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Temperature Modeling of Applegate Lake Using CE-QUAL-W2

A Report on the Development, Calibration, Verification, and Application of the Model

Tammy L. Threadgill, Daniel F. Turner, Laurie A. Nicholas, Barry W. Bunch, Dorothy H. Tillman, and David L. Smith

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Final report

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Abstract

The U.S. Army Corps of Engineers Engineer Research and Development Center (USACE-ERDC) Environmental Lab (EL) assisted USACE, Portland District (CENWP) in updating a CE-QUAL-W2 (W2) model of Applegate Lake based on a previous version of W2. The model was calibrated using data from calendar year (CY) 2001 and validated with data from calendar years 2003 and 2010. One set of W2 parameters was successfully applied to all calendar year types (2001 is a dry year; 2003 is a normal year; and 2010 is a wet year). This model and the corresponding results from the study provided CENWP with more refined estimates of water temperatures so that more defendable water temperature targets can be discussed with the State of Oregon. This is extremely important because the Rogue and Applegate Temperature Total Maximum Daily Loads and Rogue Spring Chinook Conservation Plan require the Corps to review the Rogue Basin Project operations to determine whether improvements can be achieved to downstream temperature for the benefit of endangered fish. This is the second of three USACE projects on the Rogue River; this work is identical to the Lost Creek Lake Model work for CENWP.

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Preface

This study was conducted for the U.S. Army Corps of Engineers (CENWP), Portland, Oregon, under Project Number 113347, "NWP Water Management Program."

The work was performed by the Water Quality and Contaminant Modeling Branch (WQCMB), Environmental Processes and Engineering Division (EP), U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory (EL). At the time of publication, Lesley Miller was Acting Chief, WQCMB; Warren P. Lorentz was Chief, EP. Dr. Al Cofrancesco, CEERD-EZT, was the Senior Science and Technology Manager. The Deputy Director of ERDC-EL was Dr. Jack E. Davis and the Director was Dr. Beth Fleming.

COL Bryan S. Green was Commander of ERDC; Dr. David W. Pittman was the ERDC Director.

Unit Conversion Factors

Multiply	By	To Obtain
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	meters
gallons (U.S. liquid)	3.785412 E-03	cubic meters
square miles	2.589998 E+06	square meters
Langley per day	0.48	Watts per square meter

Acronyms and Units

14WS	14^{th} Weather Squadron
APPL	Applegate Lake
APPLM	Applegate Lake Model
APPLPM	Applegate Lake Predictive-Mode Model
BOD	Biochemical Oxygen Demand
CENWP	US Army Corps of Engineers, Portland District
CY	Calendar year (January 1 through December 31)
DO	Dissolved Oxygen
ELWS	Water surface elevation
ERDC	US Army Corps of Engineers Engineer Research and Development Center
ISS	Inorganic Suspended Solids
NH4	Ammonium
NO3	Nitrate
OM	Organic Matter
PSU	Portland State University
RO	Regulating Outlet with centerline elevation of 1776.0 ft (aka STR6)
STR1	Represents the fixed invert intake with centerline elevation of 1962.0 ft
STR2	Represents the fixed invert intake with centerline elevation of 1950.0 ft
STR3	Represents the fixed invert intake with centerline elevation of 1930.0 ft
STR4	Represents the fixed invert intake with centerline elevation of 1895.0 ft
STR5	Represents the fixed invert intake with centerline elevation of 1838.0 ft

TDS	Total Dissolved Solids
TMDL	Temperature Total Maximum Daily Load
USACE	US Army Corps of Engineers
USGS	US Geological Survey
W2	CE-QUAL-W2 model

1 Introduction

Background

Applegate Lake is part of the Rogue River Basin Project. Due to the recent implementation of a Biological Opinion on the system, the Rogue Temperature Total Maximum Daily Loads (TMDL) and Rogue Spring Chinook and Fall Chinook Conservation Plans require that all systems in the Basin be reviewed to determine whether improvements to downstream temperature targets can be achieved (ODEQ 2008)(ODFW 2007)(USACE & ODEQ 2009) (ODFW 2013).

Applegate Lake is located twenty-three miles southwest of Medford, Oregon, on the Applegate River in the Rogue River National Forest. Applegate Dam consists of an earth-filled embankment, a spillway, a multi-level withdrawal tower, a regulating outlet conduit, an outlet bypass, and a stilling basin. The embankment is about 1,300 ft long and about 242 ft high. The primary authorized purposes of the dam are flood control, fisheries enhancement, and irrigation. At maximum pool, Applegate Lake is 4.6 miles long and stores approximately 82,200 acre-ft of water (USACE 1990). Figure 1 is a Google Earth screenshot of the project study area.

The selective withdrawal water temperature control tower has five intake ports that allow water to enter one of two wet wells. The intake inverts are located at elevations of 1,962 ft, 1,950 ft, 1,930 ft, 1,895 ft, and 1,838 ft. A diagram of the multi-level intake tower can be found in Figure 2.

The upstream flows into the lake come from three creeks: Elliott Creek, Middle Fork, and Carberry Creek. The reservoir empties in to the Applegate River near RM 46.3.

Approach

In order to determine whether new temperature targets could be achieved, temperature models of key projects needed to be updated and/or created. Applegate Lake was modeled in the late 1980s and early 1990s using CE-QUAL-W2 (W2), but the model needed to be updated due to code revisions and operational changes.

Objective

The goal of this project is to develop and calibrate a current W2 model for Applegate Lake that can also be used to fully evaluate the effects of operational changes on release temperatures at Applegate Dam on the Rogue River.

Figure 1. Google Earth image of the Applegate Lake project study area.

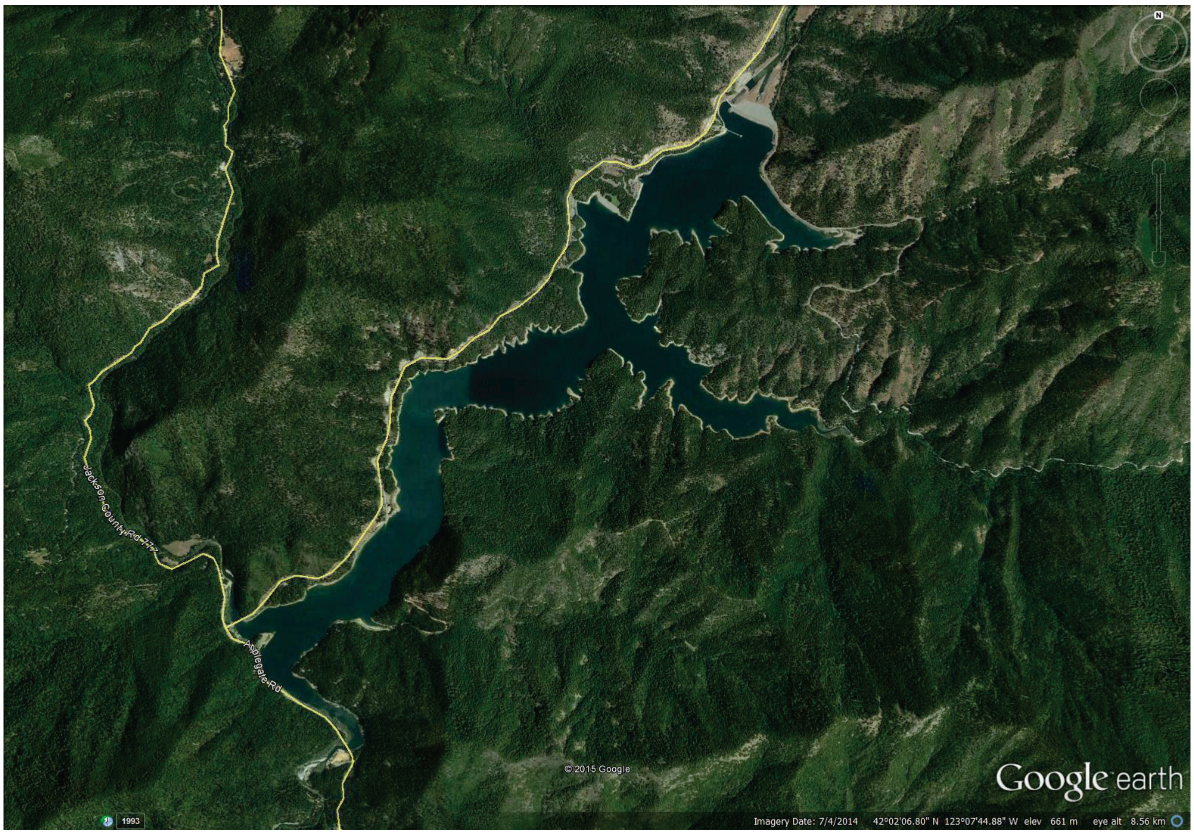
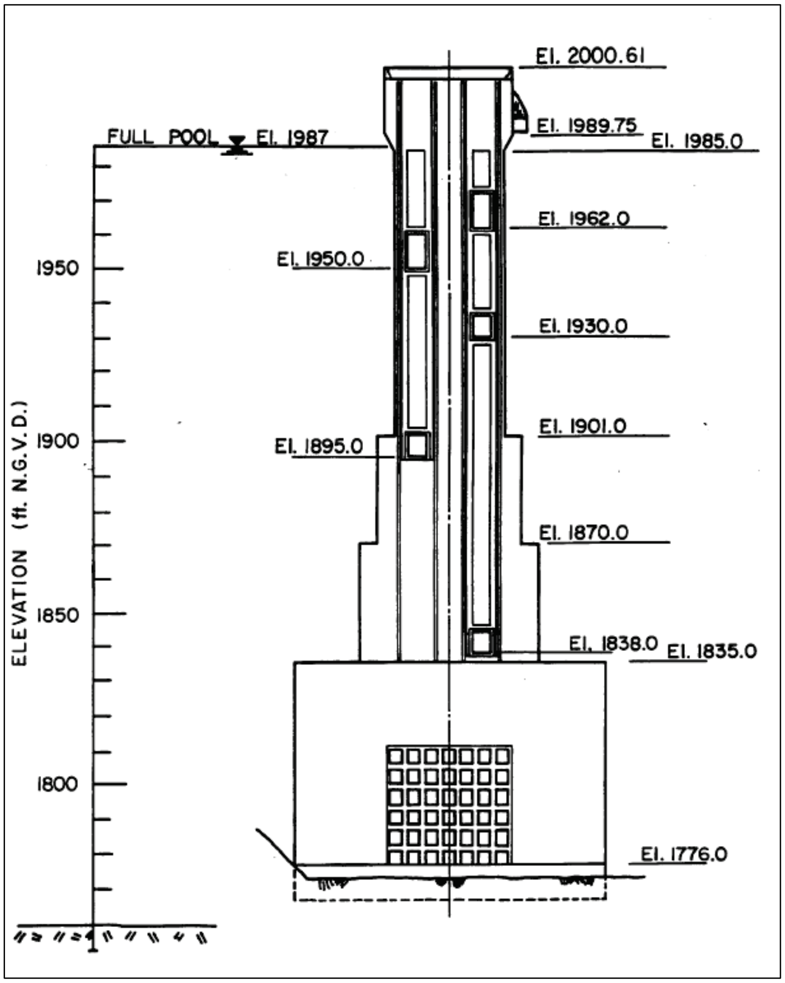


Figure 2. Representation of the WTC intake structures (Larson 1998).



2 Model Selection and Development

CE-QUAL-W2 (W2) is the code selected to develop the Applegate Lake Model (APPLM). W2 is a 2D longitudinal-vertical hydrodynamics and water quality model. It is capable of modeling basic eutrophication processes and is best-suited for long, narrow waterbodies that do not exhibit substantial lateral variation. W2 has been applied to hundreds of studies on various types of waterbodies (rivers, reservoirs, lakes, and estuaries) all over the world. For a list of the model applications, see the CE-QUAL-W2 website: http://www.ce.pdx.edu/w2/.

CE-QUAL-W2 Description

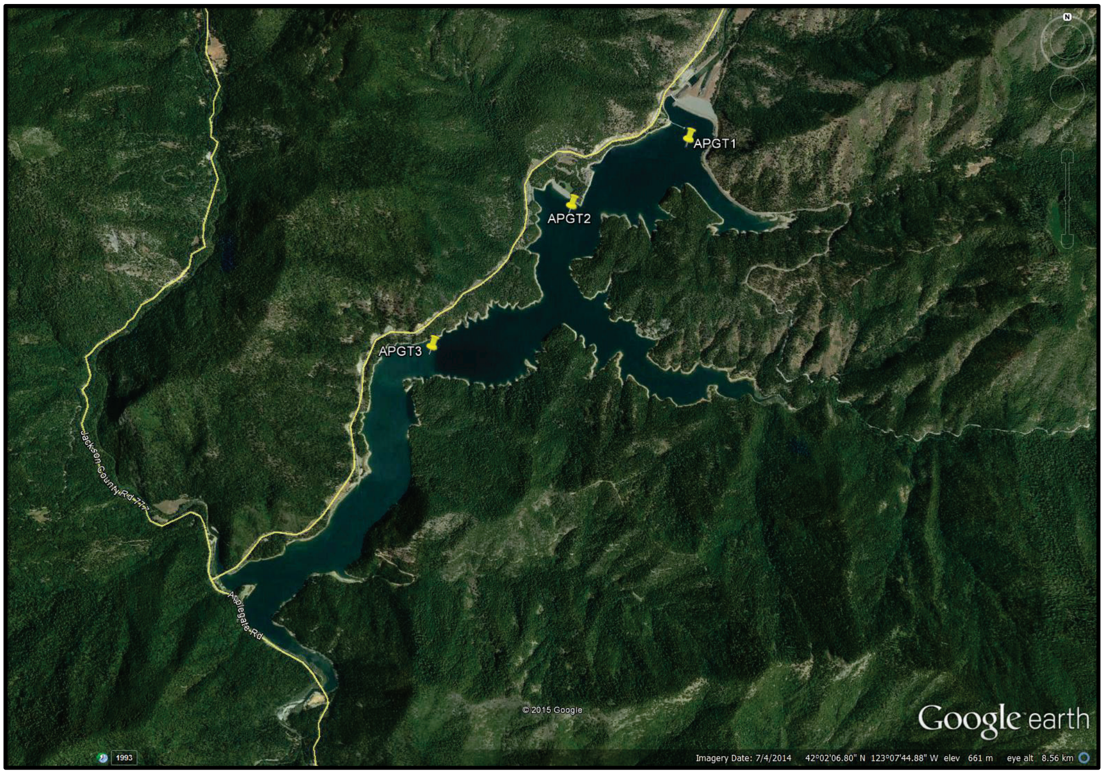
The numerical modeling code known as CE-QUAL-W2, version 3.7, was configured for application to Applegate Lake. W2 uses a finite difference solution of the laterally averaged equations of fluid motion (Cole and Wells 2013). It allows for application to very complex water systems because it accommodates multiple branches and multiple waterbody types. W2 allows the user to set up variable grid spacing (longitudinally and vertically), time-variable boundary conditions, multiple inflows and outflows, and time-variable concentrations for each water quality constituent being modeled. W2 (V3.7) contains a user-defined port selection algorithm, which allows the user to specify a varying number of elevations for dam structures. Although this feature is not utilized in the calibration, future scenarios may benefit. In addition to water temperature, W2 is also capable of modeling water surface elevation, flow, and twenty-eight water quality constituents such as total dissolved solids (TDS), inorganic suspended solids (ISS), ammonium (NH4), biochemical oxygen demand (BOD), nitrate (NO3), phytoplankton, dissolved oxygen (DO), and organic matter (OM). This study only modeled temperature; consequently, the other constituents will not be discussed.

Project Approach

CE-QUAL-W2 is well-suited for application to Applegate Lake for the same reasons it is well-suited for application to Lost Creek Lake (Threadgill et al. 2015).

Three in-lake monitoring stations were used for evaluating model performance during calibration. Locations with temperature data are: APGT1 (APP20001), APGT2 (APP20002), and APGT3 (APP20003). Data at the dam and downstream from the dam were also used for calibration. The locations of the sites are shown in Figure 3.

Figure 3. In-lake profile monitoring stations. Site locations provided by Kinsey Friesen (NWP).



Calibration Strategy

Several factors were used to determine which calendar years (CY) were used to calibrate and validate the model. The largest limiting factor was the availability of observed data. Since more data were available for 2001 for the in-lake stations, CY01 was used to develop a calibrated model. Once an acceptable set of calibration parameters were found, the same set of model parameters was used for CY03 and CY10. Each of the chosen years represents various water year types: 2001 was a dry year; 2003 was an average year; and 2010 was a wet year.

3 Data Analysis and Model Preparation

This section will review what data were available and how they were used to define the calibration input files. W2 has several data requirements to meet before simulations can begin:

1. Bathymetry of the waterbody(ies)
2. Flow and temperature characteristics for boundaries, major tributaries, and point sources
3. Dam operations and structure locations
4. Stage data
5. Meteorological conditions: air temperature, dew point temperature, wind speed, wind direction, cloud cover, and short wave solar radiation (if available)

Model Geometry

Bathymetry Data

The bathymetry file for the Applegate Lake Model (APPLM) was originally developed by Mike Schneider (USACE) for the original W2 model of Applegate Lake. Due to lack of available documentation, it is unknown where he obtained the bathymetry data (sediment range analysis, cross sections, etc.). The current model utilized the original bathymetry file, refined the grid, and modified angles of the original segments based on Google Earth imagery.

Model Grid Development

Applegate Lake was split into three branches, with Branch 1 extending from the Applegate Dam at the Applegate River upstream to the junction of Middle Fork and Elliott Creeks; Branch 2 constituting a side channel that enters the mainstem of the reservoir about 1.3 miles upstream from the dam. This side channel has inflows from Squaw Creek, but due to the lack of data, inflows are input as 0 cms in the model; Branch 3 is also a side channel that enters the reservoir about a quarter of a mile upstream from the dam. Its main inflow is the French Gulch, but again, due to the lack of data, this inflow is also input at 0 cms. The reservoir was modeled with 41 longitudinal segments, varying in length from 135.0 to 800.0 m, and 77 vertical segments of uniform 0.914 m (~3 ft) height. Figure 5 is a Google Earth image with the segments laid out as the model sees them.

Table 1 provides a description of the branches in the reservoir; the segment numbers do not include the inactive (or "null") segments that start and end each branch (required in W2). Figure 4 shows an image of the longitudinal segments used in the model along with the branch configuration. Figure 5 is a Google Earth image with the segments laid out as the model sees them.

Table 1. Geometry characteristics.

Description	Branch	Segment Start	Segment End	# Segments	Slope
Branch 1 – Mainstem (Middle Fork and Elliott to Dam)	1	2	29	28	0.000
Branch 2 – Ungauged leg of the lake (Squaw Creek)	2	32	35	4	0.000
Branch 3 – Ungauged leg of the lake (French Gulch)	3	38	40	3	0.000

Figure 4. Longitudinal segments with branch configuration for the APPLM.

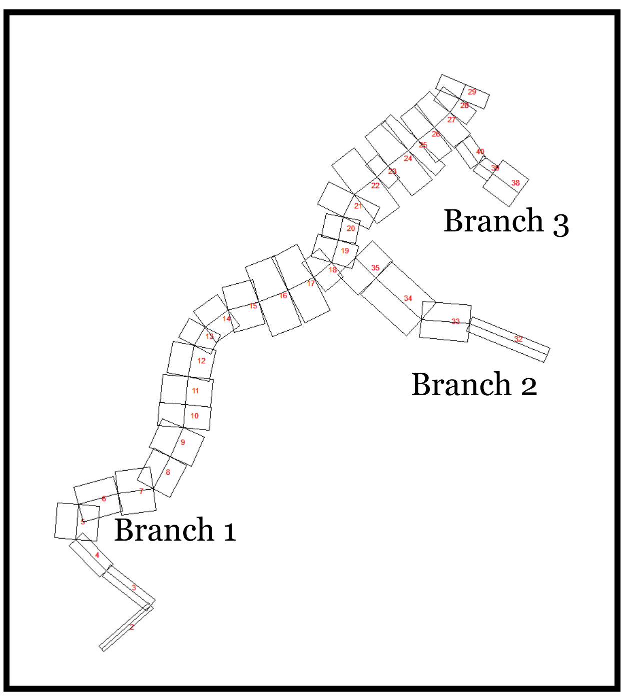
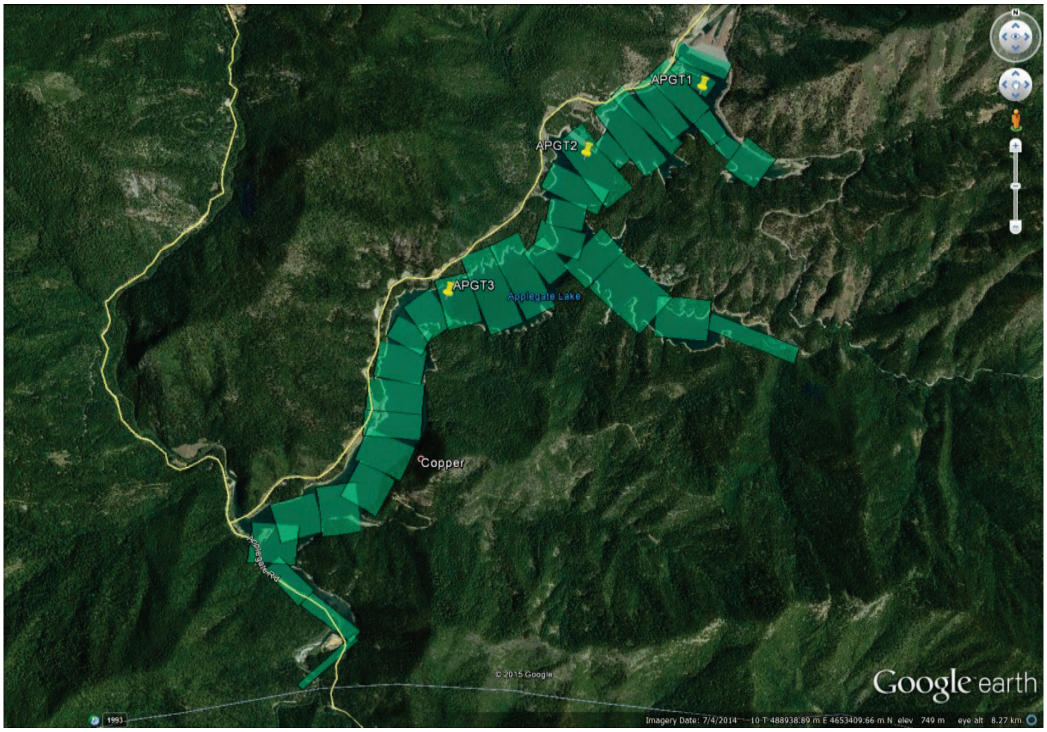


Figure 5. Google Earth image with model grid overlay (produced by W2 Tools) for the APPLM.



The bathymetry of the APPLM that has been developed has been verified to replicate the observed storage-elevation curve (obtained from NWP). The storage-elevation curve obtained from NWP was dated 01/31/2006 and is titled "5% Encroachment on Rule Curve, in terms of Maximum Conservation Pool." Figure 6 shows the storage-elevation curve represented by the model compared to the observed storage-elevation curve (or volume-elevation curve). This provides the ERDC with confidence that the bathymetry is good and sufficient for the APPLM. A complete copy of the bathymetry file used can be found in Appendix A and the model input file was delivered to CENWP.

Dam Features and Withdrawal Locations

Table 2 presents an abbreviated list of segment numbers in the APPLM bathymetry along with a brief description of what site is located at the segment. For example, the in-lake monitoring site, APP1, is located at segment 28 in the APPLM bathymetry.

Figure 6. Volume-elevation curve comparison for the APPLM.

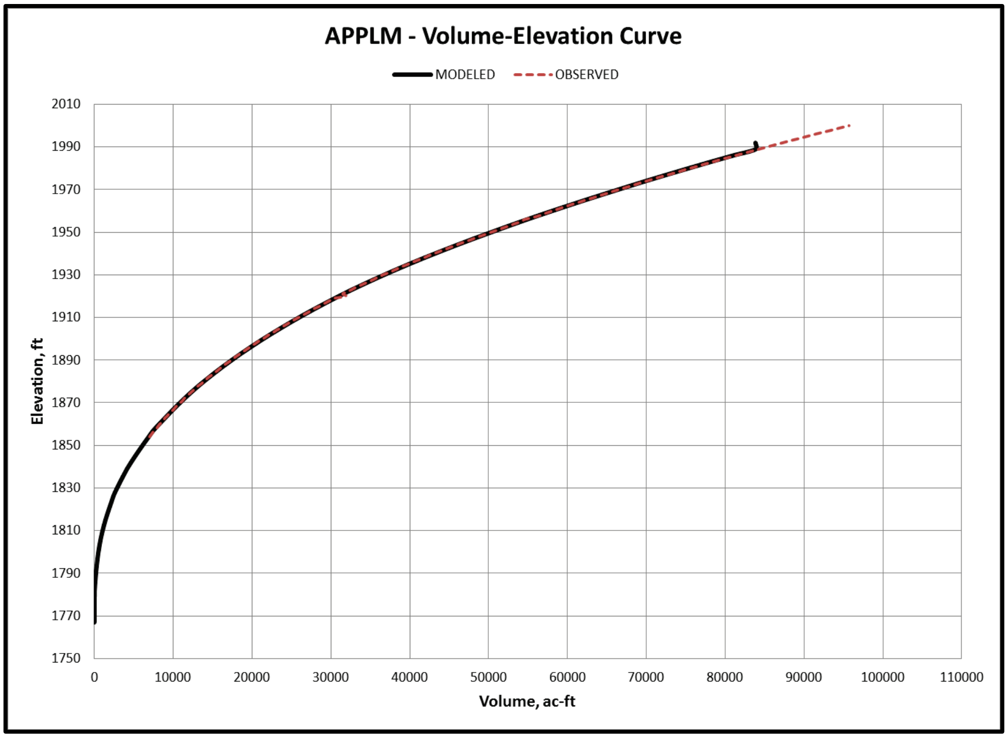


Table 2. Model segments of important locations.

Segment	Length (m)	Distance Upstream from Dam (m)	Distance Upstream from Dam (miles)	Identification/Location
1	0	7811.900	0.000	Boundary (Null Segment)
2	623.3	7811.900	6.621	Beginning of Branch 1
15	298.7	3274.400	3.801	In-lake Station: APP3 (APP20003)
22	274.3	1503.800	2.701	In-lake Station: APP2 (APP20002)
28	159.1	304.500	1.956	In-lake Station: APP1 (APP20001)
29	145.4	145.400	1.857	DAM
30	0	0.000	1.767	End of Branch 1
31	0	2104.400	1.767	Beginning of Branch 2
36	0	0.000	0.459	End of Branch 2
37	0	739.100	0.459	Beginning of Branch 3
41	0.000	0.000	0.000	End of Branch 3

Flow and Elevations

Model Inflow Boundaries

Upstream and Downstream Boundaries

Mean daily inflows for Applegate Dam were available only for the year 2003 and later. The observed inflows were obtained by NWP from the project site and were contained in the gate settings file spreadsheet. For 2001, however, these data were not available, so the ERDC obtained six-hourly estimated inflow via the NWPQuery site for the Applegate Dam site (APP). W2 requires that all branches require input files for flow and temperature. However, since the second and third branches are ungauged, a dummy file of zero flows was used as input for the model. These branches were included in the model only to capture the geometry of the reservoir and to maintain the volume-elevation relationship. Their inclusion will have no impact on the model. The model will fill solely using the upstream inflow. Due to the inaccuracy associated with flow estimation, a decision was made to account for any water balance issues (ungauged flows, rainfalls, etc.) by using the water balance utility (available with the W2 download).

At the downstream boundary, located at the dam, total outflows were available for all calendar years from NWP via the gate settings spreadsheet from the project site. Flow at each intake gate was recorded each day as open, closed, or the amount the gate was open. Based on that information, the gate size, the total outflow, and intake gate flow was calculated. The elevation data available at the dam were used solely for model-to-data comparison. Table 3 shows the data sources for flow and elevation for the upstream and downstream (Applegate Dam) boundaries. Figure 7-Figure 9 are plots of all flow data used as input for the model at the upstream and downstream boundary for all three calendar years.

Table 3. Data sources for flow and elevation at the model boundaries.

River/Location Name	ID	Source	Variable	Calendar Year
Upstream Boundary (Middle Fork and Elliot)	APP	NWP	Flow, Mean Daily	2001
		Gate Settings Spreadsheet from Dam	Flow, Mean Daily	2003, 2010
Downstream Boundary (Applegate Dam)	APP	Gate Settings Spreadsheet from Dam	Elevation, Mean Daily	2001, 2003, 2010
Downstream Boundary (Applegate Dam)	APP	Gate Settings Spreadsheet from Dam	Flow, Mean Daily	2001, 2003, 2010

Figure 7. Flow input data for upstream and downstream boundaries for CY01.

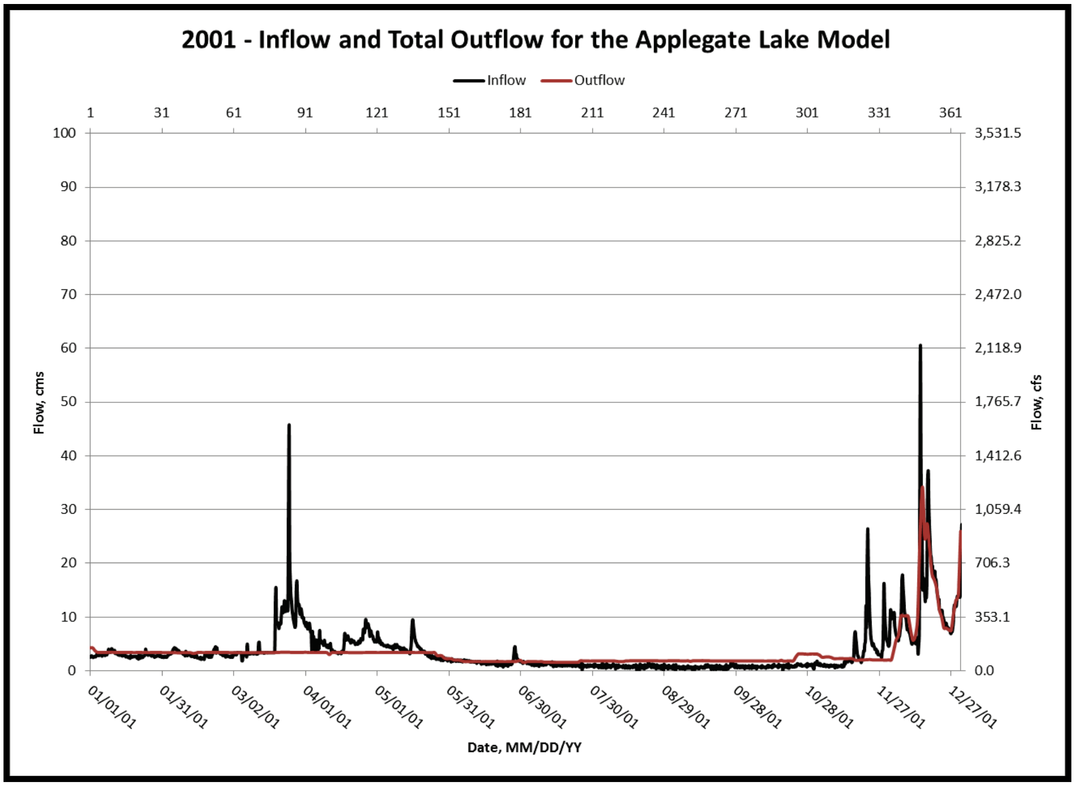


Figure 8. Flow input data for upstream and downstream boundaries for CY03.

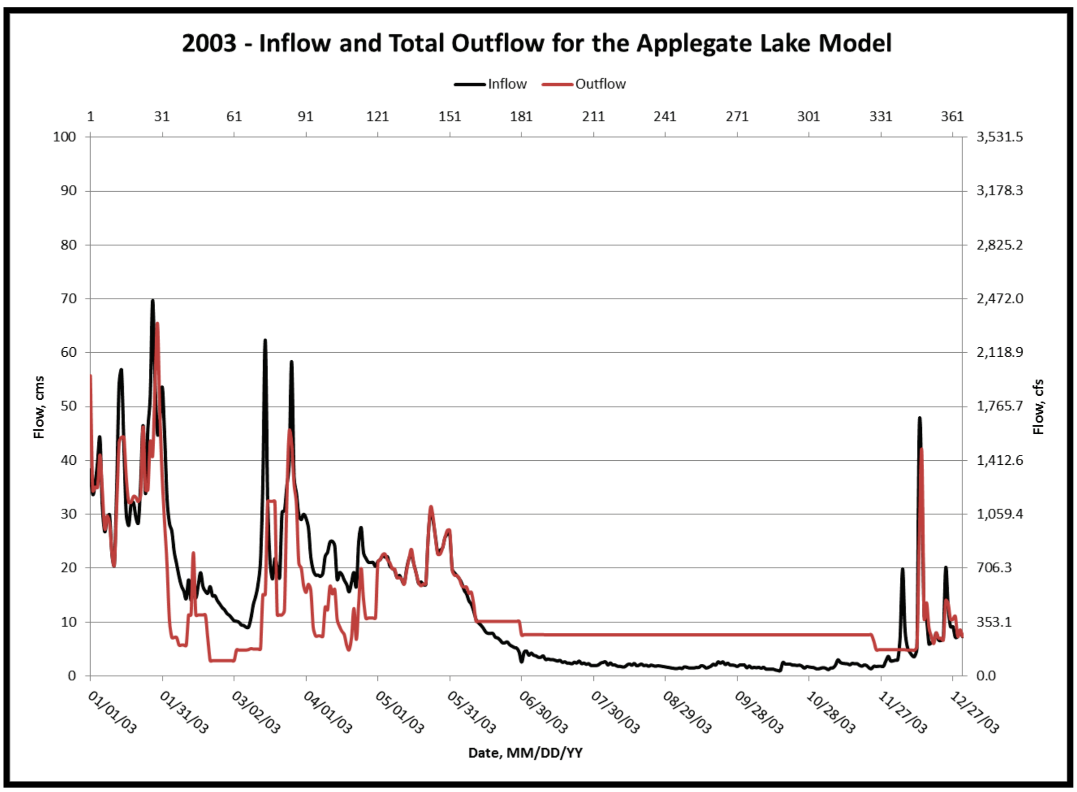
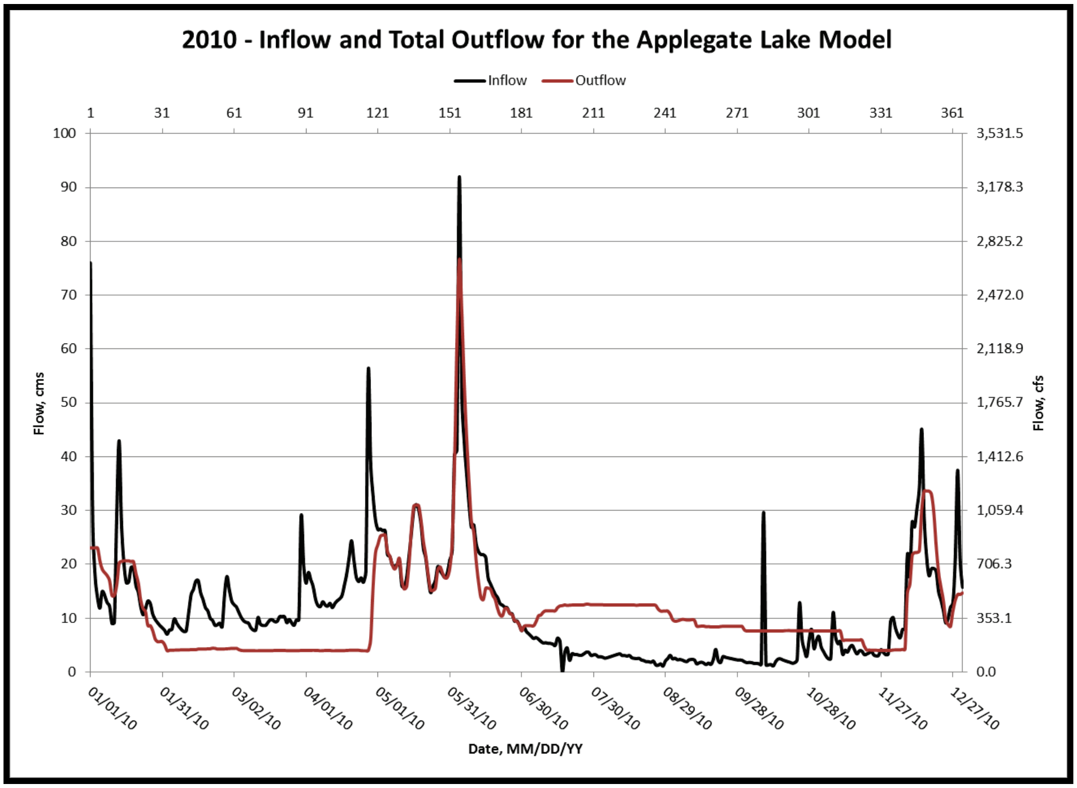


Figure 9. Flow input data for upstream and downstream boundaries for CY10.

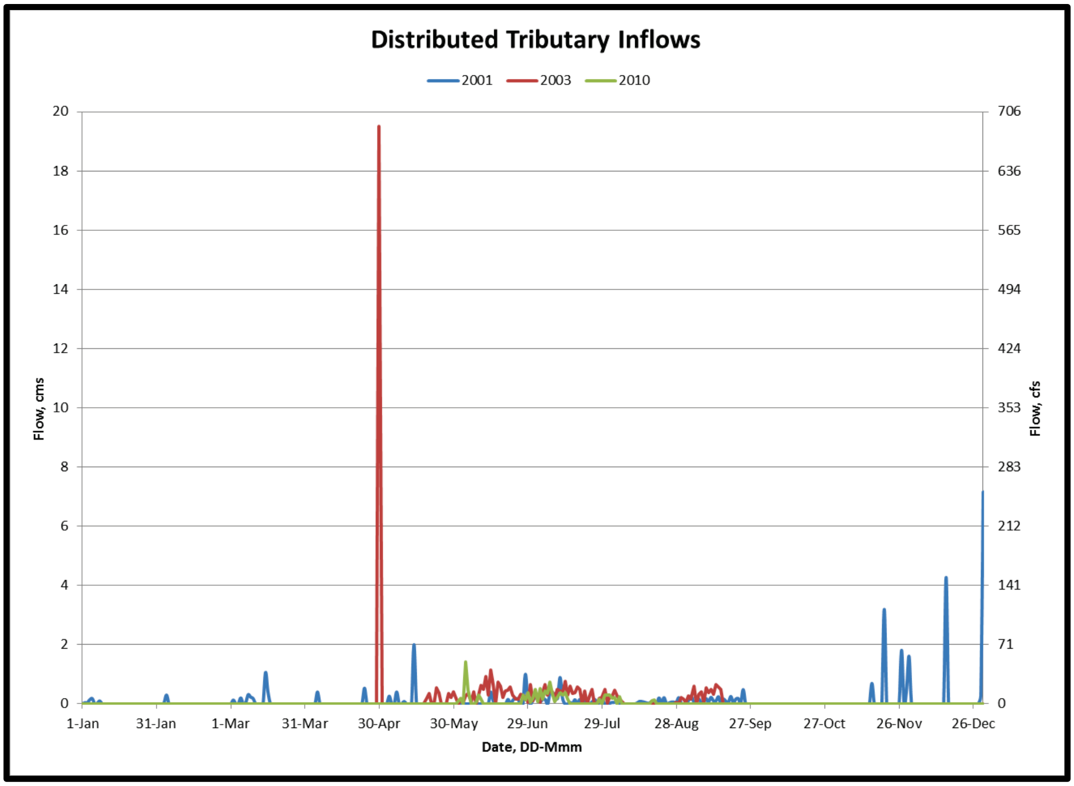


Tributaries

No gauged streams discharge to Applegate Lake. For this reason, no tributaries were defined in the model. Upon initial runs for all calendar years modeled, the model still seemed to underpredict the elevation at the dam. For this reason, a distributed tributary was added to the system to account for the flow imbalance.

To develop a distributed tributary input file, initial model output and observed elevations must be input into the Water Balance Utility developed by Portland State University for use with W2. More information on developing a distributed tributary file can be found in the "Release Notes" that accompany the full W2 download along with the Users' Manual. The water balance utility will calculate negative flows; to account for this, the ERDC averaged out the negative flows with the positive flows from the surrounding time period. Figure 10 is the total flow that was added to the system for each year to account for the water balance problems.

Figure 10. Distributed tributary Inflow input data.



Model Outflow Boundaries

The amount of flow withdrawn through each intake port is not measured; however, gate settings are recorded. Gate setting information was obtained from NWP as an Excel spreadsheet from Dam operators. These values were then used to develop the necessary input files for W2.

Figure 11-Figure 13 are plots of the outflow specified at each intake structure (intake port). The ERDC applied conditions to the total outflow based on elevations and operations procedures as detailed in the Water Control Manual (U.S. Army Corps of Engineers 1991) to apportion the total outflow to each intake port.

Figure 11. Outflow input data at specified structure for CY01.

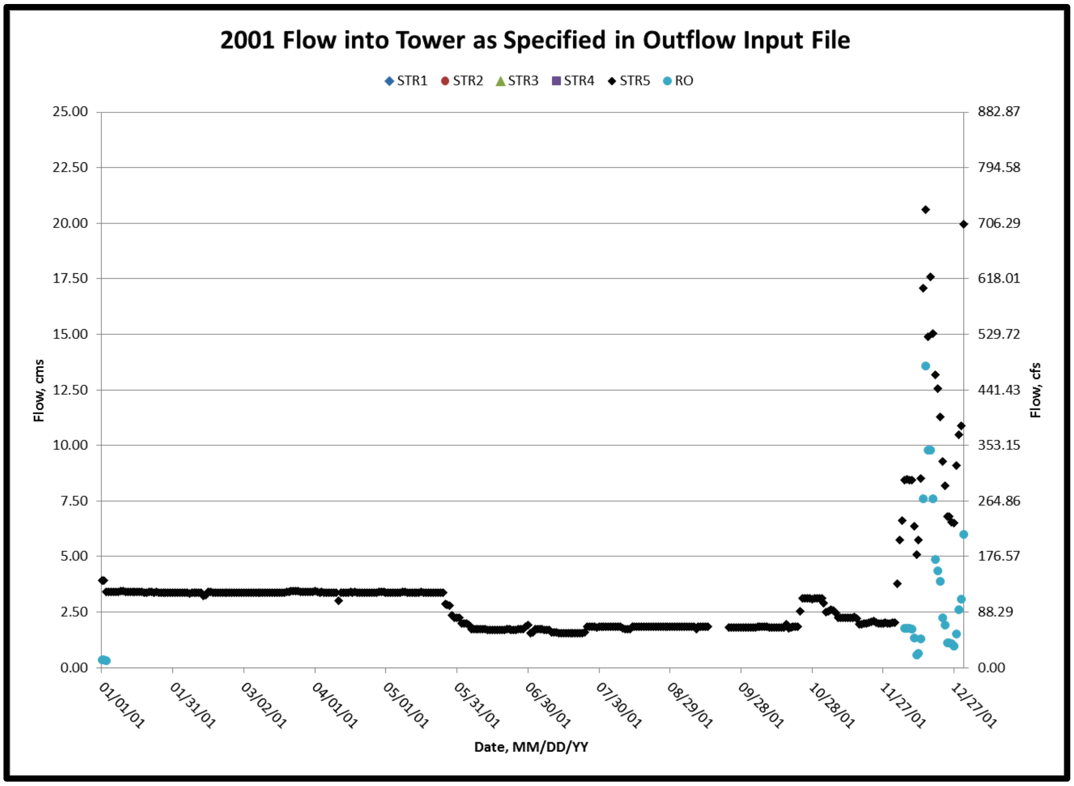


Figure 12. Outflow input data at specified structure for CY03.

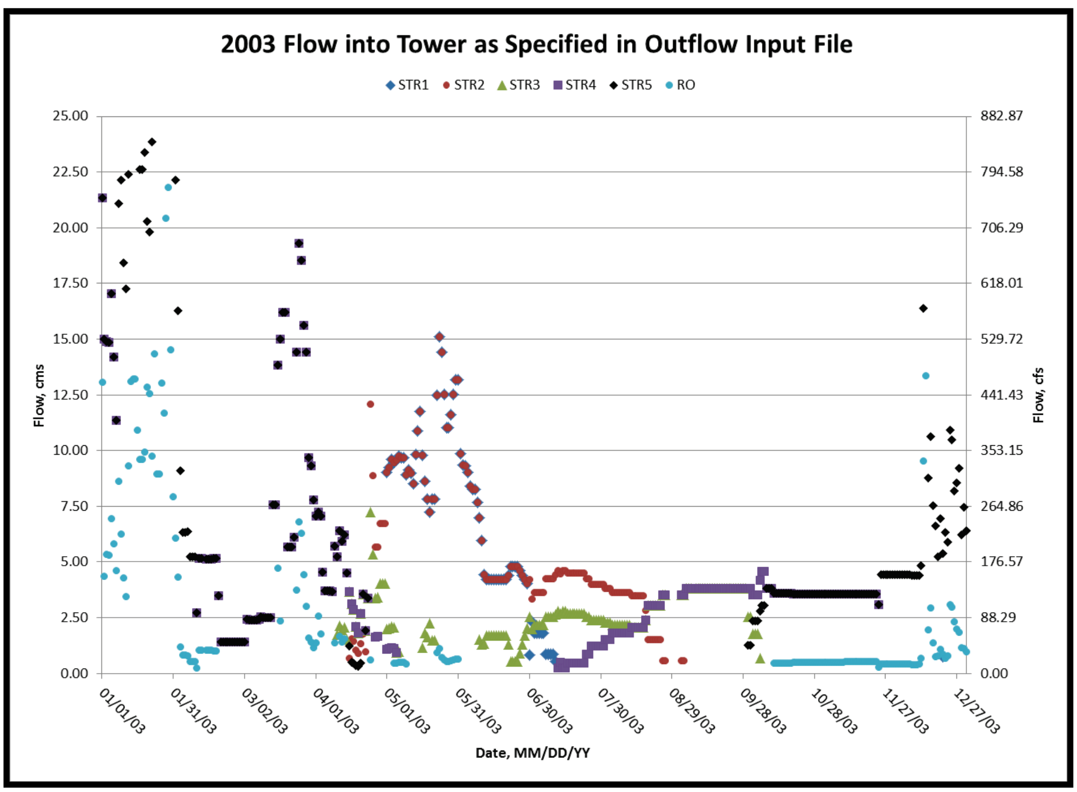
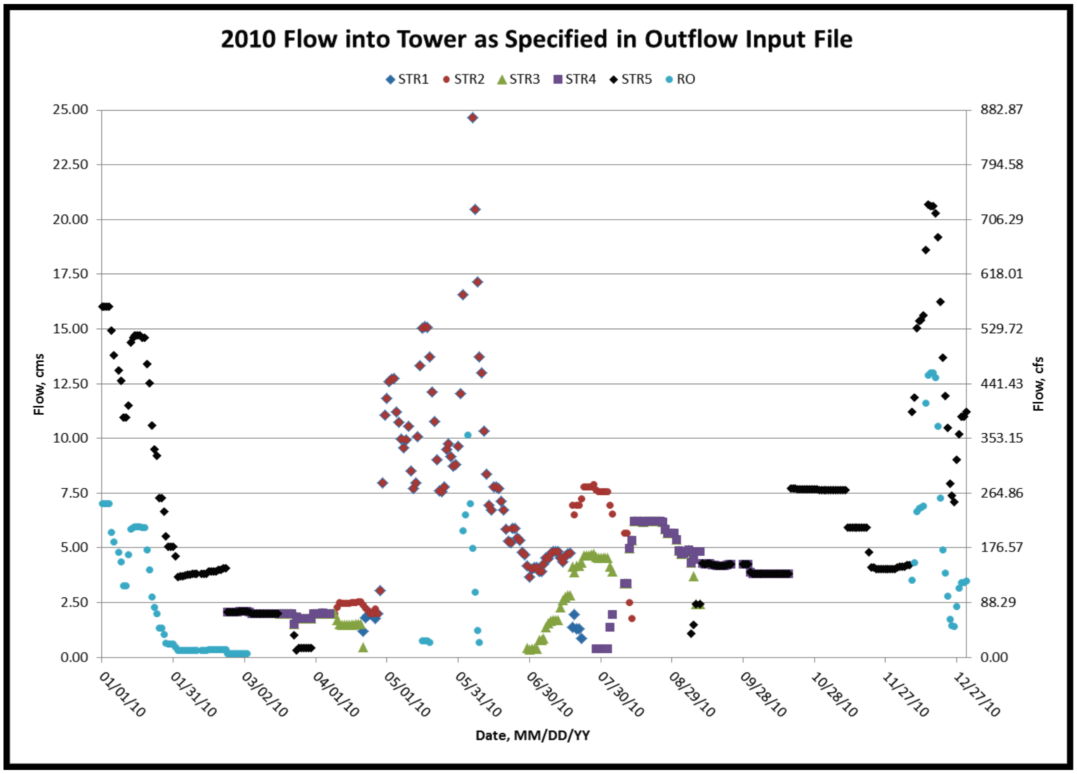


Figure 13. Outflow input data at specified structure for CY10.



Temperature

Model Boundaries

For all calendar years, temperature at the upstream boundary was defined with calculated daily inflows. Temperature was not measured at any of the upstream sites for the years modeled in this study. The ERDC obtained period-of-record daily temperatures at the Middle Fork Applegate River (USGS 14361590), Elliott Creek (USGS 14361600), and Carberry Creek (USGS 14361700). Data were available for 10/01/1979-09/30/1987. These mean daily temperatures were then averaged and plotted against mean daily air temperature from Medford, OR, in order to define a correlation to use to estimate inflow temperature for the modeled years. Figure 14 shows the correlation between air temperature and mean water temperature. Notice the R-squared value for this correlation is 0.87, which suggests that the trendline equation (shown in the chart) represents the data fairly well. In order to determine just how well the equation would estimate the inflow temperature, the ERDC used the correlation to estimate what the temperature would have been for the air temperatures in 1986; Figure 15 shows this comparison. The blue line represents the calculated temperatures using the correlation equation. Overall, ERDC felt the equation provided a good approximation for inflow temperatures when no data were available.

Figure 14. Temperature correlation used in calculating the inflow temperature.

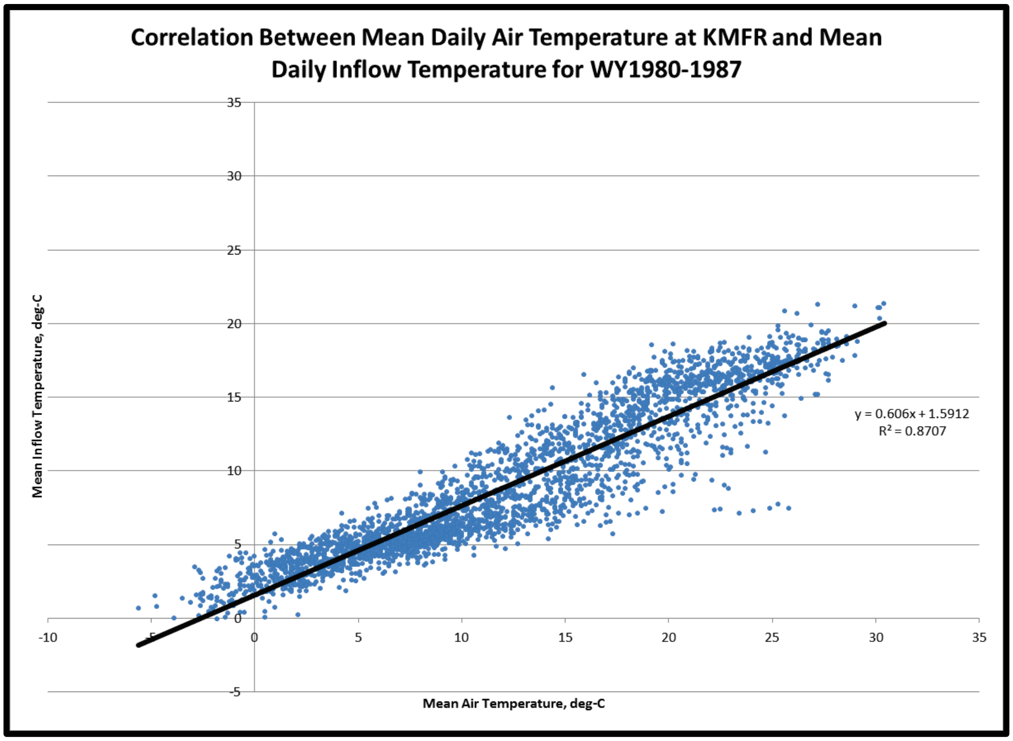
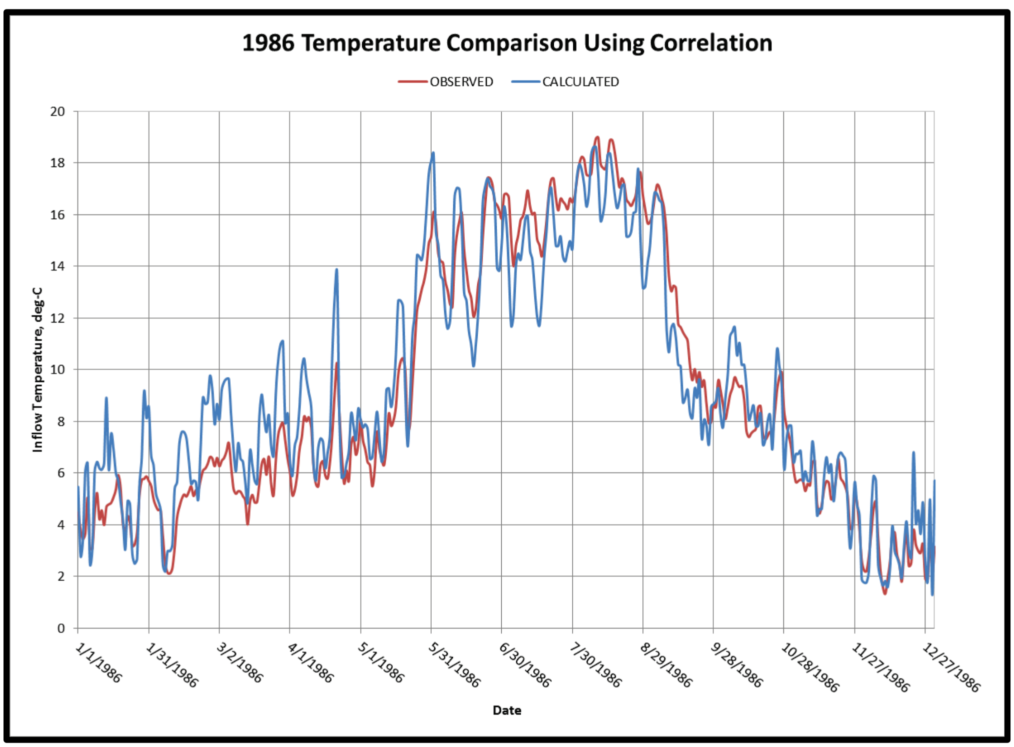


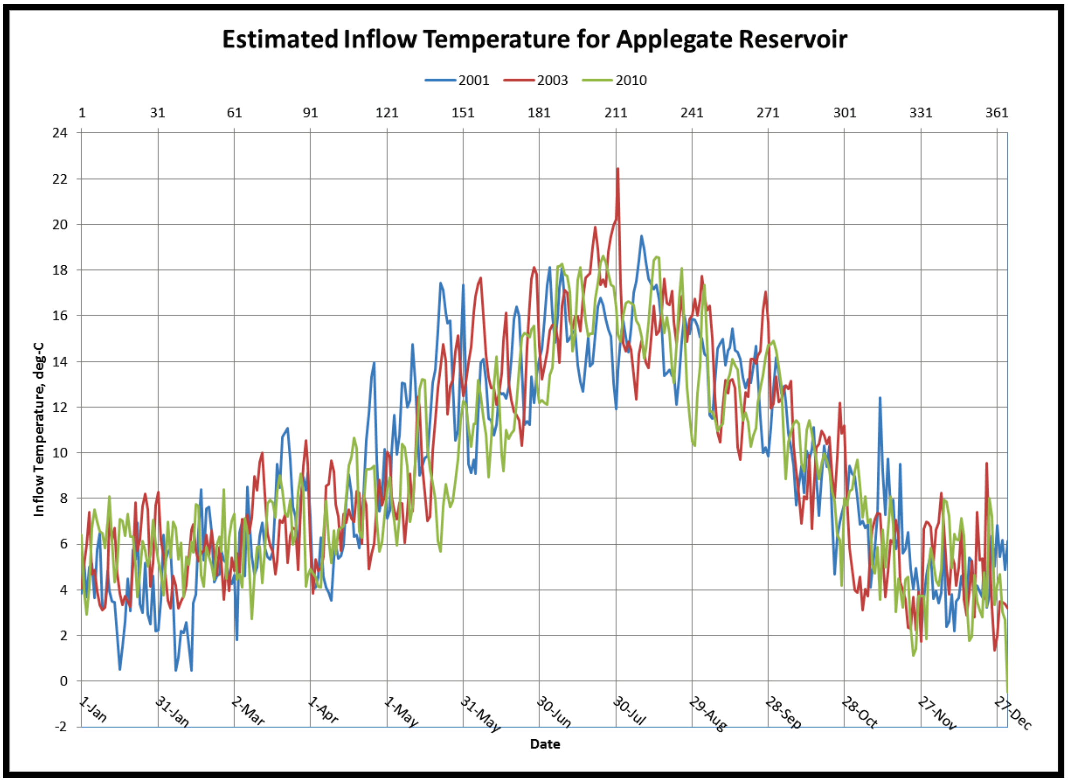
Figure 15. Temperature comparison using observed and correlated temperatures for 1986.



Temperature at the upstream boundary was also used as input for the second and third branches. However, since flows for those branches are input as zero, the temperature will have no impact on the model.

Temperature data at the dam were used as calibration data for the model. Figure 16 provides a time-series plot of temperature at the upstream boundary as defined in the model for all calendar years.

Figure 16. Temperature input data for the upstream boundary for 2001, 2003, and 2010.



Tributaries

Since tributaries were not monitored, there are none included in the model. However, because a distributed tributary must be used to improve the water balance, the upstream temperature input file was duplicated and used as input temperature for the distributed tributary.

Meteorological Data

The same meteorological data were used for APPLM and APPLPM that was used in the Lost Creek Lake Model. The plots of the data are shown again below as a reference. Data were obtained from Medford, OR. Please refer to pages 16-19 of the Lost Creek Lake Model Report (Threadgill et al. 2015).

CE-QUAL-W2 Control File

The control file for the model calibration (CY01) can be found in Appendix B along with a table detailing any differences for all other model simulations. In order to keep this section concise, only parameters related to temperature will be discussed.

Calculations, Transport Scheme, and Heat Exchange

Since evaporation is always considered in the W2 surface heat exchange calculations, it is important to turn EVC on if needed. According to the manual, if calculated inflows are used in setting up a model, then EVC is generally set to OFF; however, in the case of the APPLM, EVC is set to ON since we are using direct observed inflows from the project. This is true for all three years modeled, despite the fact that the inflow for 2001 was an estimated flow.

The transport solution scheme used in the APPLM is the ULTIMATE scheme. This scheme is a higher order solution scheme that reduces numerical diffusion and eliminates the over- and undershoots that the QUICKEST scheme generates near regions of shear concentration gradients (Cole & Wells 2013).

In the W2 control file, the user must specify heat exchange parameters. The first parameter specified is the approach used for computing surface heat exchange, SLHTC. For the APPLM, the ERDC chose to use SLHTC = TERM because it is more theoretically sound according to Cole and Wells (2013) and because it produced better model results than SLHTC=ET. Since the meteorological data files contain shortwave solar radiation, but the model produces better results when calculating it internally, the model setting SROC was set to OFF, which specifies that W2 does not need to read an extra column from the meteorological input file. Although the ERDC was provided with hourly meteorological data, W2 was still allowed to interpolate the input data to correspond to the model time-step by setting the parameter METIC to ON. The wind speed measurement height was set to 10 m in the APPLM as indicated by the 14WS. All other heat exchange parameters were set to the suggested manual values.

Extinction Coefficients

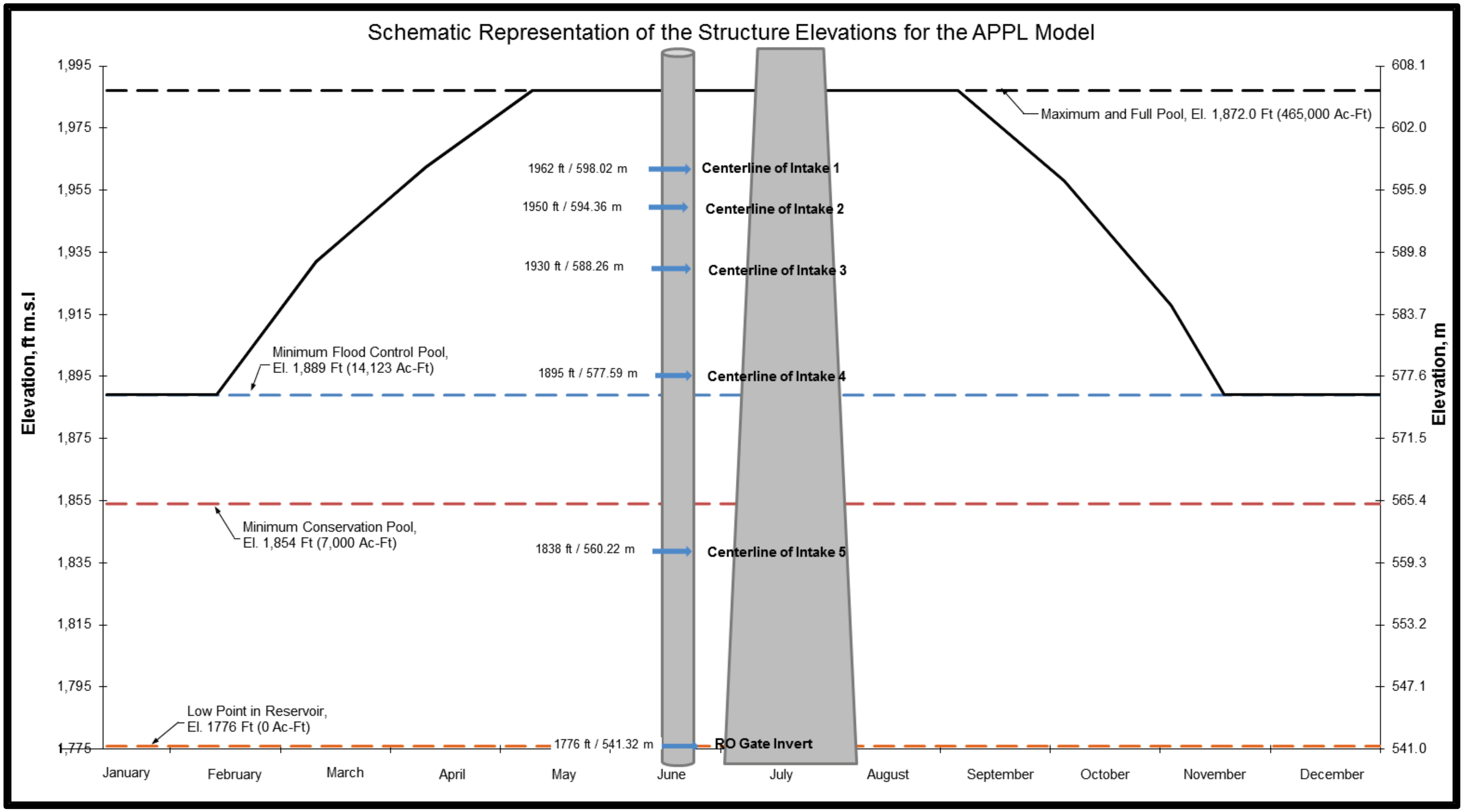
The extinction coefficient card contains two important coefficients for temperature calibration. When water quality constituents, other than temperature, are not being modeled, as in the APPLM, the extinction for pure water, EXH2O, is set to 0.45 m^{-1} as recommended in the W2 manual. BETA, the fraction of incident solar radiation absorbed at the water surface, is also set to the value of 0.45 in the APPLM model. The W2 manual suggests that typical values for BETA are approximately 0.2-0.7 (Cole & Wells 2013).

Selective Withdrawal

W2 is capable of modeling a temperature control tower with selective withdrawal features. The latest version also has the added capability of dynamic port selection; however, since this was not used for the calibration model, it will not be discussed here.

The Applegate Lake Water Temperature Control tower (WTC) has six intake structures: five water temperature control ports and one regulating outlet (RO) (USACE 1990). Figure 17 is an image of where each intake port is identified in the model control file.

Figure 17. Schematic representation of the water temperature control port elevations.



4 Model Calibration Results – CY01

Final calibration results are presented in this section. In all of the time series plots shown, a black solid line represents model output, a solid red circle or solid or dashed red line represents measured data. Three statistics are also presented in the charts: mean error (ME), absolute mean error (AME), and root mean square error (RMSE). These statistics are calculated as shown in Equations 1-3. The model was output every day as a daily average; when making time series comparisons to the observed data, a tolerance of 0.5 days was used for the model output so that model output and measured data were compared spatially and temporally with minimal averaging. A tolerance of 7 days was used for the model output when making profile plot comparisons. In both of the cases with the tolerance as selected, the statistical comparison is a one-to-one comparison. The authors use the closest date and the closest depth for comparing values. The tolerances used also allowed enough spacing to avoid observed data averaging.

$$ME = \frac{\sum_{1}^{n}(model - data)}{n} \tag{1}$$

$$AME = \frac{\sum_{1}^{n}abs(model - data)}{n} \tag{2}$$

$$RMSE = \sqrt{\frac{\sum_{1}^{n}(model - data)^2}{n}} \tag{3}$$

Cumulative distribution plots are also presented in this section. For these plots, the solid black line represents model output and the dashed red line represents observed data. These plots are used to indicate how the model is behaving overall when compared to the observed values. For example, at high temperatures, the model over-/underpredicts temperature by XX deg-F, where XX represents the AME value. Scatter plots are also presented to give a statistical representation of how the model is behaving.

A general rule of thumb for water quality calibration is that the absolute mean error should be within 10% of the range of monitored data (Scott Wells)[1], temperature AME should be within 1 deg-C (~1.8 deg-F), and elevations should be within 0.5 m (1.64 ft). Equation 4 is the equation used to calculate the target values for AME. These target values were calculated for each calendar year and will be presented in tabular form in the following sections. Units for these targets are consistent with the minimum and maximum values for each constituent. For example, for flow, the minimum, maximum, the AME, and 10% target are presented in cubic feet per second.

Target = 0.10((maximum observed value) – (minimum observed value))* (4)

Flow

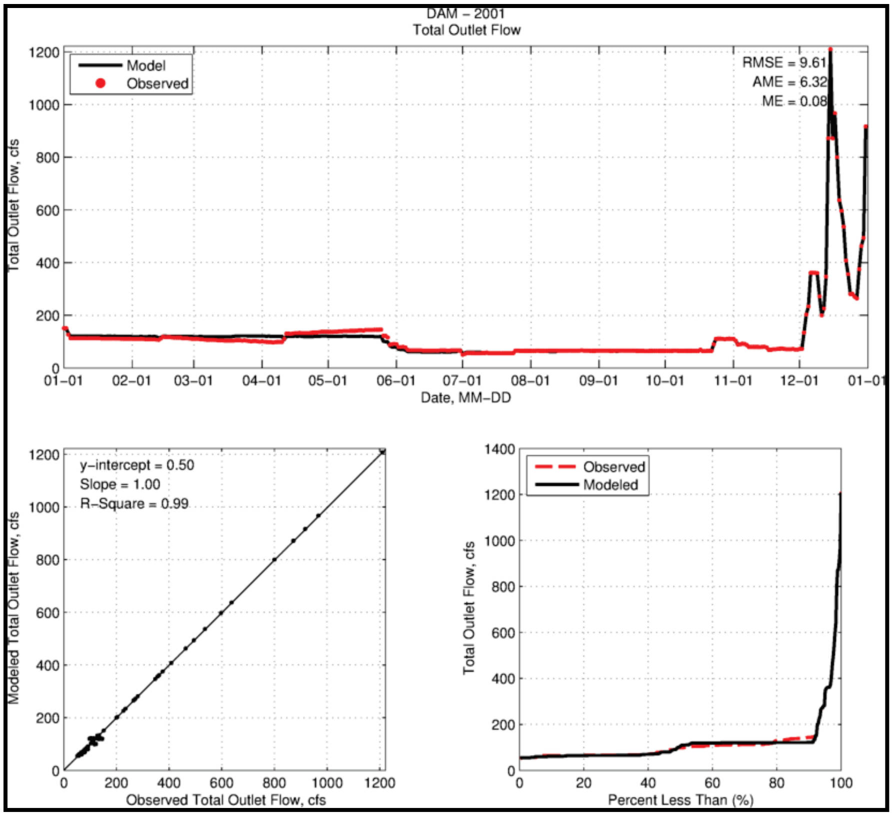
Since the model upstream boundary condition segment often changes based on the reservoir volume, the ERDC cannot produce flow plots to verify that the upstream boundary condition for flow is satisfied. Model output along with observed data for CY01 at the dam is shown in Figure 18. Note that this is really just a representation that the data are being read in correctly from the input outflow file. The AME for all data pairs for 2001 at the dam is 6.32 cfs, which is well less than 1.0% of the measured range of flows the calendar year. Table 4 presents several basic stats for flow. Based on Figure 18, the slope of the trendline fitted through the data pairs is 1.00 and the R-squared value is 0.99. Overall, the model only overpredicts outflow at the dam by 0.08 cfs.

Table 4. Basic statistics for flow (cfs) for CY01 calibration.

SITE	Observed Minimum	Observed Maximum	AME	ME	Slope	R-Squared
Dam	51.00	1210.00	6.32	0.08	1.00	0.99

[1] Wells, Scott. 2008. Personal communication with Tammy Threadgill. June 15. CE-QUAL-W2 Workshop, Portland, OR

Figure 18. Withdrawal flow at the dam for CY01 calibration.



Temperature

The best hope in correctly predicting the outflow temperature is to correctly predict the in-lake temperature profiles at various locations in the reservoir. If the temperature profiles are not satisfactory, the chance of correctly predicting total outflow temperature is highly unlikely. Profile plots and statistical plots for all in-lake monitoring sites are presented in Figure 19-Figure 24. (Figure 3 shows the location of each of these sites.) A time series plot and statistical plots are presented for the dam in Figure 25. The average AME for each of the in-lake sites are within the acceptable target. Table 5 presents the calculated AME and the temperature target that ERDC attempted to reach for the in-lake sites and for the outflow temperature at the dam. Based on Figure 22-Figure 24, the average slope of the trendlines is 0.97 and the R-squared value is 0.95 for the in-lake sites. At the dam, the AME is 0.69 deg-C with a slope of 1.03 and an R-squared value of 0.99 (see Figure 25).

Table 5. Basic statistics for temperature (deg-C) for CY01 calibration.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
APP20001 (CY AVG)	7.83	24.54	1.00	0.80	0.52	0.88	0.93
APP20002 (CY AVG)	10.29	25.44	1.00	0.57	-0.23	0.95	0.96
APP20003 (CY AVG)	19.14	22.13	1.00	0.29	0.19	1.08	0.96
Dam (Outflow)	4.20	19.80	1.00	0.70	-0.52	1.03	0.99

Figure 19. Temperature profiles at APP20001 in CY01 calibration.

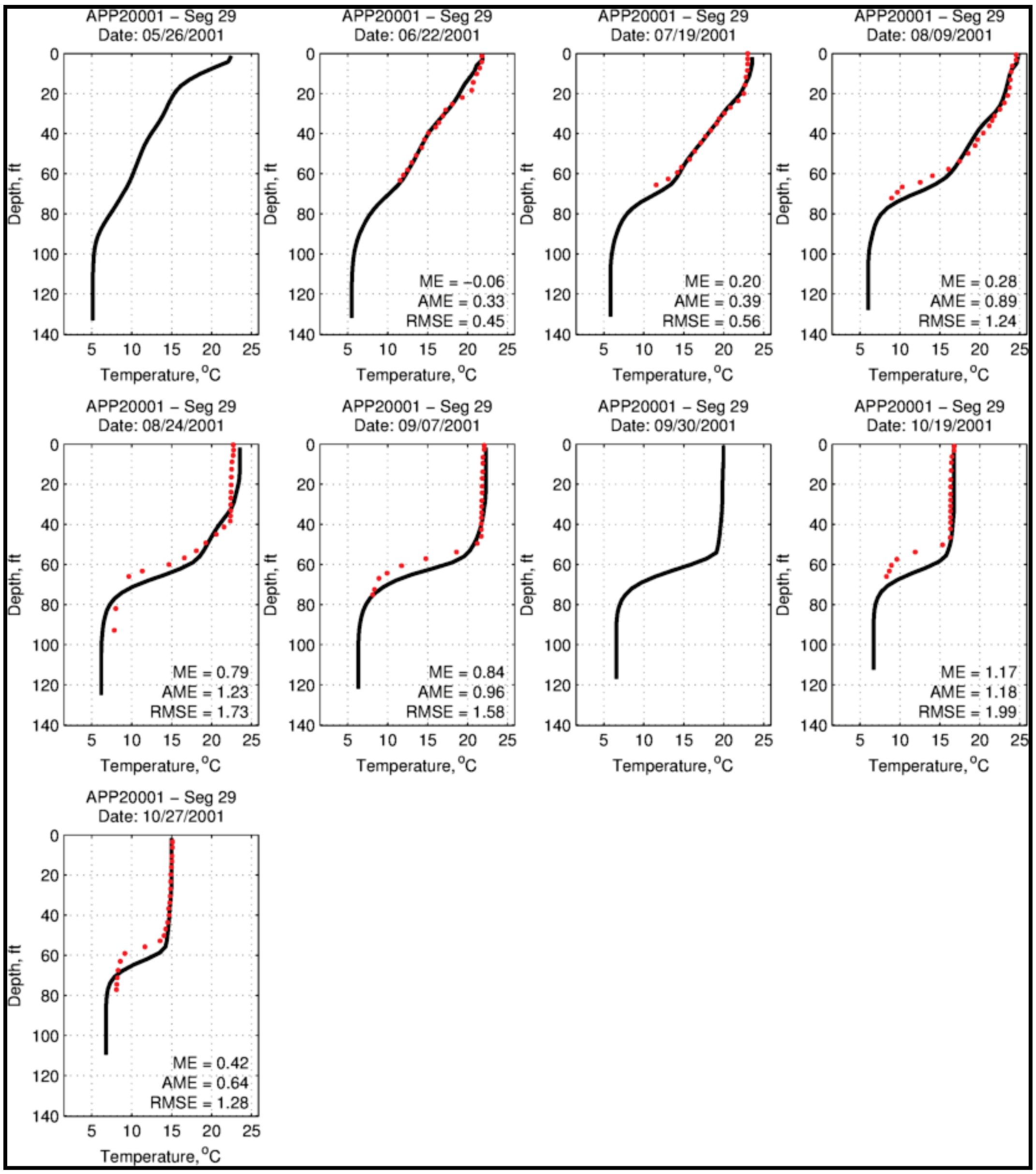


Figure 20. Temperature profiles at APP20002 in CY01 calibration.

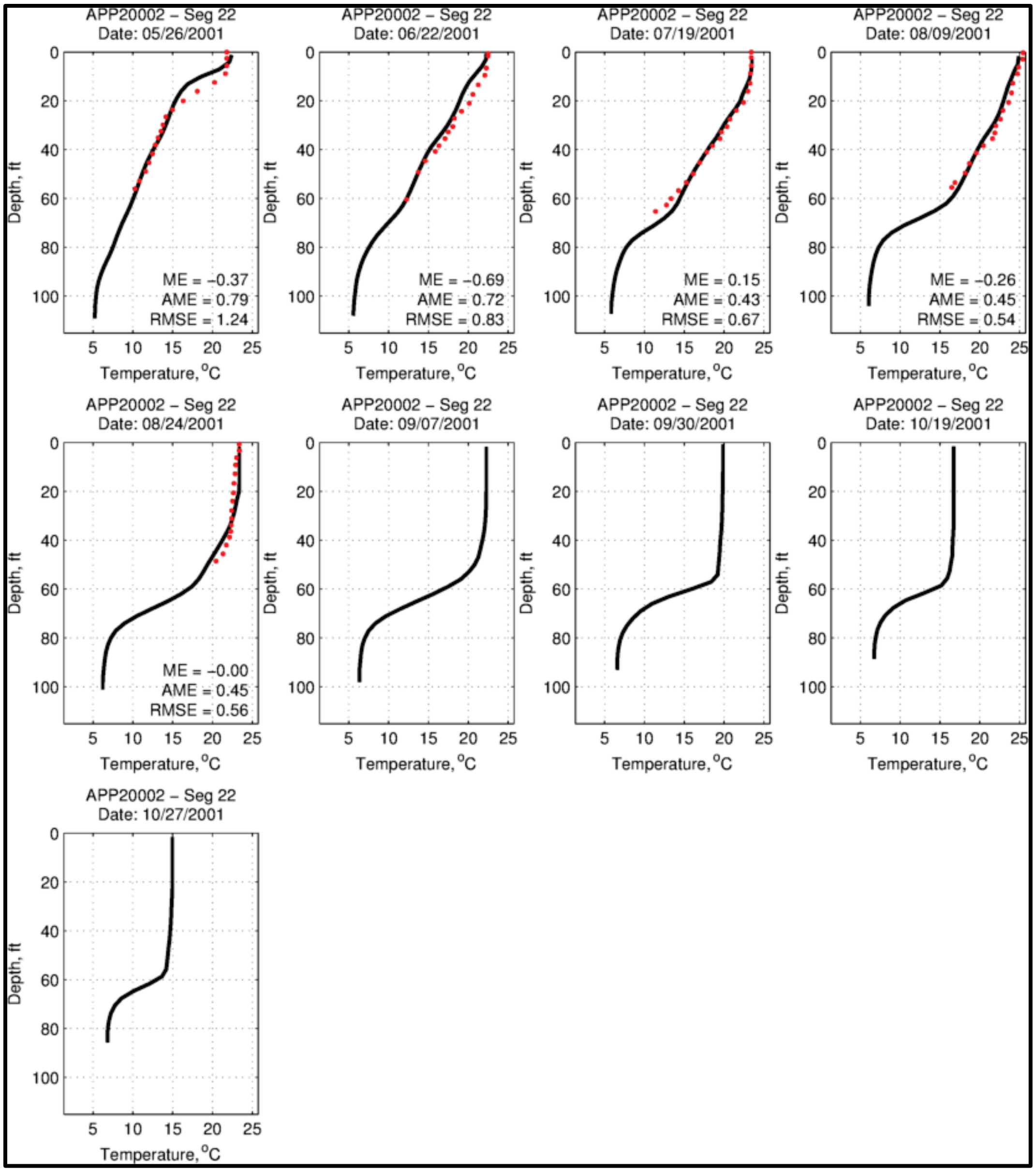


Figure 21. Temperature profiles at APP20003 in CY01 calibration.

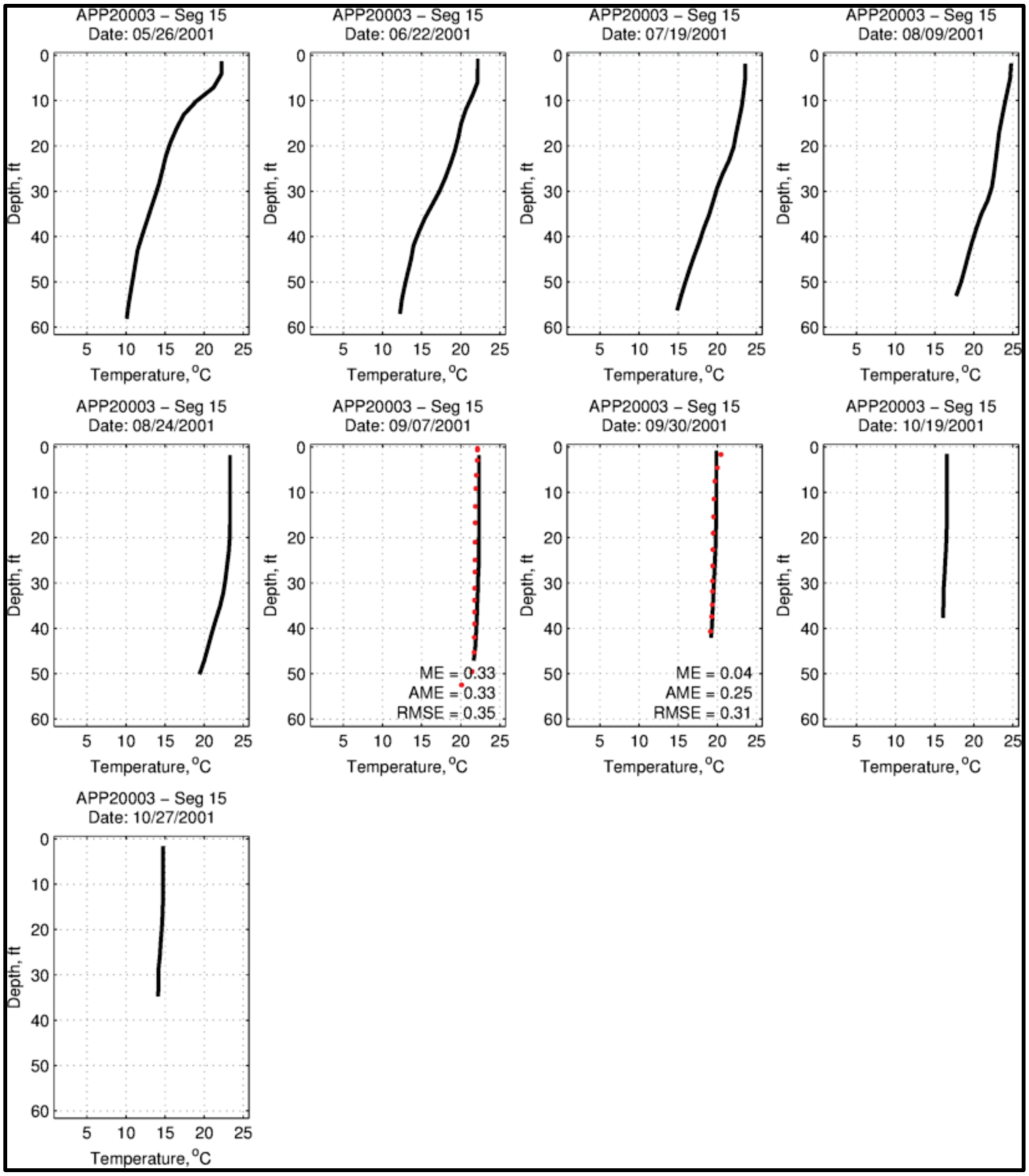


Figure 22. Flow linear and cumulative distribution plots at APP20001 for CY01 calibration.

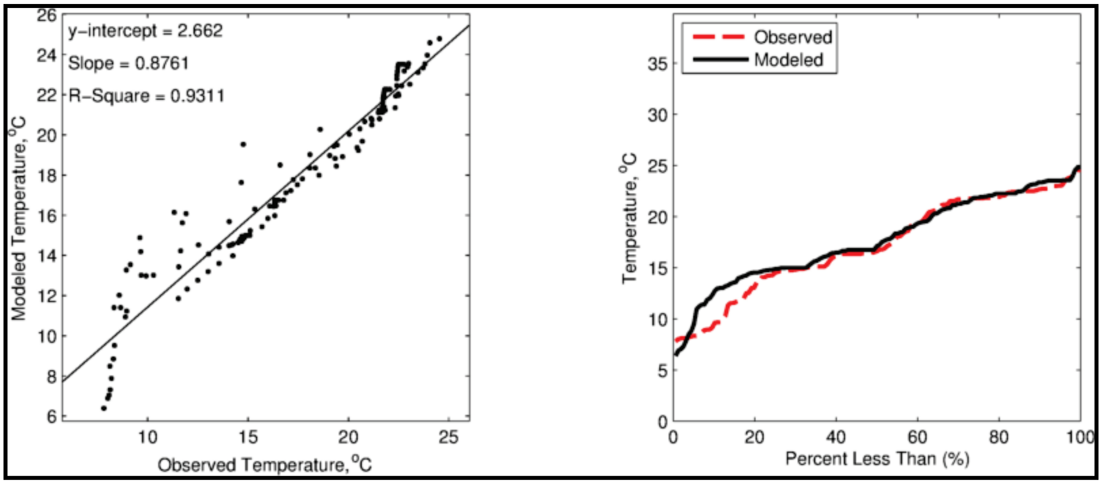


Figure 23. Flow linear and cumulative distribution plots at APP20002 for CY01 calibration.

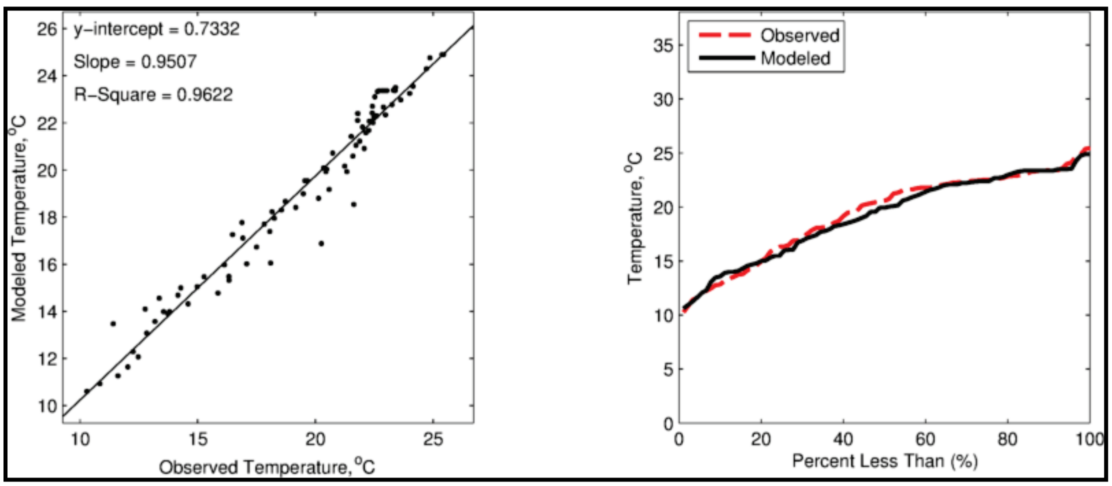


Figure 24. Flow linear and cumulative distribution plots at APP20003 for CY01 calibration.

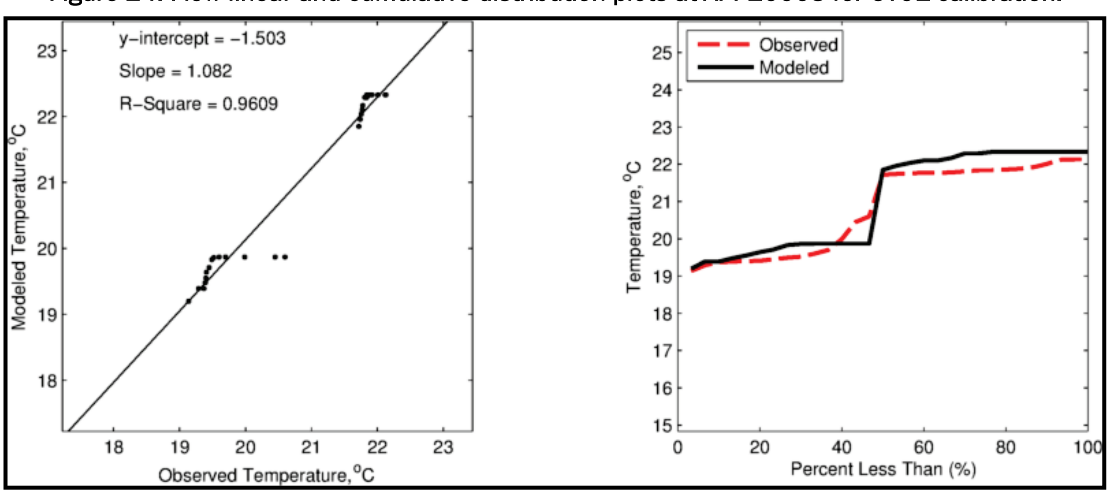
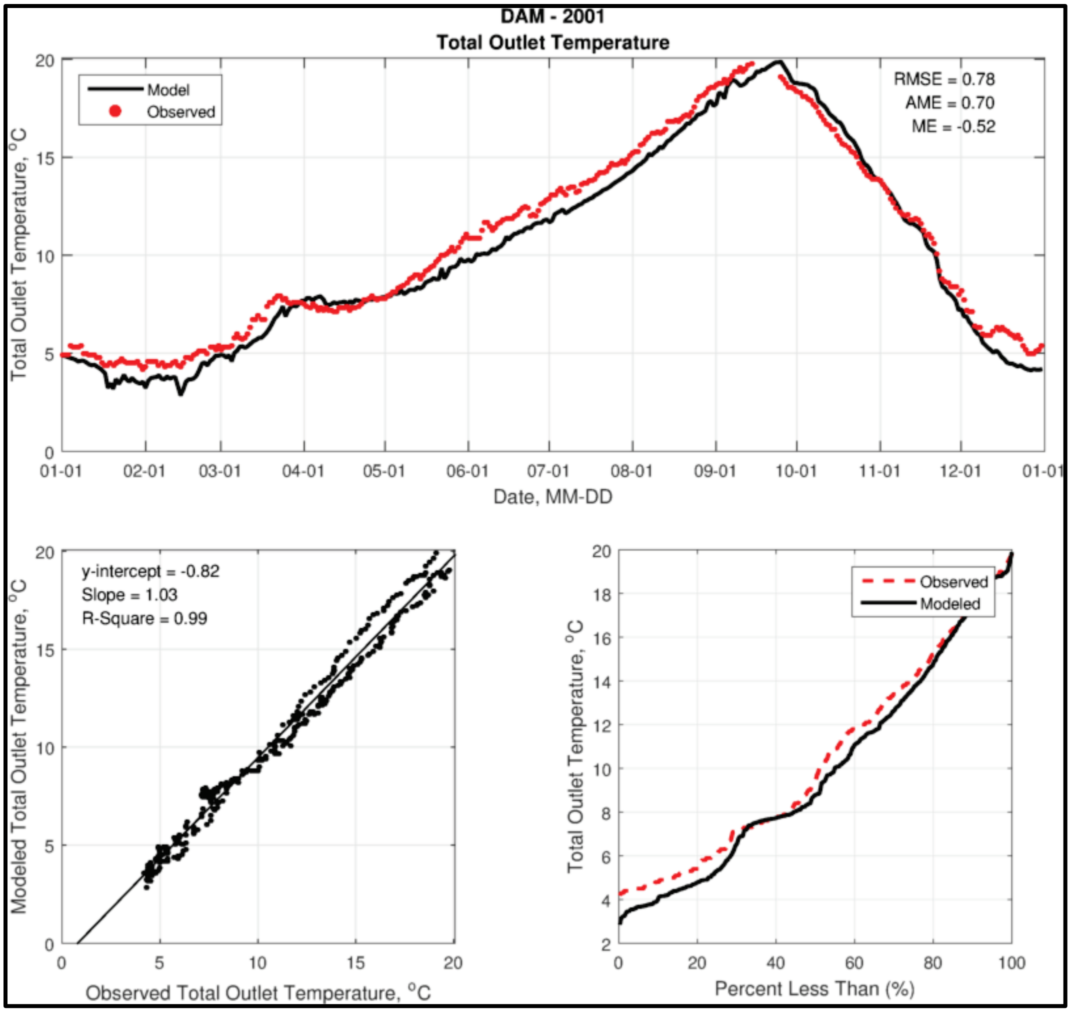


Figure 25. Withdrawal temperature at the dam for CY01 calibration.



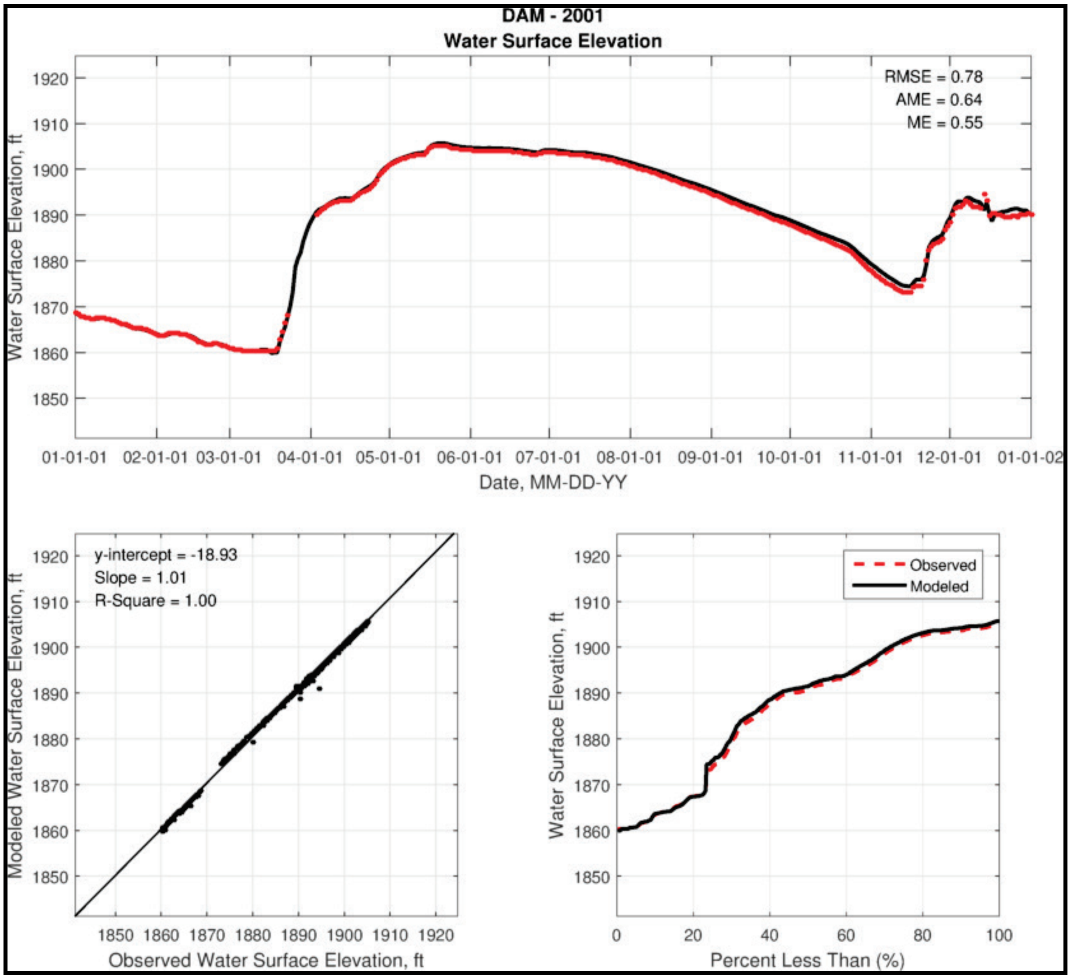
Water Surface Elevation

Model output along with observed data for water surface elevations (ELWS) in CY01 at the dam is shown in Figure 26. The AME for all data pairs for 2001 at the dam is 0.64 ft (~0.20 m). Table 6 presents the basic statistics for observed water surface elevation at the dam. The slope of the trendline fitted through the data pairs is 1.01 and the R-squared value is 1.0. Overall, the model only overpredicts ELWS at the dam by 0.55 ft.

Table 6. Basic statistics for water surface elevations (ft) for CY01 calibration.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
Dam	1860.35	1905.23	4.49	0.64	0.55	1.01	1.00

Figure 26. Water surface elevations at the dam for CY01 calibration.



5 Calibration Discussion

Model calibration results and all model assumptions are discussed in this section. As stated previously, not only does this report detail graphical comparison, but the authors also present several statistical comparisons: AME, RMSE, and ME. Both the flow results and the temperature results will be discussed below.

Water Surface Elevation

As stated previously, due to the water balance instabilities in the model, a distributed tributary was added to the calibration run. This drastically improved the initial results. Figure 27 shows the impact of not using distributed tributary. Notice how the model severely underestimates the water surface elevation for ten months out of the year. By the end of the year, the model needs almost 8 ft of unaccounted for water. Once the distributed tributary was added, and before any other parameters were modified, there was definitely an improvement to the results (see Figure 28).

Temperature

Initially, before the water balance issues were corrected, the model was drastically miscalculating the temperature. However, once the distributed tributary was added, the model was still overpredicting the temperature (CY01-Run02). Upon observing the in-lake profile plots, the surface temperature was too warm. The ERDC performed two more successive simulations with the following changes:

1. Decreased the shading coefficient from 1.0 to 0.85. Due to the fact that the lake is located in a valley, the ERDC has decided to reduce the amount of short wave radiation actually reaching the surface. This improved the results of the thermocline location in the profile plots at the in-lake sites. (CY01-Run07)
2. Changed EXH20 from 0.55 to 0.45 in order to decrease the amount of heat retained at the surface instead of letting the heat descend into the water column. Next, the team changed BETA from 0.55 to 0.45. BETA is similar to EXH20 in that it also helps to retain more heat surface. These changes had a very small positive impact on model temperature predictions. These

values are the recommended values set in the W2 manual; however, given the fact that in the Lost Creek Lake Model, these values needed to be increased, the ERDC originally decided to leave the higher values. (CY01-Run08)

Figure 27. Time series and statistical plots of ELWS without the distributed tributary.

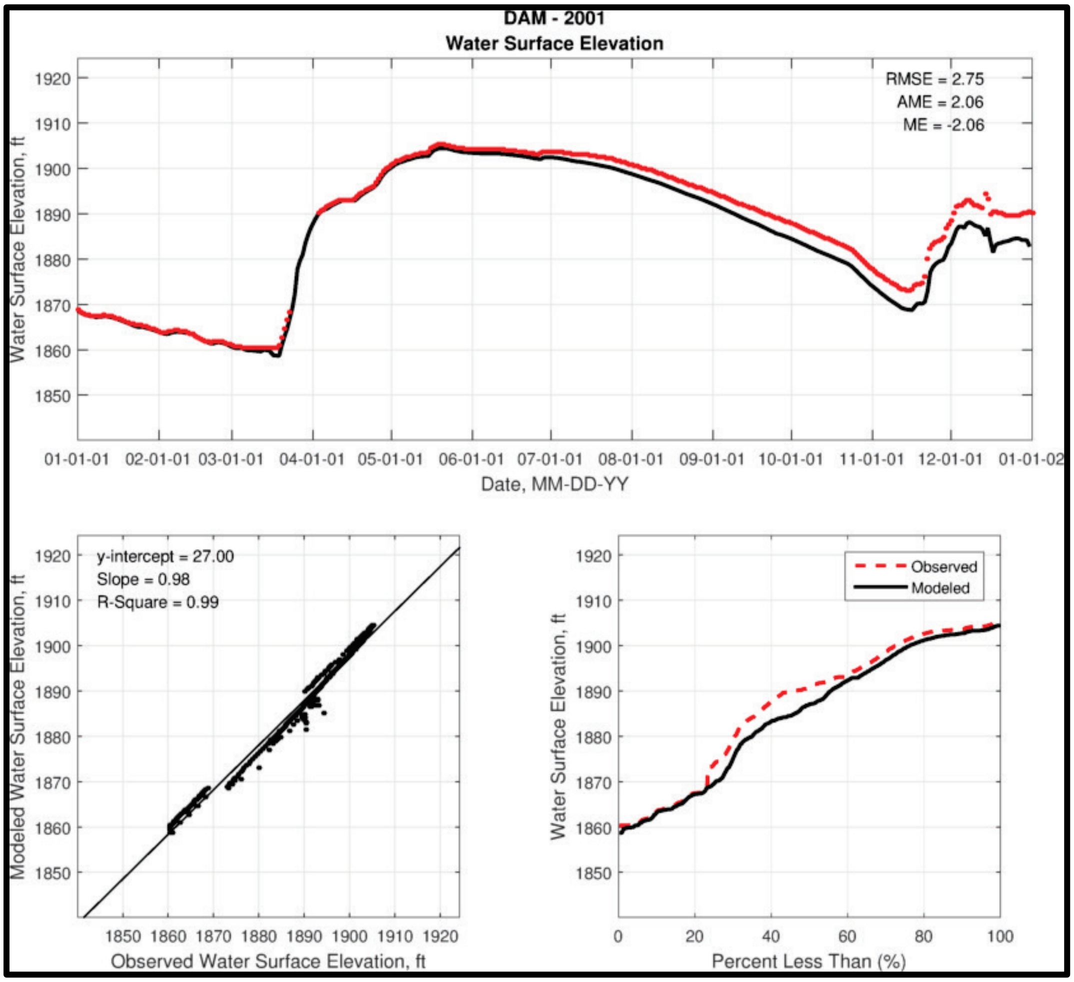
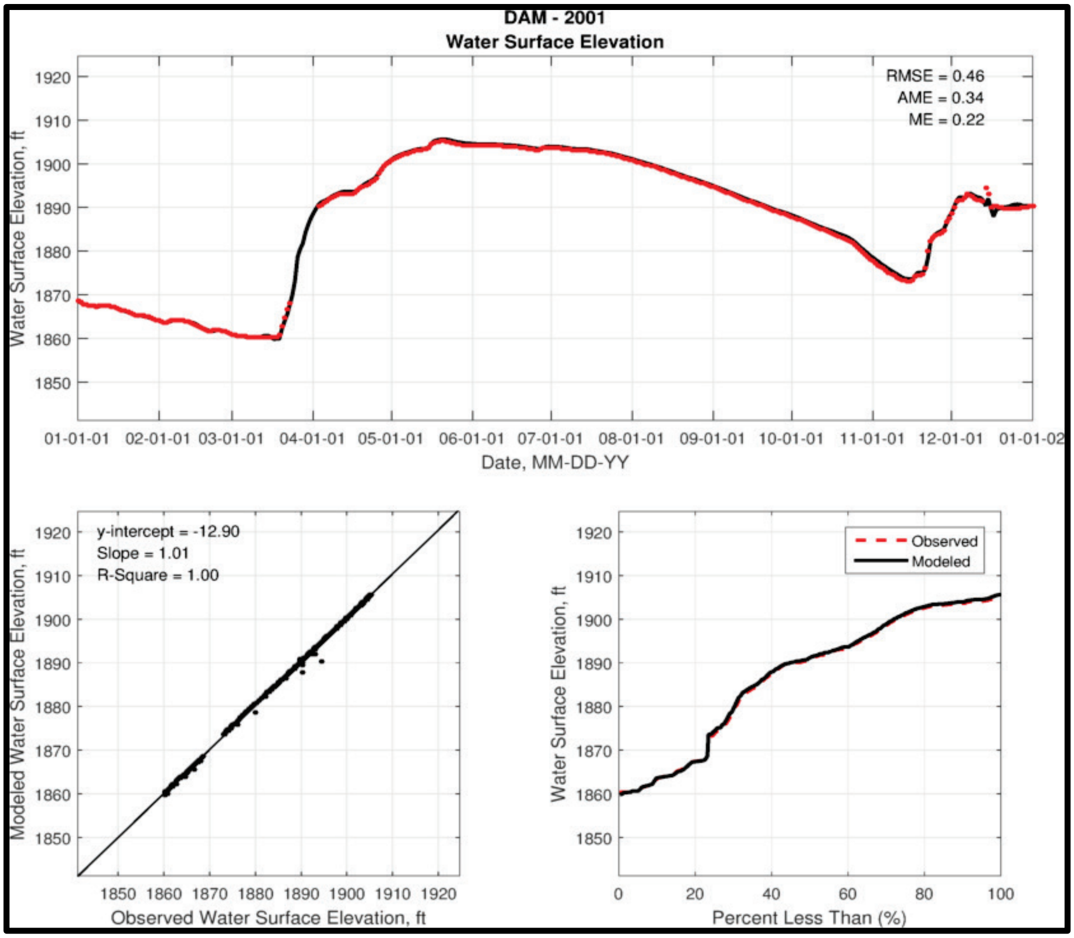


Figure 28: Time series and statistical plots of ELWS with the distributed tributary.



Temperature comparisons at the in-lake stations and the dam between each of the runs discussed above is seen in Figure 29-Figure 32. In all of the plots below, the red dots are observed data. The time series comparison is more indicative of the gains in temperature improvement with the above modifications than are the profile comparisons.

Figure 29. Profile comparison at APP20003.

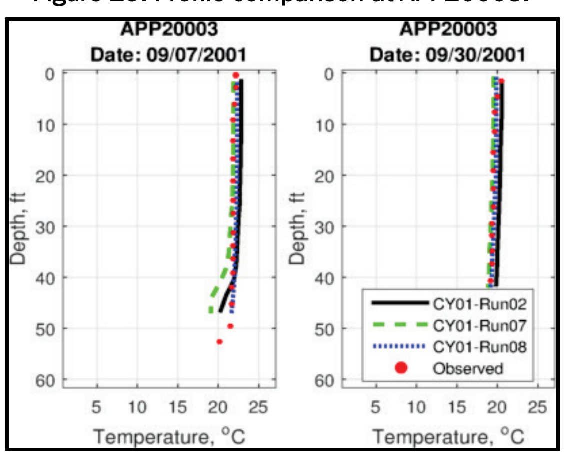


Figure 30. Profile comparison at APP20002.

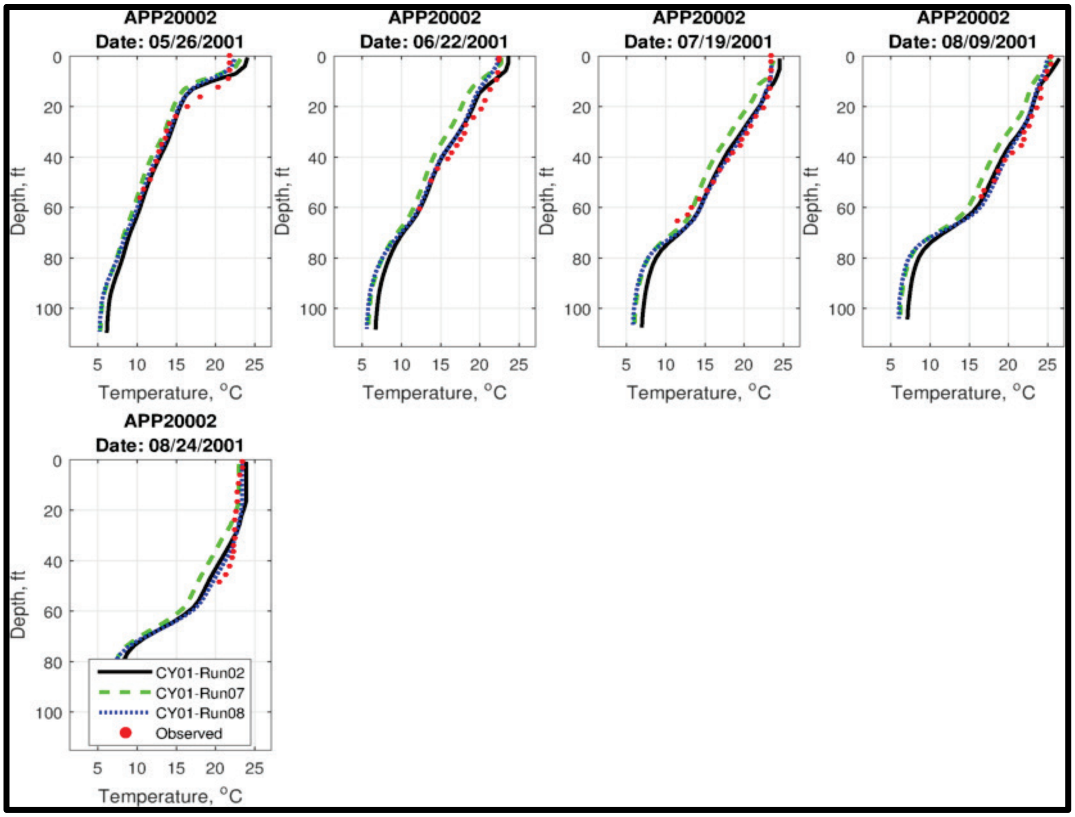


Figure 31. Profile comparison at APP20001.

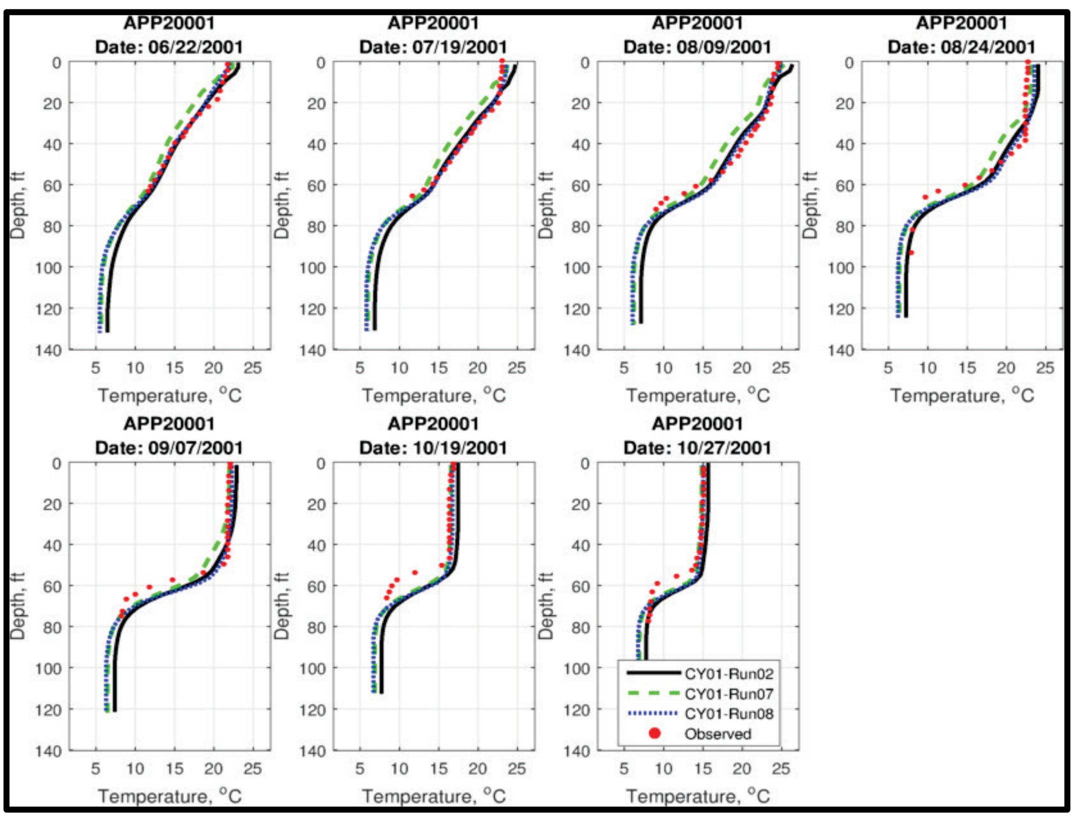
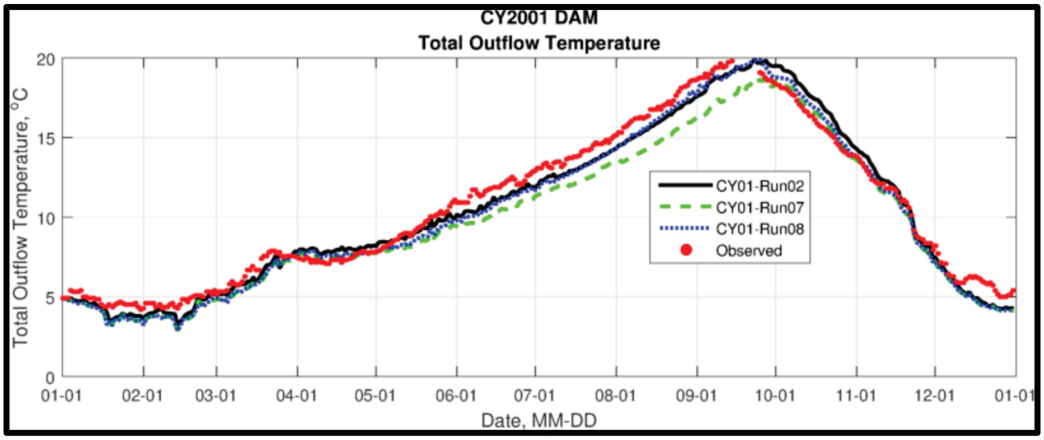


Figure 32. Time series comparison at the dam for CY01.



6 Model Verification Results – CY03 and CY10

Model verification results are presented in this section. CY03 and CY10 were used because they had the same types of monitored data and similar available in-lake profile data. All of the plots and statistics presented in this section were developed in an identical manner to those in the previous section.

Flow

Model output along with observed data for CY03 and CY10 at the dam is shown in Figure 33 and Figure 34. Again, this is really just a representation that the data are being read correctly from the input outflow file. The AME for all data pairs for CY03 and CY10 at the dam is 121.05 cfs and 124.65 cfs, respectively, which is well less than 5% of the measured range of flows for the calendar year. Table 7 presents the 5% target AME and the model versus observed data statistics.

Temperature

The data available for the verification years was a little different than in CY01. For CY03, only one sample date at all stations was available (August 22). For CY10, no true in-lake stations were monitored. In order to still provide feedback on in-lake temperatures, ERDC chose to use temperatures from selected dates available from the temperature string located at the dam (in place since 2006). It is important to note that the temperature string data was only available through May. The 15th day of Jan-May was chosen as representative for each month in CY10. Having plotted the observed data from the temperature string for CY10, the plots showed obvious problems with the gauge at elevations 1851 ft and 1791 ft (see Figure 39). These values were removed from the plot and the statistical comparison (Figure 40).

Table 7. 1% Target for flow (cfs) for CY03 verification.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
Dam - 2003	99.00	2520.00	121.05	25.44	-2.77	0.95	0.95
Dam - 2010	137.00	2630.00	124.65	14.26	3.07	1.00	0.99

Figure 33. Withdrawal flow at the dam for CY03 verification.

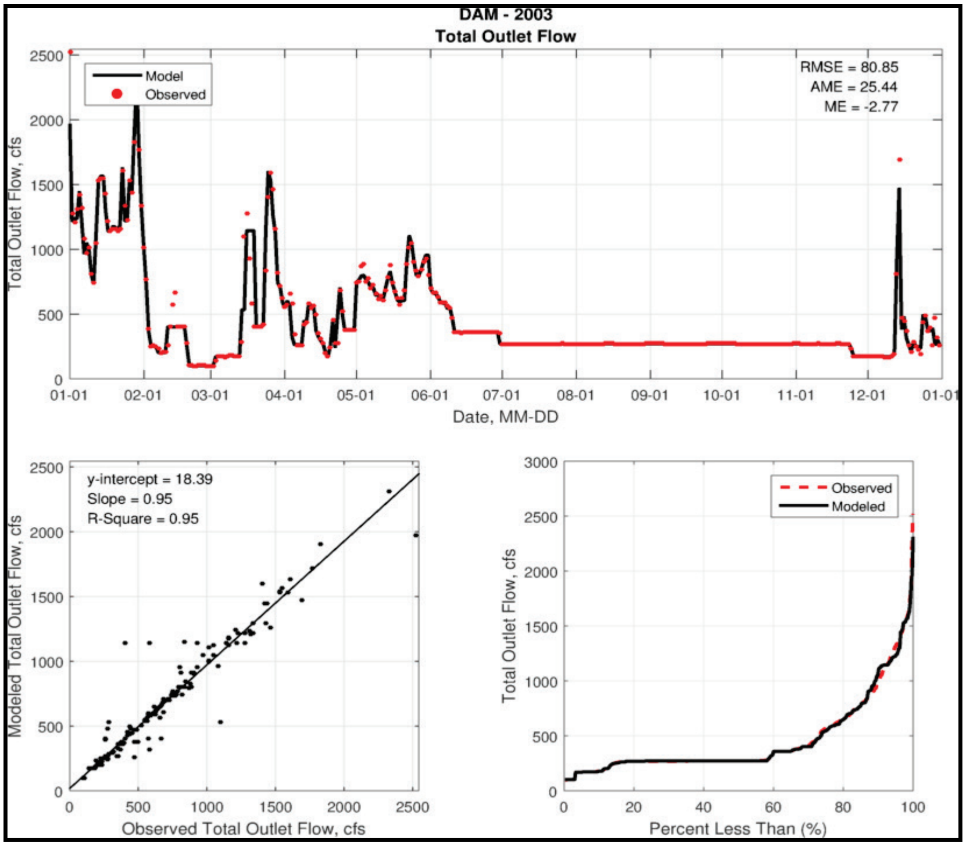
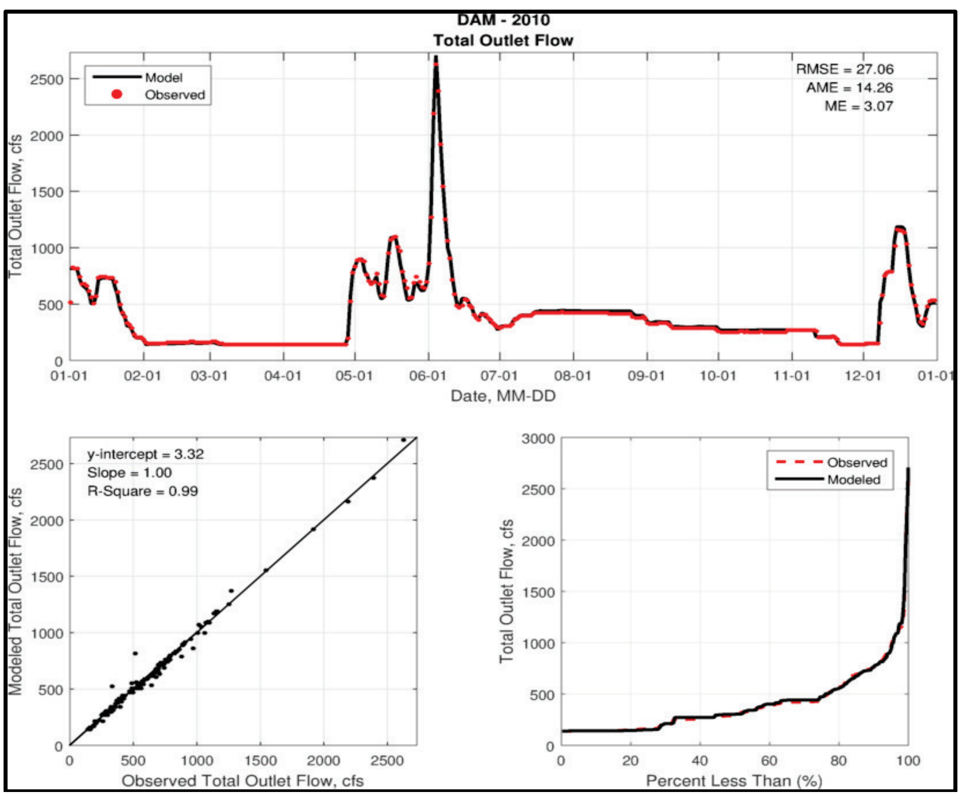


Figure 34. Withdrawal flow at the dam for CY10 verification.



Profile plots and statistical plots for all in-lake monitoring sites are presented in Figure 35-Figure 41. Time series plots and statistical plots are presented for the dam outflow in Figure 42 (CY03) and Figure 43 (CY10). Table 8 presents the calculated AME and the temperature target that ERDC attempted to reach along with comparison statistics for the in-lake sites and for the outflow temperature at the dam. The average AME for all of the in-lake sites are within the acceptable target of 1 deg-C. And the statistical values are within typically accepted ranges. At the outlet, our best comparison site, the temperature AME is 0.80 deg-C and 0.88 deg-C for CY03 and CY10, respectively (see Figure 42 and Figure 43). The model underpredicts temperature by an average of approximately 0.36 deg-C at the dam.

Table 8. Temperature stats (deg-C) for verification years.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	SLOPE	R-squared
APP20003 (CY03)	7.34	23.91	1.00	0.37	-0.01	1.05	0.99
APP20002 (CY03)	7.18	24.12	1.00	0.53	0.20	1.03	0.99
APP20001 (CY03)	7.02	23.81	1.00	0.63	-0.02	1.05	0.99
Dam Temp. String (CY10 AVG)	4.83	12.92	1.00	0.63	-0.01	1.20	0.88
Dam – Outflow Temp (CY03)	4.86	15.60	1.00	0.80	-0.35	1.09	0.96
Dam – Outflow Temp (CY10)	4.50	14.50	1.00	0.88	-0.39	1.02	0.90

Figure 35. Temperature profiles at in-lake stations in CY03 verification.

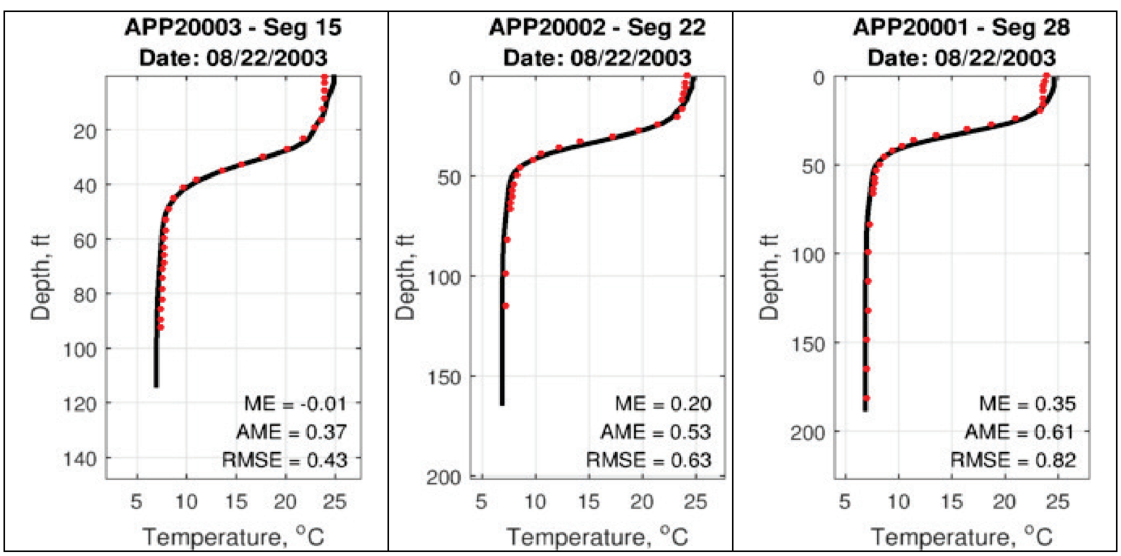


Figure 36. Flow linear and cumulative distribution plots at APP20003 for CY03 verification.

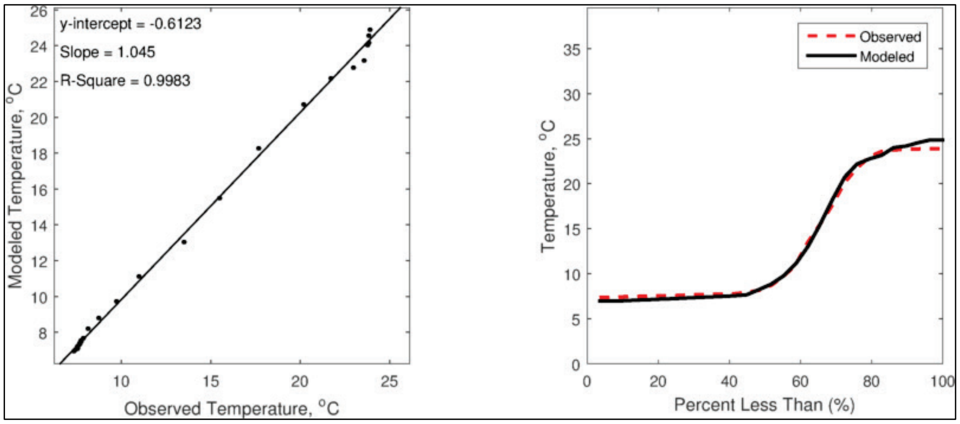


Figure 37. Flow linear and cumulative distribution plots at APP20002 for CY03 verification.

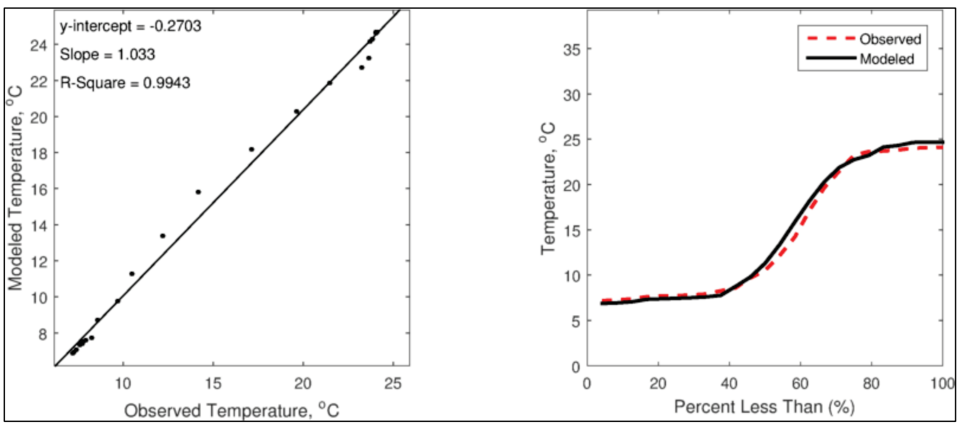


Figure 38. Flow linear and cumulative distribution plots at APP20001 for CY03 verification.

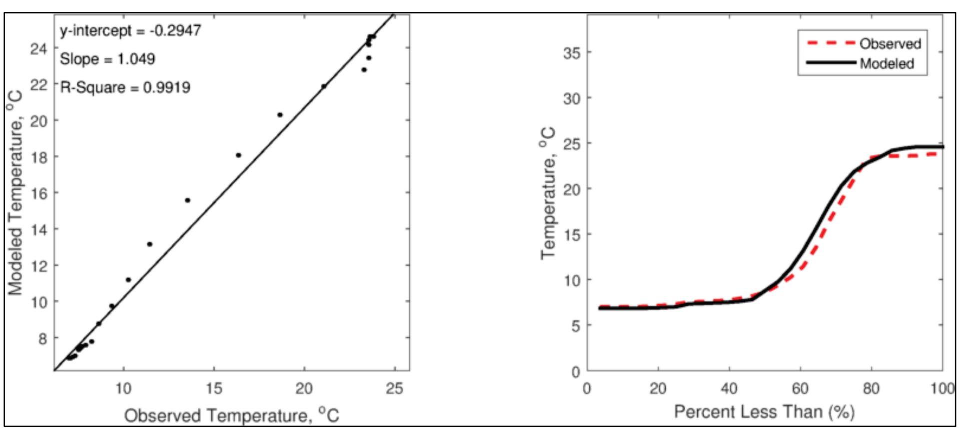


Figure 39. Temperature profiles at the dam temperature string in CY10 verification – with bad observation values.

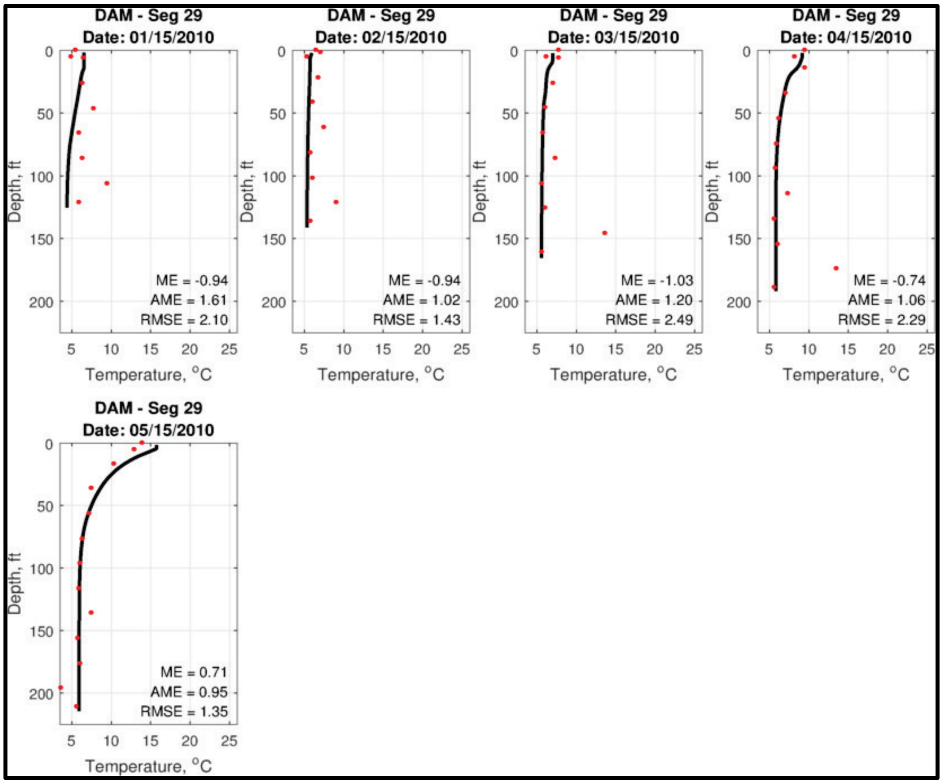


Figure 40. Temperature profiles at the dam temperature string in CY10 verification.

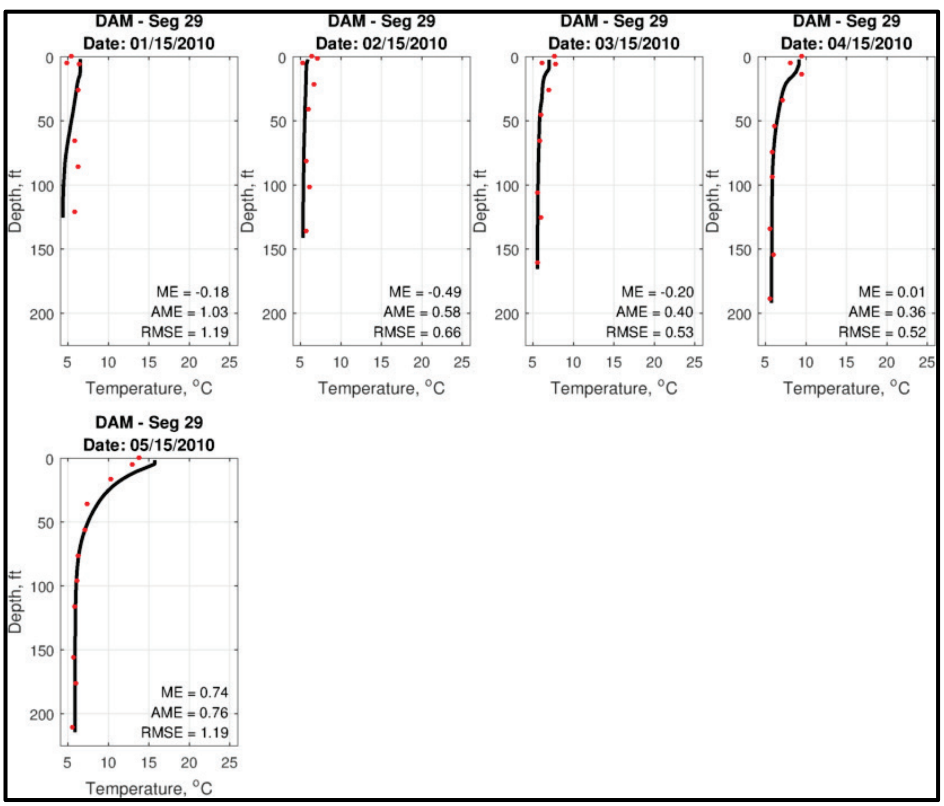


Figure 41. Flow linear and cumulative distribution plots at the dam temperature string for CY10 verification.

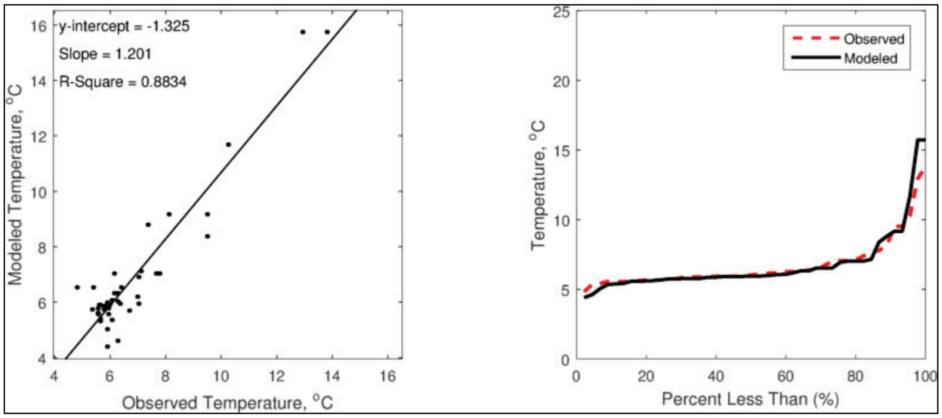


Figure 42. Withdrawal temperature at the dam for CY03 verification.

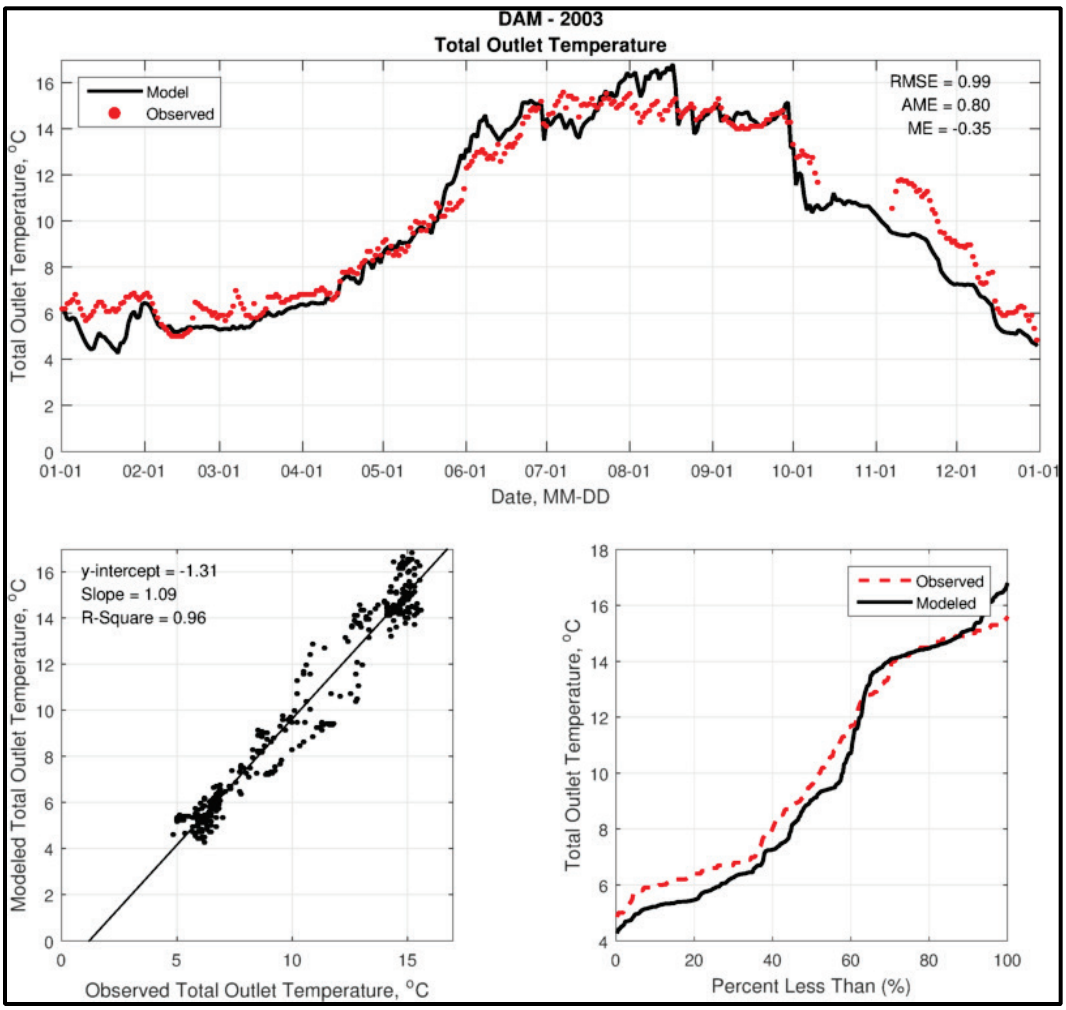
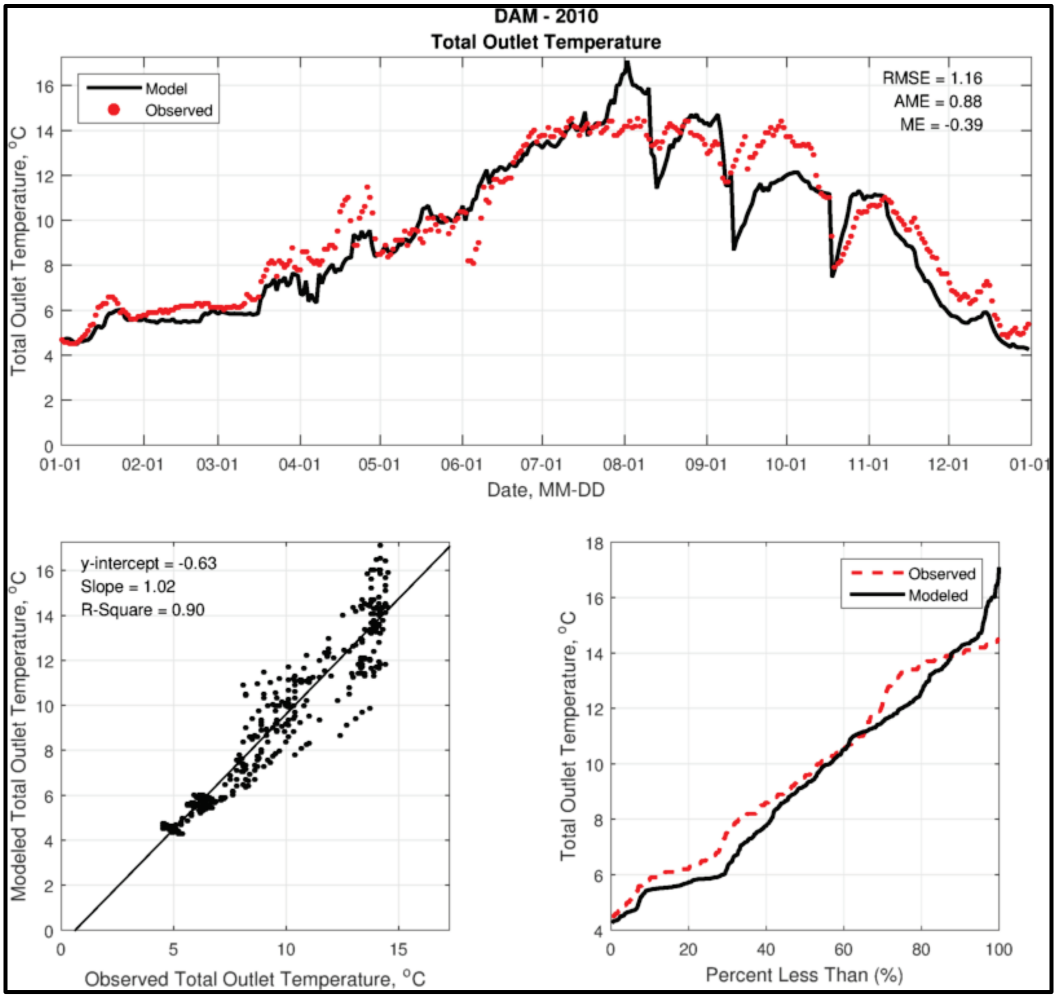


Figure 43. Withdrawal temperature at the dam for CY10 verification.



Water Surface Elevation

Model output along with observed data for ELWS CY03 at the dam is shown in Figure 44 and in Figure 45 for CY10. Table 9 presents several stats and lists the target AME for each verification year. In general, the ELWS AME should be within 0.5 m (1.64 ft).

Table 9. Basic statistics water surface elevations (ft) for CY03 verification.

SITE	Observed Minimum	Observed Maximum	Target AME	AME	ME	Slope	R-Squared
Dam (CY03)	1882.89	1987.06	1.64	0.84	0.59	1.00	1.00
Dam (CY10)	1882.18	1986.97	1.64	1.10	-0.07	0.98	1.00

Figure 44. Water surface elevations at the dam for CY03 verification.

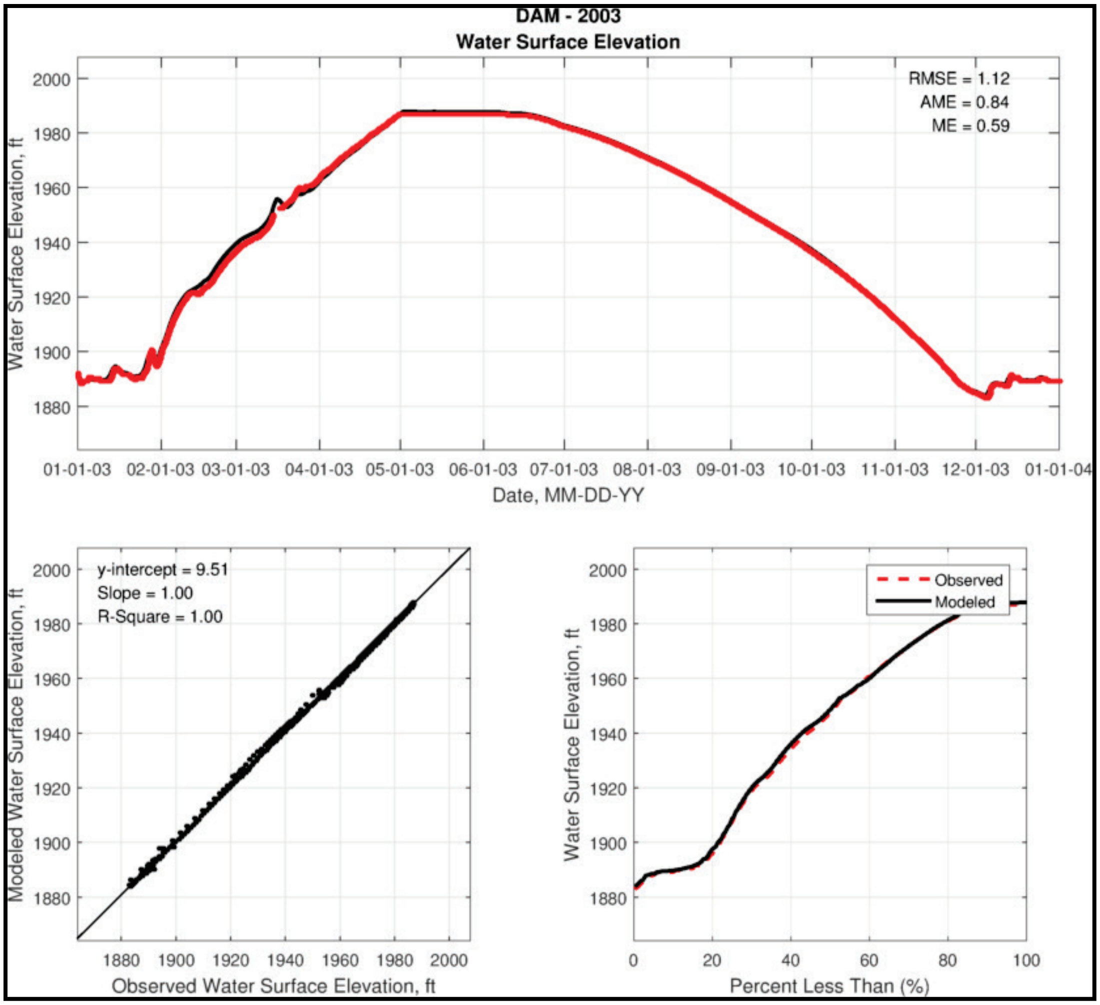
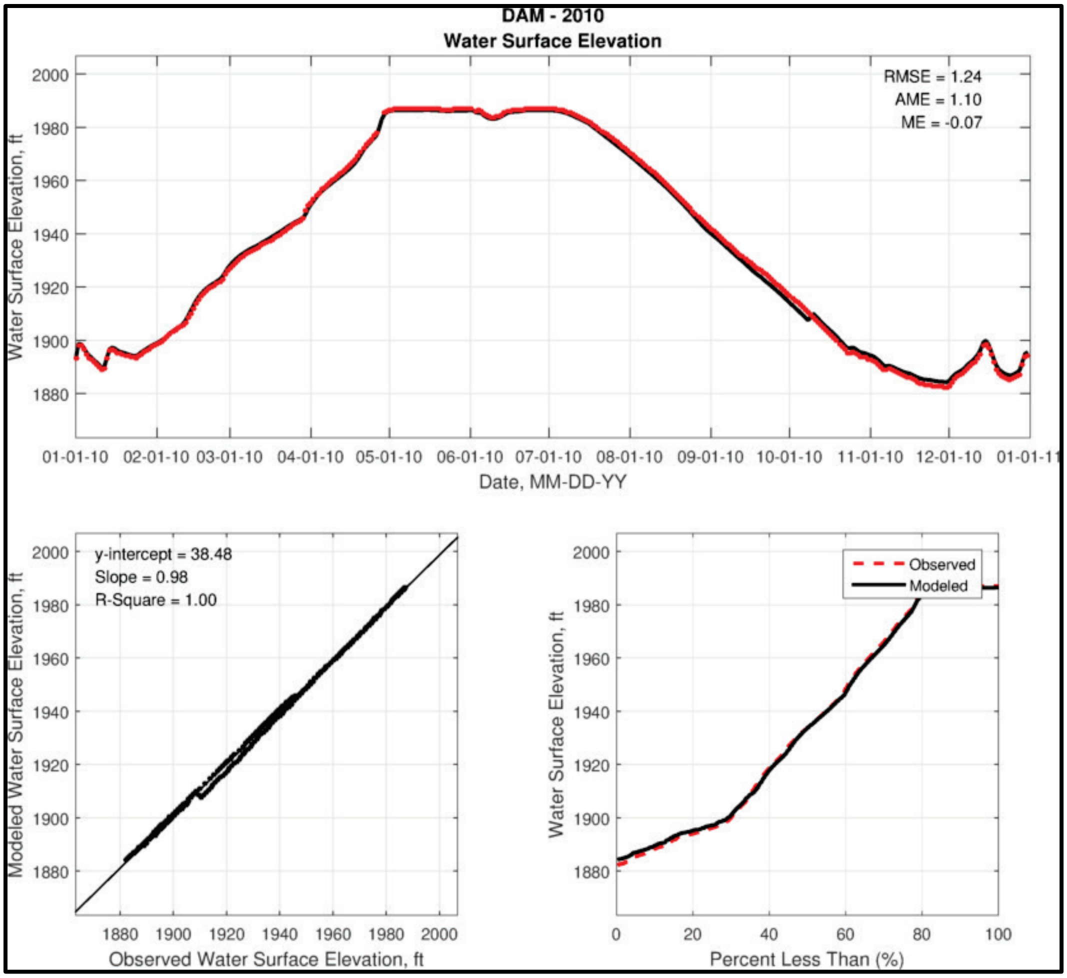


Figure 45. Water surface elevations at the dam for CY10 verification.



7 Verification Discussion

This section serves to discuss the results and the impacts that changes have made on the model runs. Just as with the Lost Creek Lake Model, no changes were made to the control file for either verification year. Just as for CY01, a distributed tributary was needed for both calendar years. As stated previously (see Section 3, Tributaries), a distributed tributary is utilized in W2 when there is an inconsistent trend with the water balance and when the user can account for missing or too much flow (i.e., ungauged flows). It can be used to add or remove water from the system. In the case of the APPLM, a distributed tributary was used to add water to the system. Refer to Figure 10 for the flows added to the system for CY03 and CY10.

8 Predictive Port Selection Model Application

In order to provide NWP with the best model to use for operation modifications, the calibrated model was used as a base run to set up a fully predictive model in which the model will guide dam operations based on desired temperature targets. The temperature target presented is the bi-weekly target developed by Oregon Department of Fish and Wildlife for 2014 operations. Based on results from the Lost Creek Lake Model (Threadgill et al. 2015), the ERDC-EL chose to only focus on the USGS version of the W2 model. An inventory of all files used for each model simulation can be found in Appendix B (Table B3).

USGS – W2 Predictive Port Selection

Detailed information on the development and modifications to the original W2 code can be found in "Improved Algorithms in the CE–QUAL–W2 Water-Quality Model for Blending Dam Releases to Meet Downstream Water-Temperature Targets" (Rounds and Buccola 2015). Specifics relating to setup of the Applegate Lake Predictive Model (APPLPM) will be discussed here. The USGS code uses an iterative process to determine the optimal flows that will produce the desired target temperatures. Of course, this means that the run time will also increase. In the case of the APPLPM, using this code tripled the run time (from about 3-5 minutes to 10-12 minutes).

Just as with the LCLPM, There were no changes to the main control file from the calibration model (aside from output filename changes). All completed changes were made in the w2_selective.npt file, which is required when the SELECTC card in the control file is turned ON. Although the structure of the w2_selective.npt file is very similar to the PSU version, there are several new options. The new cards, not discussed in detail here, are:

1. NOUTS: For two different periods throughout the year, when total flow is less than 100 cfs, the RO is nonoperational. To specify this, NOUTS during these periods was set to 5. The specified period(s) vary between different years. The time intervals used for each year can be seen in Table 10.

Table 10. Intervals when RO is nonoperational.

YEAR – TYPE	TSTR	TEND
2001 - DRY	100.1	335
2003 – AVERAGE	32.1	115.0
	325.1	340.0
2010 – WET	51.1	74.0
	329.1	346.0

2. TSSHARE: For the APPLPM, this was set to OFF. DEPTH: For the APPLPM, DEPTH was set to 0 since Applegate Dam consists of fixed ports.
3. MINFRAC: For the APPLPM, this was set to -2.832 cms for the RO only. The negative sign indicates that this an actual flow value instead of a percentage. This specification is made due to the minimum gate opening requirement for the RO. The minimum opening is 0.6 ft; although the exact flow will vary based on elevation, at a minimum, flow will be 100 cfs at the lowest elevations.
4. PRIORITY: During various times of the year, NWP operates to use more surface water sometimes and at other times, the cold lower waters are used. Consequently, for the fall and winter months, the priority was shifted to the RO. Outside of that the period, priority was set to so that Intakes 1, 3, and 5 had the highest priority, and Intakes 2, 4, and 6 had the lowest priority.
5. MINHEAD: For the APPLPM, this was set to 2.0 m. There is about a 6 ft minimum head according to the WCM.
6. MAXHEAD: For the APPLPM, this was set to 0.0 for the top 5 intakes. For the bottom intake, the RO, the MAXHEAD was set to 34.0 m. This requires the elevation to be a conservation pool level before the RO is operational.
7. MAXFLOW: For the APPLPM, this was set to 0.0.

In the APPLPM w2_selective.npt file, the user will find that three split times were identified. The reason these dates were identified is due to operational constraints with seasonal withdrawal depths. Specifying it this way allowed ERDC-EL to set the PRIORITY based on which ports were desired. In addition to the w2_selective.npt file, because DYNSEL = ON for each split, the user is required to have an additional file that identifies the target temperatures specified by Julian day.

As stated above, only the RO had a MAXHEAD value specified. Due to operational constraints, the RO must be closed or open no less than 0.6 ft, so it cannot be operated unless the total flow is greater than 100 cfs (2.832 cms). Even with the additional USGS cards, there is no card to directly specify this requirement. What specifying this MAXHEAD condition does for the model is that if the reservoir is more than 34.0 m above the RO, the RO will not be used; in other words, the RO will typically be used when the reservoir is at the lower elevations. Based on the time constraints previously set, the RO has the lowest priority during the spring and summer already; so setting the MAXHEAD stipulation also adds an additional check on the water depth. For the most part, at Applegate Lake, the RO is not used frequently. In addition to this MAXHEAD constraint, the time intervals during which the RO is allowed to be operational varies with each year.

The user should note that in all of the following plots, the red lines represent a temperature target range. The ODFW targets are used for determining the target; however, what is represented on the following plots is a target range, which is the ODFW temperature target +/- 1 deg-C, which is a standard measuring error for temperature.

Figure 46 and Figure 47 is the w2_selective.npt file and the dynsplit_selectiveX.npt file, respectively, used for all of the APPLPM model runs. In Figure 48-Figure 80, the black line/dots represent the results from the calibration run, and the green line/dots represent the results from the predictive mode run. Figure 48-Figure 54 are plots from CY01 (dry year); they compare the results from the calibration and the results from the USGS-W2 blending algorithm. It is important to note that at no time in the calibration model were Intakes 1-4 active; during the predictive model mode, Intakes 4-6 were active, however. Figure 55-Figure 67 represent the same plots for CY03 (normal year), and Figure 68-Figure 80 represent CY10 (wet year). Figure 81 shows the average percentage of model-predicted temperatures that fall within the desired target range. As one can see, the USGS Port Prediction algorithm produces better results more often than the calibration using the gate settings observed flow data.

Figure 46. W2_Selective.NPT file used for the APPLPM for CY10.

```
W2_SELECTIVE.NPT

Selective input control file - ALMP-CY10-USGS-PortRun11
Temperature outlet control - frequency of output for temperature
OUT FREQ TFRQTMP
           1.000
Structure outlet control based on time and temperature and branch
DYNSTR1  CONTROL     NUM    FREO
             OFF       1    0.50

DYNSTR2    ST/WD      JB   JS/NW  YEARLY    TSTR    TEND    TEMP   NELEV   ELEV1   ELEV2   ELEV3   ELEV4   ELEV5   ELEV6
1             ST       1       1      ON     1.0    46.0     3.3       6  598.02  594.36  588.26  577.60  560.22  541.32

MONITOR LOC ISEG    ELEV  DYNCEL
1              0    -1.0     OFF

AUTO ELEVCONTROL
1             ON

SPLIT1      CNTR     NUM  TSFREO  TSCONV
              ON       5   0.250   0.005

SPLIT2     ST/WD      JB  YEARLY    TSTR    TEND TTARGET  DYNSEL  ELCONT   NOUTS TSSHARE
1             ST       1      ON     1.0    51.0     3.0      ON     OFF       6     OFF
2             ST       1      ON    51.1    74.0     3.0      ON     OFF       5     OFF
3             ST       1      ON    74.1   329.0    13.3      ON     OFF       6     OFF
4             ST       1      ON   329.1   346.0     3.0      ON     OFF       5     OFF
5             ST       1      ON   346.1   366.0     3.0      ON     OFF       6     OFF

SPLITOUT JS1/NW1 JS2/NW2 JS3/NW3 JS4/NW4 JS5/NW5 JS6/NW6 JS7/NW7 JS8/NW8 JS9/NW9 JS0/NW0
1              1       2       3       4       5       6
2              1       2       3       4       5
3              1       2       3       4       5       6
4              1       2       3       4       5
5              1       2       3       4       5       6

DEPTH     DEPTH1  DEPTH2  DEPTH3  DEPTH4  DEPTH5  DEPTH6  DEPTH7  DEPTH8  DEPTH9 DEPTH10
1              0       0       0       0       0       0
2              0       0       0       0       0
3              0       0       0       0       0       0
4              0       0       0       0       0
5              0       0       0       0       0       0

MINFRAC  MINFRC1 MINFRC2 MINFRC3 MINFRC4 MINFRC5 MINFRC6 MINFRC7 MINFRC8 MINFRC9 MNFRC10
1              0       0       0       0       0  -2.832
2              0       0       0       0       0
3              0       0       0       0       0  -2.832
4              0       0       0       0       0
5              0       0       0       0       0  -2.832

PRIORITY  PRIOR1  PRIOR2  PRIOR3  PRIOR4  PRIOR5  PRIOR6  PRIOR7  PRIOR8  PRIOR9 PRIOR10
1              2       2       2       2       2       1
2              1       2       1       2       1
3              2       2       2       2       2       1
4              1       2       1       2       1
5              2       2       2       2       2       1

MINHEAD   MINHD1  MINHD2  MINHD3  MINHD4  MINHD5  MINHD6  MINHD7  MINHD8  MINHD9 MINHD10
1              2       2       2       2       2       2
2              2       2       2       2       2
3              2       2       2       2       2       2
4              2       2       2       2       2
5              2       2       2       2       2       2

MAXHEAD   MAXHD1  MAXHD2  MAXHD3  MAXHD4  MAXHD5  MAXHD6  MAXHD7  MAXHD8  MAXHD9 MAXHD10
1              0       0       0       0       0      34
2              0       0       0       0       0
3              0       0       0       0       0      34
4              0       0       0       0       0
5              0       0       0       0       0      34

MAXFLOW  MAXFLO1 MAXFLO2 MAXFLO3 MAXFLO4 MAXFLO5 MAXFLO6 MAXFLO7 MAXFLO8 MAXFLO9 MXFLO10
1              0       0       0       0       0       0
2              0       0       0       0       0
3              0       0       0       0       0       0
4              0       0       0       0       0
5              0       0       0       0       0       0

THRESH1    TEMPN
              12

THRESH2 TEMPCRIT
1           3.33
2           3.52
3           6.67
4          10.00
5          12.96
6          13.33
7          13.33
8          13.33
9          13.33
10         11.48
11          7.22
12          3.33
```

(**NOTE: ELEV7-10 are cut off for better image clarity. These values are blank since there are only 6 ports.)

Figure 47. dynsplit_selectiveX.npt file used for the APPLMPM.

```
NOTE:  See G:\Projects15\NWP-Portland\ALM-PortPrediction\ERDC-Data\TEMP_TARGETS_Applegate.xlsx
Identical to mean values in 'TEMP_TARGETS_Applegate.xlsx'
    JDAY    MEAN
    1.00    3.33
   11.00    3.33
   21.00    3.33
   32.00    3.33
   42.00    3.33
   52.00    3.89
   60.00    5.56
   70.00    6.67
   80.00    7.78
   91.00    8.89
  101.00   10.00
  111.00   11.11
  121.00   12.22
  127.00   13.33
  141.00   13.33
  152.00   13.33
  162.00   13.33
  172.00   13.33
  182.00   13.33
  192.00   13.33
  202.00   13.33
  213.00   13.33
  223.00   13.33
  233.00   13.33
  244.00   13.33
  254.00   13.33
  264.00   13.33
  274.00   13.33
  284.00   11.11
  294.00   10.00
  305.00    8.89
  315.00    7.22
  325.00    5.56
  335.00    3.33
  345.00    3.33
  355.00    3.33
  365.00    3.33
```

Figure 48. CY01 - APPLPM temperature comparison with target temperatures.

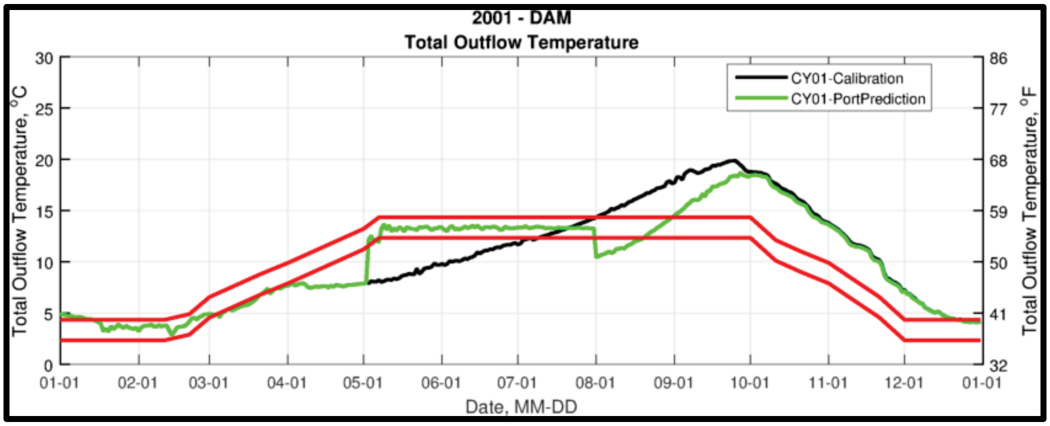


Figure 49. CY01 - Intake 4 - temperature into tower.

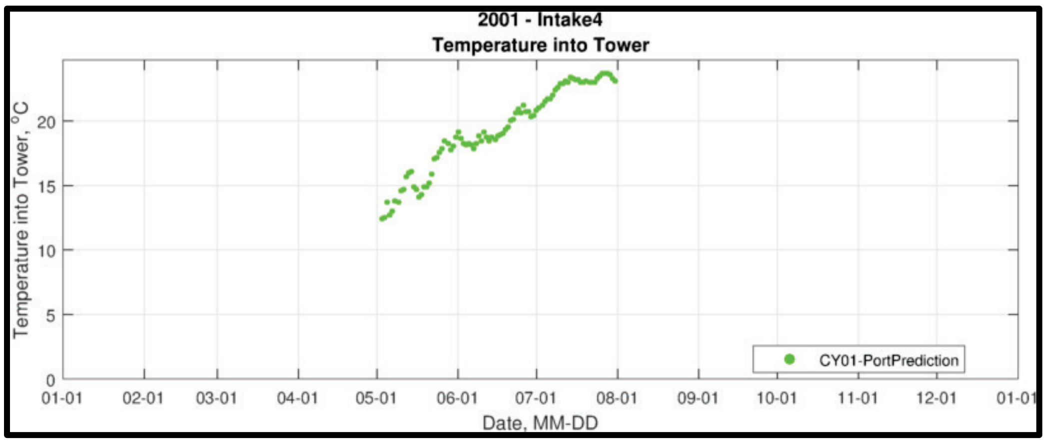


Figure 50. CY01 - Intake 5 - temperature into tower.

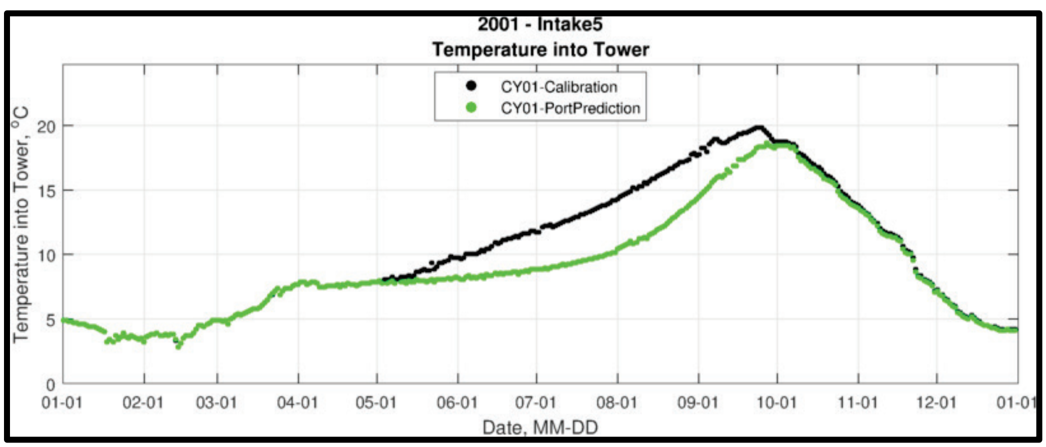


Figure 51. CY01 – RO / Intake 6 - temperature into tower.

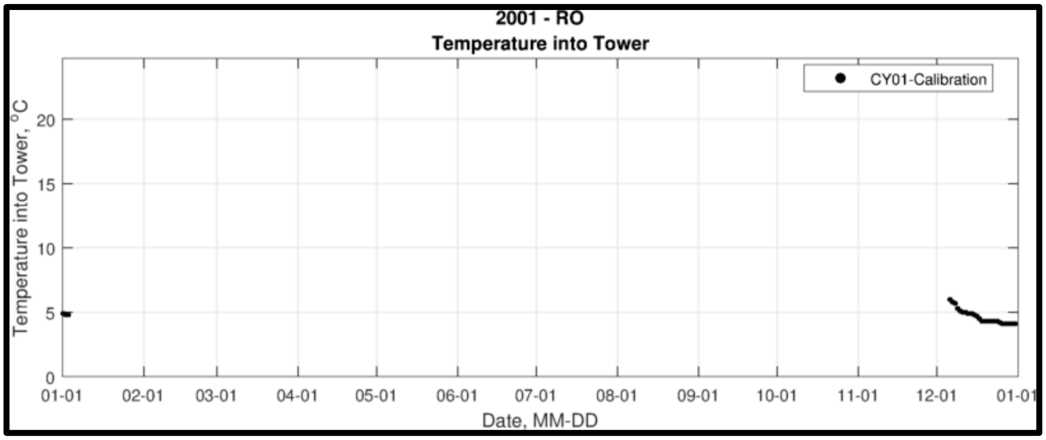


Figure 52. CY01 - Intake 4 - flow into tower.

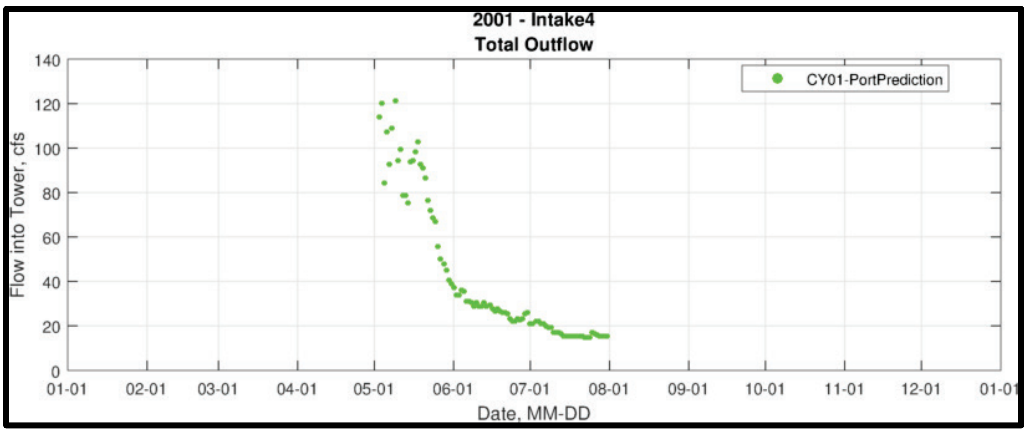


Figure 53. CY01 - Intake 5 - flow into tower.

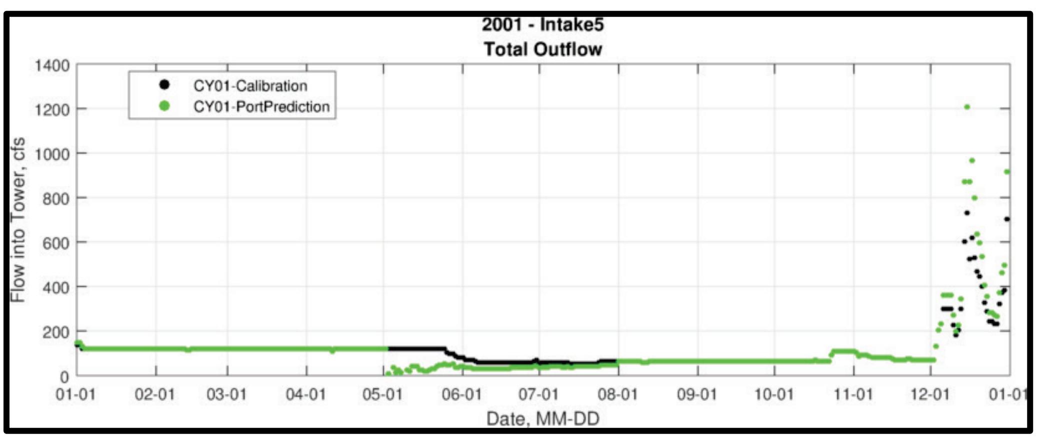


Figure 54. CY01 – RO / Intake 6 - flow into tower.

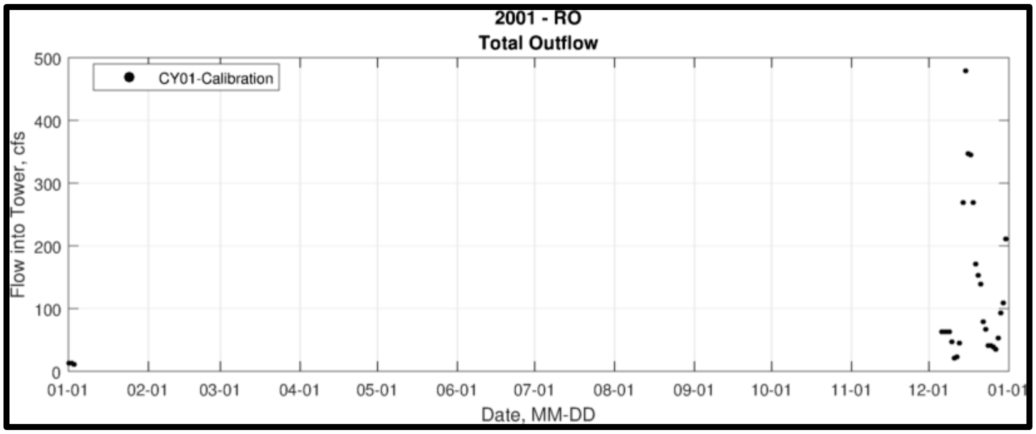


Figure 55. CY03 - APPLPM temperature comparison with target temperatures.

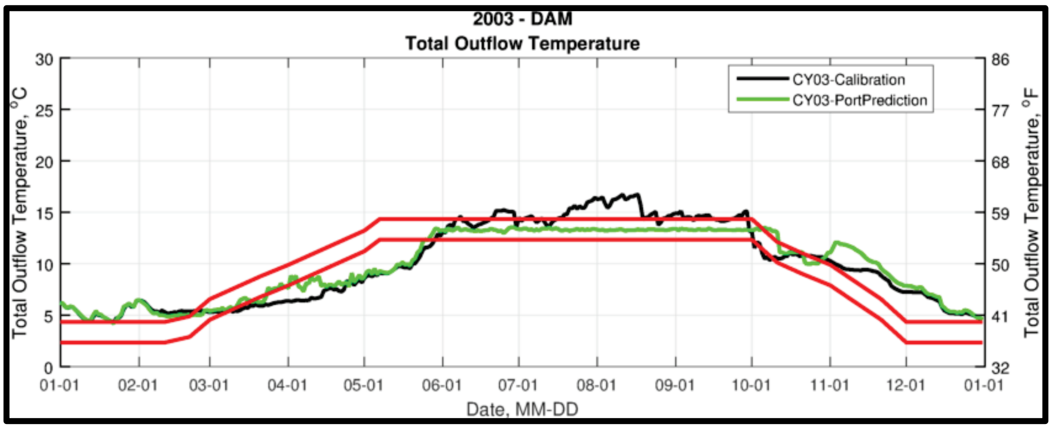


Figure 56. CY03 - Intake 1 - temperature into tower.

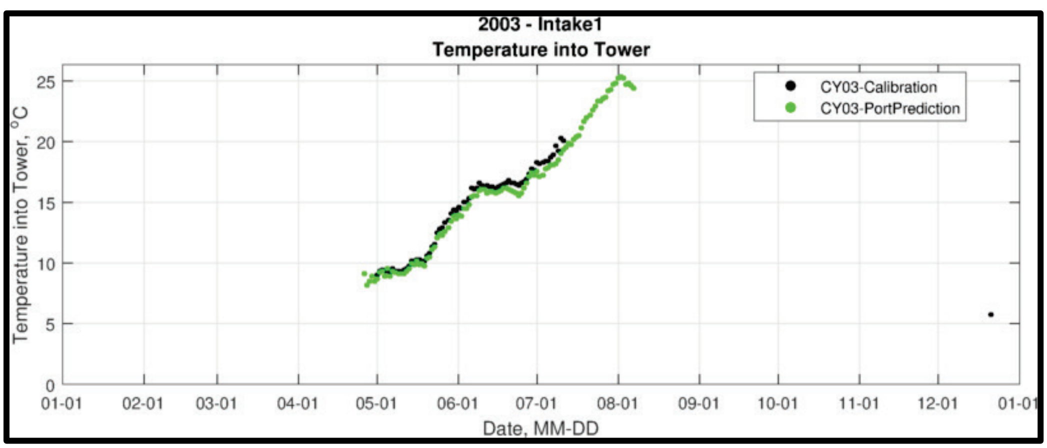


Figure 57. CY03 - Intake 2 - temperature into tower.

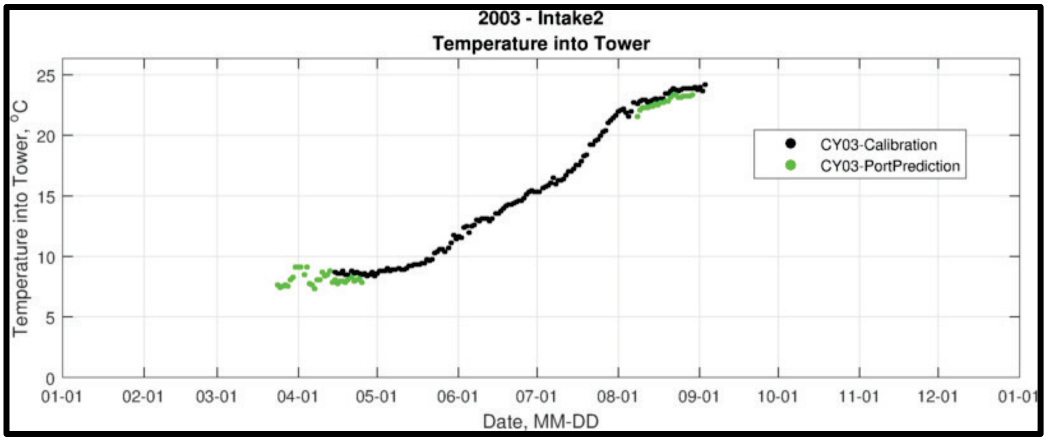


Figure 58. CY03 - Intake 3 - temperature into tower.

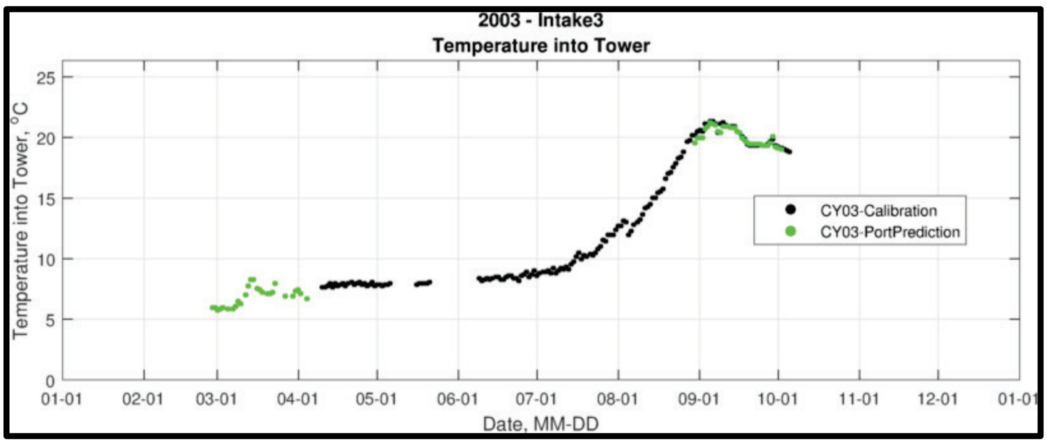


Figure 59. CY03 - Intake 4 - temperature into tower.

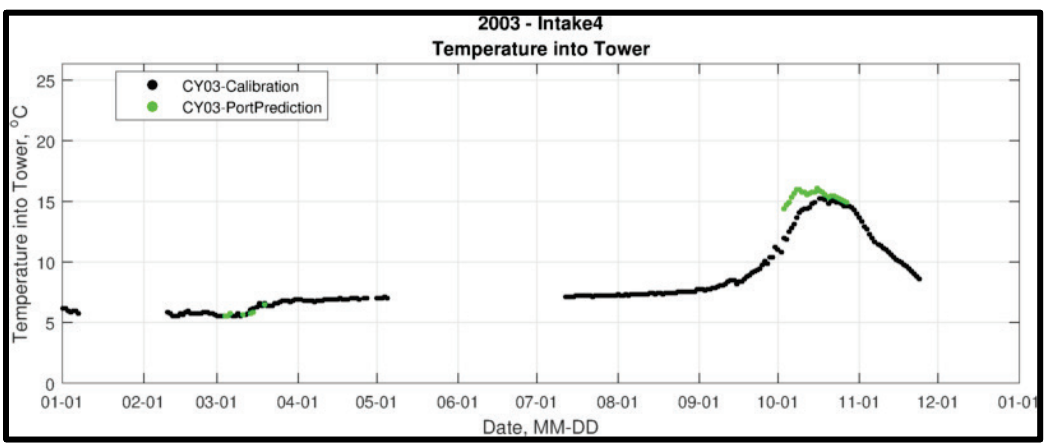


Figure 60. CY03 – Intake 5 - temperature into tower.

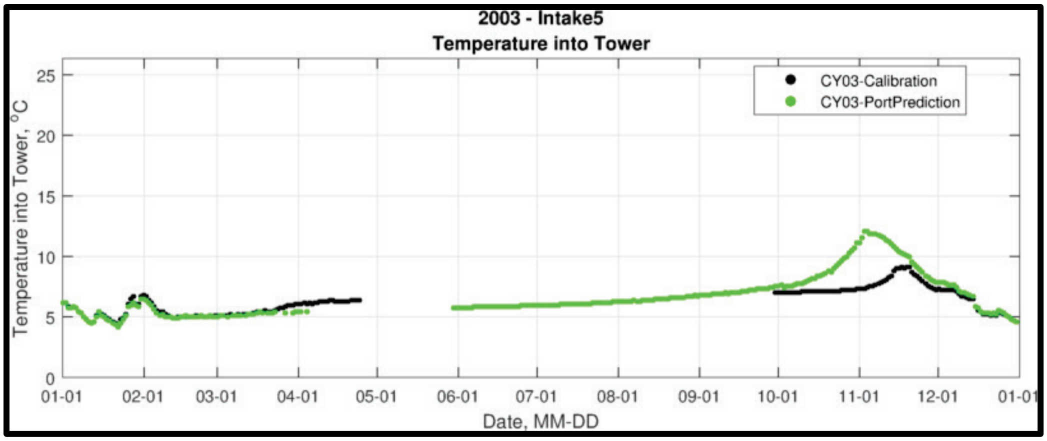


Figure 61. CY03 – RO / Intake 6 - temperature into tower.

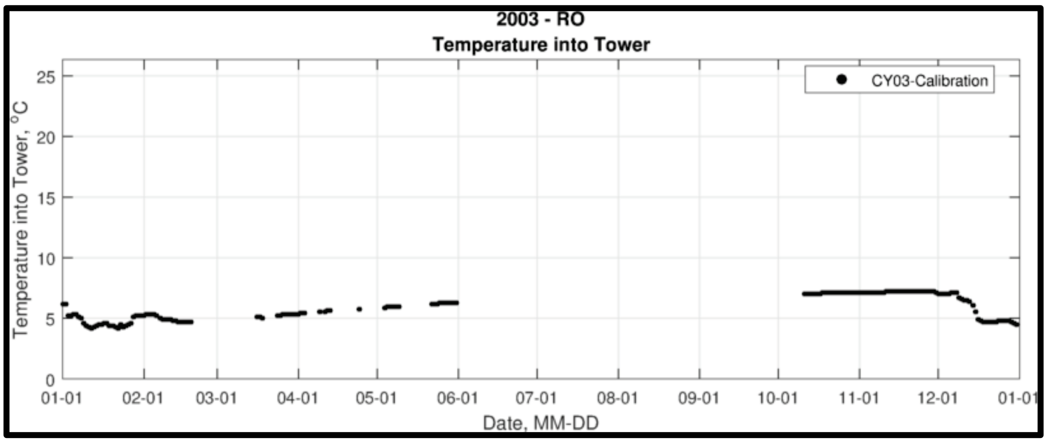


Figure 62. CY03 - Intake 1 - flow into tower.

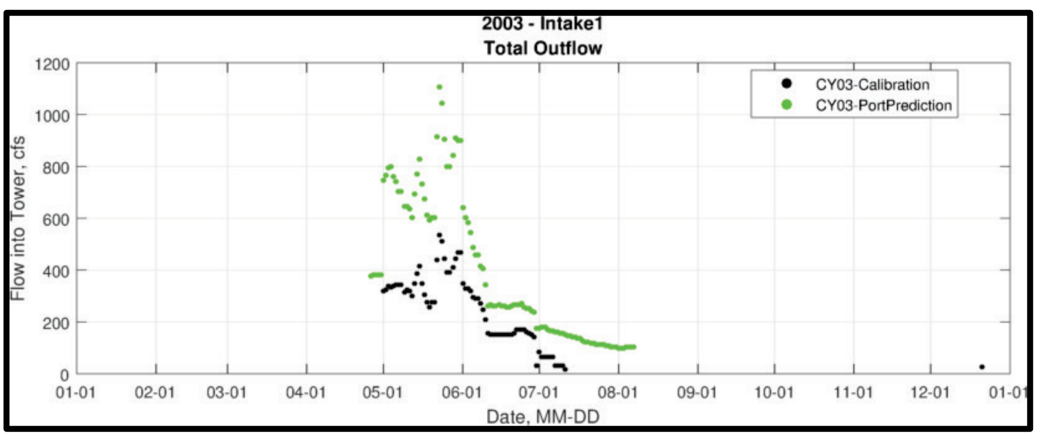


Figure 63. CY03 - Intake 2 - flow into tower.

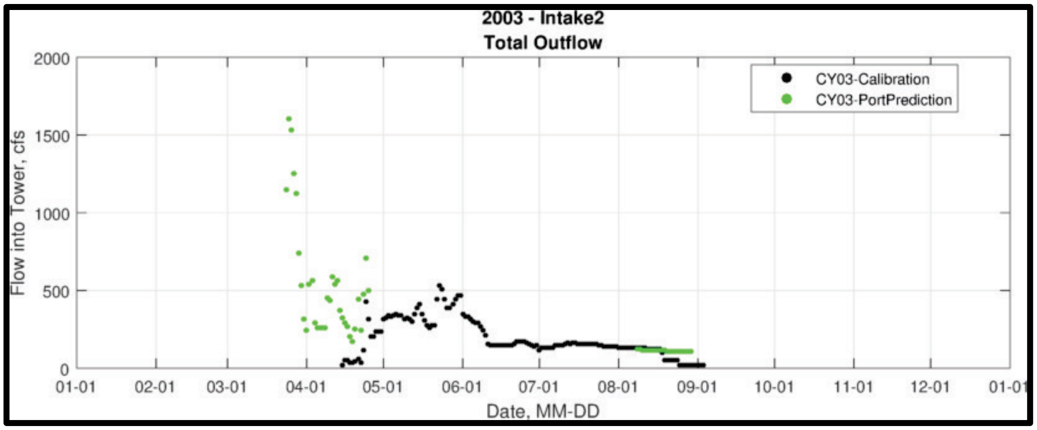


Figure 64. CY03 - Intake 3 - flow into tower.

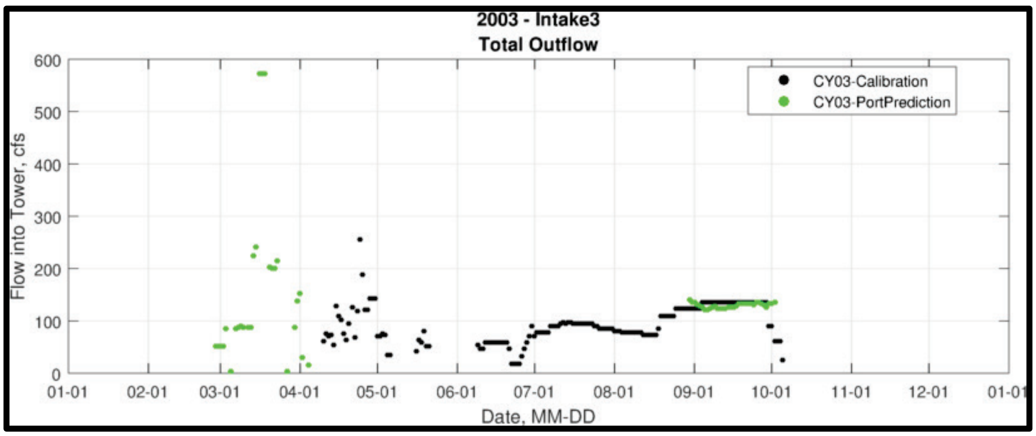


Figure 65. CY03 - Intake 4 – flow into tower.

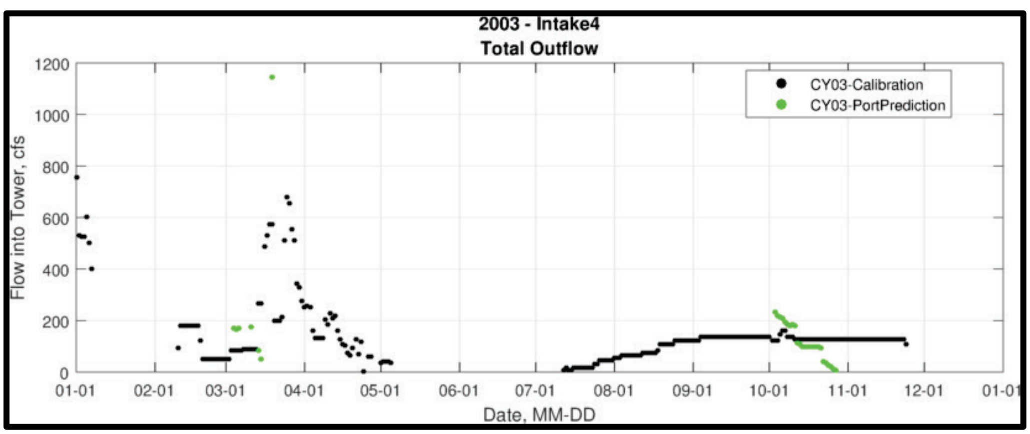


Figure 66. CY03 - Intake 5 - flow into tower.

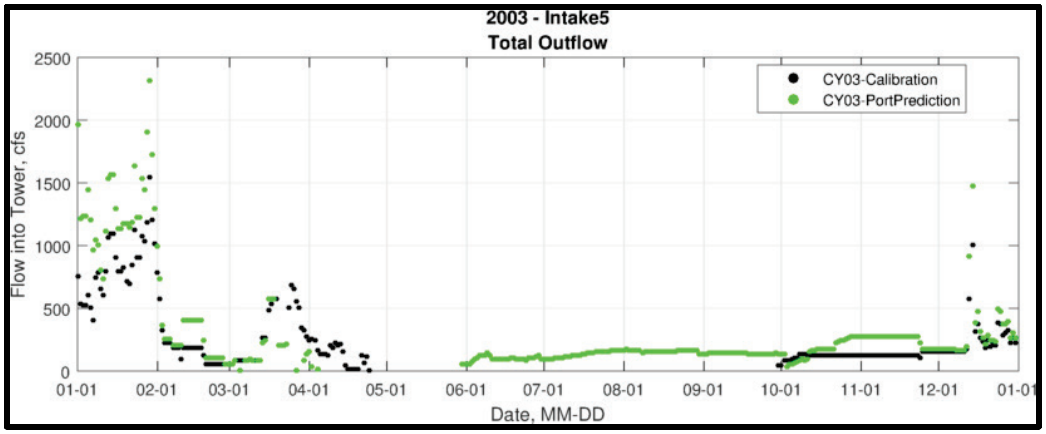


Figure 67. CY03 – RO / Intake 6 - flow into tower.

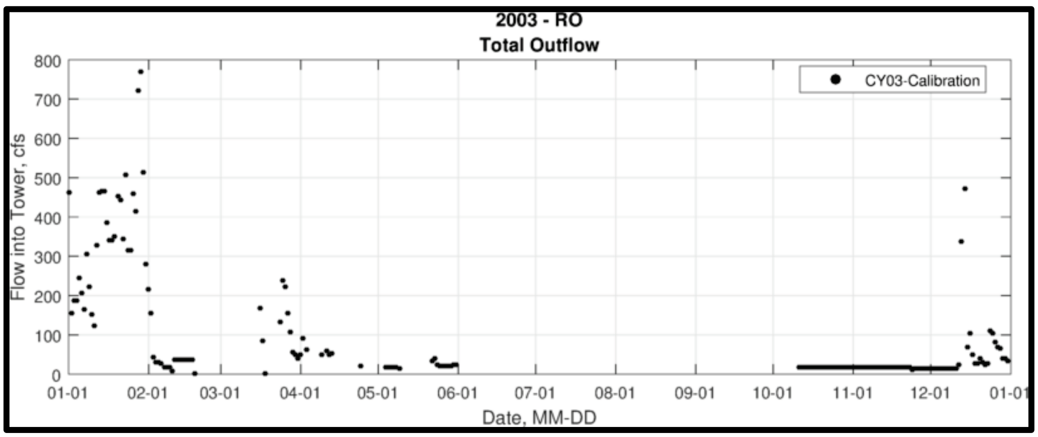


Figure 68. CY10 - APPLPM temperature comparison with target temperatures.

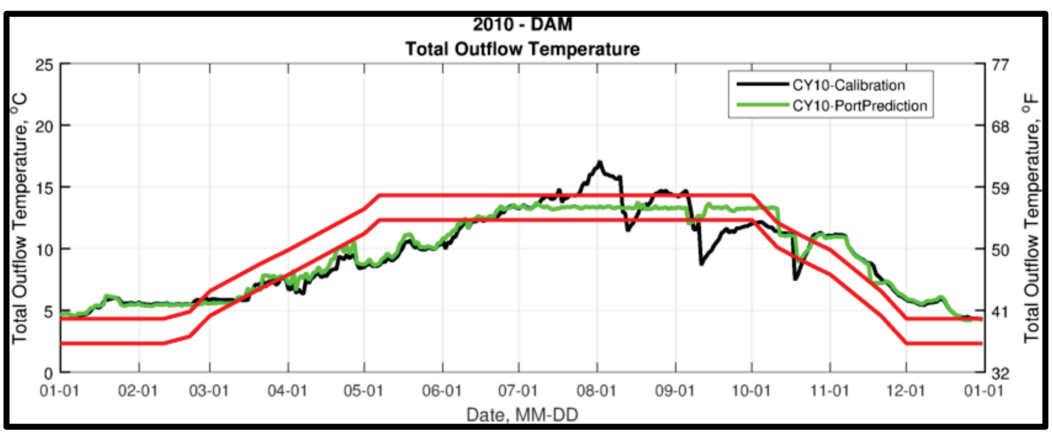


Figure 69. CY10 - Intake 1 - temperature into tower.

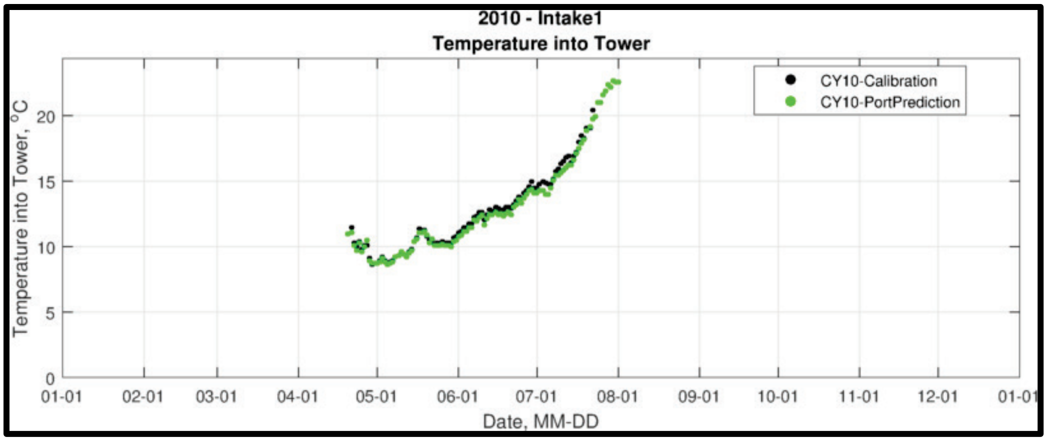


Figure 70. CY10 - Intake 2 - temperature into tower.

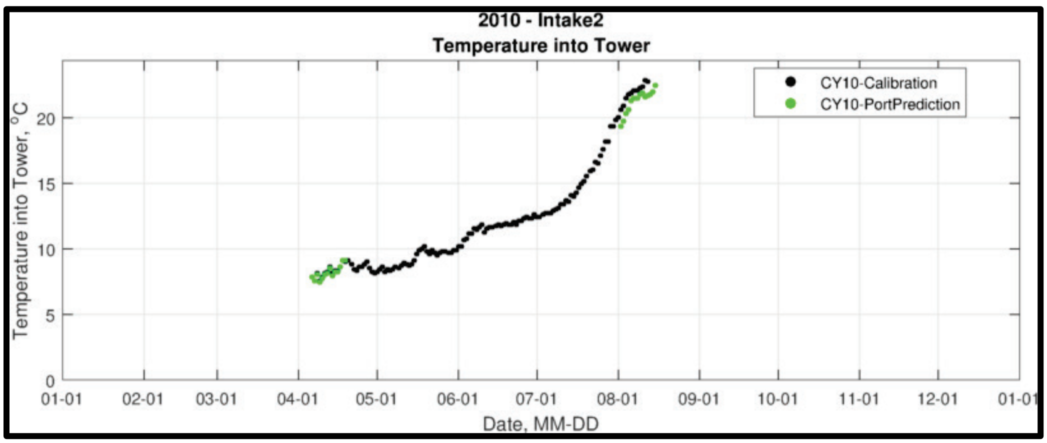


Figure 71. CY10 - Intake 3 - temperature into tower.

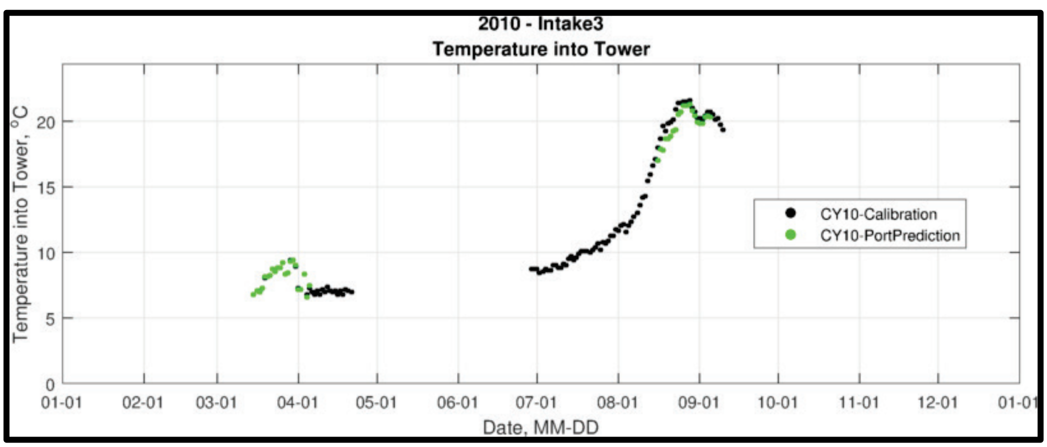


Figure 72. CY10 - Intake 4 - temperature into tower.

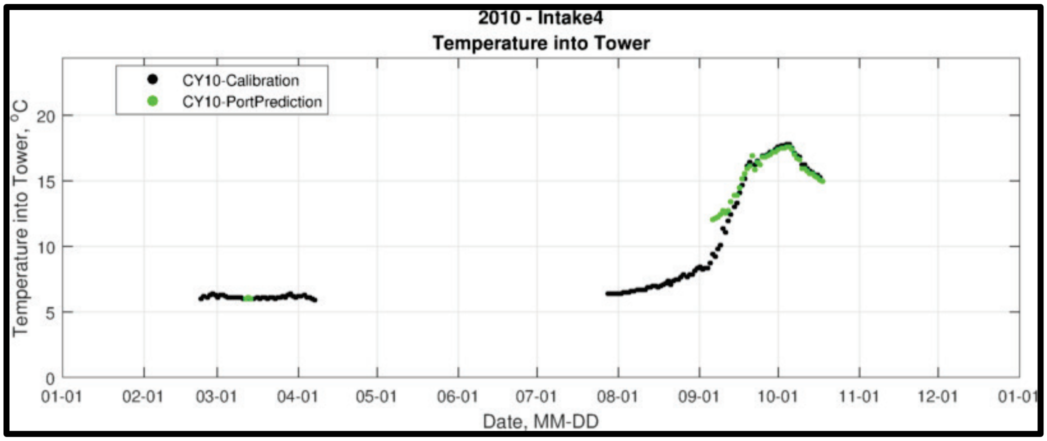


Figure 73. CY10 - Intake 5 - temperature into tower.

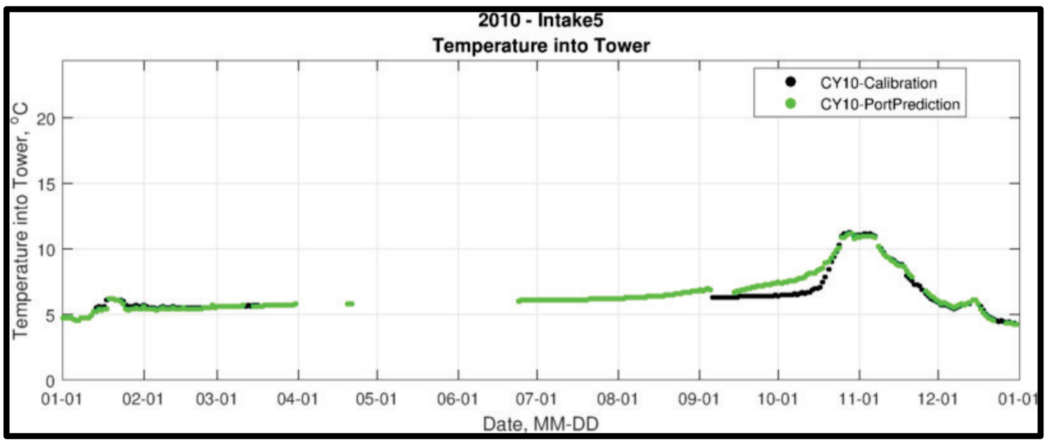


Figure 74. CY10 – RO / Intake 6 - temperature into tower.

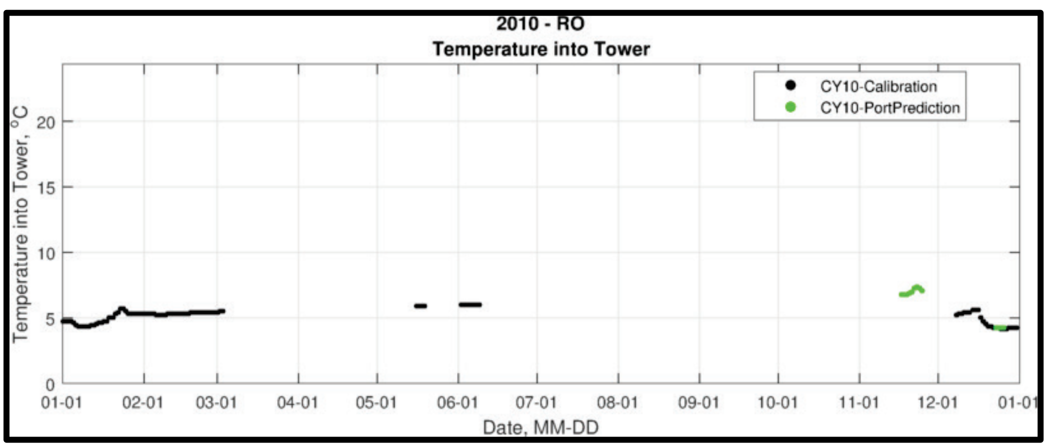


Figure 75. CY10 - Intake 1 - flow into tower.

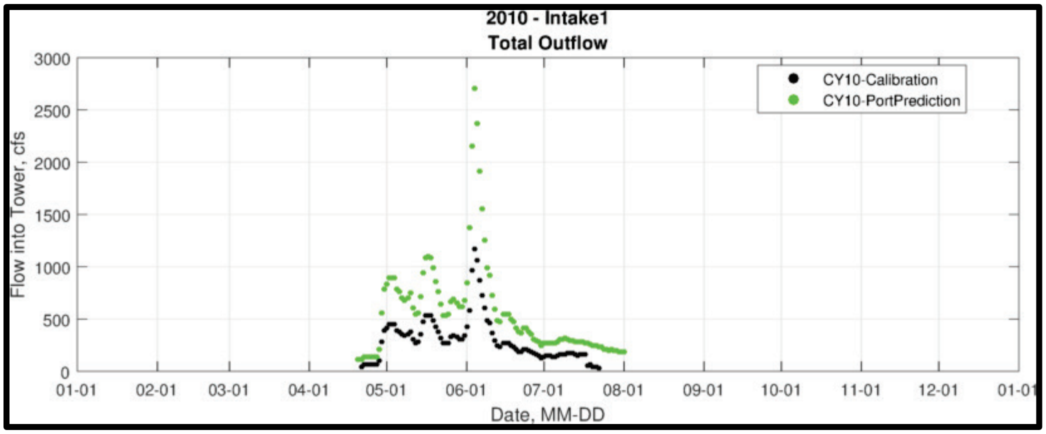


Figure 76. CY10 - Intake 2 - flow into tower.

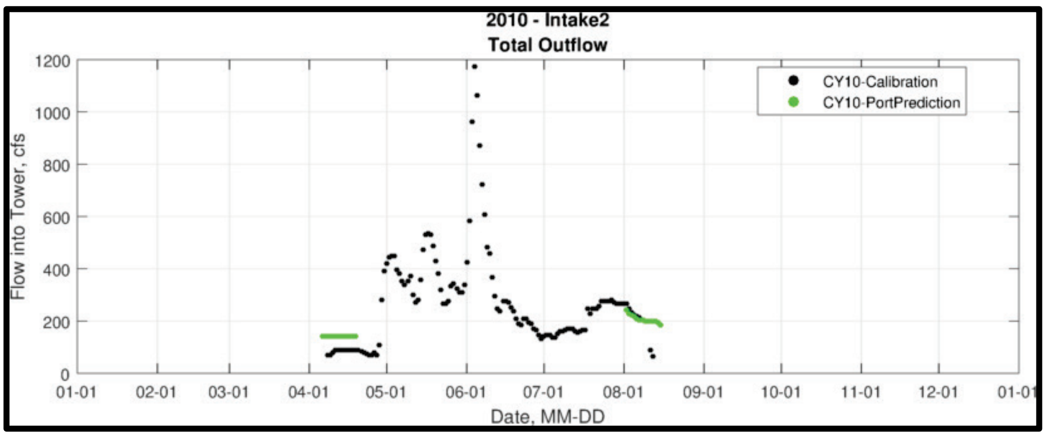


Figure 77. CY10 - Intake 3 - flow into tower.

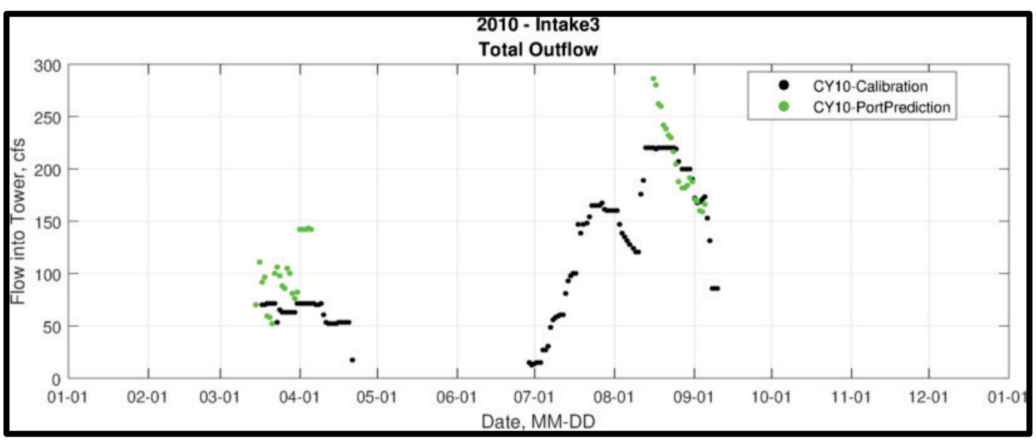


Figure 78. CY10 - Intake 4 - flow into tower.

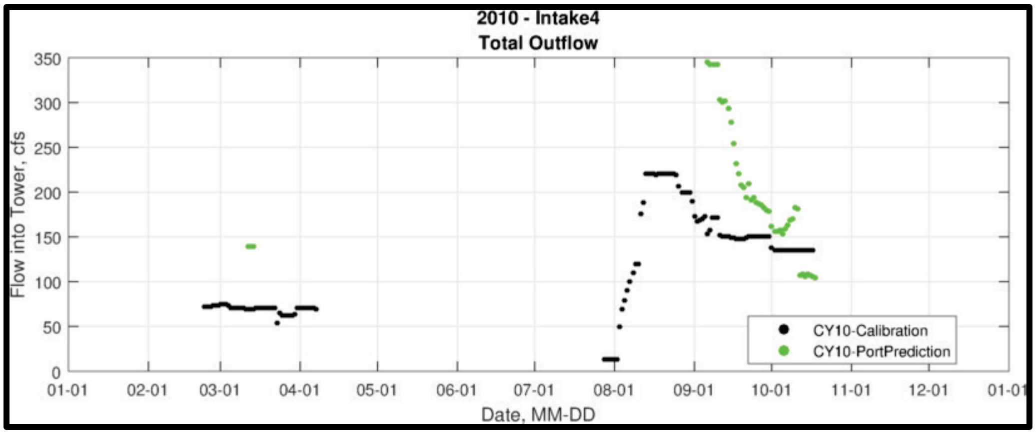


Figure 79. CY10 – Intake 5 - flow into tower.

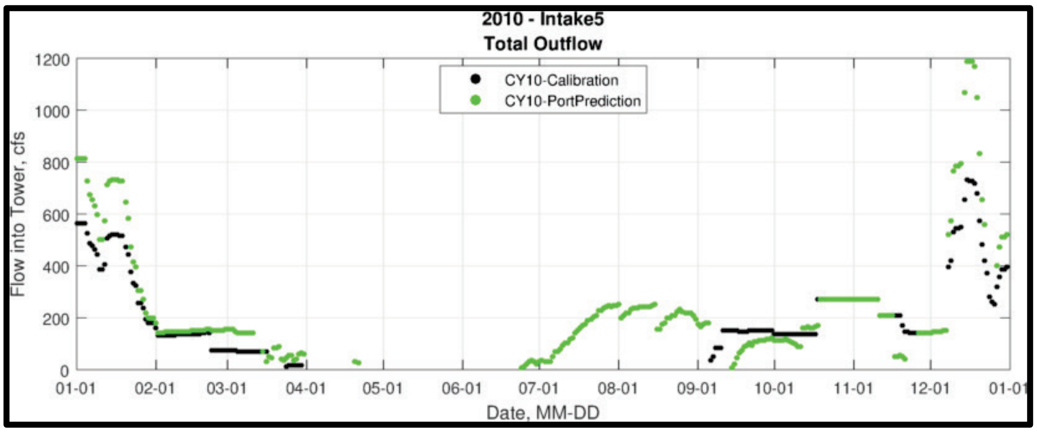


Figure 80. CY10 – RO / Intake 6 - flow into tower.

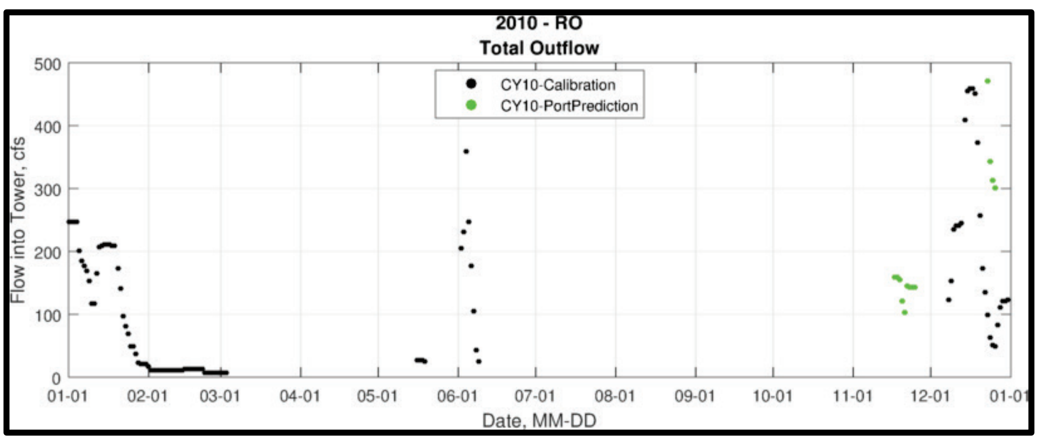
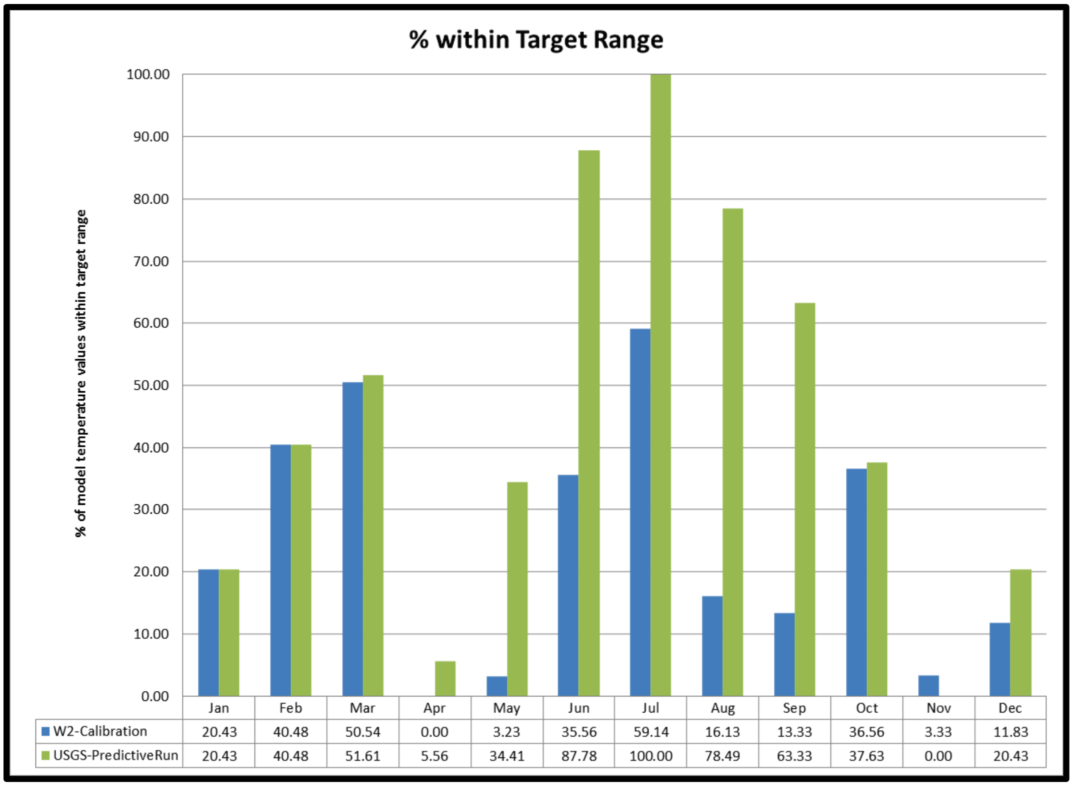


Figure 81. Average % of model temperature within the target range.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
W2-Calibration	20.43	40.48	50.54	0.00	3.23	35.56	59.14	16.13	13.33	36.56	3.33	11.83
USGS-PredictiveRun	20.43	40.48	51.61	5.56	34.41	87.78	100.00	78.49	63.33	37.63	0.00	20.43

9 Summary and Conclusions

The USACE-ERDC-EL assisted CENWP in updating a W2 model of Applegate Lake based on inputs from an existing model of the reservoir. The model was calibrated and verified using data from calendar year (CY) 2001 (dry), 2003 (normal), and 2010 (wet). Across all calendar years, the model captured the quantitative and qualitative trends for temperature and flow. Quantitatively, the model predicted temperatures within 1.0 deg-C for most of the calibration sites (in-lake sites and at the dam), which is far better than many other temperature studies (Arhonditsis and Brett 2004). Qualitatively, trends were consistent with measured data. Model performance statistics were closely paired temporally and spatially with the measured data.

In addition to a fully updated calibrated model, the ERDC-EL also developed an application of the model using modified W2 code from the USGS that allows for a better functioning blending algorithm between multiple ports. The same version of the W2 model was also used for a similar application of Lost Creek Lake (Threadgill et al. 2015).

This model and the corresponding results from the study provide NWP with a fully capable model that helps users determine how operational changes will impact downstream water temperature. This is extremely important because the Rogue and Applegate Temperature Total Maximum Daily Loads (TMDL), Rogue Spring Chinook Conservation Plan, and possibly the Rogue Fall Chinook Conservation Plan require the Corps to review operations to determine whether improvements can be achieved to downstream temperature for the benefit of endangered fish.

Additional work to consider is a deeper investigation of the actual attainability of the target temperatures and the impacts of these temperatures on fish with respect to egg emergence data. Based on the current study, there will be times during the year when reaching the desired temperature target is simply not attainable given the dam operation criteria. This model, coupled with an in depth fish analysis, would provide NWP with invaluable information regarding dam operations and the impacts to fish.

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Threadgill, T. L., D. H. Tillman, B. W. Bunch, D. L. Smith, L. A. Nicholas, and D. F. Turner. 2017. *Temperature modeling of Lost Creek Lake using temperature modeling of Lost Creek Lake using CE-QUAL-W2*. ERDC/EL TR-17-4. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

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Appendix A: Bathymetry File

This section contains an image of the bathymetry file used for the APPLM. The only difference between calendar years was the initial water surface elevation used in creating the bathymetry file. W2 V3.7 now has the capability to use a csv file developed in Excel. The images below (Figure A1-Figure A3) are pages from the Excel file used to develop the csv file. Table A1 is the initial water surface (ELWS) used in the development of the bathymetry files for each of the model simulations.

Table A1. Initial ELWS used in bathymetry files for all simulations.

Calendar Year	ELWS (m)	ELWS (ft)
Calibration-2001	569.585	1868.72
Verification-2003	576.187	1890.38
Verification-2010	577.044	1893.19

Figure A1. Page 1 from bathymetry development Excel file.

$ Applegate Lake Bathymetry - Updated from "bth-apg2-90.npt" to new csv version

SEG: I	1	2	3	4	5	6	7	8	9	10	11	12	13
DLX	0	623.3	536.4	413.6	332.2	387.1	335.3	345.9	298.7	221	265.2	301.8	202.7
ELWS	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585
PHI0	0.000	3.992593	2.24	2.362	3.2215927	4.4415927	4.5735927	3.6415927	3.5535927	3.2345927	3.2365927	3.3415927	3.6435927
FRICT	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
LAYERH		BR1											
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	65.100	132.400	173.900	400.700	343.700	415.000	354.800	436.800	489.400	475.000	409.000	340.300
0.914	0.000	54.100	126.800	169.300	394.500	330.000	410.700	351.400	431.500	488.500	469.000	403.700	335.700
0.914	0.000	43.800	119.700	162.100	384.400	323.000	400.600	347.100	426.800	483.300	463.100	398.100	331.000
0.914	0.000	35.600	112.800	154.700	373.900	316.100	391.800	343.000	422.400	478.400	457.500	392.700	326.300
0.914	0.000	28.600	106.000	147.100	362.900	309.100	384.300	339.000	418.200	473.800	452.000	387.500	321.900
0.914	0.000	22.700	99.200	138.700	351.100	301.800	377.300	334.900	413.700	473.700	446.200	382.100	317.200
0.914	0.000	17.600	92.200	129.300	338.600	294.400	370.800	330.900	409.200	469.200	440.400	376.700	312.600
0.914	0.000	13.500	85.300	119.200	324.700	286.600	364.600	326.600	404.200	465.200	434.100	371.000	307.600
0.914	0.000	10.700	78.300	108.300	309.500	278.600	358.600	322.100	399.100	461.400	432.400	369.100	302.500
0.914	0.000	9.200	68.000	97.200	291.300	252.400	353.800	318.900	395.400	452.100	428.800	365.800	302.100
0.914	0.000	0.000	40.200	89.700	266.900	203.000	350.100	313.100	392.100	448.500	425.200	362.400	299.500
0.914	0.000	0.000	25.900	81.900	244.300	187.800	344.100	302.200	384.600	445.000	416.700	355.100	293.500
0.914	0.000	0.000	0.000	73.300	220.000	172.800	336.900	290.200	375.900	441.700	413.200	351.800	293.400
0.914	0.000	0.000	0.000	64.000	193.200	158.500	328.500	277.500	366.300	438.300	413.000	350.400	289.000
0.914	0.000	0.000	0.000	54.300	165.700	144.600	319.200	264.500	356.000	437.000	407.100	344.300	283.800
0.914	0.000	0.000	0.000	38.100	128.800	131.900	306.800	251.500	351.100	435.800	405.100	341.900	282.000
0.914	0.000	0.000	0.000	24.000	105.700	117.400	287.100	232.900	343.600	430.100	398.200	335.800	277.200
0.914	0.000	0.000	0.000	22.100	84.200	103.100	265.900	213.500	334.100	422.400	389.200	328.400	271.000
0.914	0.000	0.000	0.000	0.000	64.300	89.400	240.100	196.300	323.700	413.900	379.600	320.400	264.100
0.914	0.000	0.000	0.000	0.000	45.000	76.800	211.300	179.500	313.400	405.500	370.200	312.700	257.300
0.914	0.000	0.000	0.000	0.000	26.100	65.300	184.000	161.300	302.900	402.000	364.300	308.200	252.900
0.914	0.000	0.000	0.000	0.000	14.500	55.700	162.000	145.300	300.500	393.900	357.100	302.000	247.900
0.914	0.000	0.000	0.000	0.000	0.000	41.600	127.200	115.600	271.900	372.900	335.200	284.500	233.200
0.914	0.000	0.000	0.000	0.000	0.000	29.700	98.700	90.900	261.300	365.500	328.500	281.800	231.300
0.914	0.000	0.000	0.000	0.000	0.000	22.000	65.300	70.200	238.600	358.800	327.100	276.100	226.600
0.914	0.000	0.000	0.000	0.000	0.000	15.300	32.400	51.300	215.100	343.900	319.900	273.900	225.400
0.914	0.000	0.000	0.000	0.000	0.000	0.000	9.100	34.100	190.100	325.500	311.200	267.300	220.400
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19.300	163.700	304.600	301.800	260.000	215.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13.900	136.300	281.300	291.800	252.100	209.100
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	109.300	256.000	281.400	243.800	202.800
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	82.700	228.800	270.400	235.000	195.800
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	57.600	200.200	259.100	225.900	188.400
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	36.600	170.800	247.900	216.800	181.100
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	16.900	140.300	236.700	207.600	173.600
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	109.000	225.200	198.000	165.900
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	75.900	213.700	188.400	158.100
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	24.100	177.900	174.300	148.100
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	82.700	135.500	131.100
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19.100	90.300	111.800
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	46.100	90.700
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.800	68.900
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	46.700
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	25.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.900
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.914	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure A2. Page 2 from bathymetry development Excel file.

14	15	16	17	18	19	20	21	22	23	24	25	26
274.3	298.7	297.2	271.3	218.2	222.8	226.2	236.2	274.3	147.2	241.7	135.3	196.3
569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585
4.0915927	4.4415927	4.3415927	4.2415927	4.0195927	3.4415927	3.3415927	3.6025927	4.0555927	3.9475927	4.0415927	3.8935927	4.0575927
0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
366.500	435.700	704.700	698.100	351.700	406.400	326.500	539.700	705.200	307.900	715.700	708.900	545.700
360.400	428.600	704.200	679.100	344.700	405.500	323.300	536.100	702.700	307.200	706.600	704.900	543.700
355.800	422.800	697.500	669.700	344.400	404.400	320.100	529.200	692.200	300.700	696.600	702.300	541.600
351.300	417.100	691.100	660.700	340.000	403.200	316.900	522.800	682.200	294.200	686.800	700.400	539.400
347.100	411.600	684.900	652.000	335.800	402.000	310.600	516.700	672.700	287.500	677.600	699.000	537.400
342.700	406.000	678.100	642.700	331.400	400.800	310.500	510.300	662.900	280.400	667.900	697.800	535.600
338.300	400.400	671.200	633.600	327.000	399.800	307.200	504.100	653.200	273.100	658.400	696.800	533.900
333.600	394.400	670.600	623.700	322.300	398.800	307.000	497.500	643.100	265.200	648.200	695.800	532.200
332.400	392.800	665.300	619.900	321.300	397.700	304.800	497.000	639.200	257.800	637.700	694.700	530.500
329.700	389.600	660.700	614.400	318.900	389.700	302.900	493.700	633.600	255.800	637.300	693.300	528.700
327.200	386.400	656.100	608.700	316.500	388.700	301.000	490.600	628.000	251.800	631.900	691.800	526.900
324.300	378.600	643.000	596.600	313.900	387.700	298.900	487.100	615.400	248.800	625.700	689.900	516.300
317.800	375.600	638.500	591.200	307.600	386.600	296.800	483.000	610.100	243.300	613.200	687.700	514.500
315.100	375.300	634.100	589.500	305.100	385.300	290.900	479.400	609.300	236.500	610.400	685.200	512.600
314.000	369.500	633.300	579.800	304.200	383.900	288.900	469.800	600.000	228.700	599.700	682.400	510.600
309.700	366.400	620.900	562.800	303.100	382.300	286.900	466.400	592.900	220.100	593.200	679.300	508.500
304.000	360.300	612.600	553.300	298.400	380.400	286.100	465.900	584.100	202.900	582.400	676.100	506.200
296.900	352.400	601.200	540.900	292.300	378.200	279.800	456.500	572.500	197.700	568.800	672.900	504.000
289.400	343.900	588.700	527.300	285.600	375.600	273.300	446.500	560.000	191.800	554.200	669.700	501.800
282.100	335.500	576.200	513.900	279.100	373.800	266.700	436.600	547.700	185.700	539.800	666.600	500.100
277.800	330.700	570.400	505.100	275.500	373.500	263.400	431.800	541.700	180.300	530.700	663.600	498.900
272.200	324.100	559.000	495.000	270.000	366.000	258.100	423.200	530.900	175.300	520.100	660.800	494.900
256.200	306.600	531.800	464.500	256.000	359.000	244.900	400.400	503.700	175.200	487.700	658.200	491.900
254.800	305.300	530.700	462.400	255.200	357.200	244.300	397.700	501.700	163.400	485.400	655.800	490.600
252.600	302.900	527.700	459.200	253.500	355.500	242.800	389.800	497.900	162.700	483.000	642.700	489.500
247.600	296.800	522.700	450.100	248.500	353.400	238.000	389.700	488.000	161.400	479.300	640.400	487.900
246.400	295.400	512.300	449.500	248.100	346.300	237.800	382.700	486.600	158.200	474.500	638.200	486.000
241.500	289.500	509.500	441.600	243.700	344.300	233.200	374.700	477.600	157.400	465.000	636.200	483.900
236.000	282.900	500.000	432.600	238.600	341.900	228.300	366.000	467.500	154.200	462.900	634.300	481.500
230.000	275.700	489.600	422.800	233.200	340.400	223.000	356.600	456.700	150.700	455.200	632.600	479.100
223.400	267.900	477.800	411.900	227.200	334.300	217.100	346.400	444.700	146.700	446.500	630.900	476.800
216.400	259.700	465.200	400.400	220.600	327.500	210.900	335.700	432.100	142.600	436.800	629.200	474.500
209.300	251.300	452.500	388.800	214.100	320.400	204.700	325.000	419.400	138.200	427.200	627.600	472.500
202.100	242.800	439.500	376.900	207.300	313.000	198.300	314.100	406.500	133.800	417.200	626.000	470.800
194.500	233.800	425.800	364.400	200.200	304.900	191.600	302.900	393.000	129.400	411.700	624.400	461.400
186.700	224.700	411.700	351.700	192.900	301.000	184.900	291.400	385.400	124.700	409.700	623.000	459.700
178.100	219.300	398.300	340.000	192.800	299.800	184.600	290.400	384.900	121.800	409.100	621.700	458.200
167.600	213.500	383.100	331.600	191.600	298.600	182.900	288.000	384.600	121.600	409.000	620.600	456.900
155.200	203.100	364.300	320.700	190.300	297.700	179.200	282.200	384.100	121.600	408.900	619.600	455.700
140.100	190.000	342.200	305.700	188.900	296.700	176.700	279.100	376.400	121.500	400.700	618.600	454.600
123.300	175.400	318.300	288.000	185.100	290.800	175.500	278.800	376.000	119.000	400.600	617.300	453.400
105.800	165.000	296.400	279.800	183.800	289.900	173.800	276.500	375.300	118.900	400.500	615.500	451.800
91.200	163.400	290.500	278.900	182.500	289.000	170.400	271.000	374.000	118.800	399.900	613.000	449.800
89.400	160.100	288.600	273.400	181.100	288.100	168.800	268.800	372.000	118.400	398.500	609.900	447.400
35.400	94.600	170.100	174.100	132.900	212.800	121.300	207.800	330.100	117.800	349.200	560.300	396.500
34.700	93.800	166.700	170.600	132.200	211.600	121.200	206.800	328.500	105.600	347.300	558.000	396.200
21.000	91.900	165.000	170.400	131.400	207.300	121.100	202.700	326.900	105.100	346.000	555.600	394.300
13.600	78.900	144.500	156.100	130.600	206.200	120.400	201.700	325.400	104.600	344.300	544.500	386.400
0.000	64.800	119.800	136.000	128.000	200.000	119.700	200.600	323.800	104.100	342.500	542.200	384.600
0.000	47.400	88.100	115.900	127.200	195.700	119.100	199.600	317.300	103.600	340.800	539.800	375.500
0.000	0.000	36.200	81.200	126.400	191.700	118.500	199.500	315.700	101.500	339.200	539.100	309.500
0.000	0.000	36.200	48.200	108.800	176.800	118.100	199.500	314.200	101.000	332.400	534.400	294.300
0.000	0.000	0.000	23.100	79.600	155.900	115.700	199.100	312.700	100.500	330.900	523.700	291.500
0.000	0.000	0.000	9.000	61.000	152.700	115.200	198.200	311.100	100.000	329.400	519.200	285.700
0.000	0.000	0.000	0.000	13.300	62.500	71.200	168.700	297.300	99.500	219.300	372.600	192.400
0.000	0.000	0.000	0.000	0.000	52.600	69.800	167.600	296.100	95.900	214.900	368.900	188.500
0.000	0.000	0.000	0.000	0.000	29.300	62.600	164.200	295.100	95.200	214.900	361.500	188.100
0.000	0.000	0.000	0.000	0.000	0.000	47.000	163.200	289.200	93.300	190.500	344.000	176.400
0.000	0.000	0.000	0.000	0.000	0.000	30.800	149.600	272.400	92.600	168.100	299.000	158.100
0.000	0.000	0.000	0.000	0.000	0.000	26.800	137.000	252.400	89.100	146.400	256.700	142.100
0.000	0.000	0.000	0.000	0.000	0.000	0.000	121.900	228.100	83.200	122.100	212.300	124.900
0.000	0.000	0.000	0.000	0.000	0.000	0.000	107.000	203.900	75.800	100.600	163.800	107.600
0.000	0.000	0.000	0.000	0.000	0.000	0.000	93.300	182.000	68.800	79.100	117.300	94.600
0.000	0.000	0.000	0.000	0.000	0.000	0.000	43.200	138.900	65.000	77.000	109.800	93.800
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	87.100	64.700	75.500	109.200	91.900
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	36.400	63.400	73.500	107.100	91.200
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	16.100	57.800	65.100	99.600	85.400
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	46.700	54.200	86.700	74.200
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	33.300	44.300	75.000	64.500
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.700	33.200	60.800	52.600
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	22.300	49.000	42.700
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.200	39.800	35.300
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	25.100	16.900
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure A3. Page 3 from bathymetry development Excel file.

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
204.5	159.1	145.4	0	0	792.5	457.8	582.8	271.3	0	0	310.3	167.6	261.2	0.000
569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585	569.585
3.9415927	3.7685927	3.5345927	0	0	1.954	1.665	2.305	2.362	0	0	2.212	2.192	2.536	0
0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
549.700	386.100	493.900	0.000	0.000	146.200	346.600	422.500	459.500	0.000	0.000	316.300	169.000	181.900	0.000
547.100	385.500	488.100	0.000	0.000	130.700	340.600	413.700	446.800	0.000	0.000	248.200	165.300	178.300	0.000
545.600	379.500	474.500	0.000	0.000	121.900	333.100	404.200	438.200	0.000	0.000	210.000	162.100	177.000	0.000
544.700	373.800	461.100	0.000	0.000	114.000	325.800	395.200	430.000	0.000	0.000	178.700	158.900	174.100	0.000
544.000	368.400	447.900	0.000	0.000	106.500	318.800	386.700	422.400	0.000	0.000	153.300	155.700	171.200	0.000
543.600	362.800	434.700	0.000	0.000	100.000	311.600	378.100	414.500	0.000	0.000	132.300	152.500	168.100	0.000
543.300	357.500	421.500	0.000	0.000	93.500	304.600	369.800	407.000	0.000	0.000	115.000	149.300	165.100	0.000
542.900	356.500	408.200	0.000	0.000	87.000	297.400	361.300	399.300	0.000	0.000	101.000	146.000	161.800	0.000
542.300	354.400	397.200	0.000	0.000	80.500	290.100	352.800	391.700	0.000	0.000	89.100	142.800	158.500	0.000
541.600	352.300	389.400	0.000	0.000	74.000	284.400	346.200	386.300	0.000	0.000	65.600	139.000	155.900	0.000
540.700	350.400	386.800	0.000	0.000	67.500	281.200	344.400	386.200	0.000	0.000	30.700	120.400	155.100	0.000
539.600	348.400	380.500	0.000	0.000	61.000	274.400	339.300	382.600	0.000	0.000	0.000	94.800	152.500	0.000
538.100	346.200	372.800	0.000	0.000	54.500	266.000	333.200	377.700	0.000	0.000	0.000	69.200	149.200	0.000
536.500	344.200	363.900	0.000	0.000	48.000	256.500	326.000	371.500	0.000	0.000	0.000	46.400	145.300	0.000
534.600	337.300	354.100	0.000	0.000	41.500	245.900	318.100	364.300	0.000	0.000	0.000	31.000	140.800	0.000
532.500	335.300	346.100	0.000	0.000	35.000	237.000	310.100	354.800	0.000	0.000	0.000	21.500	136.600	0.000
530.300	333.500	335.900	0.000	0.000	28.500	227.200	301.800	346.800	0.000	0.000	0.000	15.700	129.700	0.000
528.000	333.300	324.000	0.000	0.000	22.000	216.300	292.100	337.400	0.000	0.000	0.000	15.400	122.000	0.000
525.700	327.200	311.500	0.000	0.000	22.000	205.100	282.000	327.700	0.000	0.000	0.000	15.200	113.800	0.000
523.400	321.200	298.600	0.000	0.000	0.000	194.000	271.900	318.500	0.000	0.000	0.000	12.500	105.500	0.000
521.200	319.800	285.000	0.000	0.000	0.000	182.800	261.700	309.400	0.000	0.000	0.000	10.800	97.000	0.000
519.000	313.400	279.600	0.000	0.000	0.000	176.800	258.900	309.400	0.000	0.000	0.000	9.500	90.900	0.000
516.900	304.400	250.300	0.000	0.000	0.000	155.800	233.700	288.100	0.000	0.000	0.000	8.200	77.300	0.000
514.800	303.100	247.300	0.000	0.000	0.000	134.800	227.800	285.700	0.000	0.000	0.000	7.600	72.600	0.000
512.700	301.800	238.300	0.000	0.000	0.000	99.900	217.100	280.000	0.000	0.000	0.000	7.300	67.100	0.000
502.500	300.200	218.600	0.000	0.000	0.000	71.900	206.200	278.300	0.000	0.000	0.000	6.200	61.800	0.000
500.500	297.800	202.800	0.000	0.000	0.000	54.100	194.400	272.100	0.000	0.000	0.000	6.100	56.500	0.000
498.500	291.900	195.100	0.000	0.000	0.000	40.000	182.200	265.200	0.000	0.000	0.000	5.400	51.400	0.000
496.600	289.600	187.100	0.000	0.000	0.000	27.700	169.700	257.700	0.000	0.000	0.000	5.000	46.600	0.000
494.600	288.200	179.100	0.000	0.000	0.000	17.800	157.300	249.700	0.000	0.000	0.000	5.000	42.000	0.000
492.600	283.000	170.900	0.000	0.000	0.000	17.000	144.700	241.300	0.000	0.000	0.000	5.000	37.900	0.000
490.600	277.400	162.600	0.000	0.000	0.000	0.000	132.000	232.500	0.000	0.000	0.000	5.000	34.000	0.000
488.500	271.700	154.600	0.000	0.000	0.000	0.000	119.700	223.700	0.000	0.000	0.000	5.000	30.500	0.000
486.500	269.300	146.800	0.000	0.000	0.000	0.000	107.500	214.800	0.000	0.000	0.000	5.000	27.300	0.000
484.400	267.800	139.000	0.000	0.000	0.000	0.000	95.800	205.700	0.000	0.000	0.000	5.000	24.300	0.000
482.500	266.700	131.300	0.000	0.000	0.000	0.000	85.200	196.600	0.000	0.000	0.000	5.000	21.600	0.000
480.600	265.700	127.100	0.000	0.000	0.000	0.000	63.800	185.600	0.000	0.000	0.000	5.000	18.600	0.000
478.900	264.800	126.300	0.000	0.000	0.000	0.000	41.600	176.400	0.000	0.000	0.000	5.000	15.600	0.000
477.200	263.900	123.600	0.000	0.000	0.000	0.000	29.800	166.200	0.000	0.000	0.000	5.000	14.900	0.000
475.500	258.600	119.300	0.000	0.000	0.000	0.000	23.300	153.500	0.000	0.000	0.000	5.000	14.800	0.000
473.700	257.700	115.900	0.000	0.000	0.000	0.000	18.300	139.200	0.000	0.000	0.000	5.000	14.500	0.000
471.800	256.800	113.600	0.000	0.000	0.000	0.000	16.100	124.900	0.000	0.000	0.000	5.000	5.000	0.000
469.700	255.800	113.000	0.000	0.000	0.000	0.000	15.800	120.500	0.000	0.000	0.000	5.000	5.000	0.000
467.600	254.600	112.100	0.000	0.000	0.000	0.000	12.000	118.100	0.000	0.000	0.000	5.000	5.000	0.000
407.000	244.500	76.900	0.000	0.000	0.000	0.000	6.300	62.100	0.000	0.000	0.000	5.000	5.000	0.000
405.800	243.300	76.600	0.000	0.000	0.000	0.000	6.100	60.900	0.000	0.000	0.000	5.000	5.000	0.000
403.300	242.100	76.400	0.000	0.000	0.000	0.000	5.600	55.300	0.000	0.000	0.000	5.000	5.000	0.000
395.200	237.300	74.800	0.000	0.000	0.000	0.000	5.000	42.200	0.000	0.000	0.000	5.000	5.000	0.000
392.800	236.200	72.100	0.000	0.000	0.000	0.000	5.000	30.600	0.000	0.000	0.000	5.000	5.000	0.000
345.800	235.100	70.700	0.000	0.000	0.000	0.000	5.000	15.900	0.000	0.000	0.000	5.000	5.000	0.000
216.900	234.300	70.600	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000
215.100	233.900	68.800	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000
210.800	233.100	68.300	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000
209.000	231.900	66.900	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000
152.700	198.700	41.100	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000
151.400	197.000	40.700	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000
148.400	193.000	39.900	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000
144.700	187.800	35.600	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
132.500	168.200	31.300	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
122.100	149.200	27.800	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
109.500	128.700	24.300	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
97.700	108.100	21.100	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
94.600	93.200	19.900	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
94.400	92.900	19.800	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
92.500	91.000	19.700	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
92.200	90.700	19.300	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
87.000	88.900	19.200	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
75.700	79.700	19.100	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
65.900	71.800	19.100	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
54.000	61.400	19.000	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
44.400	53.100	18.900	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
39.500	52.400	15.000	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
38.700	52.000	15.000	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
15.000	50.900	15.000	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
0.000	29.400	15.000	0.000	0.000	0.000	0.000	5.000	5.000	0.000	0.000	0.000	0.000	5.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix B: W2 Control File with Detailed Modifications for the APPLM and the APPLPM

This appendix serves to present the control file (w2_con.npt) used for the calibration of the model (see Figure B1-Figure B10) along with a table of changes for every model run simulated (see Tables B1-B3). All other model simulations will be compared to the Calibration w2_selective.npt file from CY01. Discussions of all modifications are made in the main report text.

Figure B1. Page 1 from CY01 w2_con.npt file.

```
  W2 Model Version 3.7

TITLE C ..............................TITLE....................................
        Version 3.7 Applegate Dam Model
        Model Run from  January 1-Dec 31, 2001

        CY01-Run08 - CY01-Run07 improved surface temp, but worsened the thermocline,
                     therefore decreasing model performance
                   - *  Thermocline region was too cool.
                   - ** Decrease light extinction coefficients to allow more light
                        to penetrate.
        Tammy Threadgill - USACE-ERDC-EL
        .........................................................................

GRID         NWB     NBR     IMX     KMX   NPROC  CLOSEC
               1       3      41      77       1     OFF

IN/OUTFL     NTR     NST     NIW     NWD     NGT     NSP     NPI     NPU
               0       6       0       0       0       0       0       0

CONSTITU     NGC     NSS     NAL     NEP    NBOD     NMC     NZP
               0       0       0       0       0       0       0

MISCELL     NDAY SELECTC HABTATC ENVIRPC AERATEC INITUWL
            1000     OFF     OFF     OFF     OFF     OFF

TIME CON  TMSTRT   TMEND    YEAR
               1     365    2001

DLT CON      NDT  DLTMIN DLTINTR
               1 0.10000     OFF

DLT DATE    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD    DLTD
         1.00000

DLT MAX   DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX  DLTMAX
         3600.00

DLT FRN     DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF    DLTF
            0.90

DLT LIMI    VISC    CELC
WB 1          ON      ON

BRANCH G      US      DS     UHS     DHS     UQB     DQB   NLMIN   SLOPE  SLOPEC
BR1            2      29       0       0       0       0       1 0.00000 0.00000
BR2           32      35       0      19       0       0       1 0.00000 0.00000
BR3           38      40       0      27       0       0       1 0.00000 0.00000

LOCATION     LAT    LONG    EBOT      BS      BE    JBDN
WB 1     42.0565 123.115 539.667       1       3       1

INIT CND     T2I    ICEI  WTYPEC   GRIDC
WB 1        4.90 0.00000   FRESH    RECT

CALCULAT     VBC     EBC     MBC     PQC     EVC     PRC
WB 1         OFF     OFF     OFF      ON      ON     OFF

DEAD SEA   WINDC    QINC   QOUTC   HEATC
WB 1          ON      ON      ON      ON

INTERPOL   QINIC   DTRIC    HDIC
BR1           ON      ON      ON
BR2           ON      ON      ON
BR3           ON      ON      ON

HEAT EXCH  SLHTC    SROC  RHEVAP   METIC  FETCHC     AFW     BFW     CFW   WINDH
WB 1        TERM     OFF     OFF      ON     OFF 9.20000 0.46000 2.00000 10.0000

ICE COVE    ICEC  SLICEC  ALBEDO   HWICE    BICE    GICE  ICEMIN   ICET2
WB 1         OFF  DETAIL 0.25000 10.0000 0.60000 0.07000 0.05000 3.00000

TRANSPOR   SLTRC   THETA
WB 1    ULTIMATE    0.55

HYD COEF      AX      DX    CBHE    TSED      FI   TSEDF   FRICC      Z0
WB 1     1.00000 1.00000 0.30000  11.984 0.01000 1.00000    MANN 0.00100

EDDY VISC    AZC   AZSLC   AZMAX     FBC       E   ARODI STRCKLR BOUNDFR  TKECAL
WB 1          W2     IMP   1.000

N STRUC     NSTR
BR1            6
BR2            0
BR3            0

STR INT    STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC   STRIC
BR 1          ON      ON      ON      ON      ON      ON
BR 2
BR 3

STR TOP    KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR   KTSTR
```

Figure B2. Page 2 from CY01 w2_con.npt file.

```
BR1             2       2       2       2       2       2
BR2
BR3

STR BOT     KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR   KBSTR
BR 1           76      76      76      76      76      76
BR 2
BR 3

STR SINK    SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC   SINKC
BR1         POINT   POINT   POINT   POINT   POINT   POINT
BR2
BR3

STR ELEV     ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR    ESTR
BR1        598.02  594.36  588.26  577.60  560.22  541.32
BR2
BR3

STR WIDT     WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR    WSTR
BR1
BR2
BR3

PIPES        IUPI    IDPI    EUPI    EDPI     WPI   DLXPI     FPI  FMINPI   WTHLC

PIPE UP     PUPIC   ETUPI   EBUPI   KTUPI   KBUPI

PIPE DOWN   PDPIC   ETDPI   EBDPI   KTDPI   KBDPI

SPILLWAY     IUSP    IDSP     ESP    A1SP    B1SP    A2SP    B2SP   WTHLC

SPILL UP    PUSPC   ETUSP   EBUSP   KTUSP   KBUSP

SPILL DOWN PDSPC    ETUSP   EBUSP   KTDSP   KBDSP

SPILL GAS GASSPC     EQSP  AGASSP  BGASSP  CGASSP

GATES        IUGT    IDGT     EGT    A1GT    B1GT    G1GT    A2GT    B2GT    G2GT   WTHLC

GATE WEIR    GTA1    GTB1    GTA2    GTB2  DYNVAR    GTIC

GATE UP     PUGTC   ETUGT   EBUGT   KTUGT   KBUGT

GATE DOWN   PDGTC   ETDGT   EBDGT   KTDGT   KBDGT

GATE GAS   GASGTC    EQGT  AGASGT  BGASGT  CGASGT

PUMPS 1      IUPU    IDPU     EPU  STRTPU   ENDPU   EONPU  EOFFPU     QPU   WTHLC DYNPUMP

PUMPS 2      PPUC    ETPU    EBPU    KTPU    KBPU

WEIR SEG      IWR     IWR     IWR     IWR     IWR     IWR     IWR     IWR     IWR

WEIR TOP     KTWR    KTWR    KTWR    KTWR    KTWR    KTWR    KTWR    KTWR    KTWR

WEIR BOT     KBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR    KBWR

WD INT       WDIC    WDIC    WDIC    WDIC    WDIC    WDIC    WDIC    WDIC    WDIC

WD SEG        IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD     IWD

WD ELEV       EWD     EWD     EWD     EWD     EWD     EWD     EWD     EWD     EWD

WD TOP       KTWD    KTWD    KTWD    KTWD    KTWD    KTWD    KTWD    KTWD    KTWD

WD BOT       KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD    KBWD

TRIB PLA     PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC    PTRC
```

Figure B3. Page 3 from CY01 w2_con.npt file.

```
TRIB INT     TRIC     TRIC     TRIC     TRIC     TRIC     TRIC     TRIC     TRIC     TRIC


TRIB SEG      ITR      ITR      ITR      ITR      ITR      ITR      ITR      ITR      ITR
                5

TRIB TOP    ELTRT    ELTRT    ELTRT    ELTRT    ELTRT    ELTRT    ELTRT    ELTRT    ELTRT


TRIB BOT    ELTRB    ELTRB    ELTRB    ELTRB    ELTRB    ELTRB    ELTRB    ELTRB    ELTRB


DST TRIB     DTRC     DTRC     DTRC     DTRC     DTRC     DTRC     DTRC     DTRC     DTRC
BR 1           ON
BR 2          OFF
BR 3          OFF

HYD PRIN  HPRWBC   HPRWBC   HPRWBC   HPRWBC   HPRWBC   HPRWBC   HPRWBC   HPRWBC   HPRWBC
NVIOL         OFF
U              ON
W              ON
T              ON
RHO           OFF
AZ            OFF
SHEAR         OFF
ST            OFF
SB            OFF
ADMX          OFF
DM            OFF
HDG           OFF
ADMZ          OFF
HPG           OFF
GRAV          OFF

SNP PRINT    SNPC     NSNP    NISNP
WB 1           ON        1        5

SNP DATE     SNPD     SNPD     SNPD     SNPD     SNPD     SNPD     SNPD     SNPD     SNPD
WB 1      1.00000

SNP FREQ     SNPF     SNPF     SNPF     SNPF     SNPF     SNPF     SNPF     SNPF     SNPF
WB 1      1.00000

SNP SEG      ISNP     ISNP     ISNP     ISNP     ISNP     ISNP     ISNP     ISNP     ISNP
WB 1            2       15       22       28       29

SCR PRINT    SCRC     NSCR
WB 1           ON        1

SCR DATE     SCRD     SCRD     SCRD     SCRD     SCRD     SCRD     SCRD     SCRD     SCRD
WB 1      1.00000

SCR FREQ     SCRF     SCRF     SCRF     SCRF     SCRF     SCRF     SCRF     SCRF     SCRF
WB 1      0.10000

PRF PLOT     PRFC     NPRF    NIPRF
WB 1          OFF

PRF DATE     PRFD     PRFD     PRFD     PRFD     PRFD     PRFD     PRFD     PRFD     PRFD


PRF FREQ     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF     PRFF


PRF SEG      IPRF     IPRF     IPRF     IPRF     IPRF     IPRF     IPRF     IPRF     IPRF


SPR PLOT     SPRC     NSPR    NISPR
WB 1           ON        1       28

SPR DATE     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD     SPRD
WB 1        0.500      365

SPR FREQ     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF     SPRF
WB 1        1.000

SPR SEG      ISPR     ISPR     ISPR     ISPR     ISPR     ISPR     ISPR     ISPR     ISPR
WB 1            2        3        4        5        6        7        8        9       10
               11       12       13       14       15       16       17       18       19
               20       21       22       23       24       25       26       27       28
               29

VPL PLOT     VPLC     NVPL
WB 1           ON        1

VPL DATE     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD     VPLD
WB 1          0.5

VPL FREQ     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF     VPLF
WB 1          1.0
```

Figure B4. Page 4 from CY01 w2_con.npt file.

```
CPL PLOT     CPLC    NCPL TECPLOT
WB 1          OFF       2      ON

CPL DATE     CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD    CPLD


CPL FREQ     CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF    CPLF


FLUXES       FLXC    NFLX
WB 1          OFF       0

FLX DATE     FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD    FLXD
WB 1

FLX FREQ     FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF    FLXF
WB 1

TSR PLOT     TSRC    NTSR   NITSR
               ON       1       5

TSR DATE     TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD    TSRD
              0.5

TSR FREQ     TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF    TSRF
              1.0

TSR SEG      ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR    ITSR
                2      15      22      28      29

TSR LAYE     ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR    ETSR
             0.00    00.0     0.0    0.00     0.0

WITH OUT     WDOC    NWDO   NIWDO
               ON       1       1

WITH DAT     WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD    WDOD
              0.5

WITH FRE     WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF    WDOF
             1.00

WITH SEG     IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO    IWDO
WB 1           29

RESTART      RSOC    NRSO    RSIC
              OFF       0     OFF

RSO DATE     RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD    RSOD


RSO FREQ     RSOF    RSOF    RSOF    RSOF    RSOF    RSOF    RSOF    RSOF    RSOF


CST COMP      CCC    LIMC     CUF
              OFF     OFF      10

CST ACTIVE    CAC
TDS           OFF
PO4           OFF
NH4           OFF
NO3           OFF
DSI           OFF
PSI           OFF
FE            OFF
LDOM          OFF
RDOM          OFF
LPOM          OFF
RPOM          OFF
DO            OFF
TIC           OFF
ALK           OFF
LDOM-P        OFF
RDOM-P        OFF
LPOM-P        OFF
RPOM-P        OFF
LDOM-N        OFF
RDOM-N        OFF
LPOM-N        OFF
RPOM-N        OFF

CST DERI    CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC   CDWBC
DOC           OFF     OFF
POC           OFF     OFF
TOC           OFF     OFF
DON           OFF     OFF
PON           OFF     OFF
TON           OFF     OFF
TKN           OFF     OFF
TN            OFF     OFF
DOP           OFF     OFF
POP           OFF     OFF
```

Figure B5. Page 5 from CY01 w2_con.npt file.

```
TOP          OFF     OFF
TP           OFF     OFF
APR          OFF     OFF
CHLA         OFF     OFF
ATOT         OFF     OFF
%DO          OFF     OFF
TSS          OFF     OFF
TISS         OFF     OFF
CBOD         OFF     OFF
pH           OFF     OFF
CO2          OFF     OFF
HCO3         OFF     OFF
CO3          OFF     OFF

CST FLUX   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC   CFWBC
TISSIN       OFF     OFF
TISSOUT      OFF     OFF
PO4AR        OFF     OFF
PO4AG        OFF     OFF
PO4AP        OFF     OFF
PO4ER        OFF     OFF
PO4EG        OFF     OFF
PO4EP        OFF     OFF
PO4POM       OFF     OFF
PO4DOM       OFF     OFF
PO4OM        OFF     OFF
PO4SED       OFF     OFF
PO4SOD       OFF     OFF
PO4SET       OFF     OFF
NH4NITR      OFF     OFF
NH4AR        OFF     OFF
NH4AG        OFF     OFF
NH4AP        OFF     OFF
NH4ER        OFF     OFF
NH4EG        OFF     OFF
NH4EP        OFF     OFF
NH4POM       OFF     OFF
NH4DOM       OFF     OFF
NH4OM        OFF     OFF
NH4SED       OFF     OFF
NH4SOD       OFF     OFF
NO3DEN       OFF     OFF
NO3AG        OFF     OFF
NO3EG        OFF     OFF
NO3SED       OFF     OFF
DSIAG        OFF     OFF
DSIEG        OFF     OFF
DSIPIS       OFF     OFF
DSISED       OFF     OFF
DSISOD       OFF     OFF
DSISET       OFF     OFF
PSIAM        OFF     OFF
PSINET       OFF     OFF
PSIDK        OFF     OFF
FESET        OFF     OFF
FESED        OFF     OFF
LDOMDK       OFF     OFF
LRDOM        OFF     OFF
RDOMDK       OFF     OFF
LDOMAP       OFF     OFF
LDOMEP       OFF     OFF
LPOMDK       OFF     OFF
LRPOM        OFF     OFF
RPOMDK       OFF     OFF
LPOMAP       OFF     OFF
LPOMEP       OFF     OFF
LPOMSET      OFF     OFF
RPOMSET      OFF     OFF
CBODDK       OFF     OFF
DOAP         OFF     OFF
DOAR         OFF     OFF
DOEP         OFF     OFF
DOER         OFF     OFF
DOPOM        OFF     OFF
DODOM        OFF     OFF
DOOM         OFF     OFF
DONITR       OFF     OFF
DOCBOD       OFF     OFF
DOREAR       OFF     OFF
DOSED        OFF     OFF
DOSOD        OFF     OFF
TICAG        OFF     OFF
TICEG        OFF     OFF
SEDDK        OFF     OFF
SEDAS        OFF     OFF
SEDLPOM      OFF     OFF
SEDSET       OFF     OFF
SODDK        OFF     OFF

CST ICON   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB   C2IWB
TDS      0.00000  0.0000
PO4      0.00200  0.0020
```

Figure B6. Page 6 from CY01 w2_con.npt file.

```
NH4      0.00500  0.0050
NO3      0.04000  0.0400
DSI      0.00000  0.0000
PSI      0.00000  0.0000
FE       0.00000  0.0000
LDOM     0.10000  0.1000
RDOM     0.10000  0.1000
LPOM     0.10000  0.1000
RPOM     0.10000  0.1000
DO       12.0000 12.0000
TIC      5.00000  5.0000
ALK      19.8000 19.8000
LDOM-P   0.00050
RDOM-P   0.00050
LPOM-P   0.00050
RPOM-P   0.00050
LDOM-N   0.00800
RDOM-N   0.00800
LPOM-N   0.00800
RPOM-N   0.00800

CST PRIN  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC  CPRWBC
TDS          OFF     OFF
PO4          OFF     OFF
NH4          OFF     OFF
NO3          OFF     OFF
DSI          OFF     OFF
PSI          OFF     OFF
FE           OFF     OFF
LDOM         OFF     OFF
RDOM         OFF     OFF
LPOM         OFF     OFF
RPOM         OFF     OFF
DO           OFF     OFF
TIC          OFF     OFF
ALK          OFF     OFF
LDOM-P       OFF
RDOM-P       OFF
LPOM-P       OFF
RPOM-P       OFF
LDOM-N       OFF
RDOM-N       OFF
LPOM-N       OFF
RPOM-N       OFF

CIN CON   CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC  CINBRC
TDS          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DO           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
TIC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALK          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM-P       OFF     OFF
RDOM-P       OFF     OFF
LPOM-P       OFF     OFF
RPOM-P       OFF     OFF
LDOM-N       OFF     OFF
RDOM-N       OFF     OFF
LPOM-N       OFF     OFF
RPOM-N       OFF     OFF

CTR CON   CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC  CTRTRC
TDS          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF      OFF    OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF      OFF    OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF      OFF    OFF
LDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DO           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
TIC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALK          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM-P
RDOM-P
LPOM-P
RPOM-P
LDOM-N
RDOM-N
LPOM-N
RPOM-N
```

Figure B7. Page 7 from CY01 w2_con.npt file.

```
CDT CON   CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC  CDTBRC
TDS          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DO           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
TIC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALK          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM-P       OFF     OFF
RDOM-P       OFF     OFF
LPOM-P       OFF     OFF
RPOM-P       OFF     OFF
LDOM-N       OFF     OFF
RDOM-N       OFF     OFF
LPOM-N       OFF     OFF
RPOM-N       OFF     OFF

CPR CON   CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC  CPRBRC
TDS          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
PO4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NH4          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
NO3          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
PSI          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
FE           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RDOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
RPOM         OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
DO           OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
TIC          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
ALK          OFF     OFF     OFF     OFF     OFF     OFF     OFF     OFF
LDOM-P       OFF     OFF
RDOM-P       OFF     OFF
LPOM-P       OFF     OFF
RPOM-P       OFF     OFF
LDOM-N       OFF     OFF
RDOM-N       OFF     OFF
LPOM-N       OFF     OFF
RPOM-N       OFF     OFF

EX COEF    EXH2O    EXSS    EXOM    BETA     EXC    EXIC
WB 1       0.450  0.1000 0.10000    0.45     OFF     OFF

ALG EX       EXA     EXA     EXA     EXA     EXA     EXA


ZOO EX       EXZ     EXZ     EXZ     EXZ     EXZ     EXZ


MACRO EX     EXM     EXM     EXM     EXM     EXM     EXM


GENERIC    CGQ10   CG0DK   CG1DK     CGS


S SOLIDS     SSS   SEDRC   TAUCR


ALGAL RATE    AG      AR      AE      AM      AS    AHSP    AHSN   AHSSI    ASAT


ALGAL TEMP   AT1     AT2     AT3     AT4     AK1     AK2     AK3     AK4


ALG STOI    ALGP    ALGN    ALGC   ALGSI   ACHLA   ALPOM   ANEQN    ANPR


EPIPHYTE    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC    EPIC
EPI1         OFF

EPI PRIN    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC    EPRC
EPI1         OFF

EPI INIT   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI   EPICI


EPI RATE      EG      ER      EE      EM      EB    EHSP    EHSN   EHSSI


EPI HALF    ESAT     EHS   ENEQN    ENPR


EPI TEMP     ET1     ET2     ET3     ET4     EK1     EK2     EK3     EK4
```

Figure B8. Page 8 from CY01 w2_con.npt file.

```
EPI STOI       EP      EN      EC     ESI   ECHLA    EPOM

ZOOP RATE      ZG      ZR      ZM    ZEFF   PREFP  ZOOMIN    ZS2P

ZOOP ALGP   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA   PREFA

ZOOP ZOOP   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ   PREFZ

ZOOP TEMP     ZT1     ZT2     ZT3     ZT4     ZK1     ZK2     ZK3     ZK4

ZOOP STOI      ZP      ZN      ZC

MACROPHYT MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC  MACWBC
Mac1         OFF

MAC PRINT MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC  MPRWBC
Mac1         OFF

MAC INI  MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI MACWBCI

MAC RATE       MG      MR      MM    MSAT    MHSP    MHSN    MHSC    MPOM  LRPMAC

MAC SED      PSED    NSED

MAC DIST     MBMP    MMAX

MAC DRAG   CDDRAG     DWV    DWSA   ANORM

MAC TEMP      MT1     MT2     MT3     MT4     MK1     MK2     MK3     MK4

MAC STOICH     MP      MN      MC

DOM        LDOMDK  RDOMDK   LRDDK

POM        LPOMDK  RPOMDK   LRPDK    POMS

OM STOIC     ORGP    ORGN    ORGC   ORGSI

OM RATE      OMT1    OMT2    OMK1    OMK2

CBOD         KBOD    TBOD    RBOD

CBOD STOIC   BODP    BODN    BODC

PHOSPHOR     PO4R   PARTP

AMMONIUM     NH4R   NH4DK

NH4 RATE    NH4T1   NH4T2   NH4K1   NH4K2

NITRATE     NO3DK    NO3S

NO3 RATE    NO3T1   NO3T2   NO3K1   NO3K2

SILICA       DSIR    PSIS   PSIDK  PARTSI

IRON          FER     FES

SED CO2      CO2R

STOICH 1    O2NH4    O2OM
```

Figure B9. Page 9 from CY01 w2_con.npt file.

```
STOICH 2    O2AR    O2AG


STOICH 3    O2ER    O2EG


STOICH 4    O2ZR


STOICH 5    O2MR    O2MG


O2 LIMIT   O2LIM


SEDIMENT    SEDC  SEDPRC   SEDCI    SEDK    SEDS    FSOD    FSED    SEDB DYNSEDK
WB 1         OFF     OFF 0.00000 0.10000     0.1 1.00000 1.00000     0.0     OFF

SOD RATE   SODT1   SODT2   SODK1   SODK2
WB 1     4.00000 30.0000 0.10000 0.99000

S DEMAND     SOD     SOD     SOD     SOD     SOD     SOD     SOD     SOD     SOD
         0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
         0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
         0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
         0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000
         0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000 0.10000

REAERATION  TYPE    EQN#   COEF1   COEF2   COEF3   COEF4
WB 1        LAKE       6 0.00000 0.00000 0.00000 0.00000

RSI FILE..................................RSIFN.................................
        rsi.npt

QWD FILE..................................QWDFN.................................
        qwd.npt

QGT FILE..................................QGTFN.................................
        qgt.npt - not used

WSC FILE..................................WSCFN.................................
        APP-WSC.NPT

SHD FILE..................................SHDFN.................................
        APP-SHD-2.NPT

BTH FILE..................................BTHFN.................................
WB 1    APP-BTH-FINAL-2001.NPT

MET FILE..................................METFN.................................
WB 1    APP-MET-2001.NPT

EXT FILE..................................EXTFN.................................
WB 1    ext_wb1.npt - not used

VPR FILE..................................VPRFN.................................
WB 1    vpr_wb1.npt - not used

LPR FILE..................................LPRFN.................................
WB 1    lpr_wb1.npt - not used

QIN FILE..................................QINFN.................................
BR1     APP-QIN-2001.NPT
BR2     APP-BR2-QIN.NPT
BR3     APP-BR3-QIN.NPT

TIN FILE..................................TINFN.................................
BR1     APP-TIN-2001-CORR.NPT
BR2     APP-BR2-TIN.NPT
BR3     APP-BR3-TIN.NPT

CIN FILE..................................CINFN.................................
BR1     Cin br1.npt - not used
BR2     Cin br2.npt - not used
BR3     Cin_br3.npt - not used

QOT FILE..................................QOTFN.................................
BR1     APP-QOUT-2001.NPT
BR2     qout-br2.npt - not used
BR3     qout-br3.npt - not used

QTR FILE..................................QTRFN.................................
TR1     qtr_tr1.npt - not used

TTR FILE..................................TTRFN.................................
TR1     ttr_tr1.npt - not used

CTR FILE..................................CTRFN.................................
TR1     ctr_tr1.npt - not used

QDT FILE..................................QDTFN.................................
BR1     APP-QDT-2001-ADJUST.NPT
```

Figure B10. Page 10 from CY01 w2_con.npt file.

```
BR2     qdt_br2.npt - not used
BR3     qdt_br3.npt - not used

TDT FILE.................................TDTFN................................
BR1     APP-TDT-2001.NPT
BR2     tdt_br2.npt - not used
BR3     tdt_br3.npt - not used

CDT FILE.................................CDTFN................................
BR1     cdt_br1.npt - not used
BR2     cdt_br2.npt - not used
BR3     cdt_br3.npt - not used

PRE FILE.................................PREFN................................
BR1     pre_br1.npt - not used
BR2     pre_br2.npt - not used
BR3     pre_br3.npt - not used

TPR FILE.................................TPRFN................................
BR1     tpr_br1.npt - not used
BR2     tpr_br2.npt - not used
BR3     tpr_br3.npt - not used

CPR FILE.................................CPRFN................................
BR1     cpr_br1.npt - not used
BR2     cpr_br2.npt - not used
BR3     cpr_br3.npt - not used

EUH FILE.................................EUHFN................................
BR1     euh_br1.npt - not used
BR2     euh_br2.npt - not used
BR3     euh_br3.npt - not used

TUH FILE.................................TUHFN................................
BR1     tuh_br1.npt - not used
BR2     tuh_br2.npt - not used
BR3     tuh_br3.npt - not used

CUH FILE.................................CUHFN................................
BR1     cuh_br1.npt - not used
BR2     cuh_br2.npt - not used
BR3     cuh_br3.npt - not used

EDH FILE.................................EDHFN................................
BR1     edh_br1.npt - not used
BR2     edh_br2.npt - not used
BR3     edh_br3.npt - not used

TDH FILE.................................TDHFN................................
BR1     tdh_br1.npt - not used
BR2     tdh_br2.npt - not used
BR3     tdh_br3.npt - not used

CDH FILE.................................CDHFN................................
BR1     cdh_br1.npt - not used
BR2     cdh_br2.npt - not used
BR3     cdh_br3.npt - not used

SNP FILE.................................SNPFN................................
WB 1    APP-CY01-Run08-snp.opt

PRF FILE.................................PRFFN................................
WB 1    APP-CY01-Run08-prf.opt

VPL FILE.................................VPLFN................................
WB 1    APP-CY01-Run08.w2l

CPL FILE.................................CPLFN................................
WB 1    APP-CY01-Run08-cpl.opt

SPR FILE.................................SPRFN................................
WB 1    APP-CY01-Run08-spr.opt

FLX FILE.................................FLXFN................................
WB 1    APP-CY01-Run08-kfl.opt

TSR FILE.................................TSRFN................................
        APP-CY01-Run08-tsr.opt

WDO FILE.................................WDOFN................................
        APP-CY01-Run08-wdo.opt
```

Table B1. Changes to Calibration w2_con.npt File for Other Runs.

RUN	YEAR	TEMPI	TSED
Calibration-2001	2001	4.90	11.984
Verification-2003	2003	6.20	12.513
Verification-2010	2010	4.70	11.743

Table B2. Inventory of files needed to run the LCLM.

Run Name	CY01_Run08		CY03-Run02		CY10-Run02	
File Type	Calibration – 2001	Date Stamp	Verification – 2003	Date Stamp	Verification – 2010	Date Stamp
W2_CON.NPT	--	10/26/15 2:10 PM	--	01/09/15 10:57 AM	--	10/26/15 3:57 pm
GRAPH.NPT	--	10/22/12 5:01 PM	--	10/22/12 5:01 PM	--	10/22/12 5:01 PM
WSC File	APP-WSC.NPT	12/23/14 2:30 PM	APP-WSC.NPT	12/23/14 2:30 PM	APP-WSC.NPT	12/23/14 2:30 PM
SHD File	APP-SHD-2.NPT	01/05/15 10:49 AM	APP-SHD-2.NPT	01/05/15 10:49 AM	APP-SHD-2.NPT	01/05/15 10:49 AM
BTH File	APP-BATH-FINAL-2001.NPT	12/04/15 2:21 PM	APP-BATH-FINAL-2003.NPT	01/14/15 12:41 PM	APP-BATH-FINAL-2010.NPT	01/08/15 1:06 PM
MET File	APP-MET-2001.NPT	01/27/14 10:53 AM	APP-MET-2003.NPT	02/03/14 2:06 PM	APP-MET-2010.NPT	01/14/15 2:54 PM
QIN File	APP-QIN-2001.NPT	12/04/14 1:44 PM	APP-QIN-fromGates-2003.NPT	03/04/14 2:29 PM	APP-QIN-fromGates-2010.NPT	01/14/15 2:49 PM
	APP-BR2-QIN.NPT	12/17/12 4:18 PM	APP-BR2-QIN.NPT	12/17/12 4:18 PM	APP-BR2-QIN.NPT	12/17/12 4:18 PM
	APP-BR3-QIN.NPT	12/17/12 4:18 PM	APP-BR3-QIN.NPT	12/17/12 4:18 PM	APP-BR3-QIN.NPT	12/17/12 4:18 PM
TIN File	APP-TIN-2001-CORR.NPT	07/03/14 10:53 AM	APP-TIN-2003-CORR.NPT	07/03/14 10:52 AM	APP-TIN-2010-CORR.NPT	07/03/14 10:54 AM
	APP-BR2-TIN.NPT	02/24/14 3:35 PM	APP-BR2-TIN.NPT	02/24/14 3:35 PM	APP-BR2-TIN.NPT	02/24/14 3:35 PM
	APP-BR3-TIN.NPT	02/24/14 3:35 PM	APP-BR3-TIN.NPT	02/24/14 3:35 PM	APP-BR3-TIN.NPT	02/24/14 3:35 PM
QOT File	APP-QOUT-2001.NPT	02/25/14 1:33 PM	APP-QOUT-2003.NPT	02/25/14 1:33 PM	APP-QOUT-2010.NPT	05/25/14 1:33 PM
QDT File	APP-QDT-2001-ADJUST.NPT	12/23/14 2:11 PM	APP-QDT-2003-ADJUST.NPT	01/14/15 2:10 PM	APP-QDT-2010-ADJUST.NPT	01/20/15 10:29 PM
TDT File	APP-TDT-2001.NPT	07/03/14 10:53 AM	APP-TDT-2003.NPT	07/03/14 10:52 AM	APP-TDT-2010.NPT	07/03/14 10:54 AM

Table B3. Inventory of files needed to run the APPLPM (Predictive Model).

Run Name	CY01-USGS-PortRun10		CY03-USGS-PortRun13		CY10-USGS-PortRun07	
File Type	Calibration – 2001	Date Stamp	Verification – 2003	Date Stamp	Verification – 2010	Date Stamp
W2_CON.NPT	--	10/26/15 2:10 PM	--	01/09/15 10:57 AM	--	10/26/15 3:57 pm
QOT File	APP-QOUT-2001-PortRun01.NPT	05/05/15 9:41 AM	APP-QOUT-2003-PortRun01.NPT		APP-QOUT-2010-PortRun01.NPT	
W2_SELECTIVE.NPT	--	08/03/15 2:10 PM	--	08/03/15 2:10 PM	--	08/03/15 2:10 PM
DYNSPLIT_SELECTIVE1.NPT	--	05/05/15 1:37 PM	--	05/05/15 1:37 PM	--	05/05/15 1:37 PM
DYNSPLIT_SELECTIVE2.NPT	--	05/05/15 1:37 PM	--	05/05/15 1:37 PM	--	05/05/15 1:37 PM
DYNSPLIT_SELECTIVE3.NPT	--	05/05/15 1:37 PM	--	05/05/15 1:38 PM	--	05/05/15 1:37 PM

**Note: The same w2_selective.npt AND dynsplit* files are used for all 3 cases. Unless noted above, the files used in Table B2 apply to the Predictive Model.

Appendix C: APPLM and APPLPM Files

This appendix serves to provide a description of each file needed to run the model. The files are grouped by year. The ERDC typically has the following file organization system (see Table C1).

Table C1. Typical file organization.

CY01		Main folder for year identification for the particular model. Most models will be designed to run with multiple years.
	Results	Upon running the model, the results are moved out of the executables folder and into their own folder; typically, these folders are named something like CYXX_RunXX. NOTE: Always copy the control file used for the run into the results folder so that you can duplicate the run in the future if necessary.
	Executables	This is where all of the necessary files needed to run the model are located: W2 executables, Inflows, Outflows, Temperature/Concentration files, Met files, Bathymetry, etc.

Table C2. Files needed to run APPL Model for each year.

File Description	CY01	CY03	CY10
Graph File	graph.npt	graph.npt	graph.npt
Control File	w2_con.npt	w2_con.npt	w2_con.npt
Bathymetry File	APP-BATH-FINAL-2001.NPT	APP-BATH-FINAL-2003.NPT	APP-BATH-FINAL-2010.NPT
Meteorology File	APP-MET-2001.NPT	APP-MET-2003.NPT	APP-MET-2010.NPT
Wind Sheltering Coefficient File	APP-WSC.NPT	APP-WSC.NPT	APP-WSC.NPT
Shade File	APP-SHD-2.NPT	APP-SHD-2.NPT	APP-SHD-2.NPT
Upstream Inflow File	APP-QIN-2001.NPT	APP-QIN-fromGates-2003.NPT	APP-QIN-fromGates-2010.NPT
Upstream Temperature File	APP-TIN-2001-CORR.NPT	APP-TIN-2003-CORR.NPT	APP-TIN-2010-CORR.NPT
Branch 2 Inflow File (zero)	APP-BR2-QIN.NPT	APP-BR2-QIN.NPT	APP-BR2-QIN.NPT
Branch 2 Temperature File (placeholder)	APP-BR2-TIN.NPT	APP-BR2-TIN.NPT	APP-BR2-TIN.NPT
Dam Outflow File	APP-QOUT-2001.NPT	APP-QOUT-2003.NPT	APP-QOUT-2010.NPT
Distributed Tributary Inflow File	APP-QDT-2001-ADJUST.NPT	APP-QDT-2003-ADJUST.NPT	APP-QDT-2010-ADJUST.NPT
Distributed Tributary Temperature File (duplicated upstream temps)	APP-TDT-2001.NPT	APP-TDT-2003.NPT	APP-TDT-2010.NPT

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14. ABSTRACT

The U.S. Army Corps of Engineers Engineer Research and Development Center (USACE-ERDC) Environmental Lab (EL) assisted USACE, Portland District (CENWP) in updating a CE-QUAL-W2 (W2) model of Applegate Lake based on a previous version of W2. The model was calibrated using data from calendar year (CY) 2001 and validated with data from calendar years 2003 and 2010. One set of W2 parameters was successfully applied to all calendar year types (2001 is a dry year; 2003 is a normal year; and 2010 is a wet year). This model and the corresponding results from the study provided NWP with more refined estimates of water temperatures so that more defendable water temperature targets can be discussed with the State of Oregon. This is extremely important because the Rogue and Applegate Temperature Total Maximum Daily Loads and Rogue Spring Chinook Conservation Plan require the Corps to review the Rogue Basin Project operations to determine whether improvements can be achieved to downstream temperature for the benefit of endangered fish. This is the second of three USACE projects on the Rogue River; this work is identical to the Lost Creek Lake Model work for CENWP.

15. SUBJECT TERMS

CE-QUAL-W2, eutrophication processes, Applegate Lake, longitudinal-vertical hydrodynamics model, water quality model, W2

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