Total Maximum Daily Loads for the Willamette Subbasins

Technical Support Document Appendix J: Tetra Tech McKenzie River Model Scenario Report

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State of Oregon
DEQ Department of Environmental Quality

TETRA TECH

MEMO

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From:	Aileen Molloy, Sen Bai, Mustafa Faizullabhoy
Date:	December 28, 2023
Subject:	McKenzie River Model Point Source Updates and Scenario Simulation

1.0 INTRODUCTION

This document discusses the point source updates made to the McKenzie River model. While modeling was completed for the entire Willamette River watershed, this memo focuses solely on the McKenzie River watershed. A scenario with point sources at current thermal loads (calibrated current condition scenario) that serves as the baseline condition, and a scenario without point sources (no point sources scenario) is also discussed. The recently updated Willamette River W2 v4.2 model (specifically for the McKenzie River) provided by the USGS (Stratton et.al. 2022) was used for scenario simulation to support the McKenzie River Temperature TMDL.

Figure 1-1 shows all the modeled river reaches in the Willamette River watershed with the McKenzie River in the southeast portion of the watershed. The McKenzie River model was configured and calibrated for March 21 to November 1, 2015. This period covered the critical summer and spawning periods.

Model scenario interpretation in terms of calculation metrics that applied to the scenarios simulated are discussed first, followed by a description of the scenarios and the corresponding results.

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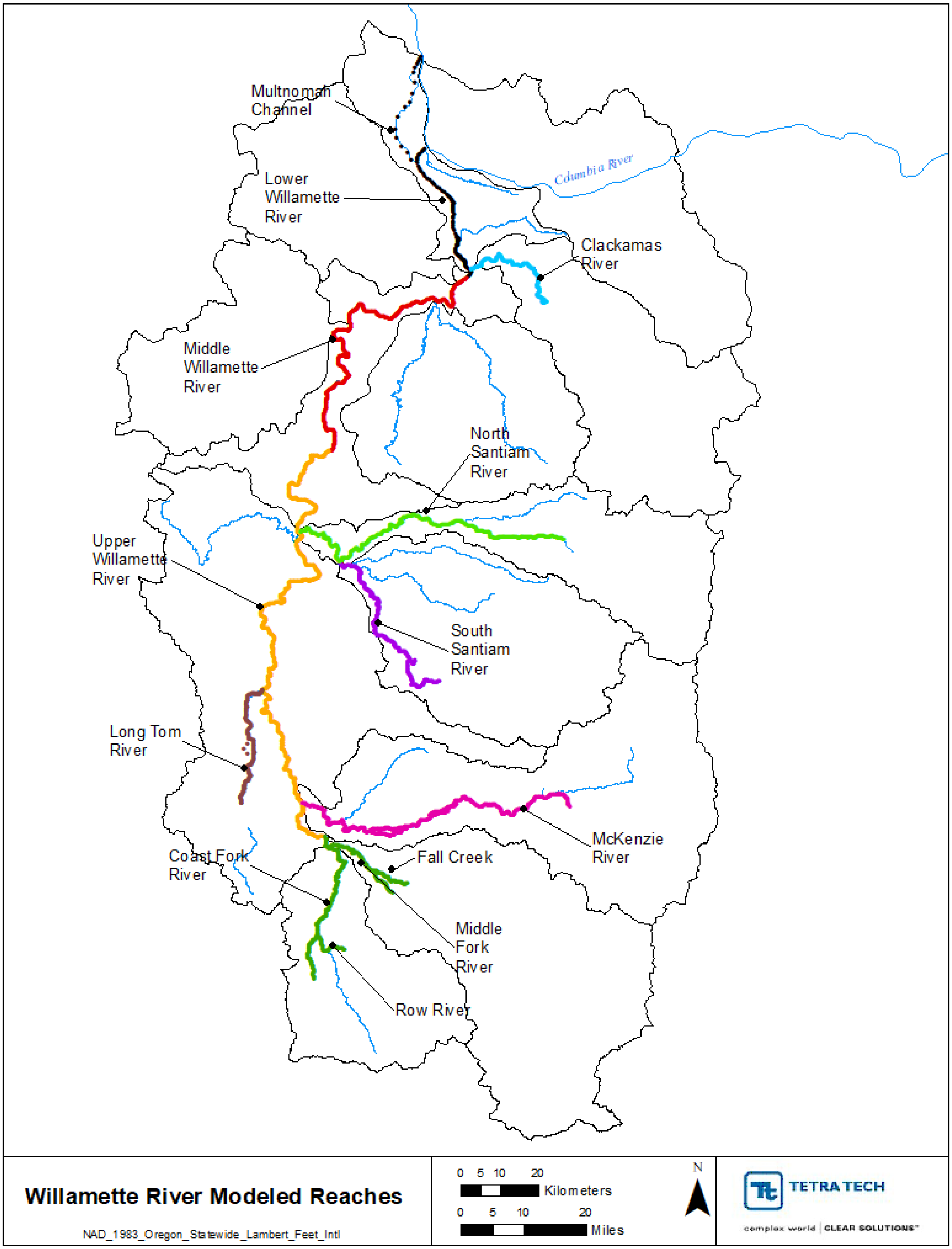


Figure 1-1: Location of modeled river reaches in the Willamette River watershed.

2.0 MODEL SCENARIO INTERPRETATION

This section discusses the calculation metrics that were used when evaluating the scenarios.

2.1 SIGNIFICANT DIGITS AND ROUNDING

The TMDL analysis, interpretation of the model results, and all scenarios account for significant digits and rounding. For evaluation of the attainment of the human use allowance (HUA), Oregon Department of Environmental Quality (DEQ) tracks values to the hundredths. Because DEQ is providing some of the HUA allocations out to the hundredths, attainment must be tracked in a similar manner. DEQ has a permit related internal management directive (IMD) on rounding and significant digits (DEQ 2013). The TMDL analysis follows the rounding procedures outlined in this IMD. The significant figures IMD says that for “calculated values” (which includes model results), if the digit being dropped is a “5,” it is rounded up. For example, if the model shows warming equal to 0.014 °C it gets rounded down to 0.01 °C and the result would attain. If the model shows warming equal to 0.015 °C, it gets rounded up to 0.02 °C, and the result would not attain.

2.2 CALCULATING THE 7-DAY AVERAGE MAXIMUM TEMPERATURE

For each scenario, the 7-day average maximum (7DADM) temperature was calculated using the hourly model output. The 7DADM was calculated using the procedure outlined in DEQ’s Temperature IMD (DEQ 2008). As outlined in the document, the 7DADM temperature is calculated by first calculating the daily maximum for each day, followed by calculating a moving average of the daily maximums, the result for which lands on the 7th day.

2.3 COMPARING TEMPERATURE BETWEEN TWO SCENARIOS

When comparing the hourly results from two model scenarios to determine the temperature changes, the following steps were taken:

1. Calculate the 7DADM temperatures for scenario 1 at every model output for every day during the model period.
2. Calculate the 7DADM temperatures for scenario 2 at every model output for every day during the model period.
3. Compute the difference between the 7DADM temperatures of scenario 1 and scenario 2 only for days that exceed the Biologically Based Numeric Criteria (BBNC). In this manner a ΔT is computed for every 7DADM temperature from each scenario for each day where the BBNC is exceeded. Finally, the max ΔT was taken and plotted longitudinally as 7DADM delta plots.
    a. Since the HUA is based on an increase above the applicable criteria, the difference between two scenarios is only calculated for each time step when the 7DADM of either scenario exceeds the BBNC. This step was necessary to ensure that we only consider the maximum change in temperatures when the river exceeds the BBNC criteria for analysis. Note that the BBNC varied spatially and temporally and are evaluated based on the 7DADM.

2.4 BIOLOGICALLY BASED NUMERIC CRITERIA

The following are applicable criteria extracted from Oregon Rules (email communication from DEQ):

- The 7DADM temperature of a stream identified as having core cold water habitat use may not exceed 16.0 deg C;
- The 7DADM temperature of a stream identified as having salmon and trout rearing and migration use may not exceed 18.0 deg C;
- The 7DADM temperature of a stream identified as having a migration corridor use may not exceed 20.0 deg C;
- The 7DADM temperature of a stream identified as having salmon and steelhead spawning use may not exceed 13.0 deg C;

The BBNC vary spatially and temporally and are evaluated based on the 7DADM. Appendix A shows the variation of the BBNC along the McKenzie River.

2.5 PROCESSING MODEL OUTPUT RESULTS

Post processers were developed to summarize and visualize the hourly flow and temperature output from the various models in the Willamette River watershed, including the McKensie River W2 model. Specifically, a Python script and an Excel spreadsheet tool were developed to process the results. It is recommended that a folder be created where the processing scripts/tools can reside and where the resulting output summaries can be stored.

A Python script (load_tsr_process_08252023_to_csv.py) was developed to read through the W2 model tsr.opt files within each of the model folders and generate the following model output summaries.

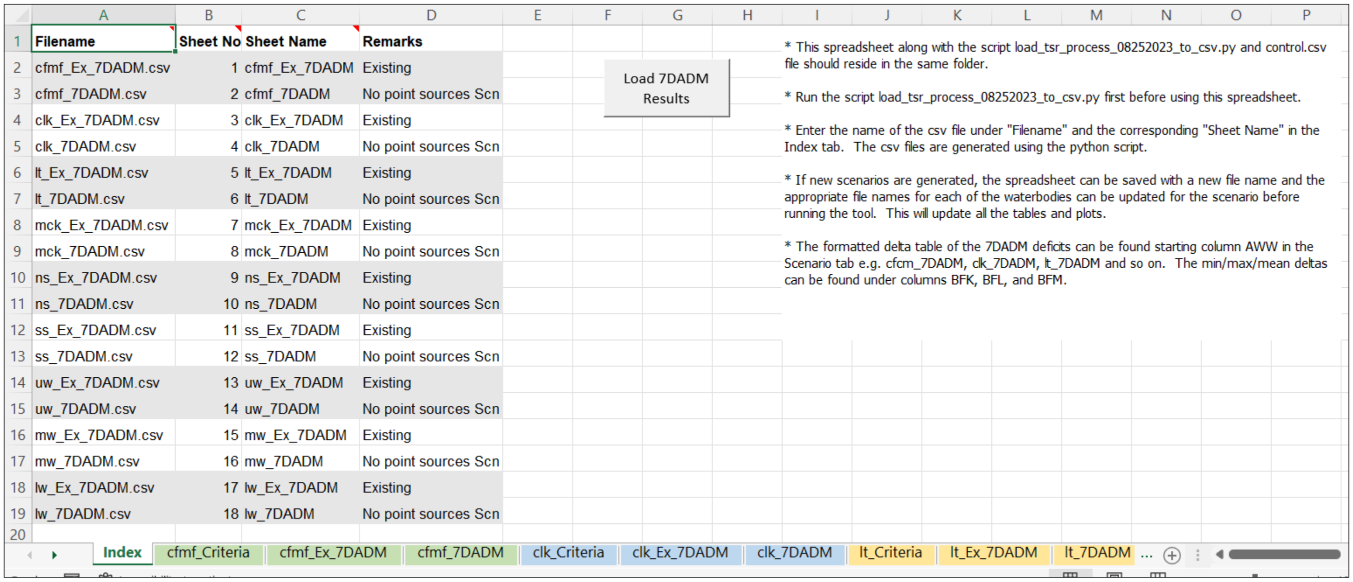
- 7DADM temperature
- Daily maximum temperature
- 7-day average flow
- Daily average flow
- Daily average temperature.
- Hourly temperature

The Python script requires that a file called control.csv reside in the same location as the script. The control.csv file is used to specify the location of the model folders and specify the name of the output desired. Table 2-1 shows and example of the structure of the control.csv file. If a particular output file is not needed, then it can be left blank in the control file. For ease of use it is recommended that the file be opened and saved using Excel. Running the script will generate csv files for each of the summary items specified in the control file.

Table 2-1: Example structure of the control file (control.csv).

```
FolderName,7DADM_Temp,DMAX_Temp,7-day_Avg_Flow,DAVG_Flow,Hr_Temp_ts
C:\Willamette\W2_Models\Scenarios\Existing\clk2015,clk_Ex_7DADM,clk_Ex_dmax,clk_Ex_7DAVG_Q,clk_Ex_davgQ,
C:\Willamette\W2_Models\Scenarios\Existing\cfmf2015,cfmf_Ex_7DADM,cfmf_Ex_dmax,cfmf_Ex_7DAVG_Q,cfmf_Ex_davgQ,cfmf_Ex_ts
C:\Willamette\W2_Models\Scenarios\Existing\lt2015,lt_Ex_7DADM,lt_Ex_dmax,lt_Ex_7DAVG_Q,lt_Ex_davgQ,
C:\Willamette\W2_Models\Scenarios\Existing\lw2015,lw_Ex_7DADM,lw_Ex_dmax,,,
C:\Willamette\W2_Models\Scenarios\Existing\mck2015,mck_Ex_7DADM,mck_Ex_admax,,,
C:\Willamette\W2_Models\Scenarios\Existing\mw2015,mw_Ex_7DADM,mw_Ex_dmax,,,
C:\Willamette\W2_Models\Scenarios\Existing\ns2015,ns_Ex_7DADM,ns_Ex_dmax,,,
C:\Willamette\W2_Models\Scenarios\Existing\ss2015,ss_Ex_7DADM,ss_Ex_dmax,,,
C:\Willamette\W2_Models\Scenarios\Existing\uw2015,uw_Ex_7DADM,uw_Ex_dmax,,,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\clk2015,clk_7DADM,clk_dmax,clk_7DAVG_Q,clk_davgQ,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\cfmf2015,cfmf_7DADM,cfmf_dmax,cfmf_7DAVG_Q,cfmf_davgQ,cfmf_ts
C:\Willamette\W2_Models\Scenarios\NoPtSrc\lt2015,lt_7DADM,lt_dmax,lt_7DAVG_Q,lt_davgQ,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\lw2015,lw_7DADM,lw_dmax,,,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\mck2015,mck_7DADM,mck_dmax,,,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\mw2015,mw_7DADM,mw_dmax,,,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\ns2015,ns_7DADM,ns_dmax,,,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\ss2015,ss_7DADM,ss_dmax,,,
C:\Willamette\W2_Models\Scenarios\NoPtSrc\uw2015,uw_7DADM,uw_dmax,,,
```

The second post processing tool is an Excel spreadsheet tool called *Summarize_tsr_7DADM_delta_criteria.xlsb*. This spreadsheet tool is used to read in the 7DADM summaries (csv files) from two scenarios and calculate the maximum 7DADM deltas for the segment (details on calculating the deltas are provided in Section 2.3). The spreadsheet assumes that the user has already run the Python script discussed earlier and generated the necessary 7DADM output csv files. The spreadsheet should be placed in the same location as the summary csv files. The *Index* tab within the spreadsheet is used to specify the names of the 7DADM csv files that are pulled into the spreadsheet. There are three tabs associated with each model within the spreadsheet i.e., a criteria tab, an CCC or exiting condition 7DADM tab, and a scenario 7DADM tab. Click on the “Load 7DADM Results” button to populate the 7DADM output into the spreadsheet and generate plots and tables. Figure 2-1 shows a screen grab of the post processing spreadsheet.



Filename	Sheet No	Sheet Name	Remarks
cfmf_Ex_7DADM.csv	1	cfmf_Ex_7DADM	Existing
cfmf_7DADM.csv	2	cfmf_7DADM	No point sources Scn
clk_Ex_7DADM.csv	3	clk_Ex_7DADM	Existing
clk_7DADM.csv	4	clk_7DADM	No point sources Scn
lt_Ex_7DADM.csv	5	lt_Ex_7DADM	Existing
lt_7DADM.csv	6	lt_7DADM	No point sources Scn
mck_Ex_7DADM.csv	7	mck_Ex_7DADM	Existing
mck_7DADM.csv	8	mck_7DADM	No point sources Scn
ns_Ex_7DADM.csv	9	ns_Ex_7DADM	Existing
ns_7DADM.csv	10	ns_7DADM	No point sources Scn
ss_Ex_7DADM.csv	11	ss_Ex_7DADM	Existing
ss_7DADM.csv	12	ss_7DADM	No point sources Scn
uw_Ex_7DADM.csv	13	uw_Ex_7DADM	Existing
uw_7DADM.csv	14	uw_7DADM	No point sources Scn
mw_Ex_7DADM.csv	15	mw_Ex_7DADM	Existing
mw_7DADM.csv	16	mw_7DADM	No point sources Scn
lw_Ex_7DADM.csv	17	lw_Ex_7DADM	Existing
lw_7DADM.csv	18	lw_7DADM	No point sources Scn

Figure 2-1: Post processing spreadsheet tool.

3.0 MCKENZIE RIVER MODEL POINT SOURCE UPDATES

DEQ provided Tetra Tech with DMR data for permitted NPDES facilities in the Willamette River watershed to update the models. The original McKenzie River USGS model included only one point source, the International Paper facility. No updates were made to this point source because no new data were available. This point source is configured in the model using the actual discharge and an artificial withdrawal. The model assigns the artificial withdrawal immediately upstream of the corresponding discharge location of the facility. The artificial withdrawal removes the same volume of water as is added by the point source to eliminate potential temperature change due to different downstream flow rates when the point source is added (Stratton et al. 2022).

DEQ identified two fish hatcheries that were not represented in the USGS models but needed to be added. These included the ODFW Leaburg Hatchery Facility and McKenzie River Hatchery. Flow and water temperature data were not available for the year 2015 for the two fish hatcheries. Effluent flow rates and effluent water temperature need to be estimated for model inputs. The following approach was used based on recommendations provided by DEQ to configure the inputs from the hatcheries in the model.

- Effluent flows used for the hatcheries were based on the maximum effluent flows. DEQ provided maximum effluent flows based on historical DMR data for summer, spring spawning and fall spawning periods. These effluent flows were used to configure the flows for the hatcheries.
- Effluent water temperatures for the hatcheries were based on temperature deltas derived using available historical effluent and influent hatchery temperatures plus the hourly water temperature from the model segment upstream of where the hatchery discharges. The temperature deltas were based on the 95th percent effluent 7DADM temperature minus the influent 7DADM temperature for the spring spawning, summer, and fall spawning periods. The model was run first to extract the hourly temperature from the model segment upstream of where the hatchery discharges. The modeled hourly timeseries from the upstream segment plus the calculated deltas for the appropriate spawning and summer period were then used to create the hatchery water temperature timeseries inputs.

Two actual withdrawals were configured at the immediate upstream segments above the discharge locations. Regardless of whether the withdrawals are artificial or actual, only the flow rates are specified for withdrawals within W2. The model removes heat associated with the flow, based on the simulated water temperature at the withdrawal location.

Since these two hatcheries are near each other, two model runs were conducted to configure the water temperature for the McKenzie River Hatchery. The model was first configured and run after adding the inputs from the Leaburg Hatchery. The results of the model with the Leaburg Hatchery included were then used to configure the McKenzie River Hatchery.

Table 3-1 shows the details of all the point sources and Figure 3-1 shows the location of all the point sources in the McKenzie River model. Figure 3-2 and Figure 3-3 show the model boundary inputs for the two hatcheries that were added in the model.

Table 3-1: Point Sources represented in the McKenzie River model.

Point Source	Latitude	Longitude	File Number	Segment	Withdrawal Segment ID	RM	Remarks
International Paper	44.0539	-122.9593	96244	321	320	12.22	No change
Leaburg Hatchery	44.1203	-122.6092	64490	168	167	35.42	Added
McKenzie River Hatchery	44.1166	-122.636	64500	184	183	33.24	Added

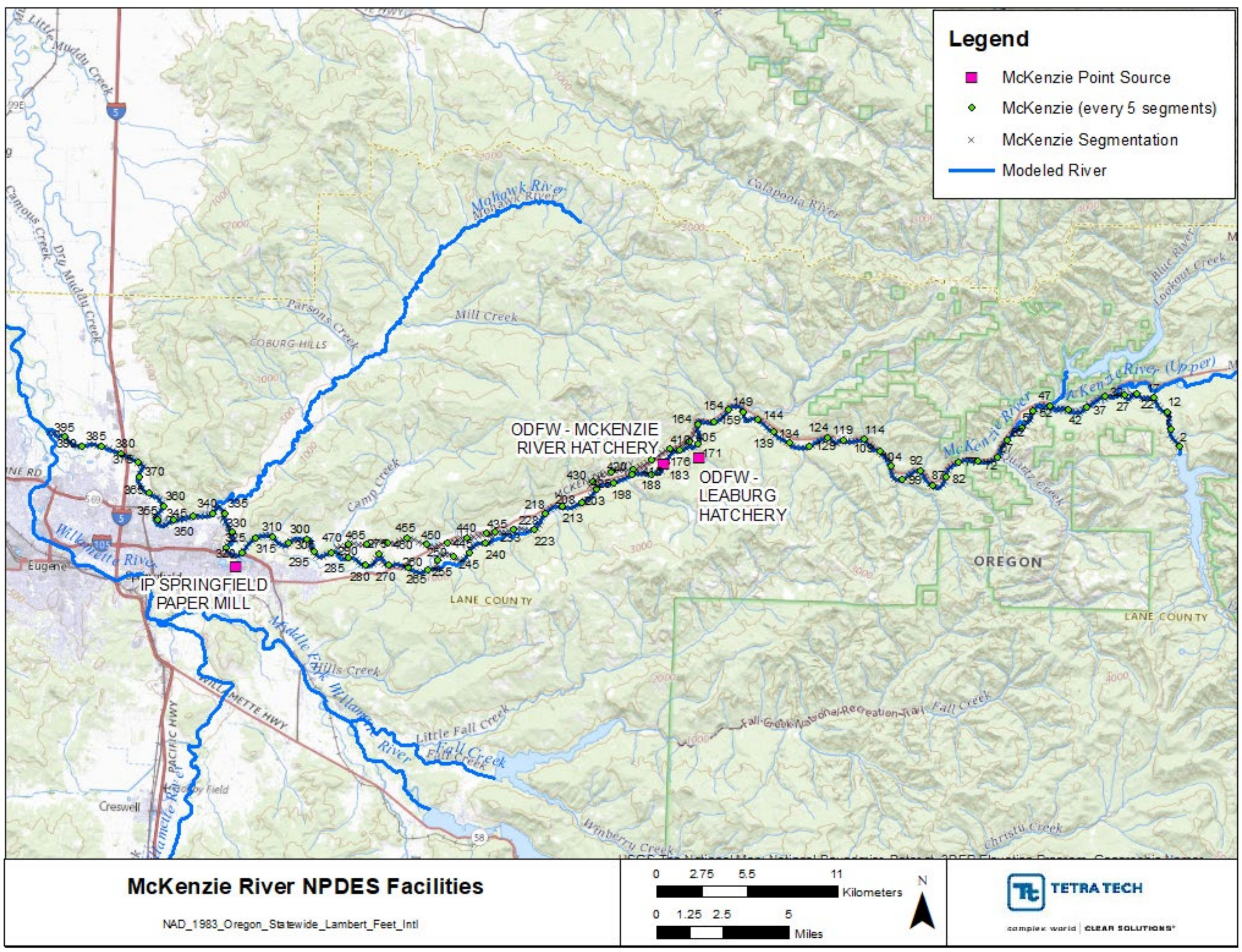


Figure 3-1: McKenzie River point source facility locations.

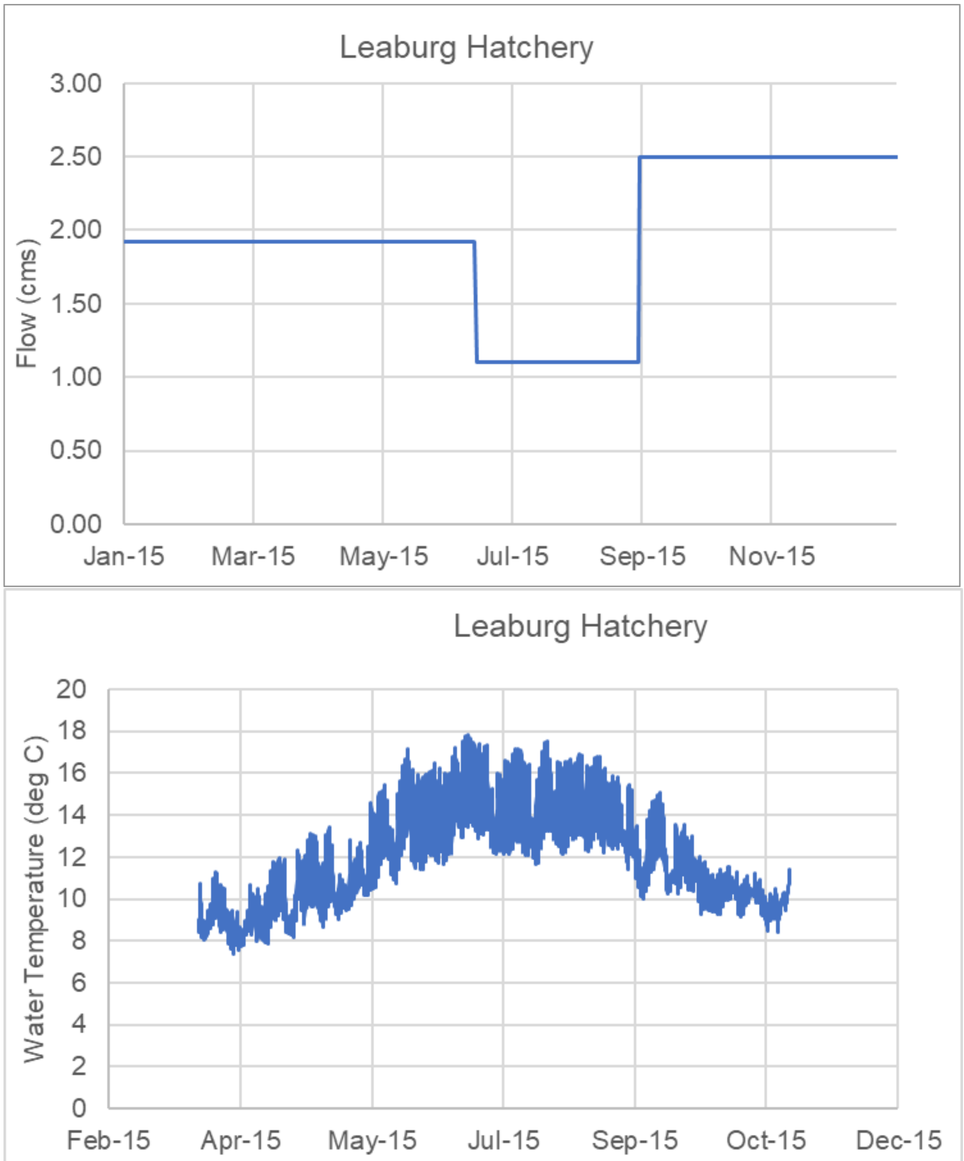


Figure 3-2: Flow and water temperature boundary inputs for Leaburg Hatchery (new point source).

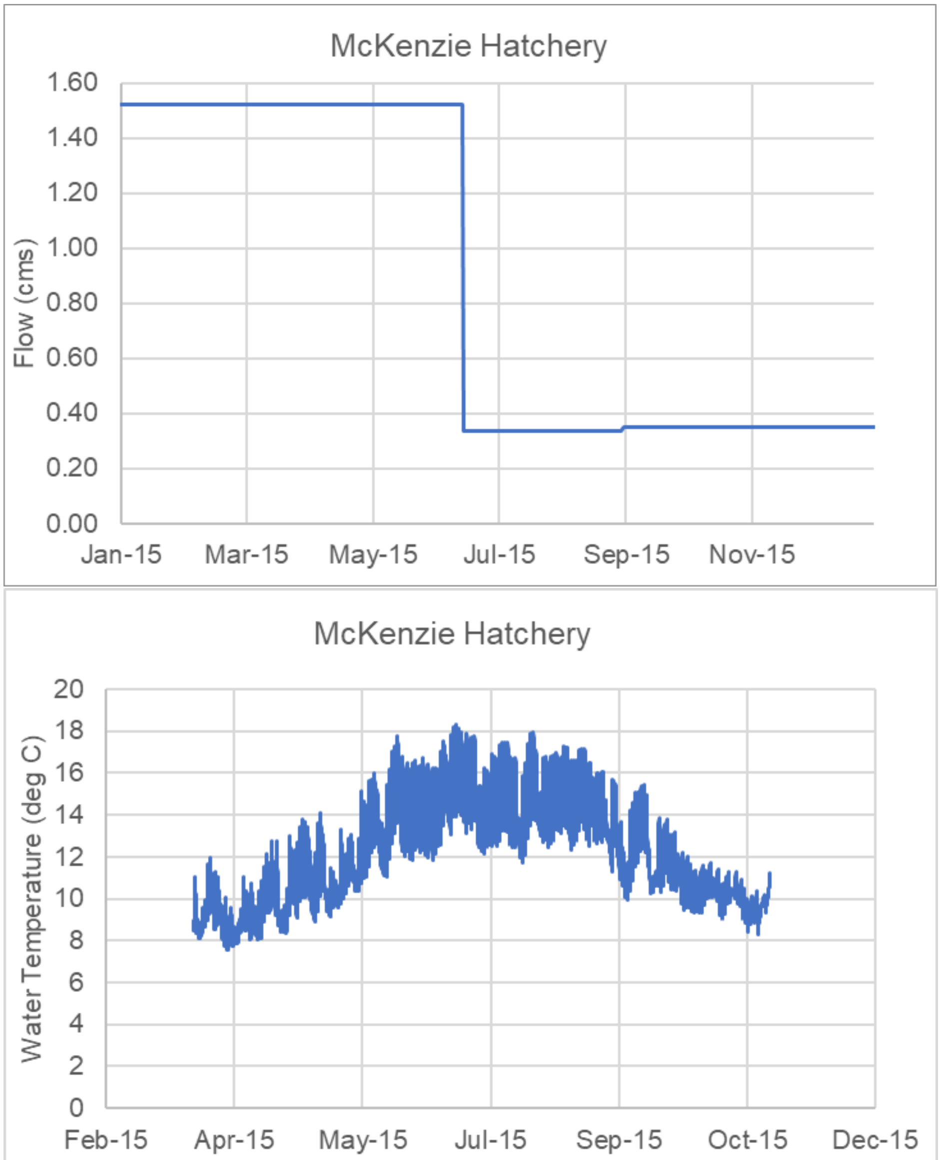


Figure 3-3: Flow and water temperature boundary inputs for McKenzie River Hatchery (new point source).

4.0 CALIBRATED CURRENT CONDITION SCENARIO

This scenario is based on the 2015 calibrated current condition (CCC), with the model boundaries and existing point sources configured for the modeling period from approximately late March through October. The CCC scenario includes updated current conditions reflected in the point source updates discussed in Section 3. These revisions are minor and are not expected to impact the model calibration.

Daily maximum water temperatures were calculated from the hourly time series output from the model at each segment, and then the 7DADM was calculated by averaging the daily maximum instream water temperatures for 7 consecutive days as a rolling average. The modeled maximum 7DADM for the modeling period from March 21, 2015, to November 1, 2015, is presented in Figure 4-1. The longitudinal 7DADM temperature profile shows the variation in temperature from upstream to downstream as it is influenced by the various point sources and tributaries along the system.

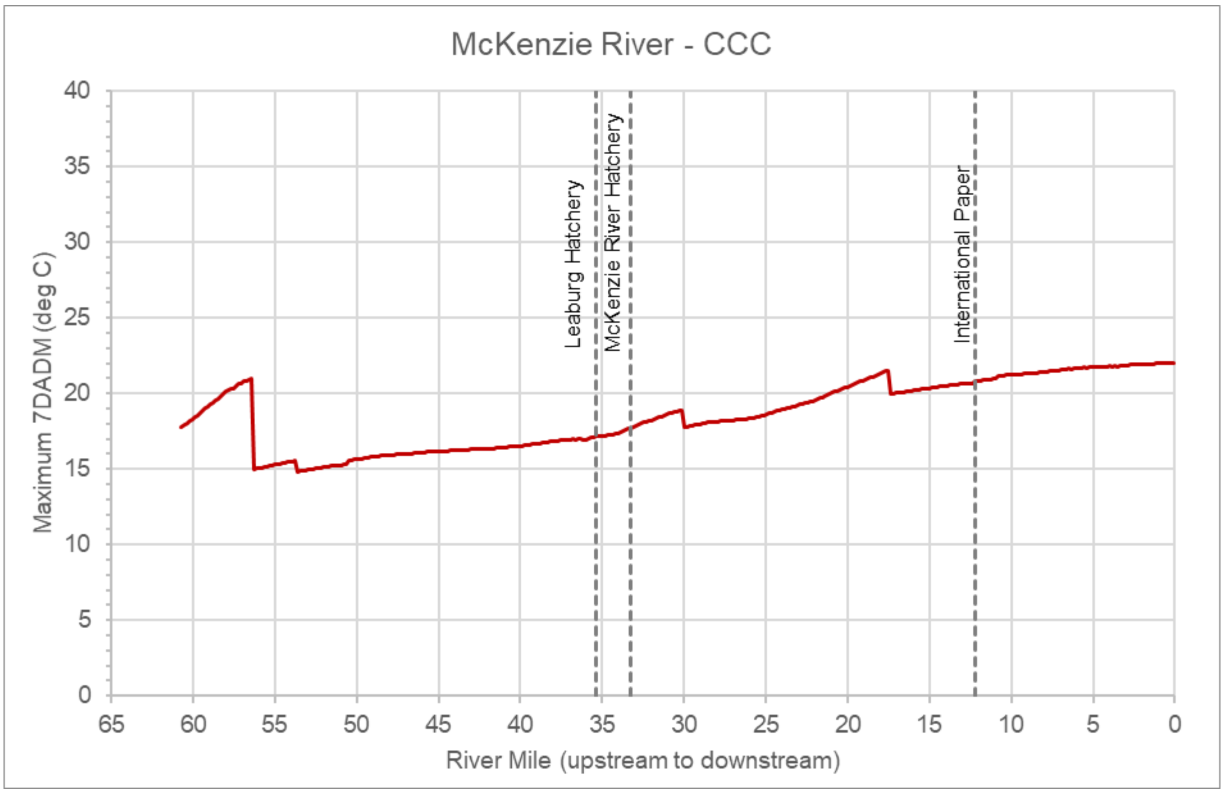


Figure 4-1: CCC Maximum 7DADM water temperature along McKenzie River (March 21 to November 1, 2015).

5.0 NO POINT SOURCES SCENARIO

This scenario was configured to assess the impact of the point sources to the various waterbodies. The settings for this scenario were set to be identical to the CCC scenario model, except that all point source discharges were removed. The maximum 7DADM change (warming) from permitted NPDES point sources was determined by computing the difference in 7DADM temperature between the point source scenario conditions and the no point sources model scenarios. Maximum 7DADM deltas were calculated when either the current condition with point sources or the no point sources scenario temperatures exceeded the BBNC. The modeled maximum 7DADM difference for the modeling period from March 21, 2015, to November 1, 2015, is presented in Figure 5-1. The figures show the impact of the point sources at their discharge locations and downstream of the discharge location. The locations where the maximum impact and when the maximum impact due to the point sources were observed were also calculated. Table 5-1 shows the maximum 7DADM delta summary for the entire modeling time period. Table 5-2 and Table 5-3 show the maximum 7DADM delta for the spawning and non-spawning periods. For each table, the date when the maximum 7DADM delta occurred and where the delta occurred are also included. Note that since the spawning and non-spawning criteria vary along some of the waterbodies, the maximum 7DADM deltas are reported individually for each reach portion where the spawning or non-spawning criteria applies.

Table 5-1: Maximum 7DADM delta observed for the McKenzie River (3/21/2015 to 11/1/2015).

Model	Waterbody	Segment ID	RM	Max 7DADM delta (deg C)	Date when Max 7DADM delta occurs
McKenzie	McKenzie River	356	6.77	0.14	10/9/2015

Table 5-2: Maximum 7DADM delta observed during the spawning period.

Model	Waterbody	Segment ID	RM	Max 7DADM (deg C)	Date when Max 7DADM delta occurs	Applicable Period for Spawning	Applicable Location for Spawning (Segment)	Applicable Location for Spawning (RM)
McKenzie	McKenzie River	323	11.91	0.14	10/9/2015	9/1 to 6/15	2 to 151; 167 to 328	60.7 to 37.8; 35.6 to 11.1
McKenzie	McKenzie River	356	6.77	0.14	10/9/2015	9/1 to 5/15	152 to 164; 329 to 399	37.6 to 35.7; 10.98 to 0

Table 5-3: Maximum 7DADM delta observed during the non-spawning period.

Model	Waterbody	Segment ID	RM	Max 7DADM (deg C)	Date when Max 7DADM delta occurs	Applicable Non-Spawning Period	Applicable Non-Spawning Location (Segment)	Applicable Non-Spawning Location (RM)
McKenzie	McKenzie River	324	11.75	0.12	8/8/2015	Applies outside spawning period	2 to 151; 167 to 328	60.7 to 37.8; 35.6 to 11.1
McKenzie	McKenzie River	399	0.08	0.13	8/9/2015	Applies outside spawning period	152 to 164; 329 to 399	37.6 to 35.7; 10.98 to 0

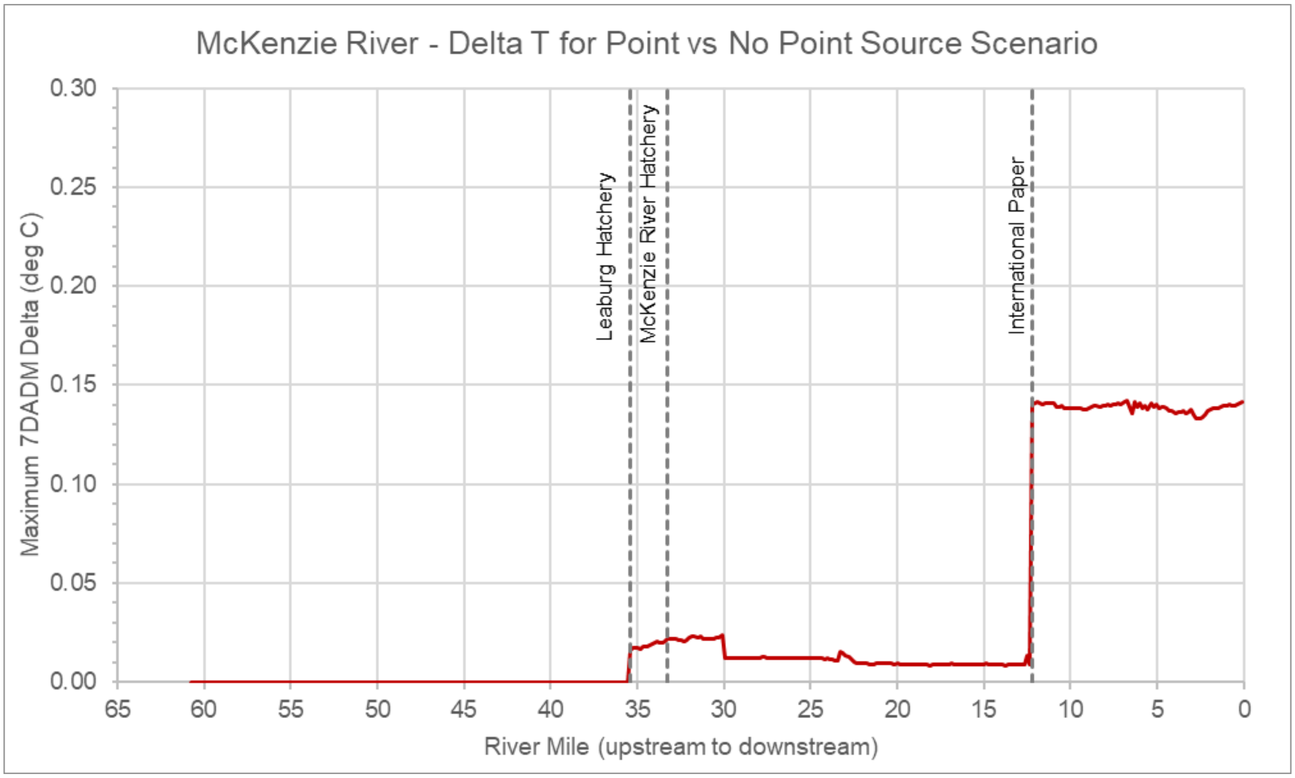


Figure 5-1: Maximum estimated warming (7DADM delta) due to point sources along the McKenzie River.

6.0 REFERENCES

DEQ (Oregon Department of Environmental Quality). 2008. Temperature water quality standard implementation—A DEQ internal management directive, Oregon. Oregon Department of Environmental. Quality. Portland, OR. https://www.oregon.gov/deq/Filtered%20Library/IMDTemperature.pdf

DEQ. 2013. Internal Management Directive - The Use of Significant Figures and Rounding Conventions in Water Quality Permitting. Water Quality Division, Surface Water Management Section, Headquarters. Portland, OR. https://www.oregon.gov/deq/Filtered%20Library/SigFigsIMD.pdf.

Stratton Garvin, L.E., S.A. Rounds, and N.L. Buccola. 2022. Updates to models of streamflow and water temperature for 2011, 2015, and 2016 in rivers of the Willamette River Basin, Oregon: U.S. Geological Survey Open-File Report 2022–1017, 73 p., https://doi.org/10.3133/ofr20221017

APPENDIX A – TEMPERATURE BBNC