APPENDIX A – TETRA TECH 2015 TECHNICAL MEMO ON FLATHEAD WATERSHED MODEL UPDATES

TETRA TECH

MEMO

To:	Jason Gildea, EPA Eric Regensburger, DEQ Erik Makus, DEQ Kyle Flynn, DEQ
From:	Ron Steg, Tetra Tech
Date:	Tuesday, June 30, 2015
Subject:	Flathead Lake Model Revisions and Recalibration

Introduction

In response to continued post-project coordination with the U.S. Environmental Protection Agency (EPA) and the Montana Department of Environmental Quality (DEQ), Tetra Tech has revised and recalibrated the Flathead Lake LSPC model. This memorandum provides a brief summary of the revisions and recalibration and also serves as a transmittal letter for updated model files that have been sent separately via RMFT (i.e., Tetra Tech's electronic file transfer application).

Model Revisions

The weather inputs to the Flathead Lake model were updated in early May 2015 to revise the ".pre" files from PRISM and ClimateWNA north of approximately model subwatershed 303. Air temperatures were reassigned in the Big Fork/Ashley Creek area and a routing error was corrected in the Stillwater basin.

These changes impacted the North Fork Flathead River simulation in Phase 1, as well as affecting the northern portions of the Stillwater and Whitefish drainages in Phase 2. The Ashley basin simulation was also impacted due to changes in PET.

Recalibration

To bring the model back into line after the above revisions, Tetra Tech recalibrated primarily by (1) modifying the factors on the PET series, and (2) adjusting lake FTables.

PET Factors

The Flathead model is set up using Penman PET that is estimated using temperature from local meteorological gages combined with other climate inputs from the Flathead Airport station. No

corrections to PET are made based on elevation differences. This approach is expected to lead to discrepancies for subbasins that lie further away (in space or elevation) from the airport station. In particular, use of dewpoint information from the airport will tend to over-estimate dewpoint temperatures at higher elevations and thus underestimate vapor pressure deficit and PET at those stations. Thus, it is entirely expected that PET factors greater than 1 may be needed.

LSPC also has a number of parameters that affect the expression of PET. There is a general multiplicative factor on the PET weather series (c20) and also a multiplicative factor by land use class (c70). Further, the actual expression of ET is modified by the monthly LZETP factor, also by land use (c200). The multiplicative factor in c70 (<1) obscures the relationship and would be better combined into monthly LZETP factors. In any case, increasing the c20 PET multiplier for the areas in the northern part of the watershed where precipitation increased was sufficient to resolve most water balance issues. (Final values of the multiplier were 1.4 to 1.85).

Although this was the standard approach when modeling began almost 10 years ago, it may be preferable to use data sources such as NLDAS that combine consistent gridded estimates of precipitation, temperature, and PET if the model is rebuilt at a future date.

Lake FTables

Phase 2 gaged flows on Stillwater River, Whitefish River, and Ashley Creek are largely determined by lake releases. The model is particularly sensitive to depth-discharge relationships above normal pool in these lakes.

For the recalibration, ad hoc adjustments were made to FTables for Whitefish Lake, Ashley Lake, Smith Lake and Lake Mary Ronan. While these ad hoc adjustments work, DEQ may wish to redo the FTables for all Phase 2 lakes based on the best available data at the time of the update.

Calibration Results

Hydrology generally fits well after the model revisions and recalibration (**Table 1** and **Figure 1**). Based on examination of one water quality calibration site in Phase 1, Phase 2, and Ashley Creek, the water quality calibration also appears to be good (**Table 2**). However, as with the previous model, phosphorus is still over-estimated in Ashley Creek.

Table 1. Hydrology calibration results.

Calibration Criteria	NF Flathead 12355000	NF Flathead 12355500	MF Flathead 12358500	Flathead 12363000
Error in total volume:	-0.71	5.44	1.92	1.04
Error in 50% lowest flows:	11.87	**10.84**	0.81	-1.18
Error in 10% highest flows:	-14.09	0.82	-0.17	-0.41
Seasonal volume error - Summer:	4.89	5.01	-1.20	-0.73
Seasonal volume error - Fall:	2.57	9.39	-3.63	-0.93
Seasonal volume error - Winter:	-7.34	-7.15	-16.66	-5.36
Seasonal volume error - Spring:	-1.93	6.49	5.55	3.63
Error in storm volumes:	15.93	16.78	3.05	10.51
Error in summer storm volumes:	50.03	24.12	9.42	6.25
Nash-Sutcliffe Coefficient of Efficiency	0.683	0.828	0.821	0.891

Calibration Criteria	Stillwater 12365000	Whitefish 12366000	Flathead 12369000	Swan 12370000
Error in total volume:	-2.21	-5.24	**10.24**	7.35
Error in 50% lowest flows:	-2.45	**-20.30**	4.10	-6.13
Error in 10% highest flows:	-2.72	7.30	11.60	8.62
Seasonal volume error - Summer:	2.06	-7.46	-0.69	22.00
Seasonal volume error - Fall:	15.26	-6.75	6.45	-3.73
Seasonal volume error - Winter:	-21.12	-28.40	6.99	-21.96
Seasonal volume error - Spring:	-2.39	0.45	16.77	10.08
Error in storm volumes:	**35.77**	**33.31**	**31.50**	9.55
Error in summer storm volumes:	38.77	35.04	10.65	23.24
Nash-Sutcliffe Coefficient of Efficiency	0.791	0.893	0.873	0.839

Very Good
Good
Fair
Poor

Figure 1. Simulated versus observed flows in Ashley Creek

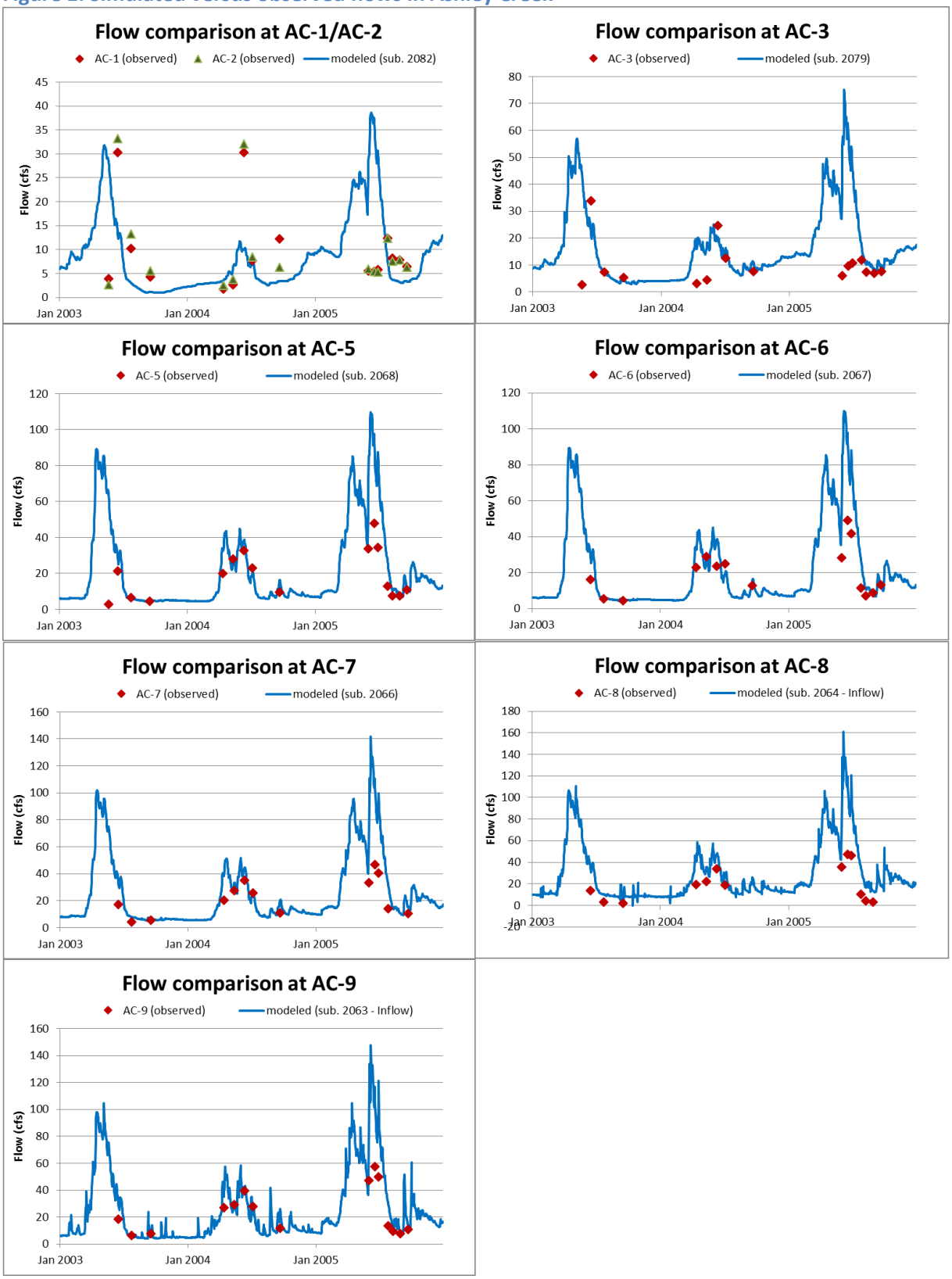

Table 2. Water quality calibration results.

Site ID	Site Name	TSS		TN		TP	
		Conc. Median Error	Load Median Error	Conc. Median Error	Load Median Error	Conc. Median Error	Load Median Error
12355500	NFFR near Colombia Falls, MT	16.33%	1.53%	24.05%	9.12%	-8.90%	-0.63%
12367800	Ashley Creek at Kalispell, MT	-9.81%	-5.38%	16.43%	-18.43%	37.82%	11.38%
12369000[3]	Flathead River near Bigfork, MT	5.24%	0.84%	4.60%	1.70%	3.68%	0.32%