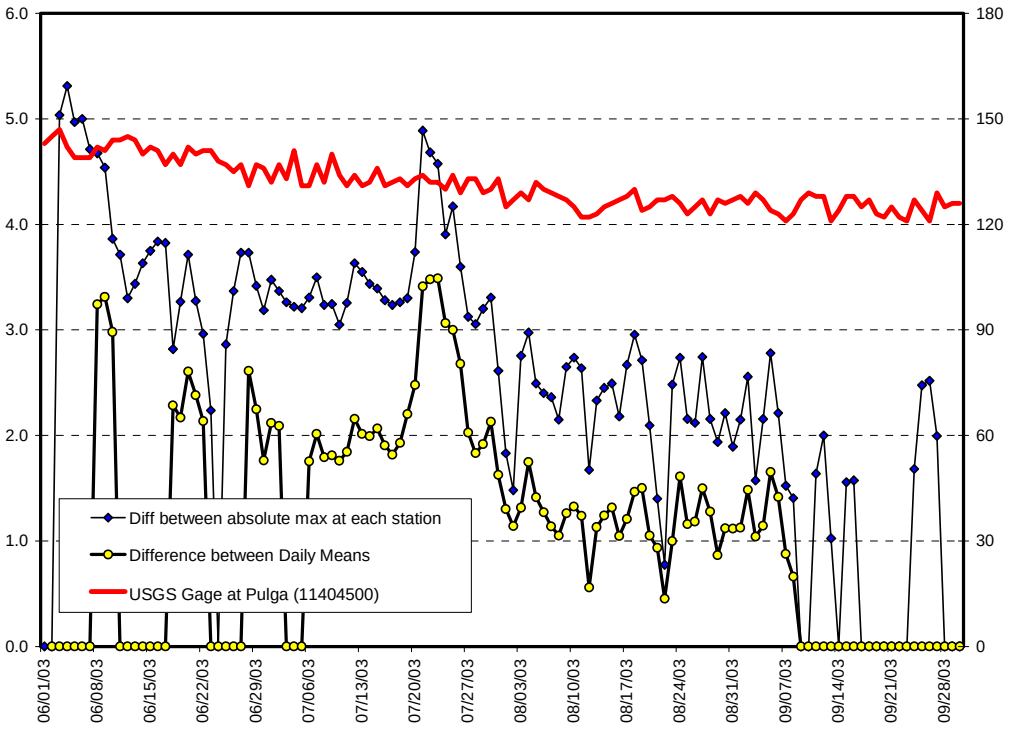

Figure 1c Delta-T Time Series for 2003

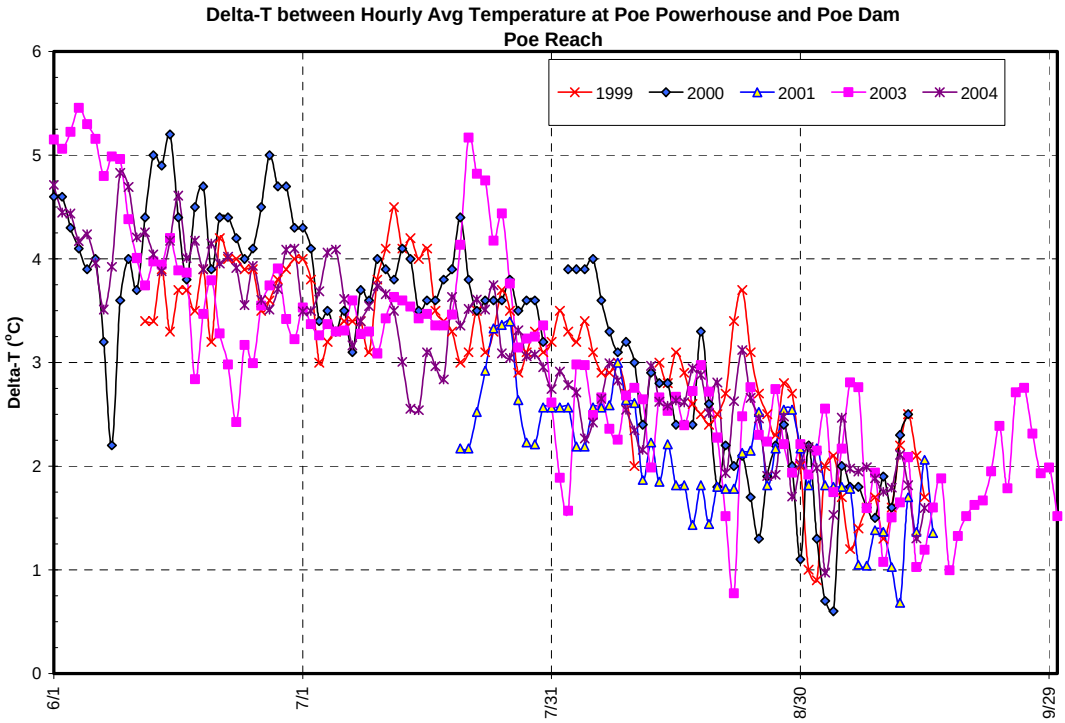

Figure 2a Hourly Average Delta-T Time Series for 1999-2004

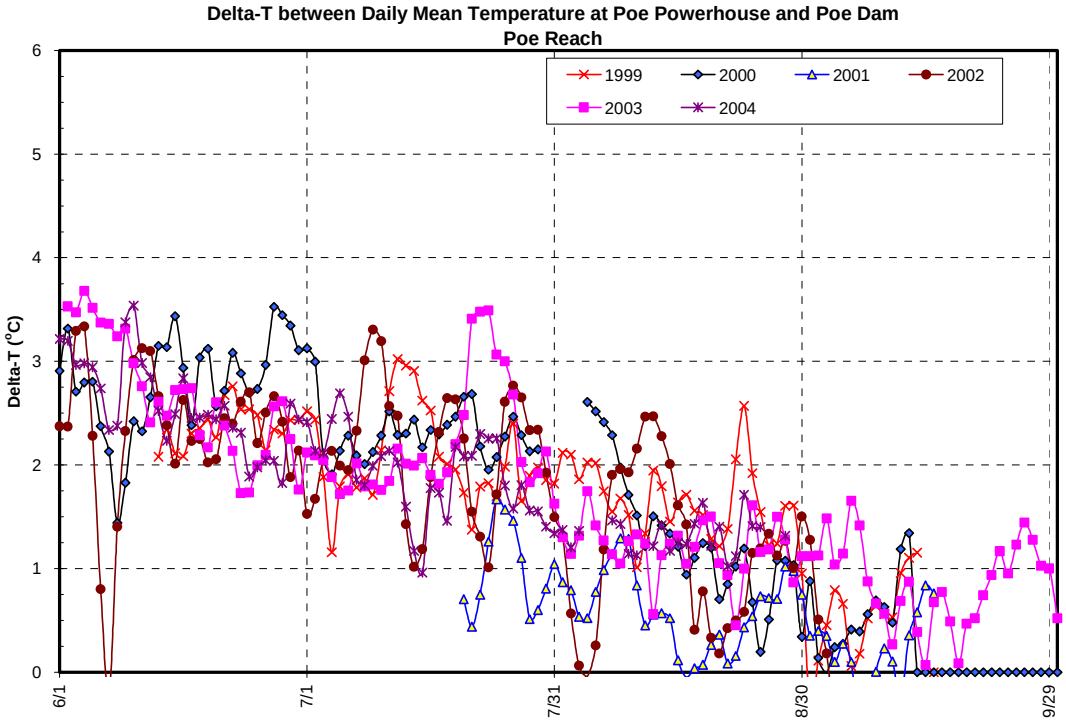

Figure 2b Daily Mean Delta-T Time Series for 1999-2004

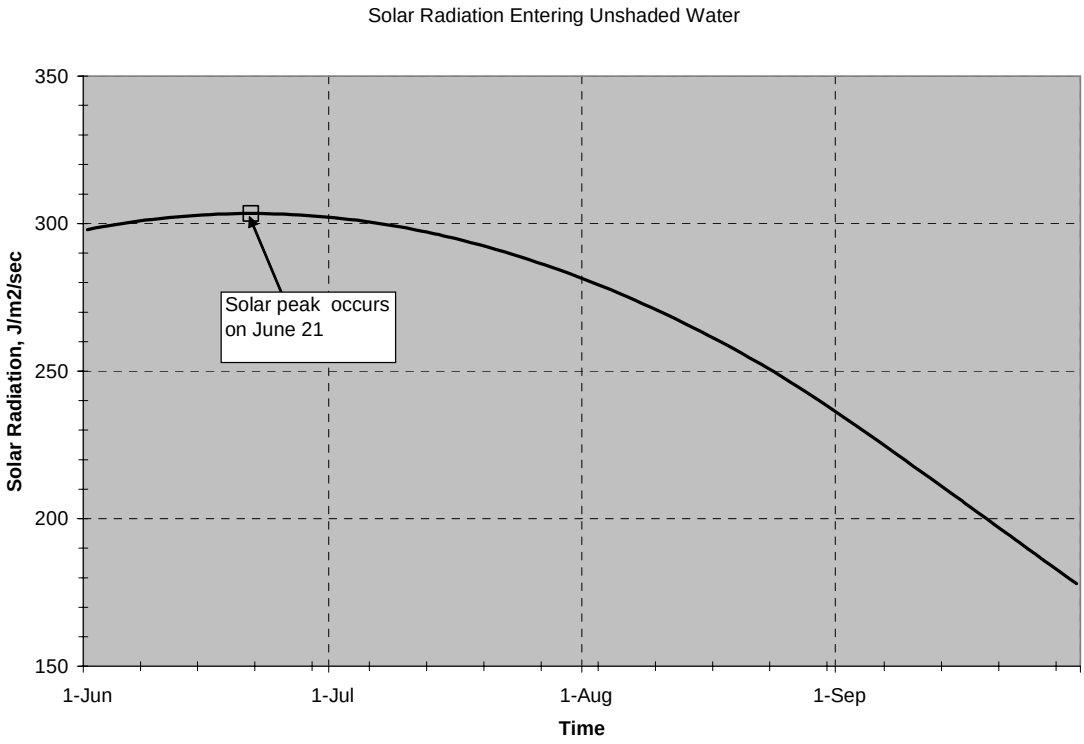

Figure 3 Solar Radiation Entering Unshaded water

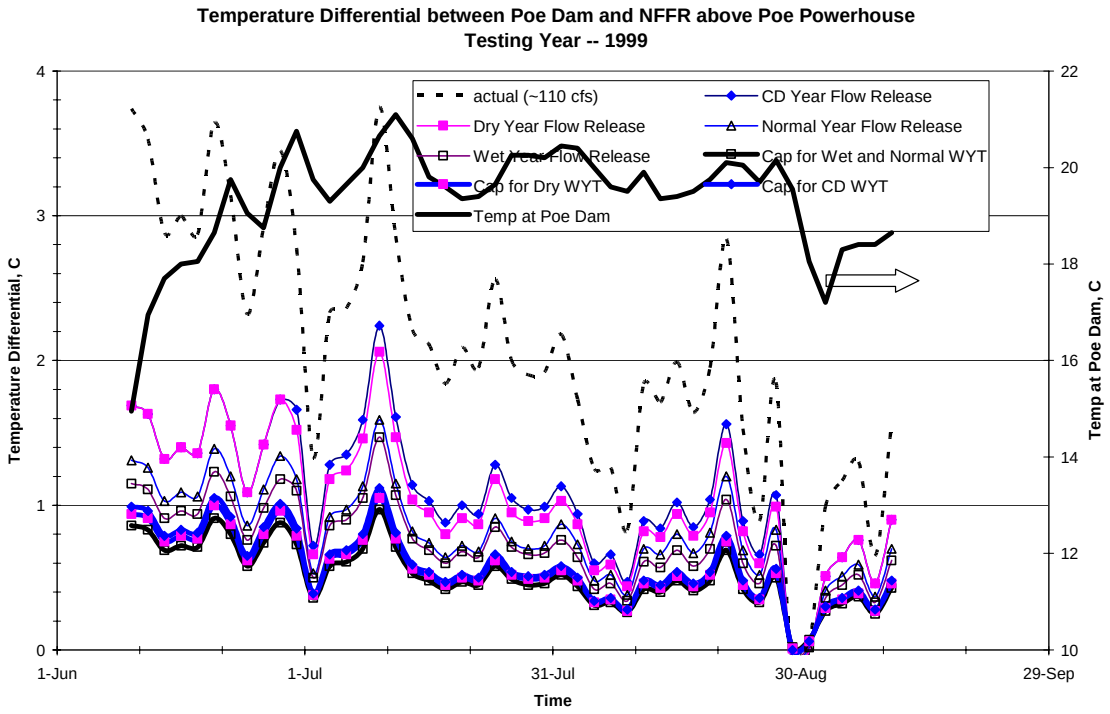

Figure 4a SNTEMP Simulated Result for 1999 under Various Higher Flow Releases

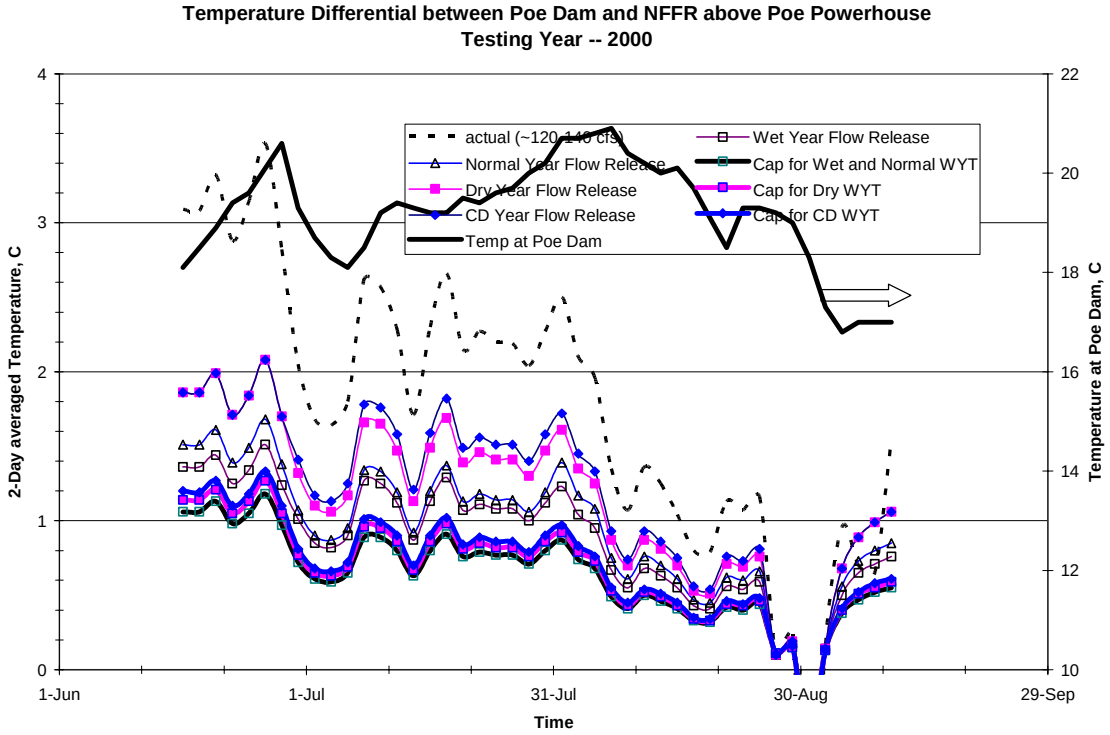

Figure 4b SNTEMP Simulation Result for 2000 under Various Higher Flow Releases

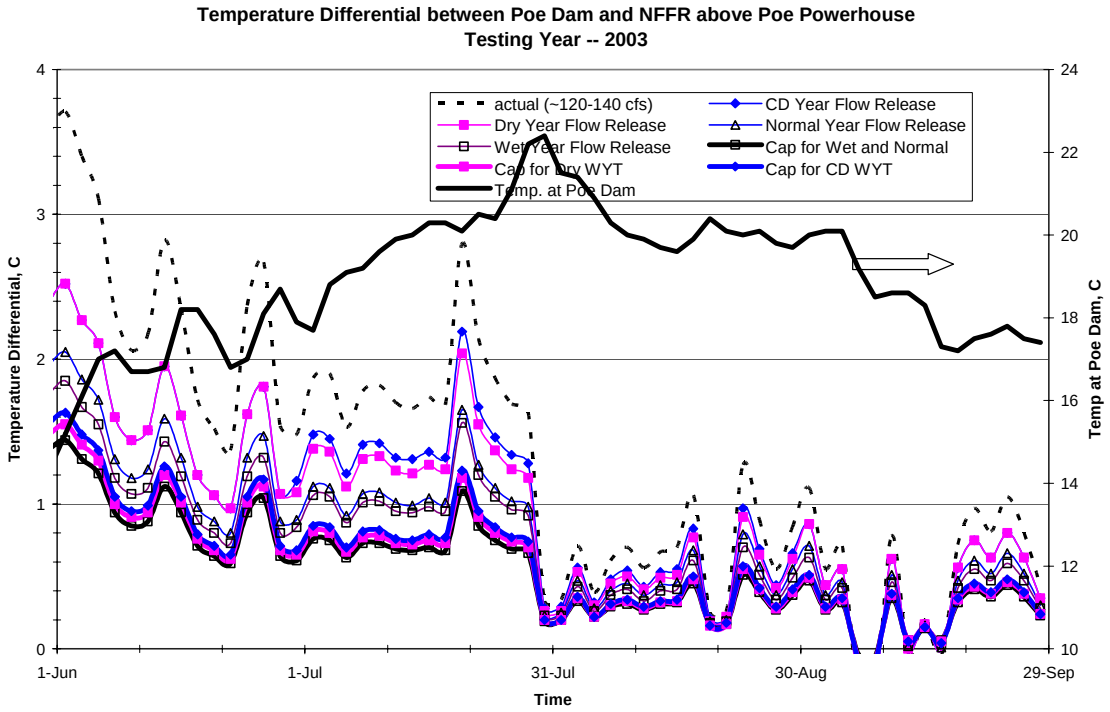

Figure 4c SNTEMP Simulation Result for 2003 under Various Higher Flow Releases

Table 1 Number of Days That Would Meet Triggering Additional Flow Release Action

Triggering Criteria

$T_{2\text{-Day Mean}} > 20\ ^oC$ and $DT_{2\text{-Day Mean}} > 1\ ^oC$

	1999		2000		2003	
Flow schedule (Jun,Jul,Aug,Sep)	Total days	Monthly distribution	Total days	Monthly distribution	Total days	Monthly distribution
Existing Condition (~110-140 cfs)	**70**	**14,32,24,0**	**62**	**14,28,20,0**	**40**	**8,26,4,2**
Critical Dry (220,180,180,180)	**30**	**4,18,8,0**	**44**	**12,26,6,0**	**26**	**0,26,0,0**
Dry (220,200,200,180)	**22**	**4,14,4,0**	**44**	**12,26,6,0**	**26**	**0,26,0,0**
Normal (300,275,250,250)	**14**	**4,8,2,0**	**40**	**12,22,6,0**	**18**	**0,18,0,0**
Wet (350,300,300,300)	**14**	**4,8,2,0**	**34**	**10,20,4,0**	**10**	**0,10,0,0**
Flow Cap in Wet/Normal (500 cfs)	**0**	**0,0,0,0**	**6**	**6,0,0,0**	**2**	**0,2,0,0**
Flow Cap in Dry (450 cfs)	**2**	**0,2,0,0**	**10**	**10,0,0,0**	**2**	**0,2,0,0**
Flow Cap in CD (420 cfs)	**4**	**2,2,0,0**	**12**	**10,2,0,0**	**2**	**0,2,0,0**