Memorandum June 7, 2017

To: Rochelle Labiosa, USEPA Region 10

From: Peter Leinenbach, USEPA Region 10

Subject: Water temperature estimates of the Lower/Middle Columbia River and tributaries in 2040 and 2080 based on the NorWeST model

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Results – Water temperature modeling showed that water temperatures in the Columbia River, along with the tributaries that drain into this section of the Columbia River, are anticipated to increase in the near future (**Figures 1**, **2**, **and 3**). This modeled response was a function of expected increases of summer air temperatures, along with summer hydrologic reductions, due to anticipated future climate changes within the Columbia basin.

These figures also show that the general temperature differential between tributaries and the Columbia River are maintained during future scenarios predictions. For example, tributaries that have current water temperatures between 2*C and 4*C cooler than the Columbia River (i.e., the green dots in **Figure 1**), are generally predicted to have the same temperature differential under the 2040 and the 2080 scenarios (i.e., green dots in **Figures 2**, **and 3**, respectively). However, it is important to point out that, despite being relatively cooler than the Columbia River, these potential "cool" tributary refuges could become warmer than the applicable water temperature standard in the near future.

Methods – Estimates of current and future tributary temperatures were obtained from a Spatial Stream Network (SSN) model developed by the USFS (www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html). This SSN model derived current stream temperatures based on 1993 through 2011 observed stream temperature data. The SSN model was also used to estimate future temperature conditions based on global climate model projections, which were also adjusted for differential stream sensitivity. Specifically, future scenarios were based on global climate model ensemble averages that represent the A1B warming trajectory for 2040's (2030-2059) and 2080's (2070-2099). Additional description of the SSN modeling techniques can be found at this website - www.fs.fed.us/rm/boise/AWAE/projects /NorWeST/downloads/NorWeST_StreamTemperatureModelDescription.pdf.

Current Columbia River stream temperatures were derived directly from the NorWeST database (www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml)[1]. Specifically, the average Columbia River August stream temperature was estimated from the available data for the 1993 through 2011 period (i.e., yellow dots in **Figure 1**)[2]. River temperatures for areas between these monitoring locations were derived by interpolation. Future Columbia River temperatures were derived from the reported temperature differential between current, 2040 and 2080 scenarios. Specifically, reported temperature differentials reported with the 2040 and 2080 SSN model scenarios were added to current temperature estimates for the Columbia River.

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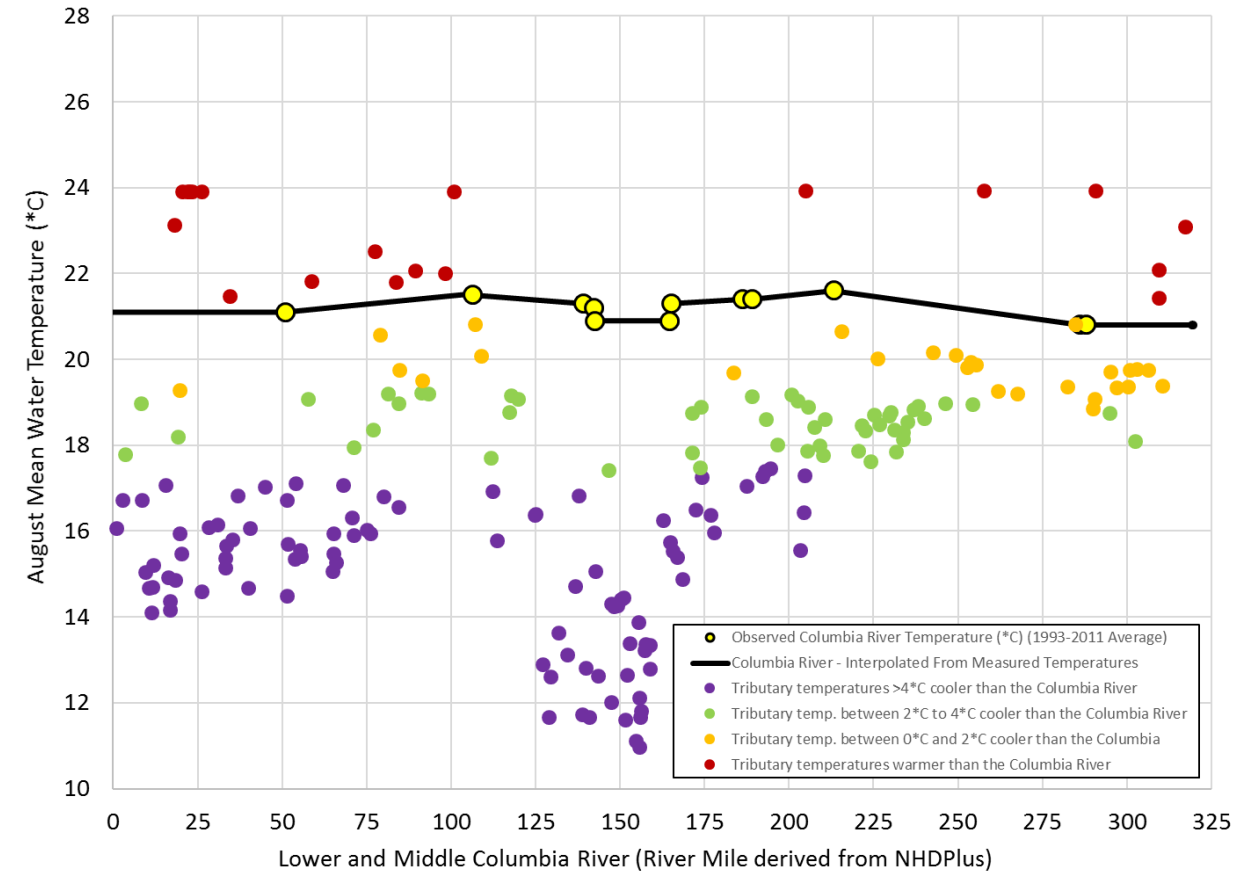
[1] Only Columbia River sites with more than 2 years of data were included in the analysis for these figures.

[2] This step was done because it appeared that the NorWeST SSN model had problems to correctly estimate current stream temperatures in a short section area along the Columbia River (i.e., just downstream of the Willamette River confluence).

Figure 1. Estimated Current August Mean Water Temperature in the lower and middle Columbia River, along with the tributaries that drain into this section of the Columbia.



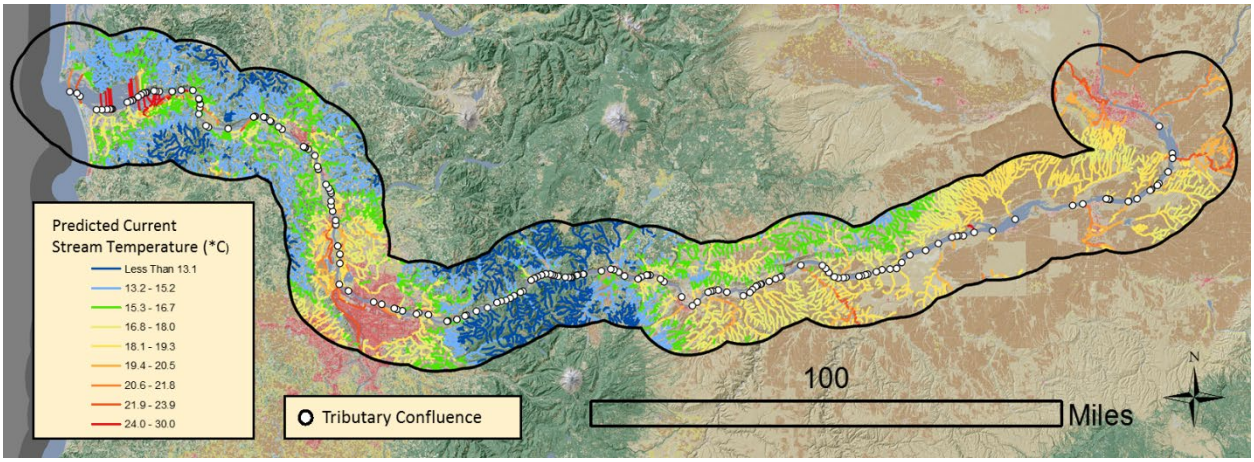
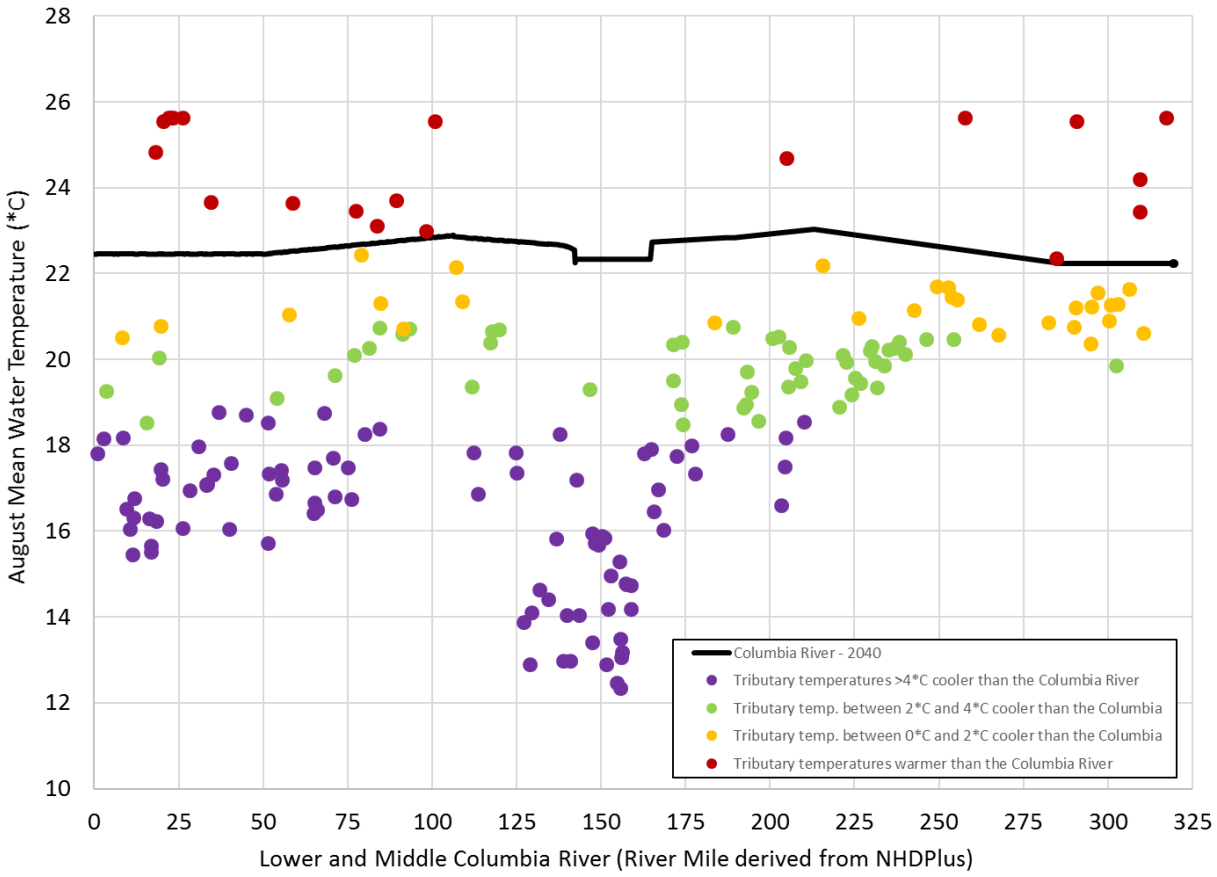


Figure 2. Estimated 2040 August Mean Water Temperature in the lower and middle Columbia River, along with the tributaries that drain into this section of the Columbia.



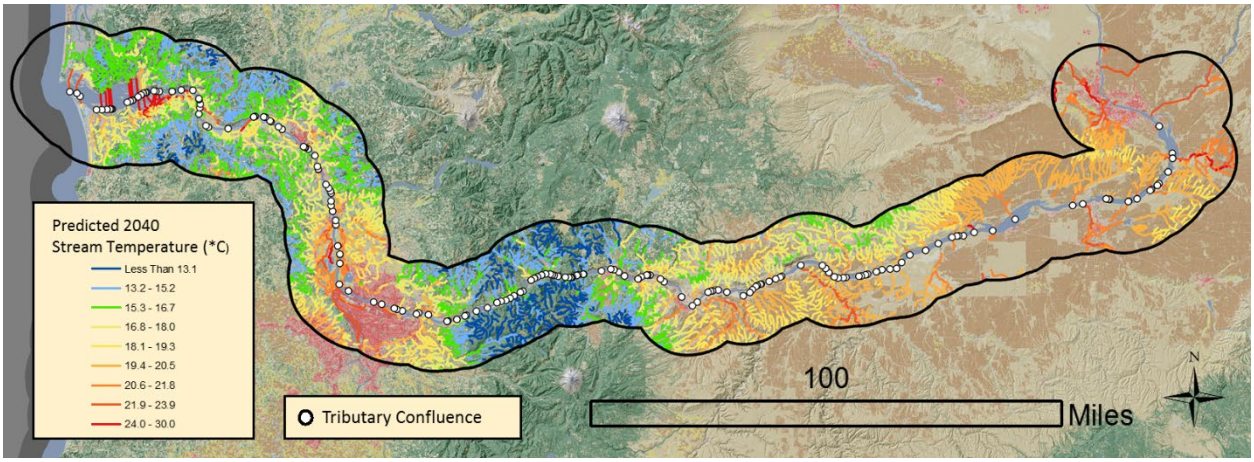


Figure 3. Estimated 2080 August Mean Water Temperature in the lower and middle Columbia River, along with the tributaries that drain into this section of the Columbia.