OPERATING CURVE CHANGE FEASIBILITY ANALYSIS

PHASE 2 REPORT

R.L. HARRIS HYDROELECTRIC PROJECT

FERC No. 2628

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

Alabama Power Company (Alabama Power) owns and operates the R.L. Harris Hydroelectric Project (Harris Project), licensed by the Federal Energy Regulatory Commission (FERC or Commission) (FERC Project No. 2628). The Harris Project consists of a dam, spillway, powerhouse, and those lands and waters necessary for the operation of the hydroelectric project and enhancement and protection of environmental resources.

Harris Reservoir is maintained at or below the elevations specified by the Harris operating curve, except when storing floodwater. From May 1 through October 1, Harris Reservoir is maintained at or below elevation 793 feet mean sea level (msl), depending on inflow conditions. Between October 1 and December 1, the operating curve elevation drops to elevation 785 feet msl. The pool level remains at or below elevation 785 feet msl until April 1. From April 1 to May 1, the operating curve elevation rises to full pool at elevation 793 feet msl. During high flow conditions, U.S. Army Corps of Engineers (USACE)-approved flood control procedures in the Harris Water Control Manual (WCM) are implemented. During low flow conditions, the drought contingency curve (the red line in Figure 1-1) is intended to be used as one of several factors in evaluating reservoir operations consistent with approved drought plans.

Alabama Power is using the Integrated Licensing Process (ILP) to obtain a new license for the Harris Project from FERC. During stakeholder one-on-one meetings and at an October 19, 2017 Issue Identification Workshop, stakeholders requested that Alabama Power investigate changing the winter operating curve for the Harris Project. Stakeholders believe that a higher winter operating curve will enhance recreation opportunities on Harris Reservoir during the winter, or typical drawdown period. Based on this request, Alabama Power filed the Operating Curve Change Feasibility Analysis Study Plan (Study Plan) to evaluate, in increments of one foot from 786 feet msl to 789 feet msl (i.e., 786, 787, 788, and 789 feet msl; collectively "winter pool alternatives" or "alternatives"), Alabama Power's ability to increase the winter pool elevation and continue to meet Project purposes (Figure 1-1).

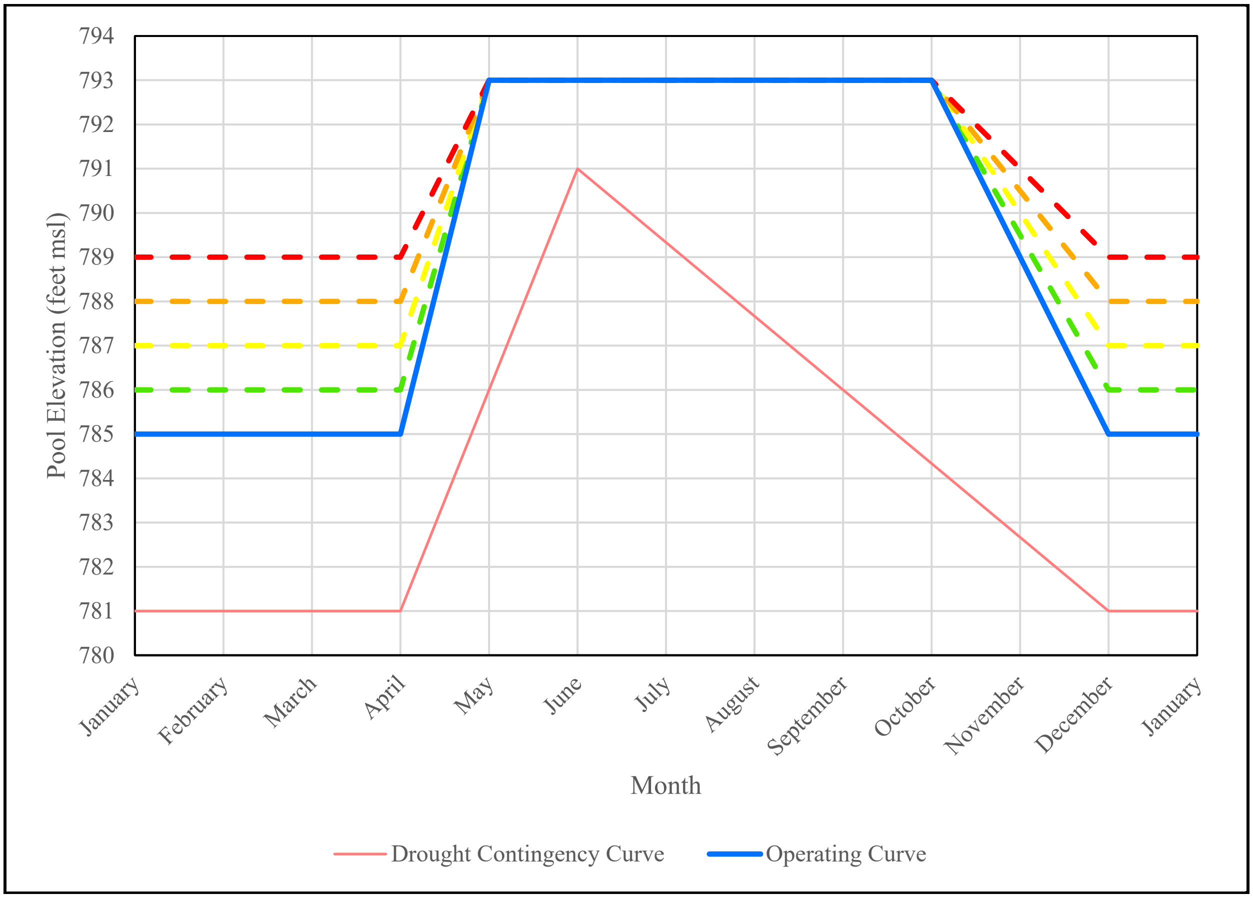

FIGURE 1–1 HARRIS OPERATING CURVE WITH PROPOSED 1-FOOT INCREMENTAL CHANGES

In the Study Plan, the evaluation of the alternatives was divided into two "phases". Consistent with the Study Plan, Alabama Power issued the Operating Curve Change Feasibility Analysis Phase 1 Report (Phase 1 Report) in August 2020 (Alabama Power and Kleinschmidt 2020). The Phase 1 Report described the hydrologic models (HEC-ResSim and HEC-RAS) developed for evaluating the alternatives and presented the Phase 1 results of the potential impacts of a winter operating curve change on hydropower generation, flood control, navigation, drought operations, Green Plan flows, and downstream release alternatives.[1]

[1] Due to timing of the development of the Phase 1 Report, the only downstream release alternatives evaluated in that report were pre-Green Plan, Green Plan, and a 150 cubic feet per second (cfs) continuous minimum flow. Shortly after Alabama Power finalized the Phase 1 Report, FERC required Alabama Power to evaluate additional downstream release alternatives. Because of the timing, these additional alternatives are analyzed in this report.

The purpose of this report is to present the Phase 2 analyses, consistent with the Study Plan. The Phase 2 analyses use the modeling results from Phase 1 along with FERC-approved relicensing study results and existing information to conduct quantitative and qualitative evaluations of potential resource impacts. These resources, and a summary of the methods used to analyze impacts are presented in Table 1-1.

Section 2.0 of this report provides a brief overview of the models developed and described in the Phase 1 Report. Section 3.0 presents the methods and results of analysis for each resource area. Section 4.0 provides a summary of all results, including those from the Phase 1 Report.

TABLE 1–1 SUMMARY OF THE RESOURCES AND STUDY METHODS USED IN PHASE 2 ANALYSES OF PROPOSED OPERATING CURVE CHANGES AT HARRIS DAM

Resource	Method: Lake Harris	Method: Tallapoosa River Downstream of Harris Dam through Horseshoe Bend
Downstream Release Alternatives	• HEC-ResSim	• N/A
Structures Downstream of Harris Dam	• N/A	• Phase 1 results • LIDAR data • County tax parcel data
Water Quality	• Phase 1 results • Baseline Water Quality Report (Kleinschmidt 2018c) • FERC-approved Water Quality Study • EFDC and HEC-ResSim	• Baseline Water Quality Report (Alabama Power and Kleinschmidt 2018) • FERC-approved Water Quality Study • EFDC to evaluate potential effects on dissolved oxygen from unit discharge in the tailrace
Water Use	• Phase 1 results • Existing information - Water Quantity, Water Use, and Discharges Report	• Phase 1 results • Existing information - Water Quantity, Water Use, and Discharges Report
Erosion and Sedimentation (including invasive species)	• Phase 1 results • FERC-approved Erosion and Sedimentation Study • LIDAR, aerial imagery, historic photos, GIS • Quantitative and qualitative evaluation of areas most susceptible to increase in nuisance aquatic vegetation	• Phase 1 results • FERC-approved Erosion and Sedimentation Study • LIDAR, aerial imagery, historic photos, GIS
Aquatics	• Phase 1 results • Existing information on the Harris Reservoir fishery	• Phase 1 results • Other FERC approved studies as appropriate
Wildlife and Terrestrial Resources- including Threatened, and Endangered Species	• Phase 1 results • FERC-approved Threatened and Endangered Species Study • GIS	• Phase 1 results • FERC-approved Threatened and Endangered Species Study • GIS
Terrestrial Wetlands	• Existing reservoir wetland data • Phase 1 results • LIDAR, aerial imagery, expert opinions, and GIS	• Existing wetlands data • National Wetland Inventory maps • Phase 1 results • LIDAR, aerial imagery, expert opinions, and GIS
Recreation Resources	• Phase 1 results • FERC-approved Recreation Evaluation Study • LIDAR data	• Phase 1 results • FERC-approved Recreation Evaluation Study • LIDAR data
Cultural Resources	• Phase 1 results • LIDAR, aerial imagery, expert opinions, and GIS	• Phase 1 results • LIDAR, aerial imagery, expert opinions, and GIS

2.0 HYDROLOGIC MODEL SUMMARY

The following data and models were used to conduct the operating curve change feasibility analysis. More details are contained in the Phase 1 Report. In addition, the models, assumptions, and their ability to address the study questions were presented to HAT 1 on September 20, 2018 and September 11, 2019.

Data

1. Alabama-Coosa-Tallapoosa (ACT) unimpaired flow database – this database was developed by the USACE with input and data from other stakeholders in the ACT comprehensive study, including both the states of Georgia and Alabama, Alabama Power, and others. These data include average daily flows from 1939 – 2011[2] with regulation influences removed. This dataset was utilized in Hydrologic Engineering Center's Reservoir System Simulation (HEC-ResSim). An unsmoothed version of this dataset for 1939-2005 was utilized in the HEC-Flood Frequency Analysis (HEC-FFA).
2. Other data – Other data sources include USGS, USACE, and Alabama Power records.

Models

3. HEC-Flood Frequency Analysis (HEC-FFA) – This USACE model conforms with Technical Bulletin #17B in determining flood flow frequency. This model was used to determine the statistical frequency of flooding for one, three, and five-day flow volumes.

    Note that the Study Plan stated that HEC-Statistical Software Package (HEC-SSP) is the USACE's newest version of the Flood Frequency Analysis. HEC-SSP combines the capabilities of HEC-FFA with other HEC software, allowing for further statistical analysis of the data. The procedures used for analyzing the flow frequency (Bulletin #17B) did not change with the development of HEC-SSP. There has been no update to the inputs used in the HEC-FFA study of the Tallapoosa River; therefore, it was not necessary to use HEC-SSP for the purposes of this study.

[2] Although when developing the study plan Alabama Power anticipated the dataset to include the years 1939-2016, the unimpaired dataset provided by the USACE includes 1939-2011.

4. HEC-River Analysis System (HEC-RAS) – This model was used in the flood study portion of evaluating the operating curve. It routes flows in the unsteady state[3] along the river.
5. HEC-ResSim – This model looked at operational changes at the Harris Project in conjunction with operating curve changes on a daily timestep. It was used to focus on the hourly flood study operations. This model, in conjunction with the HEC-RAS model, shows impacts, if applicable, to the Martin Dam Project operations.
6. HEC-Data Storage System and Viewer (HEC-DSSVue) – This is the USACE's Data Storage System, which is designed to efficiently store and retrieve scientific data that is typically sequential. Data in HEC-DSS database files can be graphed, tabulated, edited, and manipulated with HEC-DSSVue. This program was used to display some of the output of the other HEC models.
7. Alabama Power Hydro Energy (HydroBudget) Model – This model is a proprietary model that was used to evaluate the net economic gains or losses that could result from proposed operating curve changes at the Harris Project.
8. Environmental Fluid Dynamics Code (EFDC) – The EFDC is a water quality and hydrodynamic model in 2D (longitudinal-vertical) for rivers, estuaries, lakes, reservoirs, and river basin systems. The EFDC models can be used to evaluate basic eutrophication processes such as temperature-nutrient-algae-dissolved oxygen-organic matter and sediment relationships in stratified and non-stratified systems.

[3] In hydraulic modeling, simulations run in the unsteady state consider the variance of flow with respect to time.

3.0 EFFECTS OF OPERATING CURVE CHANGES ON RESOURCES

3.1 Downstream Release Alternatives

As indicated in the Phase 1 Report, model results indicated that raising the winter operating curve would not affect Alabama Power's ability to return to Pre-Green Plan operations or to pass a continuous minimum flow of 150 cfs from Harris Dam due to an increase in the winter operating curve. Because Alabama Power is evaluating additional downstream release alternatives in the relicensing process, these additional alternatives were modeled to determine if raising the winter operating curve would affect the ability to pass these downstream release alternatives through Harris Dam.

3.1.1 Methods

The HEC-ResSim model developed for the Phase 1 Report was used to determine if raising the winter operating curve would affect Alabama Power's ability to pass a Modified Green Plan (changing the time of day in which the Green Plan pulses are released), 300 cfs continuous minimum flow (CMF), 600 cfs CMF, 800 cfs CMF, and four "hybrid" Green Plan alternatives that incorporate both a base minimum flow of 150 cfs, 300 cfs, 600 cfs, or 800 cfs, and the pulsing laid out in the existing Green Plan release criteria.

It should be noted that FERC also required an evaluation of a variation of the existing Green Plan where the daily volume of Harris Dam releases are 100% of the prior day's flow at the USGS Heflin stream gauge. As explained in a Harris Action Team (HAT) 3 meeting on November 5, 2020, Alabama Power already releases approximately 100% of the prior day's flow at the USGS Heflin stream gauge under the Green Plan. The Green Plan criteria states that Harris Dam release at least 75% of the prior day's flow at Heflin; translating that minimum requirement into the 10, 15, and 30 minute pulsing operations results in releases well above 75% of the prior day's Heflin flow (Figure 3-1). Therefore, there was no need to further evaluate this alternative because there is no discernible difference between these two alternatives.

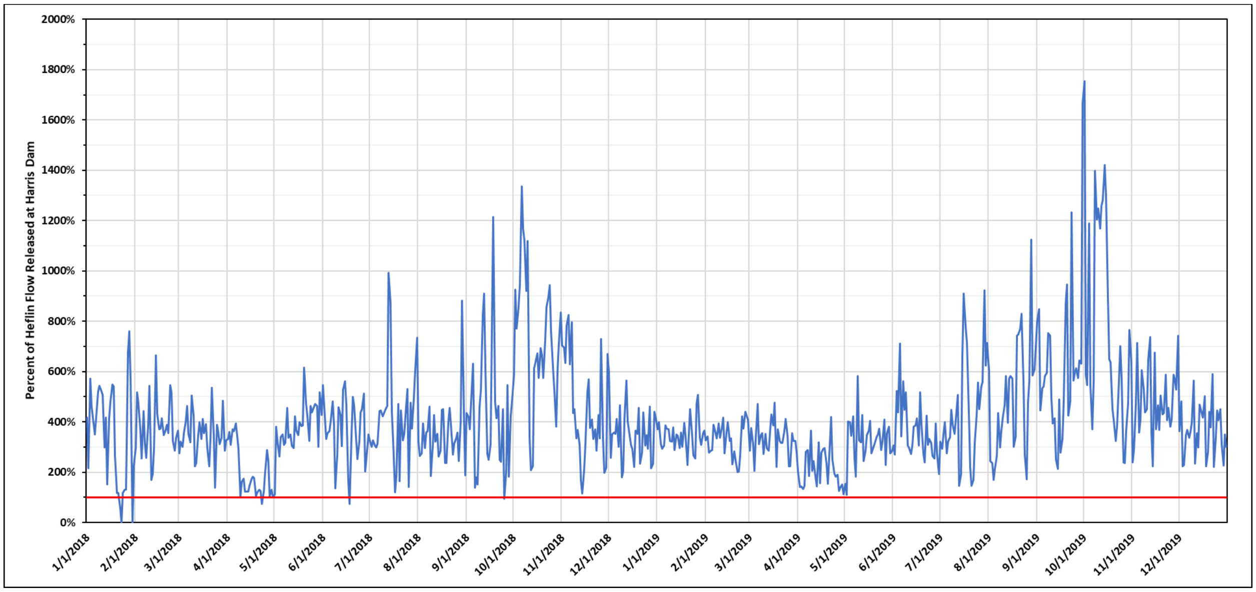

FIGURE 3–1 RELEASES FROM HARRIS DAM IN 2018 AND 2019 COMPARED TO 100% FLOW AT THE USGS HEFLIN GAGE

Note: Alabama Power suspended releases on two days in January 2018 to facilitate collecting LIDAR data around the Tallapoosa River below Harris Dam.

3.1.2 Results

Model results indicated that raising the winter operating curve would not affect Alabama Power's ability to pass any of the additional downstream release alternatives. The effect of downstream release alternatives on the reservoir level is analyzed in the Downstream Release Alternatives Phase 2 Report.

3.2 Effects on Structures Downstream of Harris Dam

As indicated in the Phase 1 Report, additional acres of land are inundated downstream of Harris Dam during the modeled 100-Year Design Flood[4] resulting from a change in winter operating curve (Appendix B, Table B-1). In addition, the depth and duration of flood above baseline elevation from the modeled 100-Year Design Flood also increases (Appendix B, Tables B-2 and B-3). Because of these effects, additional analysis was conducted to determine the potential impacts to structures affected by the modeled 100-Year Design Flood.

[4] For additional details on the 100-Year Design Flood, see the Phase 1 Report.

3.2.1 Methods

The methods for evaluating the effect of the winter pool alternatives on structures downstream of Harris Dam included:

1. Object Based Image Analysis (OBIA) with heads-up digitizing to identify structures downstream of Harris Dam,

2. An overlay analysis to find those structures affected by the operating curve alternatives,

3. A spatial join to associate affected structures with tax parcel data,

4. Summarizing the structures by tax-parcel use category (e.g., Agricultural, Forestry, Single Family, etc.), and

5. Counting the number of HEC-RAS model timesteps (hours) that each structure is inundated and summarizing by alternative.

The OBIA analysis incorporated Light Detection and Ranging (LIDAR) derived elevation products and the National Agriculture Imagery Program (NAIP) 1 m, 4 band (R,G,B,NIR) orthoimagery (USDA 2015) (Figure 3-2). When combined, the data sources provided valuable training data for an image classification algorithm that attempted to distinguish built-structures from their surroundings. The data were preprocessed by adding a height band to the NAIP image. Height was calculated as the first return (digital surface model) minus the ground (digital elevation model). A combination of automated LIDAR building classification tools and an OBIA workflow in ArcGIS Pro was used to identify structures and/or compounds of structures, and the exercise was completed with manual heads-up digitizing.[5]

[5] This method involves scanning a map or image into a computer. The digitizer then traces the points, lines and polygons using digitizing software. This method of digitizing has been named "heads-up" digitizing because the focus of the user is up on the screen, rather than down on a digitizing tablet.

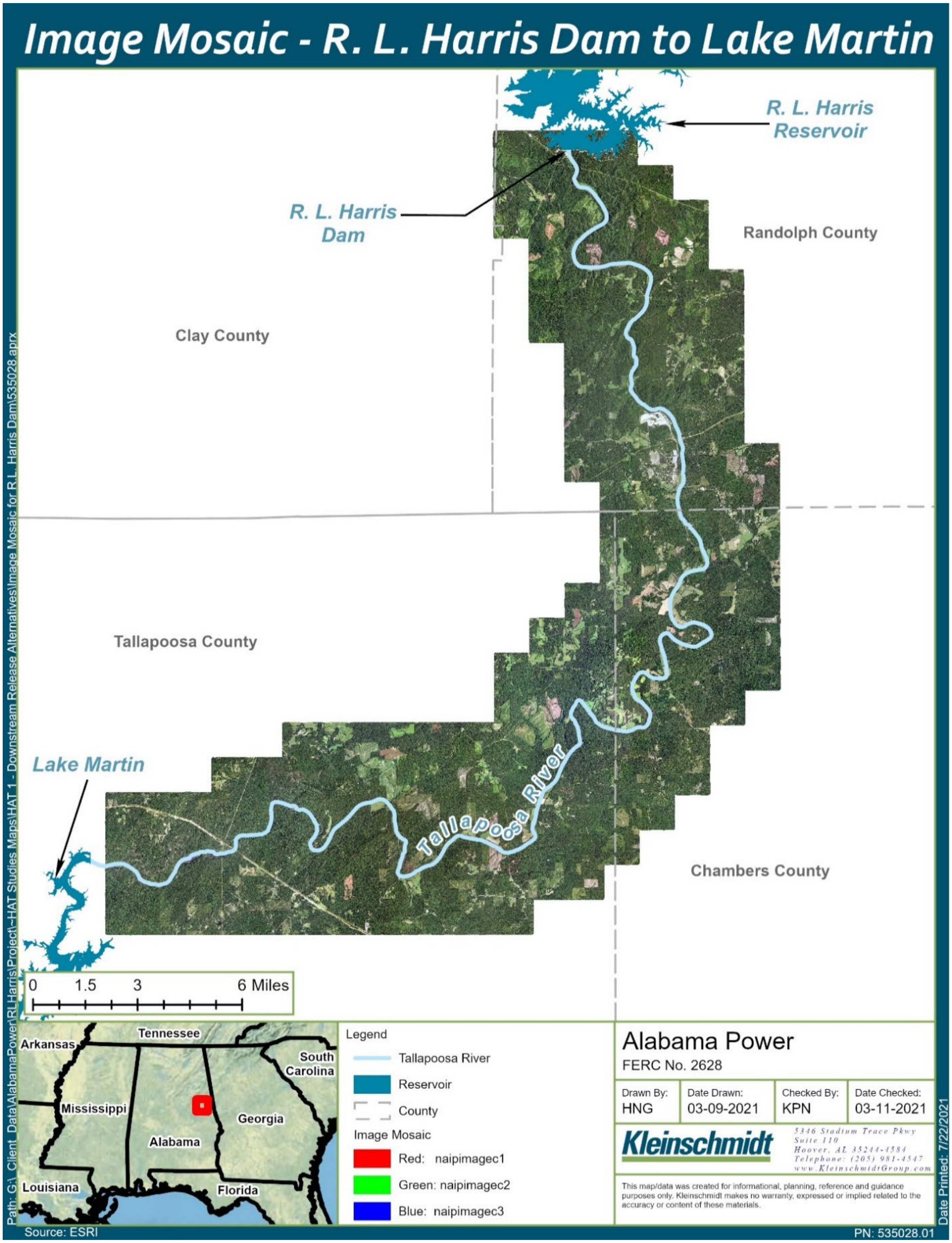

FIGURE 3–2 IMAGE MOSAIC FOR THE TALLAPOOSA RIVER BELOW HARRIS DAM

3.2.2 Results

The original intent of collecting LIDAR data was to provide data with appropriate resolution for elevation modeling. While the point cloud had at least 4 returns per square meter, the density of points was too low to accurately extract buildings returns, which prompted the use of the OBIA method.

The overall accuracy (Overall: 63%, Kappa: 56%)[6] of the OBIA classification method suffered from false positive building classifications. An examination of the confusion matrix (Table 3-1) found the user accuracy for structures at 100%, but the producer accuracy was very low at only 8%. In other words, the algorithm was able to correctly classify 100% of the training data classified as structures, but it falsely attributed other image pixels to buildings as well. The algorithm was primarily getting confused with water, shadows, and fields/bare ground and classifying them as buildings. Most likely, these classes shared similar spectral qualities to buildings. The low producer accuracy for our land cover classification of interest prompted the need for an in-depth heads-up digitizing exercise, where building classifications were manually scrutinized and adjusted as needed.

Following the heads-up digitizing exercise, 1,991 structures (Figure 3-3) were found within the study area. Table 3-2 includes the number of structures inundated (flood elevation above ground elevation) by the modeled 100-year Design Flood for the baseline and winter pool alternatives. Increasing the winter operating curve to 789 feet msl would potentially impact nine more structures during the modeled 100-Year Design Flood than the current winter operating curve.

[6] Kappa measures the degree of agreement between the training data and classifications made by the algorithm. It is an accuracy measure; generally the higher the Kappa, the better the model.

TABLE 3–1 CONFUSION MATRIX FOR OBJECT BASED IMAGE ANALYSIS (OBIA) ALGORITHM

	Structure	Vegetation	Water	Shadow	Field/Bare	Roads	User Accuracy
Structure	388	0	0	0	0	0	1
Vegetation	0	4992	12	256	167	15	0.91
Water	385	0	4684	653	51	0	0.81
Shadow	247	2	298	4010	1	0	0.88
Field/Bare	3980	5	6	81	4735	4908	0.34
Roads	0	1	0	0	46	77	0.63
Producer Accuracy	0.08	0.99	0.93	0.80	0.95	0.02	

Note the perfect user accuracy for structures, but poor producer accuracy, which created the need for heads up digitizing.

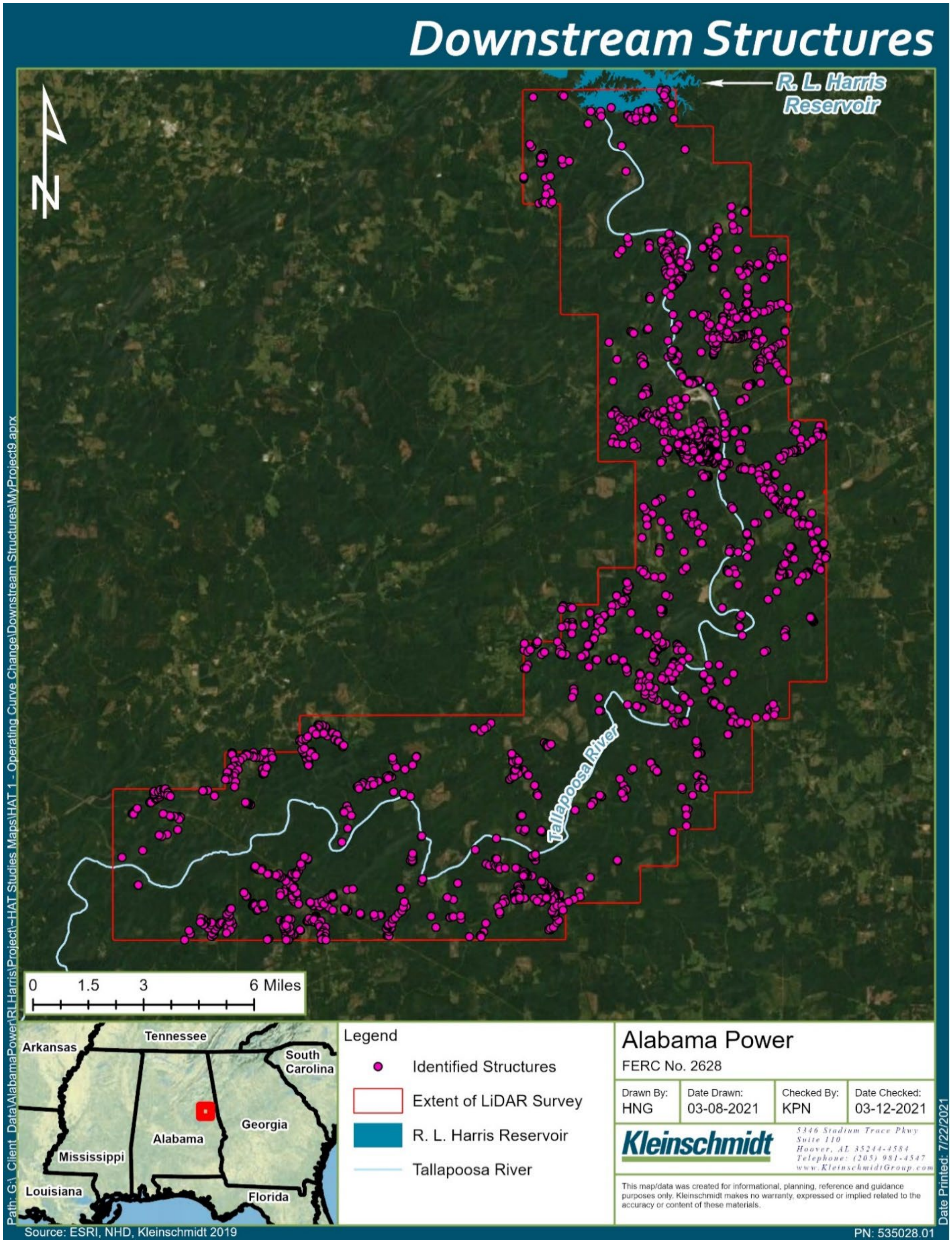

FIGURE 3–3 STRUCTURES IDENTIFIED BELOW HARRIS DAM WITHIN THE LIDAR DATA EXTENT

TABLE 3–2 NUMBER OF DOWNSTREAM STRUCTURES INUNDATED DURING THE MODELED 100-YEAR DESIGN FLOOD BY EACH WINTER POOL ALTERNATIVE

Alternative	No. of Structures Inundated
Baseline (785 feet msl)	79
+1 foot	79
+2 feet	83
+3 feet	83
+4 feet	88

After identifying the structures potentially impacted by the modeled 100-Year Design Flood, a spatial join associated the structures to each county's tax parcel database. Table 3-3 provides the number of structures by tax parcel type effected by each winter pool alternative. As the table shows, the number of single family structures and mobile homes impacted by the modeled 100-Year Design Flood increases as the winter pool alternatives increase.

TABLE 3–3 NUMBER OF DOWNSTREAM STRUCTURES BY TAX PARCEL USE TYPE IMPACTED BY THE 100-YEAR DESIGN FLOOD FOR EACH WINTER POOL ALTERNATIVE

	Winter Pool Alternative				
Tax Parcel Use	785 feet msl (Baseline)	786 feet msl	787 feet msl	788 feet msl	789 feet msl
Residential	1	1	1	1	1
Vacant Agricultural	2	2	2	2	2
Cabin	2	2	2	2	2
Unknown	2	2	2	2	3
Agricultural	4	4	4	4	4
Forestry	6	6	6	6	6
Commercial	6	6	6	6	6
Mobile Home	8	8	9	9	10
Vacant	24	24	25	25	25
Single Family	24	24	26	26	29
Total	79	79	83	83	88

With structures impacted by an increase in the winter operating curve identified, it was possible to count the number of HEC-RAS model timesteps that each structure was inundated. Each time step is an hour in duration; therefore, the count of all timesteps a structure is inundated is a measure of the number of hours it is inundated. Using GIS, the elevation and river mile for each structure was determined, which was then associated to the closest HEC-RAS cross section. Once every model time step was completed, it was determined if the modeled water surface elevation is greater than the ground elevation of the structure. Therefore, for each time step, the structure was considered inundated for one hour. Table 3-4 provides a descriptive summary of the number of hours (timesteps) structures were inundated and Table 3-5 has the number of hours inundated broken down by tax parcel type.

TABLE 3–4 NUMBER OF HOURS (TIMESTEPS) DOWNSTREAM STRUCTURES ARE INUNDATED BY THE MODELED 100-YEAR DESIGN FLOOD FOR EACH WINTER POOL ALTERNATIVE

Alternative	Minimum	25%	Median	75%	Maximum
Baseline (785 feet msl)	3.0	113.0	119.5	130.5	191.0
+1 foot	15.0	107.0	114.0	124.5	191.0
+2 feet	37.0	100.0	108.0	122.25	191.0
+3 feet	59.0	92.0	103.0	122.25	191.0
+4 feet	64.0	85.75	102.0	122.25	191.0

TABLE 3–5 NUMBER OF HOURS (TIMESTEPS) DOWNSTREAM STRUCTURES ARE INUNDATED BY THE MODELED 100-YEAR DESIGN FLOOD FOR EACH WINTER POOL ALTERNATIVE BY TAX PARCEL TYPE

Alternative	Tax Parcel Use	Number	Hours Inundated				
			Minimum	25%	Median	75%	Maximum
Baseline (785 feet msl)	Agricultural	4	132	134.25	138.5	144	150
	Vacant Agricultural	2	126	142.25	158.5	174.75	191
	Cabin	2	93	99	105	111	117
	Forestry	6	113	113.75	117	118	175
	Commercial	6	119	123.25	135	140	143
	Mobile Home	8	37	115.25	125.5	138.25	172
	Residential	1	121	121	121	121	121
	Single Family	24	3	110	119	125	177
	Vacant	24	36	114	119	124	191
	Unknown	2	74	86.5	99	124.5	150
	TOTAL	79					
+1 Foot	Agricultural	4	126	128.25	132.5	138	144
	Vacant Agricultural	2	120	137.75	155.5	173.25	191
	Cabin	2	103	105	107	109	111
	Forestry	6	107	107.5	110	111.75	173
	Commercial	6	113	116.5	129	134	136
	Mobile Home	8	58	109.25	119.5	132.25	171
	Residential	1	115	115	115	115	115
	Single Family	24	15	104	113	119	177
	Vacant	24	51	108	114	118	191
	Unknown	2	95	99	103	122	141
	TOTAL	79					

Alternative	Tax Parcel Use	Number	Hours Inundated				
			Minimum	25%	Median	75%	Maximum
+2 Feet	Agricultural	4	123	125.25	129.5	135.25	142
	Vacant Agricultural	2	116	134.75	153.5	172.25	191
	Cabin	2	95	97.5	100	102.5	105
	Forestry	6	100	100.5	103.5	105.75	173
	Commercial	6	106	113	127.5	133	136
	Mobile Home	9	63	103.25	115.5	131.75	171
	Residential	1	109	109	109	109	109
	Single Family	26	37	98	106	116	177
	Vacant	25	59	101	108	116	191
	Unknown	2	94	95	96	117	138
	TOTAL	83					
+3 Feet	Agricultural	4	123	124.5	129	135.25	142
	Vacant Agricultural	2	115	134	153	172	191
	Cabin	2	88	90.25	92.5	94.75	97
	Forestry	6	92	92.25	94.5	99	173
	Commercial	6	104	113	127.5	133	136
	Mobile Home	9	77	94.25	115.5	131.75	171
	Residential	1	101	101	101	101	101
	Single Family	26	59	90	101	116	177
	Vacant	25	64	92	98	116	191
	Unknown	2	87	87.5	88	112.5	137
	TOTAL	83					
+4 Feet	Agricultural	4	123	124.5	129	135.25	142
	Vacant Agricultural	2	113	132.5	152	171.5	191
	Cabin	2	82	84.25	86.5	88.75	91
	Forestry	6	85	85.75	90	96.5	173
	Commercial	6	104	113.75	127.5	133	136
	Mobile Home	10	76	89.25	114	131.75	171
	Residential	1	96	96	96	96	96
	Single Family	29	64	83	95	116	177
	Vacant	25	73	87	94	116	191
	Unknown	3	79	80.5	82	109.5	137
	TOTAL	88					

Table 3-4 and Table 3-5 show that although the four foot winter pool increase has the largest impact in terms of number of structures inundated, the median duration of inundation was the lowest. This phenomenon occurs because changes to the winter operating curve increase the starting pool elevation and Harris has less storage available in the reservoir to store floodwaters before Alabama Power must begin releasing water. Therefore, the downstream flood is more intense in terms of magnitude (greater rise) since water is released more quickly due to the higher reservoir elevation and less storage (Appendix B, Figure B-1). Additionally, after the flood, the reservoir returns to a water level that is 4 feet higher than the baseline elevation, which means Alabama Power can stop releasing water sooner than under the baseline. In other words, under existing conditions (baseline), Harris Reservoir is able to absorb more flood water because there is more storage available to use for flood control. Therefore, currently the magnitude of the inundation for each structure is lower because the peak of the flood hydrograph is attenuated by having smaller magnitude floodwaters released over a longer time.

The analysis of the duration of inundation of downstream structures is different than increases in flood duration presented in the Phase 1 Report. The Phase 1 Report provided the results of how the flood duration for each operating curve alternative exceeded the maximum existing conditions (baseline) flood elevation. The Phase 1 Report showed that the greater the proposed change in the winter operating curve, the longer the duration that downstream flooding exceeds the maximum flood elevation under existing conditions.

To further illustrate this, Figures 3-4 and 3-5 show the river stage hydrographs for the different winter pool alternatives at the Malone and Wadley cross sections, respectively. Both figures show two horizontal dotted lines; the upper line represents the maximum flood elevation under existing conditions (baseline), and the lower line represents the elevation of a hypothetical downstream structure. Both figures indicate that any of the winter pool alternatives would result in peak flood elevations greater than baseline, but the river stage drops below the ground elevation of the structure sooner for the winter pool alternatives compared to baseline.

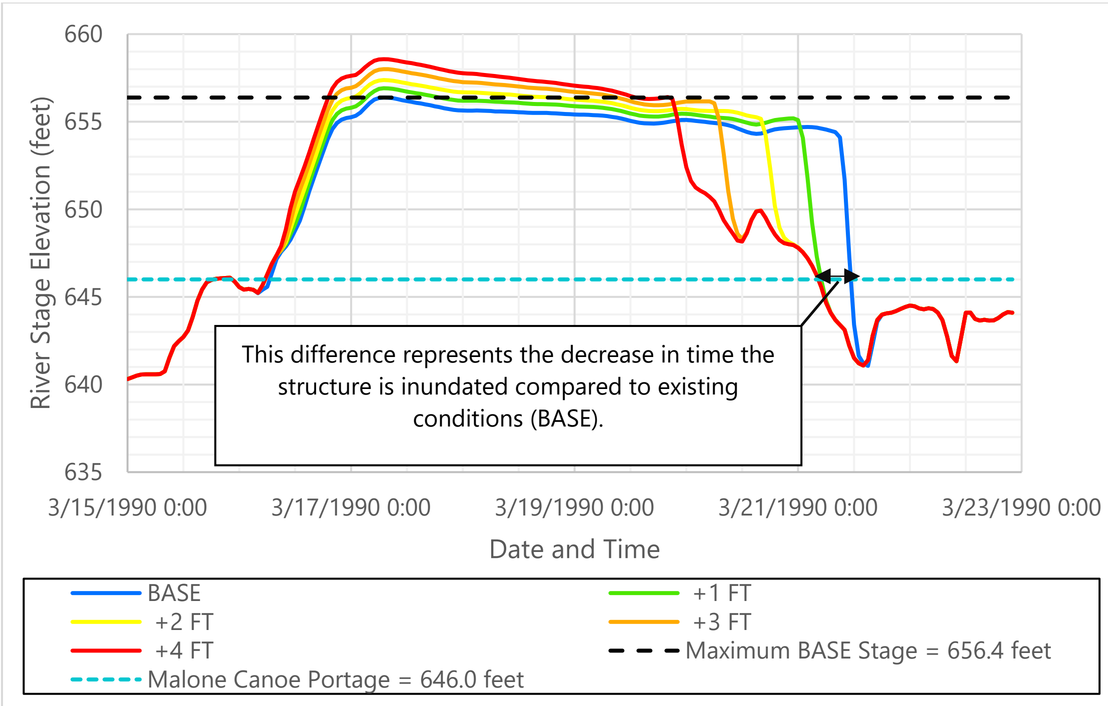

FIGURE 3–4 TALLAPOOSA RIVER STAGE HYDROGRAPHS AT RM 129.7 (MALONE) FROM RESULTS OF 100-YEAR DESIGN FLOOD IN HARRIS-MARTIN HEC-RAS MODEL

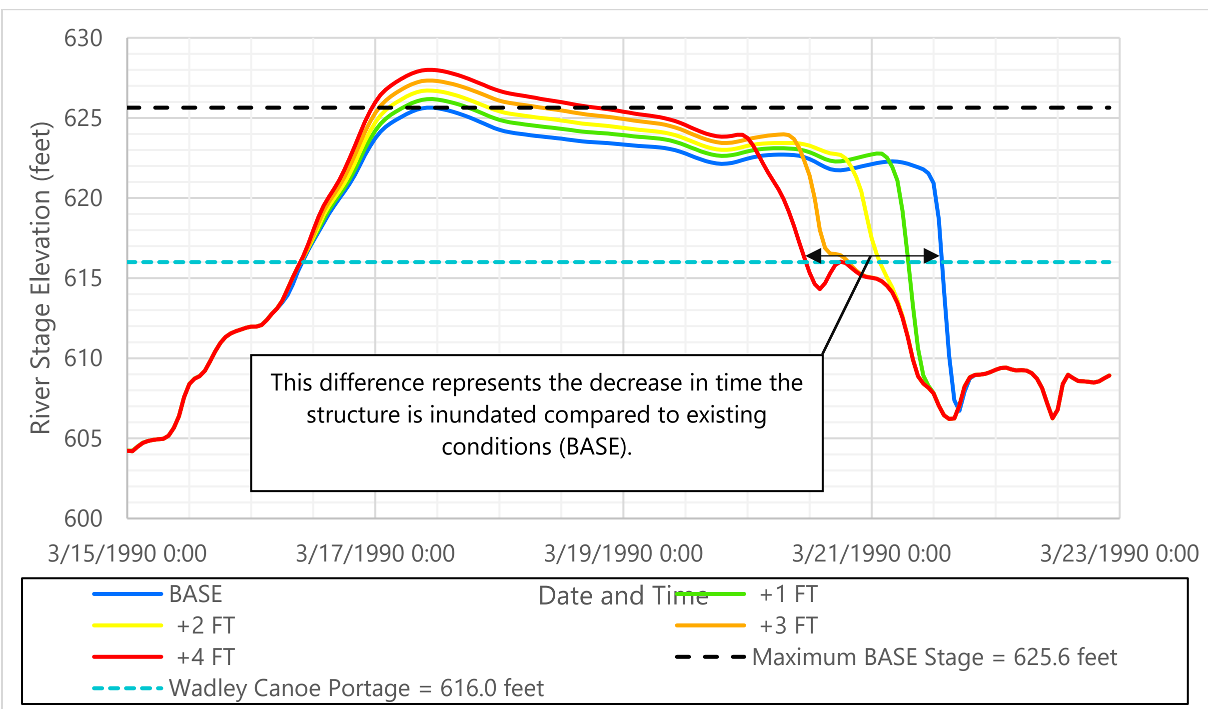

FIGURE 3–5 TALLAPOOSA RIVER STAGE HYDROGRAPHS AT RM 122.7 (WADLEY) FROM RESULTS OF 100-YEAR DESIGN FLOOD IN HARRIS-MARTIN HEC-RAS MODEL

3.3 Water Quality

As indicated in the Study Plan, water quality was assessed using existing information, Phase 1 Results, and an additional water quality model developed for the Phase 2 analysis.

3.3.1 Methods

Alabama Power commissioned the development of a three-dimensional Environmental Fluid Dynamics Code (EFDC) hydrodynamic and water quality model for Lake Harris (Dynamic Solutions 2020). A report detailing the development, calibration, and validation of the model is provided as Appendix C. It should be noted that the EFDC model was used to evaluate the potential effects of an operating curve change on water quality and it does not reflect Alabama Power's ability to meet state water quality standards. The calibrated and validated EFDC model of Harris Reservoir was used to evaluate the effects of each winter pool alternative on water temperature and dissolved oxygen in the forebay area of Harris Reservoir. Further, the effects of each winter pool alternative on Harris Dam discharge were evaluated based on temperature and dissolved oxygen changes at the intake elevation of the penstock. For all winter pool alternatives, the EFDC model of Lake Harris was run for the 6-year period from January 1, 2014 to December 31, 2019.

3.3.2 Results

Harris Reservoir

Since retention time is a function of reservoir volume and release rate, increasing the winter pool elevation would result in increased winter reservoir volume thereby increasing retention time. Since the EFDC model simulation showed little difference in water temperature and dissolved oxygen in the forebay between the baseline and the four winter pool alternatives, it is likely that other areas of the reservoir would also exhibit minimal differences among the winter pool alternatives.

Tallapoosa River Downstream of Harris Dam

The EFDC model indicated only small differences in simulated water temperature (less than 0.05 degrees Celsius) and dissolved oxygen (less than 0.02 mg/L) in the withdrawal zone of the forebay between the baseline and the four winter pool alternatives. The model simulation results indicated that raising the winter operating curve up to four feet would result in only minor differences in water temperature and dissolved oxygen in the dam discharge (Dynamic Solutions 2020).

3.4 Water Use

As indicated in the Study Plan, water use was assessed using existing information and Phase 1 Results.

3.4.1 Methods

The effects of the winter pool alternatives on existing and potential water withdrawals in Harris Reservoir and the Tallapoosa River downstream of Harris Dam were qualitatively assessed. The Water Quantity, Water Use, and Discharge Report for the R.L. Harris Project (Kleinschmidt 2018b) provided locations of water users and average maximum daily volumes of water discharged or withdrawn by water users. HEC-ResSim was used to determine the effect of an increase in winter operating curve on available water in Harris Reservoir. HEC-RAS modeling was used to assess how changes in outflow from Harris Dam could affect water users in tributaries and the mainstem of the Tallapoosa River downstream of Harris Dam.

3.4.2 Results

Harris Reservoir

The Lakeside Campground and Marina withdraws groundwater near Cohobadiah Creek, a tributary to Harris Reservoir (Kleinschmidt 2018b); however, the well is located at an elevation greater than 793 feet msl, which is outside of Harris Reservoir and the Harris Project Boundary (Project Boundary). The Wedowee Water, Sewer, and Gas Board (WSGB) withdraws from and discharges to the upper Little Tallapoosa River (Kleinschmidt 2018b) and is the only water user that withdraws within the Project Boundary.

The Wedowee WSGB withdraws from the upper Little Tallapoosa River a daily average of 0.411 million gallons per day (mgd) (0.636 cfs) and a permitted daily maximum of 0.50 mgd (0.774 cfs) and discharges a daily average of 0.045 mgd (0.070 cfs) and a daily maximum of 0.150 mgd (0.232 cfs) (Kleinschmidt 2018b).

A potential increase in the winter operating curve is expected to have no negative impact on current or potential future water users. Each one foot winter operating curve increase provides additional water available for use during the winter. While Alabama Power does not guarantee any amount of water to be available for withdrawal at any time, increased winter operating curve elevations could increase peak elevation in drought years and store more water into the dry season. An increase in the winter operating curve would also increase the assimilative capacity of the Little Tallapoosa River arm of Harris Reservoir, which the Wedowee Water, Sewer, and Gas Board discharges into; however, this increase may be negligible and there are no reported issues with the existing assimilative capacity.

Tallapoosa River Downstream of Harris Dam

The Roanoke Utilities Board has two surface water intakes and one discharge point in Highpine Creek (Kleinschmidt 2018b), a tributary leading to the Tallapoosa River downstream of the Harris Project. Water use by the Roanoke Utilities Board would not be impacted by changes to the winter operating curve, because the intakes are located over 14 miles upstream of the confluence of Highpine Creek and the Tallapoosa River. The Town of Wadley Water System has one discharge in Hutton Creek (Kleinschmidt 2018b), a tributary leading to the Tallapoosa River downstream of the Harris Project. Because the amount of water available for assimilative capacity will not decrease due to a change in the winter operating curve, there would be no impact to the Town of Wadley Water System's discharge.

3.5 Erosion and Sedimentation

As indicated in the Study Plan, erosion and sedimentation were assessed using existing information and Phase 1 Results.

3.5.1 Methods

Harris Reservoir

Data (e.g., soil types, slope) were reviewed from the Erosion and Sedimentation Study (Kleinschmidt 2021a) to evaluate the potential effects of each winter pool alternative on erosion and sedimentation areas. Information from the Recreation Evaluation Report (Kleinschmidt 2020) was also used to determine the potential increase in recreation from higher winter operating curve elevations and its effect on erosion and sedimentation areas. Finally, the results of the Erosion and Sedimentation Study were used to determine the risk for occurrence of nuisance aquatic vegetation due to changes in erosion and sedimentation areas resulting from changes to the operating curve. Areas of sedimentation in the reservoir and near creek mouths were qualitatively assessed, and LIDAR data and a Geographic Information System (GIS) were used for Harris Reservoir to estimate the area that could be impacted at each site by each winter pool alternative. While use of historic photos was mentioned in the Study Plan, photos could not be used to assess the effects of the winter pool alternatives due to the limited resolution of publicly available historical photos needed to assess individual erosion areas.

Tallapoosa River Downstream of Harris Dam

The information gathered in the Tallapoosa River from Harris Dam through Horseshoe Bend in the Erosion and Sedimentation Study along with existing LIDAR data and results from the Phase 1 Report were used to determine the potential effects on erosion and sedimentation associated with a change in magnitude and frequency of flood events predicted with each winter pool alternative. While use of historic photos was mentioned in the Study Plan, photos could not be used to assess the downstream effects of the winter pool alternatives due to the limited resolution of publicly available historical photos needed to assess individual erosion areas.

3.5.2 Results

Harris Reservoir

Erosion

The Erosion and Sedimentation Study identified 22 sites on Harris Reservoir that were either experiencing or susceptible to erosion (Appendix D). Because soil types and their associated characteristics can lend to their erodibility, soil types at each of these sites is summarized below (Table 3-6).

TABLE 3–6 HARRIS RESERVOIR EROSION SITES AND ASSOCIATED SOIL TYPES AND CHARACTERISTICS

Erosion Site[1]	Latitude	Longitude	Potential Cause(s) of Erosion/Sedimentation	Description of Exposed Soils	Approximate Slopes (%)	Soil Group Associated Landform Location
E1	33.39649	-85.44412	Natural Factor Independent of Operations, Land Use	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E2	33.39618	-85.44512	Natural Factor Independent of Operations, Land Use	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E3	33.39448	-85.44763	Land Use	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E4	33.39253	-85.44797	Land Use	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E5	33.38870	-85.44677	Anthropogenic	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E6	33.38817	-85.45264	No active erosion	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E7	33.38399	-85.45285	Natural Factor Independent of Operations, Land Use	Bu, Buncombe loamy sand	0-5	Levees
E8	33.37972	-85.45260	Natural Factor Independent of Operations, Land Use	Bu, Buncombe loamy sand	0-5	Levees
E9	33.37732	-85.45879	Natural Factor Independent of Operations, Land Use	LtE, Louisa stony sandy loam	15-40	Overlay weathered bedrock on hillslopes
E10	33.37785	-85.45851	Natural Factor Independent of Operations, Land Use	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E11	33.38727	-85.47761	No active erosion	Mantachie fine sandy loam	0-2	Floodplains

Erosion Site[1]	Latitude	Longitude	Potential Cause(s) of Erosion/Sedimentation	Description of Exposed Soils	Approximate Slopes (%)	Soil Group Associated Landform Location
E12	33.36759	-85.47331	No active erosion	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E13	33.36509	-85.47680	No active erosion	MaD3, Madison gravelly clay loam	10-15	Hillslopes
E14	33.36407	-85.47728	Natural Factor Independent of Operations, Land Use	Oc, Ochlockonee fine sandy loam	0-2	Floodplains
E15	33.37197	-85.49914	No active erosion	LgE, Louisa gravelly sandy loam	15-40	Hillslopes
E16	33.37216	-85.50173	No active erosion	LtE, Louisa stony sandy loam	15-40	Overlay weathered bedrock on hillslopes
E17	33.37371	-85.50122	No active erosion	Mt, Mantachie fine sandy loam	0-2	Floodplains
E18	33.35833	-85.49693	Land Use, Anthropogenic	LtE, Louisa stony sandy loam	15-40	Overlay weathered bedrock on hillslopes
E19	33.35334	-85.50611	Land Use, Anthropogenic	LtE, Louisa stony sandy loam	15-40	Overlay weathered bedrock on hillslopes

Erosion Site[1]	Latitude	Longitude	Potential Cause(s) of Erosion/Sedimentation	Description of Exposed Soils	Approximate Slopes (%)	Soil Group Associated Landform Location
E20	33.35544	-85.51280	No active erosion	LtE, Louisa stony sandy loam	15-40	Overlay weathered bedrock on hillslopes
E21	33.33941	-85.55814	Anthropogenic	MdC2, Madison gravelly fine sandy loam	6-10	Hillslopes
E24	33.34779	-85.51483	Anthropogenic	DaD3, Davidson gravelly clay loam	10-15	Hillslopes

[1] Note that sites E22 and E23 are located downstream of Harris Dam.

Review of LIDAR information at these sites shows that none of the winter pool alternatives would likely affect existing erosion, as water levels will remain below where the erosion is taking place at these sites. Most of the existing erosion sites exhibited hard clay, bedrock, or increased amounts of larger rock (i.e., cobble/boulders) substrates below the current summer pool elevation of 793 feet msl. Because the substrates below summer pool at the erosion sites are stable, there should be no increase in erosion as a result of a winter operating curve change. One primary cause of erosion on Harris Reservoir noted in the Erosion and Sedimentation Study was the impact created by anthropogenic disturbance (Kleinschmidt 2021a). Examples of this type of disturbance include bank clearing/clear-cutting and boat-induced wave action. With an increase in the operating curve during the winter, the lake could experience an increase in recreation/boating activity. This is a result of fewer boating hazards introduced during low water periods and more dock and boat ramp access. Section 3.9 of this report assesses the expected increase in lake recreation structure access as a result of each winter pool alternative.

With each incremental increase in the winter operating curve, increased numbers of recreation structures around the lake become available for use. These structures include: boardwalks, boathouses, floats, piers, and wet slips. This likely will correlate with incremental increases to boater recreation during the winter months. With the expected increase in boater recreation during "off-season" periods (i.e., winter months), boat wave action may increase, and reservoir banks could endure an increase in exposure to erosive forces. However, none of the identified erosion sites will be affected as the erosion at these sites occurs well above the winter pool alternative elevations.

Sedimentation and Invasive Aquatic Vegetation

Nine sedimentation areas were identified in the Erosion and Sedimentation Study. Approximate surface area was calculated for the identified sedimentation areas using the 2015 LIDAR data (Table 3-7). The acreage for each winter pool alternative was also calculated using the 2015 LIDAR.

TABLE 3–7 INCREASE IN SURFACE AREA OF SEDIMENTATION SITES ON HARRIS RESERVOIR FOR EACH WINTER POOL ALTERNATIVE

Site	Latitude	Longitude	Baseline Acreage	+1 foot	+2 feet	+3 feet	+4 feet
S1	33.3763	-85.472	23.83	3.95	5.66	4.25	5.95
S2	33.3672	-85.478	4.96	1.93	0.93	0.27	0.15
S3	33.3659	-85.482	10.51	4.42	1.01	1.62	2.94
S4	33.3662	-85.485	5.49	1.51	1.27	2.34	0.13
S5	33.3605	-85.486	6.68	2.57	2.70	0.73	0.23
S6	33.3743	-85.514	13.55	7.11	2.14	1.18	0.83
S7	33.3264	-85.489	26.14	7.07	5.46	5.15	3.13
S8	33.4538	-85.61	10.59	0.93	1.32	1.46	1.78
S9	33.3065	-85.629	18.25	6.54	2.57	1.90	1.81

The sedimentation areas were also surveyed for the growth of invasive aquatic vegetation. Field surveillance conducted during 2020 did not detect any submerged aquatic vegetation (SAV) populations on the reservoir. The survey did identify some emergent vegetation growing in some of the areas. Results of the 2020 survey are found in Table 3-8.

Sedimentation rates on the reservoir will be relatively unchanged by a higher winter operative curve, while changes to depositional patterns could result; however, methods to predict these changes do not exist. Sedimentation areas will continue to be most prevalent in upstream areas of the major tributaries. Because sedimentation rates are entirely dependent on upstream, non-project related forces, changes to the operating curve will not affect reservoir sedimentation rates. Higher winter operating curve elevations could contribute to increased sedimentation area size over time. Drawdown periods that expose areas of accumulated sediment allow for winter and early spring rains to flush sediment to deeper depths, reducing overall size.

Risk of establishment of SAV populations is increased as a result of increased “habitat” in the sedimentation areas. Higher winter pool elevations will result in less acreage of exposed sediments during winter. This exposure helps manage any SAV introduced by killing seeds due to freezing, drying, or soil compaction. Furthermore, higher winter operating curve elevations will not allow for winter and early spring rains to flush accumulated sediments to deeper depths, resulting in more shallow water habitat for SAV.

TABLE 3–8 PRESENCE AND SIZE (IN ACRES) OF EMERGENT AQUATIC VEGETATION ON HARRIS RESERVOIR

Site	Location Description	Sedimentation Acreage	American Water-willow	Pickerel Weed	Alligator Weed	Juncus Grass
S1	Little Tallapoosa River	23.83	<0.25	<0.10		
S2	Little Tallapoosa River	4.96	<0.10			
S3	Little Tallapoosa River	6.61	<0.10			
S4	Little Tallapoosa River	5.49				
S5	Little Tallapoosa River	6.68				
S6	Pineywood Creek	13.55	< .25			
S7	Wedowee Creek	26.14	<.25			
S8	Tallapoosa River	10.58	1.00		<0.50	
S9	Fox Creek	18.25	<0.25			<0.25

Tallapoosa River Downstream of Harris Dam

Erosion

The Erosion and Sedimentation Study identified twenty-four sites that were either experiencing or susceptible to erosion (Appendix D). Two of these sites, E22 and E23, were located along the Tallapoosa River downstream of the dam. In addition, the downstream streambank assessment (Trutta 2019) identified (by river mile downstream of Harris Dam) additional streambank segments scoring as "slightly impaired" or worse (Table 3-9). A slightly impaired segment is defined as banks showing moderate erosion impact or some impact from human development. Impaired banks are defined as areas with a surrounding area consisting of more than 50% exposed soil with low riparian diversity or surface protection. Obvious impacts are from cattle, agriculture, industry, and poorly protected streambanks (Trutta 2019).

TABLE 3–9 MOST IMPAIRED STREAMBANK SEGMENTS ON THE TALLAPOOSA RIVER DOWNSTREAM OF HARRIS DAM

Bank[1]	River Mile Downstream of Harris Dam	Condition Score[2]	Latitude	Longitude
Right Bank	16.7	4.45	33.0833	-85.5526
Right Bank	16.6	3.96	33.0836	-85.5509
Right Bank	7.7	3.57	33.1919	-85.5791
Right Bank	16.5	3.55	33.084	-85.5494
Right Bank	16.3	3.35	33.0859	-85.5483
Left Bank	10	3.22	33.1625	-85.5843
Right Bank	16.9	3.2	33.0826	-85.5561
Right Bank	16.4	3.18	33.0848	-85.5486
Right Bank	43.8	3.17	32.9845	-85.7515
Left Bank	19.2	3.11	33.0612	-85.5551
Left Bank	17.9	3.09	33.0707	-85.5648
Right Bank	34.4	3.07	32.9716	-85.6631
Left Bank	20.6	3.05	33.0503	-85.5547
Left Bank	36.5	3.05	32.9568	-85.6914
Left Bank	36.6	3.04	32.956	-85.6928

[1] Left bank or right bank is a reference to the side of the river when traveling downstream.
[2] Bank Condition Scores: 1-Fully Functional, 2-Functional, 3-Slightly Impaired, 4-Impaired, 5-Non-Functional.
Source: Trutta 2019

Consistent with much of the streambank along the Tallapoosa River between Lake Harris and Lake Martin, many of these banks are steep sided and, as identified in the Phase 1 Report, are more apt to contain higher flood flows. Soils in these areas are more susceptible to erosion when streambank vegetation is disturbed or clear-cut, as identified in the Erosion and Sedimentation Study. Soils at sites E22 and E23, along with large portions of the streambanks between Harris Dam and Lake Martin are constituted of sand and loam, which are more susceptible to erosion. Because steeper banks contain the higher flood flows and do not overtop as easily, streambanks could experience increased scour. Increased scour would occur as velocities increase with the higher channelized flows resulting from the decreased storage in Harris Reservoir associated with higher winter operating curve elevations (for example, see the percent increase in spillway operations and at turbine capacity resulting from the winter operating curve alternatives in Appendix B, Table B-4).

Sedimentation

The Erosion and Sedimentation Study did not identify any sedimentation areas downstream of the Harris Dam. Subsequent agency and stakeholder consultation identified sedimentation at the Cornhouse Creek and No Business Creek confluences. Sandbar or delta sediment accumulation is a common natural process found at stream confluences. Because the creeks are free flowing, these creeks likely carry a considerably higher sediment load than the impounded Tallapoosa River. Sediment accumulation will ebb and flow as seasonal higher flows in the Tallapoosa River remobilize the deposited sediments downstream.

3.6 Aquatic Resources

As indicated in the Study Plan, the effects of increasing the winter operating curve on aquatic resources (fish spawning and fish entrainment) were assessed using existing information and Phase 1 Results.

3.6.1 Methods

<u>Fish Spawning</u>

The effects of increasing the winter operating curve on fish spawning in Harris Reservoir and the Tallapoosa River downstream of Harris Dam were qualitatively and quantitively assessed. The HEC-ResSim model and LIDAR were used to determine the effects of increasing the winter operating curve on wetted perimeter and littoral area of Harris Reservoir. The HEC-RAS model was used to determine the effects of winter pool alternatives on time spent in spillway operations and at turbine capacity.

<u>Fish Entrainment</u>

The Desktop Fish Entrainment and Turbine Mortality Report (Kleinschmidt 2018a) estimated the rate of fish entrainment at Harris Dam under current operations using a database of fish entrainment information by the Electric Power Research Institute (EPRI 1992). Information used for the study were derived from specific studies on projects that are similar to Harris with regard to geographic location, station hydraulic capacity, station operation, and fish information (species, assemblage, water quality) and that had available entrainment data (Kleinschmidt 2018a). Estimated turbine-induced mortality rates were then applied to fish entrainment estimates to determine potential fish mortality.

Turbine-induced mortality rates can vary based on the volume or velocity of water passing through turbines. The effects of an operating curve change on fish entrainment at Harris Dam were assessed based on changes in volume and velocity of water passing the turbines.

3.6.2 Results

<u>Fish Spawning</u>

Harris Reservoir

Harris Reservoir contains many primarily warm water species and many popular sport fishes, such as Largemouth Bass (*Micropterus salmoides*), Alabama Bass (*Micropterus henshalli*), Black Crappie (*Pomoxis nigromaculatus*), Redear Sunfish (*Lepomis microlophus*), Bluegill Sunfish (*Lepomis macrochirus*), White Bass (*Morone chrysops*), Flathead Catfish (*Pylodictis olivaris*), Blue Catfish (*Ictalurus furcatus*), and Channel Catfish (*Ictalurus punctatus*). During the spring, Alabama Power coordinates with the Alabama Department of Conservation and Natural Resources (ADCNR) to manage Harris Reservoir levels for the benefit of fish species (e.g., Largemouth Bass and crappie) that spawn in littoral (near-shore) areas. Based on input from ADCNR and when conditions permit, Alabama Power voluntarily maintains the lake at a stable or a slightly rising elevation for a period of 14 days to increase the spawning success of these species. An increase in the winter operating curve would increase the littoral area used by spawning fish in the early spring. At the existing winter operating curve of 785 feet msl, approximately 1,622 acres of shoreline are exposed. Winter operating curves of 786, 787, 788, and 789 feet msl would create an additional 276, 506, 804, and 944 acres of wetted area, respectively (Table 3-10). Additional wetted perimeter could provide additional spawning area during drought years.

TABLE 3–10 INCREASE IN RESERVOIR SURFACE AREA FOR EACH WINTER POOL ALTERNATIVE

Alternative	Reservoir Area (Acres)	Area Increase Compared to Baseline (Acres)
Baseline (785 feet msl)	8,341.78	0
+1 foot	8,618.13	276.35
+2 feet	8,848.22	506.44
+3 feet	9,145.52	803.74
+4 feet	9,285.35	943.57

Additional wetted area in Harris Reservoir would reduce desiccation of aquatic plants in littoral areas during winter drawdown and would be subject to increased aquatic plant growth, which could have a positive effect on the fishery (Durocher 1984; Bettoli et al. 1993) by increasing spawning areas and structure for young-of-year fish and benthic invertebrates. However, the increased aquatic plant growth associated with additional wetted area could have adverse effects, such as the establishment of invasive species (Spencer 2003) and necessitate the increased use of herbicidal controls.

Tallapoosa River Downstream of the Harris Project

Modeling results show that increasing the winter operating curve results in greater outflow from Harris Dam and subsequent flooding associated with outflow (Appendix B, Table B-4). Spill occurs at Harris 0.2 percent of the time under baseline operations. Winter operating curves of 786, 787, and 788 feet msl increased the frequency of spill to 0.3 percent of the time. A winter pool of 789 feet msl increased the frequency of spill to 0.4 percent. Percent of time spent at turbine capacity is 0.7 percent under baseline operations, increases to 0.8 percent at winter operating curves of 787 and 788 feet msl, and increases to 1.0 percent at a winter operating curve of 789 feet msl. Operating at turbine capacity can impact spawning sites and spawning behavior (Irwin et al. 2001; Martin 2008), but the increases in time spent in spillway operations and at turbine capacity are small and would likely occur most often in the winter, outside of spawning season.

Fish Entrainment

The volume and velocity of water passing through the turbines would not change under a different winter operating curve; therefore, fish entrainment is not expected to change under any of the winter pool alternatives.

3.7 Wildlife, Threatened and Endangered Species

As indicated in the Study Plan, the effects of increasing the winter operating curve on wildlife resources and threatened and endangered species were assessed using existing information and Phase 1 Results.

3.7.1 Methods

Wildlife and Terrestrial

Data were reviewed from the Pre-Application Document (PAD) (Alabama Power and Kleinschmidt 2018) to evaluate the potential effects of each winter pool alternative on Wildlife and Terrestrial Resources.

Threatened and Endangered Species

Data (e.g., species habitat range, species surveys, etc.) were reviewed from the Threatened and Endangered Species Study (Kleinschmidt 2021b) to evaluate the potential effects of each incremental winter operating curve elevation on threatened and endangered species (T&E).

3.7.2 Results

Wildlife and Terrestrial

Harris Reservoir

The proposed one to four foot increase in the winter operating curve would increase availability of shallow littoral habitats in coves and sloughs, which may increase availability of cover and feeding sites for overwintering resident and migratory waterfowl (Appendix E). The proposed higher winter operating curve elevations may similarly increase winter foraging habitat for wading birds (Appendix E). The increased wetted area in coves and sloughs during the winter months may result in marginal increases in availability of shallow breeding sites for early spring breeding amphibians, such as southern leopard frog (*Rana pipiens sphenocephala*), bullfrog (*Rana catesbeiana*), and spotted salamander (*Ambystoma maculatum*) (Mirarchi et al. 2004, as cited in Alabama Power and Kleinschmidt 2018) (Appendix F).

Tallapoosa River Downstream of Harris Dam

Temporary, short-term effects on wetted areas downstream of Harris Dam are expected to occur as a result of a one to four foot increase in the winter operating curve. Although a greater number of flood days are expected due to the one to four foot increase, no long-term effects to wildlife downstream are expected.

<u>Threatened and Endangered Species</u>

Harris Reservoir

An increase in the winter operating curve elevation in Lake Harris of one to four feet would increase the reservoir size by approximately 276 to 944 acres (one foot to four feet, respectively) (Table 3-10). Occupied and critical habitats of T&E species were examined to determine if they may potentially be affected by the one to four foot elevation increase. Habitat ranges of 20 federally-listed T&E species were identified within the Lake Harris Project Vicinity (Table 3-11). Of these species, only the Finelined Pocketbook (*Hamiota altilis*) was determined to have a critical habitat bordering the northernmost portion of the Lake Harris Project Boundary. The U.S. Fish and Wildlife Service (USFWS) recommended field surveys for Finelined Pocketbook, which were subsequently conducted in areas of critical habitat, in the Little Tallapoosa River, and in nearby tributaries in 2019 and 2020. The change in the winter operating curve elevation is not expected to affect the Finelined Pocketbook because no water elevation change is expected to occur within its critical habitat range (Figure 3-6). At the maximum proposed winter operating curve (789 feet msl), water elevation is expected to increase 1.47 RMs upstream when compared to the baseline winter operating curve (785 feet msl) (Figure 3-5). Survey results indicated that much of the critical habitat near the Lake Harris Project Boundary was degraded by siltation, and no Finelined Pocketbook were collected during the November 2019 and 2020 surveys (Kleinschmidt 2021b). No occupied or critical habitat was identified for any other T&E species within the Lake Harris Project Boundary

(Kleinschmidt 2021b). A one to four foot operating curve elevation increase is not expected to have an effect on T&E species within the Lake Harris Project Boundary.

TABLE 3–11 FEDERALLY THREATENED AND ENDANGERED SPECIES POTENTIALLY OCCURRING IN HARRIS PROJECT VICINITY

Scientific Name	Common Name	Federal Status[1]	State Protected	County of Occurrence	Occurrence	Documented Historic Range in Al
Picoides borealis	Red-cockaded Woodpecker	E	Yes	Clay & Randolph	No	Statewide in appropriate habitat
Notropis albizonatus	Palezone Shiner	E	Yes	Jackson	No	Tennessee River system
Erimonax monachus	Spotfin Chub	T	Yes	Jackson	No	Tennessee River system
Hamiota altilis	Finelined Pocketbook	T	Yes	Cleburne	No	Coosa, Tallapoosa, Cahaba River systems
Lampsilis virescens	Alabama Lampmussel	E	Yes	Jackson	No	Tennessee River system
Venustaconcha trabalis	Cumberland Bean	E	Yes	Jackson	No	Tennessee River system
Fusconaia cuneolus	Fine-rayed Pigtoe	E	Yes	Jackson	No	Tennessee River system
Toxolasma cylindrellus	Pale Lilliput	E	Yes	Jackson	No	Tennessee River system
Theliderma cylindrica	Rabbitsfoot	T	Yes	Jackson	No	Tennessee River system
Fusconaia cor	Shiny Pigtoe	E	Yes	Jackson	No	Tennessee River system
Epioblasma triquetra	Snuffbox	E	Yes	Jackson	No	Tennessee River system
Pleurobema georgianum	Southern Pigtoe	E	Yes	Clay & Cleburne	No	Coosa River system
Pleuronaia dolabelloides	Slabside Pearlymussel	E	Yes	Jackson	No	Tennessee River system
Myotis sodalis	Indiana Bat	E	Yes	Clay, Cleburne, Randolph, Chambers, Tallapoosa, & Jackson	Yes	Statewide in appropriate habitat
Myotis septentrionalis	Northern Long-eared Bat	T	Yes	Clay, Cleburne, Randolph, Chambers, Tallapoosa, & Jackson	Yes	Piedmont and Cumberland regions
Myotis grisescens	Gray Bat	E	Yes	Jackson	Yes	Statewide in appropriate habitat
Gratiola ampthiantha	Little Amphianthus	T	No	Randolph, Chambers, & Tallapoosa	Yes	Piedmont region (Bridges 1988)
Platanthera integrilabia	White Fringeless Orchid	T	No	Clay, Cleburne, Jackson, Chambers, & Tallapoosa	No	Talladega National Forest
Apios priceana	Price's Potato-bean	T	No	Jackson	Yes	Statewide in appropriate habitat
Clematis morefieldii	Morefield's Leather Flower	E	No	Jackson	No	Northern regions of state (USFWS 2007)

[1] E = Federally listed as Endangered, T = Federally listed as Threatened
Source: Mirarchi et.al. 2004, USFWS 2016a, USFWS 2016b, Williams et.al. 2008, FERC 2018; as cited in Kleinschmidt 2021b

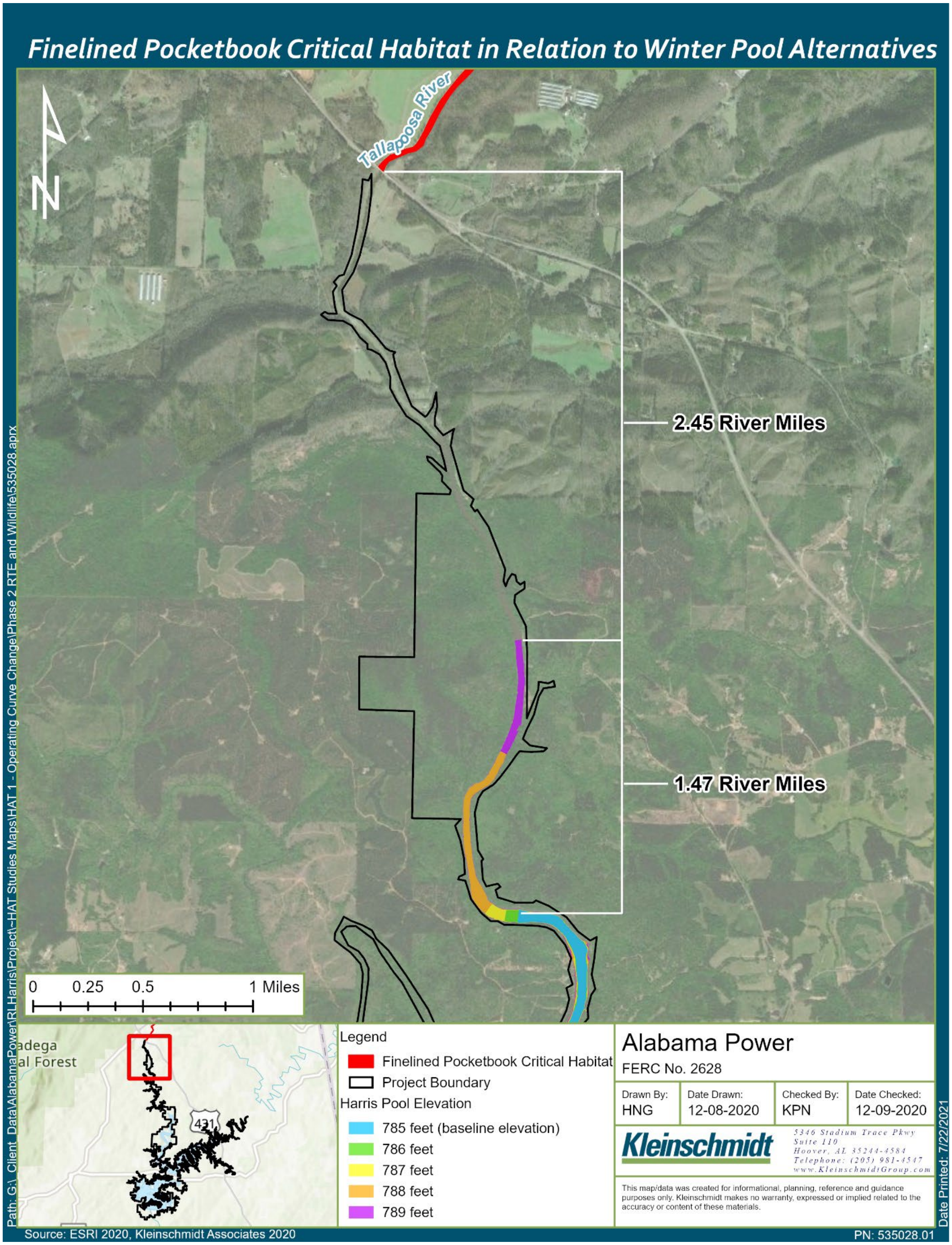

FIGURE 3–6 FINELINED POCKETBOOK CRITICAL HABITAT IN RELATION TO WINTER POOL ALTERNATIVES

Tallapoosa River Downstream of Harris Dam

No T&E species or critical habitats are present in the Tallapoosa River from Harris Dam through the Horseshoe Bend. Therefore, there would be no effects on T&E species from any of the winter pool alternatives.

3.8 Terrestrial Wetlands

As indicated in the Study Plan, the effects of increasing the winter operating curve on terrestrial resources (wetlands) were assessed using existing wetland data and Phase 1 Results.

3.8.1 Methods

Existing wetlands data in and around Harris Reservoir and downstream of Harris Dam in the Tallapoosa River through Horseshoe Bend were obtained. These data were incorporated into GIS, and the evaluation of changes to the winter operating curve indicated if the reservoir wetland areas were inundated or dry based on the winter operating curve alternative. For the Tallapoosa River downstream of Harris Dam, identified wetlands were analyzed based on changes in magnitude and frequency of flood events for each of the winter pool alternatives.

3.8.2 Results

<u>Harris Reservoir</u>

Existing National Wetland Inventory (NWI) data within the Lake Harris Project Boundary depict wetlands present prior to Project construction (Alabama Power and Kleinschmidt 2018). To document post-inundation wetlands, Cahaba Consulting, LLC (2016) conducted a wetland assessment in the winter of 2012 and the spring of 2013 at a pool elevation of 786 feet msl and 793 feet msl, respectively. Detailed methodology for the wetland assessment is presented in Appendix O of the PAD (Alabama Power and Kleinschmidt 2018). A total of 189 wetlands were identified throughout the impoundment's 271 miles of shoreline and islands, totaling 11.35 miles (14.98 acres) of wetland habitat (Alabama Power and Kleinschmidt 2018). Linear feet, quality and type of wetland recorded is provided in Table 3-12.

TABLE 3–12 HARRIS RESERVOIR WETLANDS

Quality	Lacustrine/Littoral on Shoreline		Shoreline and Alluvial Wetlands
	Linear Feet	Miles	Wetland Acres
Poor	5,268	1.00	2.16
Moderate	24,258	4.59	3.45
Good	30,430	5.76	9.28
Total	59,956	11.35	14.98

Source: Cahaba Consulting 2016, as cited in Alabama Power and Kleinschmidt 2018

A one to four foot increase in the winter operating curve elevation could potentially alter the dominant vegetation composition of wetlands bordering Harris Reservoir. Generally, as wetlands become more wetted, trends have involved a shift in dominant vegetation from woody vegetation to more herbaceous vegetation. For example, a freshwater forested/shrub wetland dominated by trees may shift toward a more shrub-dominated wetland. Wetlands bordering between a forested/shrub wetland and an emergent wetland may become more emergent, and emergent wetlands may shift toward ponds. Although these wetlands have a potential to change composition, they are not expected to reduce in size or diminish current habitat because wetland inundation is not expected to occur as a result of a higher winter pool elevation or a more wetted littoral environment. Because a one to four foot increase in elevation of the winter operating curve would increase the acreage of Harris Reservoir (Table 3-10), existing wetlands may also increase in size.

Tallapoosa River Downstream of Harris Dam

Although the modeled 100-Year Design Flood increased inundated acres downstream of Harris Dam for each of the winter pool alternatives, no long-term effects to wetlands downstream are expected from these short term events.

3.9 Recreation

The potential effects of a change in the winter operating curve on recreational use in Lake Harris were examined by using data on recreational access points (the number of private docks useable during the current winter drawdown and the lowest possible elevation that public boat ramps can be used). The number of access points (both private docks and public boat ramps) available at each one foot increment change in winter operating curve elevation were then compared. Further, downstream access sites on the Tallapoosa River were evaluated for any effects from the winter pool alternatives.

3.9.1 Methods

Harris Reservoir

The two key components of determining the usability of a structure are: 1) water depth and 2) the location on the structure at which water depth is measured. Elevation data was gathered during winter pool using LIDAR, a remote sensing method that uses pulsed lasers to measure distances. The elevation data was overlain with aerial imagery of the area so that each pixel of the imagery had an elevation value. Using the elevation data, imagery of the winter operating curve contours was developed (Figure 3-7). These data were used to determine at what elevation water reaches a structure.

FIGURE 3–7 EXAMPLE ELEVATION CONTOURS FOR EACH WINTER POOL ALTERNATIVE

Alabama Power keeps and maintains an inventory of recreation structures on Lake Harris by gathering GPS data near or at each recreation structure and classifying those structures by type (e.g., boathouses, floats, piers, wet slips, and boardwalks). GPS data were converted to a shapefile, which is a file type used to mark geographic locations and provide information on geographic features. Each GPS point, represented by a yellow circle (marker), was then moved to a location on the structure where depth was measured to determine usability.

Depth was calculated using elevation data for each marker that was placed on or upland of the 785 feet msl contour (Figure 3-8). For example, a marker placed at 785.5 feet msl is at a depth of 0.5 feet at a lake surface elevation of 786 feet msl. Because LIDAR cannot penetrate the water's surface, the elevation of markers placed below the 785 feet msl contour (Figure 3-8) was estimated using the slope of the nearby bank to interpolate the slope under the lake's surface.

FIGURE 3–8 EXAMPLE OF POINTS USED TO DETERMINE DEPTH OF WATER
The image to the left shows a point on the upland side of a structure; depth was determined from the elevation contour. The image to the right shows a point where the slope of the bank was used to determine depth. The blue elevation contour is the 785 ft msl contour.

Structure Type

Different types of structures may become usable during different conditions; therefore, a single method of analysis could not be applied to all structure types. The amount of depth and location on the structure at which depth was measured was determined separately for each type of private structure (i.e., boathouses, floats, piers, wet slips, and boardwalks) and for public boat ramps.

Boathouses

Boathouses require a certain amount of water to moor a boat and may be oriented allowing boats to enter the structure either parallel or perpendicular to the bank. Regardless of which direction these structures are oriented, a marker was placed at the edge of the structure nearest to the bank (back edge) (Figure 3-9). A depth of two feet at this marker was required to classify these structures as usable.

Floats

Floats are often used to moor boats and are not fixed to the lake bottom, but float on the water's surface. A depth of two feet at the back edge of the structure was required to classify these structures as usable (Figure 3-9); a two foot depth is sufficient to moor a boat on most of the floats. Floats located in shallow areas that have a very gradual sloping lake bottom may not be usable using these standards, but a minimum of two feet at the back edge would keep the structure from resting on dry ground during the winter, preventing possible damage.

Piers

Piers are built in a variety of shapes and lengths and were therefore classified into three sub-categories and analyzed separately. "Platform" piers (Figure 3-9) look similar to floats and are characterized by a long walkway often ending in a square-shaped platform used to moor boats. A depth of two feet at the back edge of this platform was required to classify "platform" piers as usable.

Piers that have no definable platform on the end and therefore no obvious place to measure depth were classified as mooring and fishing piers. Mooring piers were defined as greater than 30 feet in length. The marker was moved 30 feet from the front edge of the pier to provide a sufficient amount of scope to moor a boat (Figure 3-9).

Fishing piers were defined as 30 feet or less in length. The marker was moved midway from the front edge of the pier (away from the bank) to ensure that anglers could fish off the front or could cast underneath the pier (Figure 3-9). A depth of two feet was required to classify the mooring and fishing piers as usable.

Wet Slips

Wet slips are similar to boathouses in purpose and appearance but are not enclosed with walls and a roof. Therefore, wet slips were analyzed similarly to boathouses, with a requirement of two feet of depth at the back edge of the structure regardless of the direction the structure is oriented (Figure 3-9). Wet slips with multiple slips were classified as usable when all slips are usable (Figure 3-9).

Boardwalks

Although boardwalks are not used for access to the reservoir, they are used by visitors to enjoy the scenery or access other structures. The objective analysis on boardwalks is to improve aesthetics during the winter months. A depth of one foot at the front edge of boardwalks was required to classify these structures as usable and to reduce the amount of dry ground around boardwalks (Figure 3-9).

Public Boat Ramps

The ADCNR builds the majority of public boat ramps on Harris Reservoir to be usable at low winter pool. Specifically, most boat ramps are constructed with a 15 percent grade as the bottom edge enters the water at the current winter operating curve of 785 feet msl. This means the bottom edge of the concrete boat ramp is at a depth of 4.5 feet. This standard allows boats up to 26 feet in length to be launched with minimal effort at low winter pool.

The ADCNR was consulted and aerial imagery of Harris Reservoir at winter pool was used to determine which ramps are usable at the current low winter pool. The remaining ramps were analyzed by placing the point at the bottom edge of the concrete ramp and were determined to be usable at a depth of 4.5 feet (Figure 3-9). The lowest elevation at which public ramps are usable was assessed to the nearest 0.5 foot. It is worth noting that a criteria of 4.5 feet of depth at the end of the ramp was applied to all ramps, regardless of the percent grade.

Boathouse

Float

Platform Pier

Mooring Pier

Fishing Pier

Boardwalk

Continued On Next Page

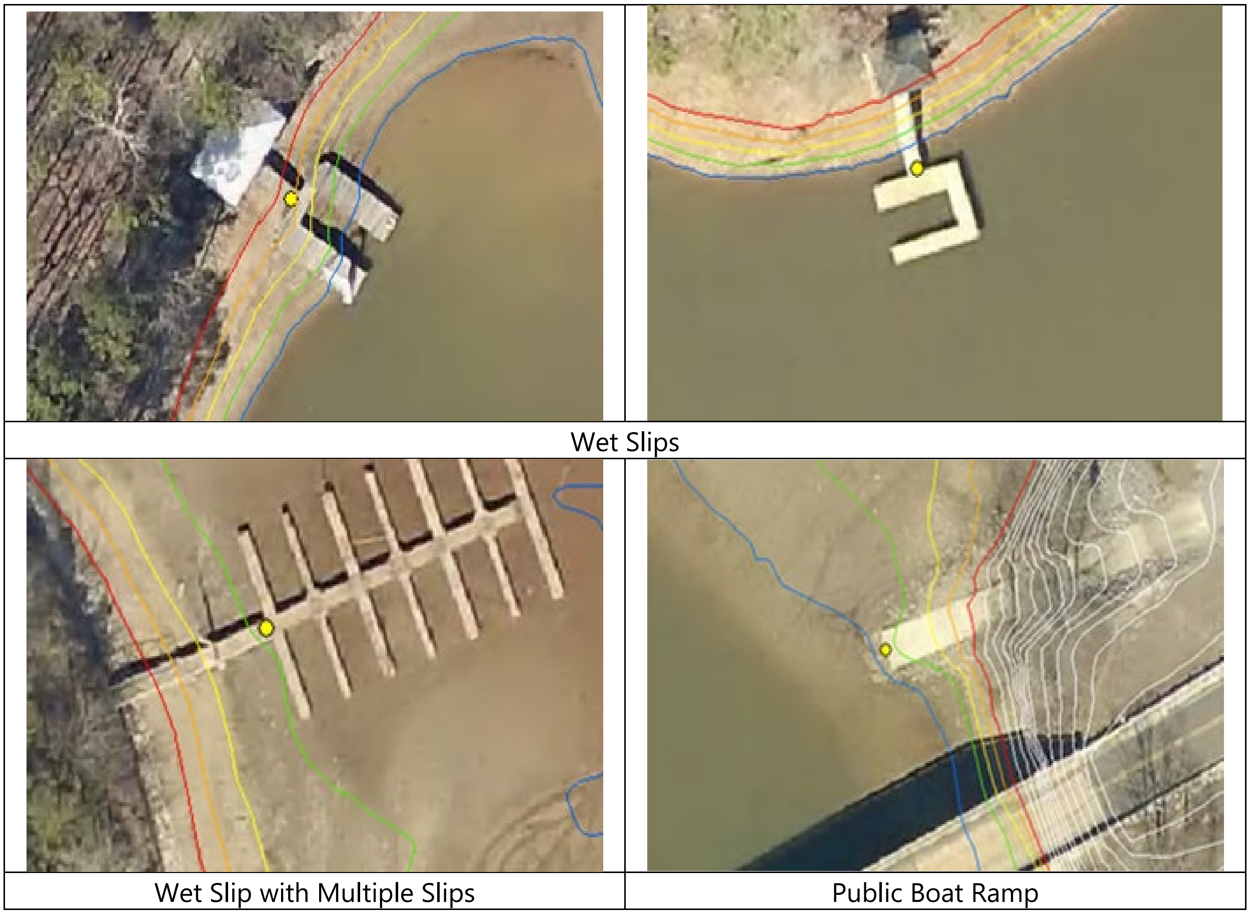

FIGURE 3–9 STRUCTURE TYPES AND THE POINTS AT WHICH USABILITY WAS DETERMINED

Field Assessment

Field confirmation was required for certain structures because: 1) some structures were constructed after the aerial imagery used for analysis was acquired (Figure 3-10) and 2) other structures were not clearly visible on the aerial imagery (i.e., structure is obscured by foliage or shadow on the imagery) (Figure 3-10). During July 2020, the location for depth analysis for these structures was confirmed in the field by acquiring a GPS reading at the physical location on the structure where depth at winter pool alternatives would be calculated. Field confirmation was also used to determine whether some structures were still operational or in use.

FIGURE 3–10 STRUCTURES BUILT AFTER IMAGERY WAS OBTAINED (LEFT) AND STRUCTURES COVERED BY FOLIAGE OR SHADOW (RIGHT)

Tallapoosa River Downstream of Harris Dam

Alabama Power evaluated the change in flood depth and duration at seven recreation sites downstream from Harris Dam. Using LIDAR data, the ground elevations at the access points were identified and, using the HEC-RAS model results from the Phase 1 Report, the peak flood elevation at each location for each winter pool alternative was compared to the ground elevation to determine depth of flooding above that point and the duration that the flood depth was higher than the ground elevation.

3.9.2 Results

Harris Reservoir

Private Structures

There were 2,282 private structures identified on Lake Harris; however, structures that appeared to be severely damaged, abandoned, unmaintained, or that were under construction were omitted from analysis. Omitting these structures resulted in 2,123 private recreation structures. Of these 2,123 structures, the elevation of the marker was estimated for 742 structures, and depths were obtained during the field assessment for 211 structures.

There are 449 usable structures at the current winter operating curve of 785 feet msl (21.1 percent of analyzed structures). This number increases to 642 at 786 feet msl (30.2 percent of total structures), to 826 at 787 feet msl (38.9 percent of total structures), to 1,112 at

788 feet msl (52.4 percent of analyzed structures), and to 1,327 at 789 feet msl (62.5 percent of analyzed structures). Total structure usability is summarized in Table 3-13.

TABLE 3-13 USABILITY OF ALL STRUCTURE TYPES ON HARRIS RESERVOIR AT EACH WINTER POOL ALTERNATIVE

Alternative	Number of Usable Structures[1]	Percentage of Usable Structures	Incremental Percentage Increase
Baseline (785 feet msl)	449	21.1	-
+1 foot	642	30.2	9.1
+2 feet	826	38.9	8.7
+3 feet	1112	52.4	13.5
+4 feet	1327	62.5	10.1

[1] There are 796 structures that would not be usable at any of the proposed alternatives.

A total of 25 boardwalks were analyzed. No boardwalks are usable at the current winter pool, and usability does not increase until lake level reaches 789 feet msl, at which level one boardwalk becomes usable. A total of 929 boathouses were analyzed, 303 of which are usable at the current winter operating curve (2.6 percent of analyzed boathouses). Percentage of usable boathouses increases an average of 12.4 percent (standard error = 1.4) with each one foot increase in winter operating curve. A total of 393 floats were analyzed, 101 of which are usable at the current winter operating curve (25.7 percent of analyzed floats). Percentage of usable floats increases an average of 14.7 percent (standard error = 1.8) with each one foot increase in winter operating curve. A total of 689 piers were analyzed, 37 of which are usable at the current winter operating curve (5.4 percent of analyzed piers). Percentage of usable piers increases an average of 5.1 percent (standard error = 1.7) with each one foot increase in winter operating curve. A total of 87 wet slips were analyzed, eight of which are usable at the current winter operating curve (9.2 percent of analyzed wet slips). Percentage of usable wet slips increases an average of 12.9 percent (standard error = 1.7) with each one foot increase in winter operating curve. Usability by structure type is summarized in Table 3-14.

TABLE 3–14 USABILITY OF ALL STRUCTURES ON HARRIS RESERVOIR BY STRUCTURE TYPE FOR EACH WINTER POOL ALTERNATIVE

Structure Type	Alternative	Number of Usable Structures	Percentage of Usable Structures	Incremental Percentage Increase
Boardwalks (n=25)	Baseline (785 feet msl)	0	0.0	-
	+1 foot	0	0.0	0.0
	+2 feet	0	0.0	0.0
	+3 feet	0	0.0	0.0
	+4 feet	1	4.0	4.0
Boathouses (n=929)	Baseline (785 feet msl)	303	32.6	-
	+1 foot	417	44.9	12.3
	+2 feet	526	56.6	11.7
	+3 feet	675	72.7	16.1
	+4 feet	762	82.0	9.3
Floats (n=393)	Baseline (785 feet msl)	101	25.7	-
	+1 foot	157	39.9	14.2
	+2 feet	204	51.9	12.0
	+3 feet	282	71.8	19.9
	+4 feet	332	84.5	12.7
Piers (n=689)	Baseline (785 feet msl)	37	5.4	-
	+1 foot	52	7.5	2.1
	+2 feet	71	10.3	2.8
	+3 feet	114	16.5	6.2
	+4 feet	178	25.8	9.3
Wet Slips (n=87)	Baseline (785 feet msl)	8	9.2	-
	+1 foot	16	18.4	9.2
	+2 feet	26	29.9	11.5
	+3 feet	41	47.1	17.2
	+4 feet	53	60.9	13.8

Public Boat Ramps

Boat ramps determined to be usable at the current winter operating curve were the Highway 48 Bridge, Big Fox Creek, Crescent Crest, and Foster’s Boat Ramps. In addition, Lonnie White Boat Ramp is currently used by recreators during winter pool (Figure 3-11). Although Lonnie White is currently in use at winter pool, the ramp does not extend far into the reservoir and it may not be possible to launch larger boats without backing the trailer off the edge of the concrete slab. The ramp currently extends about 15 feet into the reservoir and the edge of the concrete slab is approximately 2.5 feet deep at current winter pool. The ADCNR is currently extending the Lonnie White Boat Ramp an additional 15 feet so that it can be fully usable at winter pool by the winter of 2021. The lowest elevation Lonnie White Boat Ramp is usable is about 787.5 feet msl currently.

Aerial imagery shows Swagg Boat Ramp in use by multiple recreators during winter pool, but it appears only a small portion of the ramp is submerged and launching under winter conditions does not appear ideal (Figure 3-12). Swagg Boat Ramp does not become usable under the criteria of this study until lake elevation reaches 790 feet msl. Lee's Bridge and Little Fox Creek Boat Ramps become usable at 790 and 791.5 feet msl, respectively. The elevations at which public ramps become usable is summarized in Table 3-15.

FIGURE 3–11 AERIAL IMAGE OF LONNIE WHITE BOAT RAMP AT A RESERVOIR LEVEL OF APPROXIMATELY 785 FEET MSL

Note: Lonnie White is frequently used during winter pool, but improvements will lengthen the ramp and increase usability by the drawdown of 2021.

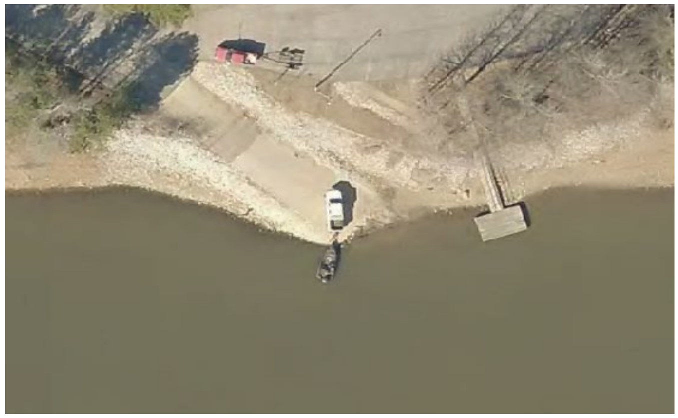

FIGURE 3–12 EXAMPLE OF LIMITED WINTER USE AT SWAGG BOAT RAMP AT A RESERVOIR LEVEL OF APPROXIMATELY 785 FEET MSL

TABLE 3–15 PUBLIC BOAT RAMP USABILITY AT THE LOWEST POSSIBLE RESERVOIR ELEVATION

Boat Ramp	Lowest Reservoir Elevation Usable (feet msl)
Big Fox Creek	785.0
Crescent Crest	785.0
Foster's Bridge	785.0
Hwy 48 Bridge	785.0
Lee's Bridge	791.5
Little Fox Creek	790.0
Lonnie White*	787.5
Swagg**	790.0

*Lonnie White Boat Ramp is frequently used at current winter pool, but larger boats cannot launch and many boat trailers need to back off the edge of the ramp. ADCNR is currently extending the ramp so that it is fully usable by the drawdown of 2021.
**Swagg Boat Ramp ends right at the water's edge during current winter pool but is still in use by some recreators.

Tallapoosa River Downstream of Harris Dam

The depth increases and duration of flooding at the seven recreation sites located downstream of Harris Dam are presented in Table 3-16. Table 3-16 shows that the maximum depth of inundation at each recreation site increases as the winter pool alternatives increase. However, the duration of time above the ground elevation that each recreation site is inundated tends to decrease as the winter pool alternatives increase. As explained in Section 3.2.2, this is due to the decreasing amount of storage available in Harris Reservoir for each winter pool alternative compared to existing conditions (baseline).

TABLE 3–16 RECREATION ACCESS SITES BELOW HARRIS DAM AND THE EFFECT OF FLOODING DEPTH AND DURATION FROM EACH WINTER POOL ALTERNATIVE

Location	Type of Access	Approximate Ground Elevation at Access (feet msl)	Baseline Flood Elevation (feet msl)	Depth Increase Above Base (feet)				Flood Duration (hours)				
				+1 foot	+2 feet	+3 feet	+4 feet	Baseline (785 feet msl)	+1 foot	+2 feet	+3 feet	+4 feet
R.L. Harris Dam	Tailwater Fishing	670.0	678.3	0.6	1.1	1.8	2.4	117	110	104	104	104
Malone	Canoe Portage	646.0	655.5	0.5	1.0	1.6	2.1	123	116.5	113.5	113.5	113.5
Wadley Bridge	Canoe Portage	616.0	625.9	0.5	1.1	1.7	2.4	123.5	117.5	112.5	106.5	98
Bibby's Ferry	Canoe Portage	582.0	597.0	0.6	1.1	1.8	2.5	130	124.5	121	120	119.5
Germany's Ferry	Boat Launch Area	569.0	579.9	0.4	0.8	1.2	1.6	148	140	137	136	136
Horseshoe Bend National Military Park	Boat Launch Area	537.0	543.5	0.3	0.5	0.8	1.1	144	137	133.5	132.5	132.5
Jaybird Landing	Boat Launch Area	494.0	503.9	0.4	0.7	1.2	1.6	150	140.5	138	137	137

Note: Flood duration is the time that the water surface elevation exceeds the ground elevation of each access point. An elevation for each access point was obtained using the digital elevation.

3.10 Cultural Resources

As indicated in the Study Plan, the effects of increasing the winter operating curve on cultural resources were assessed using existing information and Phase 1 Results.

3.10.1 Methods

Existing information (LIDAR, aerial imagery) was used, along with expert opinion, to evaluate cultural resources that may be impacted by reservoir fluctuation. Ninety-six cultural resources on Harris Reservoir were reviewed for possible effects from the winter pool alternatives.[7] A primary point of interest is the Miller Covered Bridge pier located at Horseshoe Bend National Military Park.[8] Qualitative information is used in the analysis below (rather than quantitative information noted in the Study Plan) as the cultural resources on Harris Reservoir are still being reviewed.

3.10.2 Results

<u>Harris Reservoir</u>

The most common adverse effects to historic properties, disregarding shoreline modifications, is reservoir fluctuation (raising and lowering) and watercraft activities (Faye 1987; Gage and Herrmann 2009; Keown et al. 1977; Thorne et al. 1987). Minimizing these fluctuations also minimizes periods when archaeological deposits are exposed or lie within the wave-action zone of the reservoir's shoreline. While keeping the water level higher during the winter may provide some benefits through increased inundation and minimizing periods of fluctuation, cultural resources along the shoreline of the Harris Reservoir may also be susceptible to damage as a result of changes in water levels. Effects can result from forces such as wind erosion, recreational activities, and vandalism. The

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[7] The Harris PAD identified 327 cultural resources in and around Lake Harris. Harris Action Team (HAT) 6 worked together to identify 96 cultural resources that may be eligible for listing in the National Register for Historic Places (NRHP) and may be affected by Harris Project operations. These 96 cultural resources are still under review and this number may be revised in the final Historic Properties Management Plan.

[8] Miller Covered Bridge was built in 1908 and was once the longest covered bridge in the United States at 600 feet in length. It has become recognized as a significant cultural resource associated with Horseshoe Bend Military Park and, as such, the National Park Service requested specific consideration be taken to the effects of changes to downstream flow. The remnants of the bridge include abutments on the left and right banks of the Tallapoosa River, as well as four stone and masonry piers within the river that are constantly affected by the flow of the river as the piers stand on the riverbed (OAR Personal Communication December 2020).

type and level of effects on cultural resources can vary widely, depending on the setting, size, and visibility of the resource, as well as whether there is public knowledge about the location of the resource (OAR Personal Communication December 2020).

At 785 feet msl, there would be no changes to the impacts to cultural resources on Harris Reservoir. A change to the operating curve above 785 feet msl would leave otherwise exposed cultural resources inundated and less susceptible to water fluctuation, wind erosion, recreational activities, and looting (vandalism), but more susceptible to erosion from variations in currents, general flow pattern fluctuations, and aquatic species nesting activities. With each one foot increase of a higher winter operating curve, potential negative effects on cultural resources would slightly decrease (OAR Personal Communications December 2020).

Tallapoosa River Downstream of Harris Dam

Changing the winter operating curve may result in a change to releases to the Tallapoosa River downstream of Harris Dam. A higher operating curve in the winter may result in more frequent high flow events downstream of Harris Dam. These releases have the potential to impact cultural resources downstream, including the Miller Covered Bridge, exposing them to additional fluctuations and erosion. These releases would be sporadic and would result in irregular inundation periods for the cultural resources downstream of Harris Dam.

4.0 SUMMARY

The purpose of this report is to present the Phase 2 analyses of the winter pool alternatives. In the preceding section, effects on resources were analyzed using the Phase 1 modeling results along with other FERC-approved relicensing study results; both quantitative and qualitative results were presented. The Phase 1 Report included effects on generation, navigation, flood control, drought management, and reservoir level. The primary adverse effect of raising the winter pool is on downstream resources in the form of an increase in flooding as shown by the modeled 100-Year Design Flood (an increase in acres inundated and an increase in flood depth). The primary beneficial effect of raising the winter pool is in the number of reservoir recreational structures (boat slips, docks, etc.) that are available for private recreational use/access during the winter months.

The effects of the winter pool alternatives on all resources are summarized in Table 4-1.

TABLE 4–1 SUMMARY OF EFFECTS OF WINTER POOL ALTERNATIVES

Resource	+1 Foot	+2 Feet	+3 Feet	+ 4 Feet	Notes
Change in Hydro Generation (Revenue)	$(19,400)	$(40,600)	$(52,100)	$(124,900)	Average annual revenue loss across Alabama Power's hydro fleet.
Change in Hydro Generation (Megawatt Hours)[9]	1,448	941	1,671	110	Average annual generation gain across Alabama Power's hydro fleet
Change in Hydro Generation (Revenue)	$(27,100)	$(26,200)	$(24,000)	$(60,804)	Average annual revenue loss at the Harris Project
Change in Hydro Generation (Megawatt Hours)[10]	(531)	(418)	(229)	(941)	Average annual generation loss at the Harris Project

[9] Although there would be a gain in average annual generation across Alabama Power's hydro fleet for each winter pool alternative, it results in an average annual revenue loss to Alabama Power. This is because that under each winter pool alternative the Harris Project would be placed into flood control more frequently (see Spillway Operation and Turbine Capacity Operation in Table 4-1). The Harris flood control procedure requires that the units operate at full gate (maximum hydraulic) capacity rather than at best (most efficient) gate when the reservoir elevation rises above 790 ft msl. Therefore, the units produce more power, but do it less efficiently. Additionally, more time spent in flood control results in more generation that occurs at off-peak times, resulting in additional revenue loss. These off-peak generation effects are also realized at the downstream Martin, Yates, and Thurlow developments.

[10] The +4 foot winter pool alternative (789 ft msl) results in greater losses in average annual generation and average annual revenue at the Harris Project than the other winter pool alternatives due to there only being one foot from this winter pool alternative and 790 ft msl; the elevation at which the Harris flood control procedures require the units to be operated at full gate (maximum hydraulic) capacity rather than at best (most efficient) gate. Therefore, the units produce more power, but do it less efficiently. Further, the +4 foot winter pool alternative results in additional days of spillway operations, resulting in lost generation from the water that otherwise would have been used to generate electricity.

Resource	+1 Foot	+2 Feet	+3 Feet	+ 4 Feet	Notes
Harris Reservoir Elevations	Over the period of record, increasing the winter pool elevation did not affect the amount of time the reservoir was at or above the full summer pool elevation of 793 feet msl.				Increasing the winter pool elevation can result in higher elevations during low flow years compared to the existing operating curve (i.e., baseline).
Downstream Effects of 100-Year Design Flood (Increase in inundated acres and percent increase over baseline)	298 acres (4.9%)	485 acres (7.9%)	686 acres (11.2%)	889 acres (14.6%)	Each incremental increase in winter pool results in an increase in flood depth.
Spillway Operation (Number of additional days of spill and percent increase over baseline)	12 (0.1%)	13 (0.1%)	20 (0.1%)	37 (0.2%)	Over the period of record.
Turbine Capacity Operation (Number of additional days of capacity operations and percent increase over baseline)	15 (0.0%)	29 (0.1%)	54 (0.1%)	103 (0.3%)	Over the period of record.
Navigation	No Effect				
Drought Operations	No Effect				
Green Plan Flows (Ability to release GP flows)	No Effect				

Resource	+1 Foot	+2 Feet	+3 Feet	+ 4 Feet	Notes
Downstream Release Alternatives[11] (Alabama Power's ability to release downstream flow alternatives)	No Effect				
Structures Downstream of Harris Dam (Number of additional structures affected over baseline)	0	4	4	9	
Water Quality – Harris Reservoir	No Effect				
Water Quality – Harris Dam Discharge	No Effect				Minor differences in water temperature and dissolved oxygen
Water Use – Harris Reservoir	Minor Beneficial Effect				Increase in winter pool would mean more water is available during the winter and could help reach full pool in the summer
Water Use – Tallapoosa River	No Effect				
Erosion – Harris Reservoir	Minor Adverse Effect				Potential increase in boating during winter may result in additional erosion

[11] Note that only the Pre-Green Plan, Green Plan, and 150 cfs continuous minimum flow were evaluated in the Phase 1 Report. The modified Green Plan and the other downstream release alternatives were analyzed in this report.

Resource	+1 Foot	+2 Feet	+3 Feet	+ 4 Feet	Notes
Sedimentation – Harris Reservoir	Adverse Effect				Could increase size of sedimentation areas over time due to decreased "flushing" effect; this increase would also provide "habitat" for aquatic vegetation
Erosion – Tallapoosa River	Minor Adverse Effect				Increased potential for scour associated with higher flows and higher spill days due to a decrease in reservoir storage
Sedimentation – Tallapoosa River	No Effect				
Aquatic Resources – Harris Reservoir	Beneficial Effect				Increase in wetted area of reservoir would lead to increased productivity
Aquatic Resources – Tallapoosa River	No Effect				
Wildlife – Harris Reservoir	Beneficial Effect				Increase in shallow littoral habitats
Wildlife – Tallapoosa River	No Effect				
T&E Species – Harris Reservoir	No Effect				No species present
T&E Species – Tallapoosa River	No Effect				No species present

Resource	+1 Foot	+2 Feet	+3 Feet	+ 4 Feet	Notes
Terrestrial Wetlands – Harris Reservoir	Beneficial Effect				Could alter composition of existing wetlands and increase their size
Terrestrial Wetlands – Tallapoosa River	No Effect				
Recreation – Harris Reservoir (Percent increase in usable structures over baseline)	9.1%	17.8%	31.3%	41.4%	
Recreation – Tallapoosa River	Minor Adverse Effect				Maximum depth of inundation at formal recreation sites would increase; duration of time above ground elevation would decrease
Cultural Resources – Harris Reservoir	Minor Beneficial Effect				Higher winter pool would leave more cultural resources inundated year round
Cultural Resources – Tallapoosa River	Potential to Adverse Effect				Increased fluctuation of river could adversely affect known cultural resources

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APPENDIX A

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

A

A&I	Agricultural and Industrial
ACFWRU	Alabama Cooperative Fish and Wildlife Research Unit
ACF	Apalachicola-Chattahoochee-Flint (River Basin)
ACT	Alabama-Coosa-Tallapoosa (River Basin)
ADCNR	Alabama Department of Conservation and Natural Resources
ADECA	Alabama Department of Economic and Community Affairs
ADEM	Alabama Department of Environmental Management
ADROP	Alabama-ACT Drought Response Operations Plan
AHC	Alabama Historical Commission
Alabama Power	Alabama Power Company
AMP	Adaptive Management Plan
ALNHP	Alabama Natural Heritage Program
APE	Area of Potential Effects
ARA	Alabama Rivers Alliance
ASSF	Alabama State Site File
ATV	All-Terrain Vehicle
AWIC	Alabama Water Improvement Commission
AWW	Alabama Water Watch

B

BA	Biological Assessment
B.A.S.S.	Bass Anglers Sportsmen Society
BCC	Birds of Conservation Concern
BLM	U.S. Bureau of Land Management
BOD	Biological Oxygen Demand

C

°C	Degrees Celsius or Centrigrade
CEII	Critical Energy Infrastructure Information
CFR	Code of Federal Regulation
cfs	Cubic Feet per Second
cfu	Colony Forming Unit
CLEAR	Community Livability for the East Alabama Region
CPUE	Catch-per-unit-effort
CWA	Clean Water Act

D

DEM	Digital Elevation Model
DIL	Drought Intensity Level
DO	Dissolved Oxygen
dsf	day-second-feet

E

EAP	Emergency Action Plan
ECOS	Environmental Conservation Online System
EFDC	Environmental Fluid Dynamics Code
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act

F

°F	Degrees Fahrenheit
ft	Feet
F&W	Fish and Wildlife
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FNU	Formazin Nephelometric Unit
FOIA	Freedom of Information Act
FPA	Federal Power Act

G

GCN	Greatest Conservation Need
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning Systems
GSA	Geological Survey of Alabama

H

Harris Project	R.L. Harris Hydroelectric Project
HAT	Harris Action Team
HEC	Hydrologic Engineering Center
HEC-DSSVue	HEC-Data Storage System and Viewer
HEC-FFA	HEC-Flood Frequency Analysis
HEC-RAS	HEC-River Analysis System
HEC-ResSim	HEC-Reservoir System Simulation Model
HEC-SSP	HEC-Statistical Software Package

HDSS	High Definition Stream Survey
hp	Horsepower
HPMP	Historic Properties Management Plan
HPUE	Harvest-per-unit-effort
HSB	Horseshoe Bend National Military Park

I

IBI	Index of Biological Integrity
IDP	Inadvertent Discovery Plan
IIC	Intercompany Interchange Contract
IVM	Integrated Vegetation Management
ILP	Integrated Licensing Process
IPaC	Information Planning and Conservation
ISR	Initial Study Report

J

JTU	Jackson Turbidity Units

K

kV	Kilovolt
kva	Kilovolt-amp
kHz	Kilohertz

L

LIDAR	Light Detection and Ranging
LWF	Limited Warm-water Fishery
LWPOA	Lake Wedowee Property Owners' Association

M

m	Meter
m^3	Cubic Meter
M&I	Municipal and Industrial
mg/L	Milligrams per liter
ml	Milliliter
mgd	Million Gallons per Day
µg/L	Microgram per liter
µs/cm	Microsiemens per centimeter
mi^2	Square Miles
MOU	Memorandum of Understanding

MPN	Most Probable Number
MRLC	Multi-Resolution Land Characteristics
msl	Mean Sea Level
MW	Megawatt
MWh	Megawatt Hour

N

n	Number of Samples
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTU	Nephelometric Turbidity Unit
NWI	National Wetlands Inventory

O

OAR	Office of Archaeological Resources
OAW	Outstanding Alabama Water
ORV	Off-road Vehicle
OWR	Office of Water Resources

P

PA	Programmatic Agreement
PAD	Pre-Application Document
PDF	Portable Document Format
pH	Potential of Hydrogen
PID	Preliminary Information Document
PLP	Preliminary Licensing Proposal
Project	R.L. Harris Hydroelectric Project
PUB	Palustrine Unconsolidated Bottom
PURPA	Public Utility Regulatory Policies Act
PWC	Personal Watercraft
PWS	Public Water Supply

Q

QA/QC	Quality Assurance/Quality Control

R

RM	River Mile
RTE	Rare, Threatened and Endangered
RV	Recreational Vehicle

S

S	Swimming
SCORP	State Comprehensive Outdoor Recreation Plan
SCP	Shoreline Compliance Program
SD1	Scoping Document 1
SH	Shellfish Harvesting
SHPO	State Historic Preservation Office
Skyline WMA	James D. Martin-Skyline Wildlife Management Area
SMP	Shoreline Management Plan
SU	Standard Units

T

T&E	Threatened and Endangered
TCP	Traditional Cultural Properties
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRB	Tallapoosa River Basin
TSI	Trophic State Index
TSS	Total Suspended Soils
TVA	Tennessee Valley Authority

U

USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

W

WCM	Water Control Manual
WMA	Wildlife Management Area
WMP	Wildlife Management Plan
WQC	Water Quality Certification

APPENDIX B

RELEVANT TABLES AND FIGURES FROM THE PHASE 1 REPORT

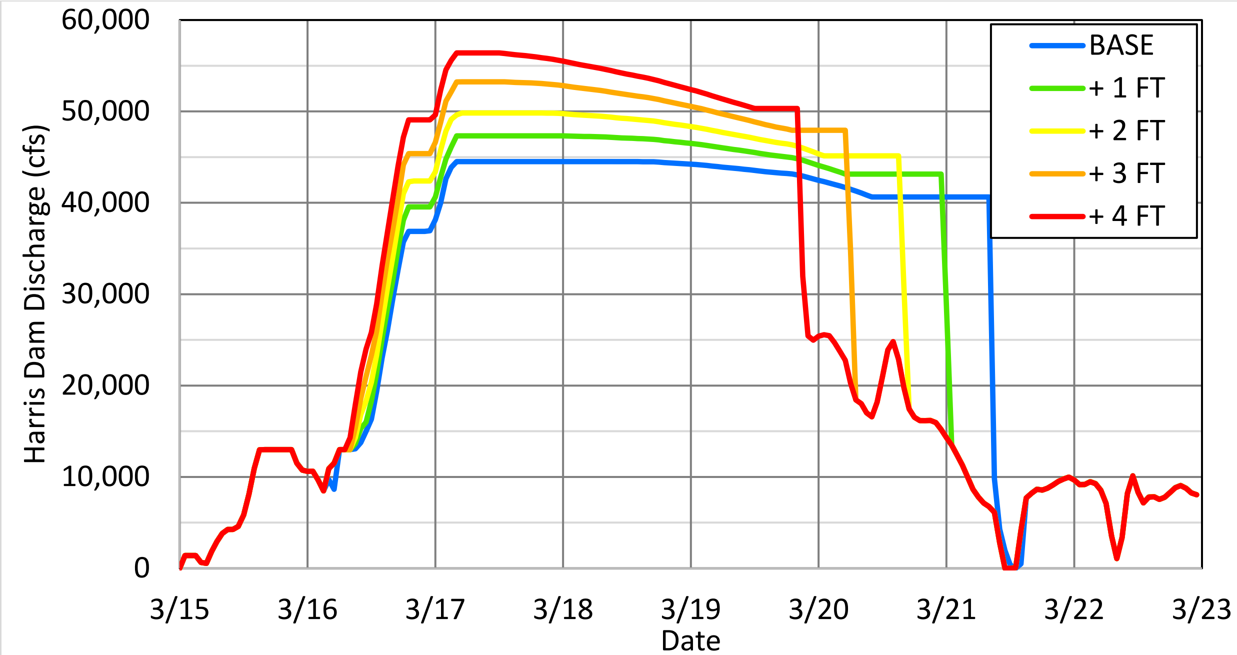

FIGURE B–1 OUTFLOW HYDROGRAPHS FROM THE 100-YEAR DESIGN FLOOD ROUTED THROUGH THE HARRIS RESERVOIR RESSIM MODEL

TABLE B–1 TOTAL ACRES INUNDATED DOWNSTREAM OF HARRIS DAM BASED ON RESULTS OF 100-YEAR DESIGN FLOOD IN HARRIS-MARTIN HEC-RAS MODEL

Elevation	Total Inundation Area (acres)	Increase over Baseline (acres)	Percent Increase over Baseline
Baseline (785 feet msl)	6,105	-	-
+ 1 foot	6,403	298	4.9%
+ 2 feet	6,590	485	7.9%
+ 3 feet	6,791	686	11.2%
+ 4 feet	6,995	889	14.6%

TABLE B–2 CHANGES IN MAXIMUM DOWNSTREAM WATER SURFACE ELEVATIONS RESULTING FROM CHANGE IN WINTER OPERATING CURVE

Location	Distance from Dam (miles)	Max Water Surface Rise (feet)			
		+ 1 foot	+ 2 feet	+ 3 feet	+ 4 feet
RM 129.7 (Malone, AL)	7	0.5	1.0	1.6	2.2
RM 122.7 (Wadley, AL)	14	0.5	1.1	1.7	2.4
RM 115.7	21	0.6	1.1	1.8	2.5
RM 108.7	28	0.5	1.0	1.6	2.2
RM 101.7	35	0.4	0.7	1.1	1.4
RM 93.7 (Horseshoe Bend)	43	0.3	0.7	1.0	1.4

TABLE B–3 CHANGES IN FLOOD DURATION RESULTING FROM CHANGE IN WINTER OPERATING CURVE

Location	Distance from Dam (miles)	Duration above Baseline Condition Max Elevation (hours)			
		+ 1 foot	+ 2 feet	+ 3 feet	+ 4 feet
RM 129.7 (Malone, AL)	7	15	43	61	67
RM 122.7 (Wadley, AL)	14	12	19	32	43
RM 115.7	21	13	21	35	46
RM 108.7	28	14	26	38	48
RM 101.7	35	17	27	40	48
RM 93.7 (Horseshoe Bend)	43	18	29	39	47

TABLE B–4 PERCENT OF TIME OVER THE PERIOD OF RECORD (1939 TO 2011) SPENT IN TURBINE CAPACITY AND SPILLWAY OPERATIONS FOR EACH WINTER POOL ALTERNATIVE

Elevation	Spillway Operations	Turbine Capacity
Baseline (785 feet msl)	0.2%	0.7%
+ 1 foot	0.3%	0.7%
+ 2 feet	0.3%	0.8%
+ 3 feet	0.3%	0.8%
+ 4 feet	0.4%	1.0%

APPENDIX C

3-DIMENSIONAL HYDRODYNAMIC AND WATER QUALITY MODEL OF LAKE HARRIS, ALABAMA

3-Dimensional Hydrodynamic and Water Quality Model of Lake Harris, Alabama

Prepared for:

Alabama Power Company

600 18th St N, Birmingham, AL 35203

November 25, 2020

DYNAMIC SOLUTIONS, LLC
6421 DEANE HILL DRIVE
KNOXVILLE, TENNESSEE 37919

Executive Summary

The purpose of this modeling effort was to calibrate and validate an EFDC model of hydrodynamics, sediment transport and water quality for Lake Harris to provide a technically credible modeling framework to support an evaluation of the simulated effects of raising the winter pool elevation on water temperature and dissolved oxygen in the forebay area of Lake Harris.

The Lake Harris EFDC model simulation period covered the 6-year period from 1 January 2014 through 31 December 2019. Results generated for the first year (2014) were used to spin-up the model to eliminate the effects of the initial conditions assigned for model setup. The model was calibrated using data collected during the 2-year period from 1 January 2018 to 31 December 2019 and the model was validated to data collected during the 3-year period from 1 January 2015 to 31 December 2017.

The calibrated and validated state variables of the EFDC model included stage, water temperature, total suspended solids, dissolved oxygen, algae biomass (as chlorophyll a), total organic carbon, nitrogen species (ammonia, nitrite/nitrate, total organic nitrogen, and total nitrogen), and phosphorus species (total phosphate, total organic phosphorus, and total phosphorus). The model was also calibrated and validated to Secchi depth as a derived output variable for water clarity.

Modeled water surface elevation showed excellent agreement with the observed stage data for both calibration and validation periods. Model performance for water temperature was very good with simulated water temperature following the seasonal trend of observed water temperature data very well as surface and bottom layer time series and vertical profiles. The water quality results for dissolved oxygen, total suspended solids, secchi depth, algae biomass (as chlorophyll a) and the inorganic and organic forms of nitrogen and phosphorus also demonstrated good agreement with the observed data sets over the entire domain.

The calibrated and validated EFDC model of Lake Harris was applied to evaluate the effects of raising the existing winter pool level on water temperature and dissolved oxygen in the forebay area of the lake. Comparison of the baseline conditions with the results of the scenario analysis clearly indicated that raising the winter pool elevation by up to 4 ft showed only minor impacts on water temperature and dissolved oxygen concentrations in the dam discharge flow.

Table of Contents

List of Figures

List of Tables

1. Introduction and Background

Lake Harris, located on the Tallapoosa River near Lineville, Alabama, has a length of 29 miles, a maximum depth of 121 feet at the dam and covers an area of approximately 9,870 acres with 367 miles of shoreline. The Tallapoosa River and the Little Tallapoosa River are the two main tributaries to the lake as shown in Figure 1-1. Lake Harris, also known as Lake Wedowee, was impounded on April 20, 1983 and the R.L. Harris Dam is one of the 14 hydroelectric power plants operated by Alabama Power Company (APC). The Federal Energy Regulatory Commission (FERC) issued an operating license to Alabama Power on December 27, 1973 and the 50-year license will expire on November 30, 2023. In order for Alabama Power to continue operating the Harris hydroelectric Project, the company must obtain a new operating license from FERC.

As part of the FERC relicensing process, stakeholders have requested that APC evaluate the feasibility of modifying the operating curve for seasonal elevation of Lake Harris. Specifically, stakeholders requested that APC evaluate raising the winter pool level from the current pool level by up to four feet. Currently, the operating curve consists of a target summer pool elevation of 793 ft (NGVD29) from May 1 to October 1, a drawdown to 785 ft (NGVD29) from October 1 to December 1, a target winter pool elevation of 785 ft (NGVD29) from December 1 to April 1, and a refilling to summer pool elevation of 793 ft (NGVD29) from April 1 to May 1, as shown in Figure 1-2.

In order to assess the potential effects of a higher winter pool elevation on water temperature and water quality, APC solicited technical assistance from Dynamic Solutions, LLC (DSLLC) to develop, calibrate, and validate a 3-dimensional Environmental Fluid Dynamic Code (EFDC) hydrodynamic and water quality model. The calibrated and validated EFDC model was then applied to evaluate the effects of increasing the winter pool elevation on water temperature and water quality, especially with regards to dissolved oxygen (DO) in the reservoir forebay and how increasing the winter pool elevation may impact water temperature and DO immediately downstream.

This report presents a summary of data sources used to setup the EFDC lake model, model calibration and validation results, and model performance results. Based on a range of winter elevation scenarios generated with the calibrated and validated lake model, the report presents assessments of the effects of increasing the winter pool elevation on water temperature and dissolved oxygen in the forebay area of Lake Harris.

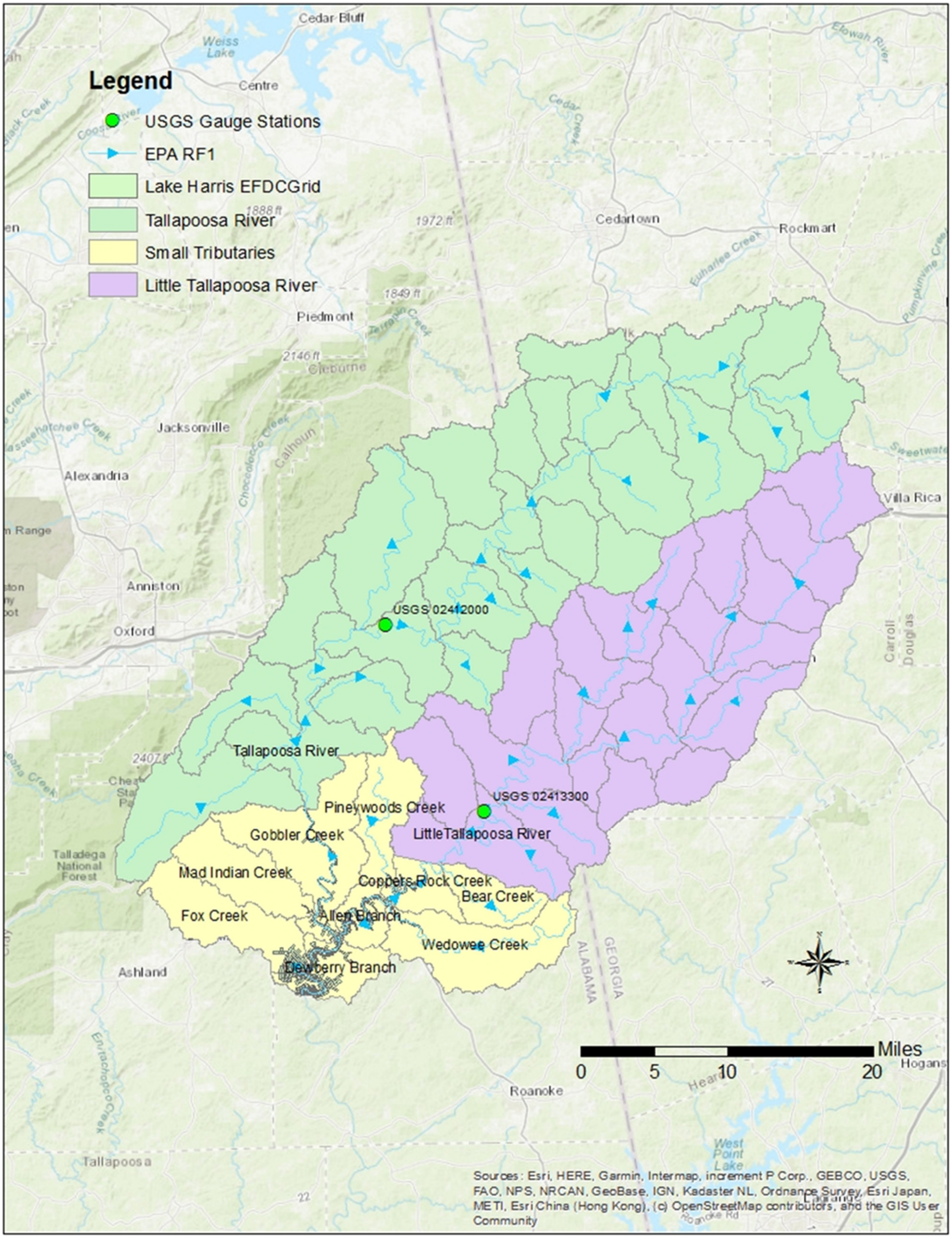

Figure 1-1 Location of Lake Harris

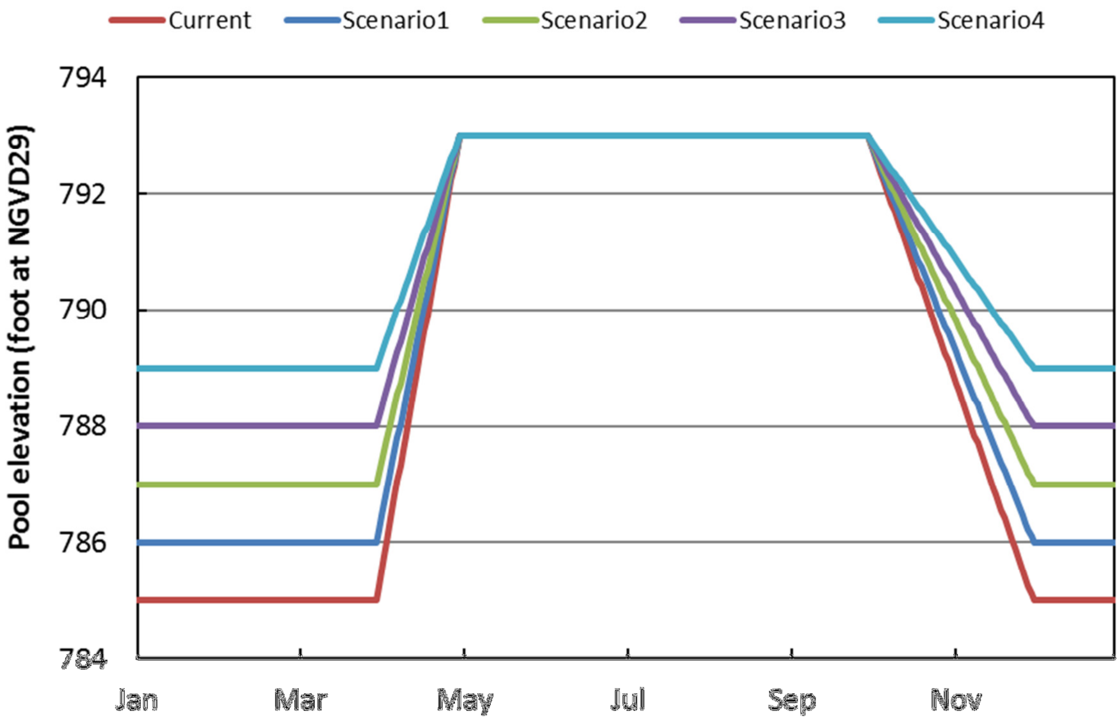

Figure 1-2 Operating Curves of Lake Harris Dam

2. Development of EFDC model

2.1 Overview of the EFDC Model

The Environmental Fluid Dynamics Code (EFDC) is a general-purpose surface water modeling package for simulating three-dimensional (3-D) circulation, mass transport, sediments and biogeochemical processes in surface waters including rivers, lakes, estuaries, reservoirs, nearshore and continental shelf-scale coastal systems. The EFDC model was originally developed at the Virginia Institute of Marine Science for estuarine and coastal applications (Hamrick, 1992; 1996). Over the past decade, the US Environmental Protection Agency (EPA) has continued to support its development and EFDC is now part of a family of public domain surface water models recommended by EPA to support water quality investigations including TMDL studies. In addition to state of the art hydrodynamics with salinity, water temperature and dye tracer simulation capabilities, EFDC can also simulate cohesive and non-cohesive sediment transport, the transport and fate of toxic contaminants in the water and sediment bed, and water quality interactions that include dissolved oxygen, nutrients, organic carbon, algae and bacteria. A state of the art sediment diagenesis model (Di Toro, 2001) is internally coupled with the water quality model (Park et al., 2000; Hamrick, 2007). Special enhancements to the hydrodynamic code, such as vegetation resistance, drying and wetting, hydraulic structure representation, wave current boundary layer interaction, and wave-induced currents, allow refined modeling of tidal systems, wetland and marsh systems, controlled-flow systems, and near-shore wave-induced currents and sediment transport. The EFDC code has been extensively tested, documented and used in more than 100 surface water modeling studies (Ji, 2017). The EFDC model is currently used by university, government, engineering and environmental consulting organizations worldwide.

2.2 Model Simulation Period

The Lake Harris EFDC model simulation period covered the 6-year period from 1 January 2014 through 31 December 2019. The model was calibrated for the period from 1 January 2018 through 31 December 2019 and the model was validated for the period from 1 January 2015 through 31 December 2017. The initial 1-year period for 2014 was used as the spin-up period to diminish the impact of the initial conditions on model results. The lake model was run continuously for the entire period from 1 January 2014 to 31 December 2019 and results were split out to present results for model calibration and model validation.

Hydrologic conditions were based on long-term annual rainfall data collected from the National Oceanic and Atmospheric Agency (NOAA) stations in the vicinity of Lake Harris, as shown in Figure 2-1. Historical annual rainfall data, compiled for the long-term period record from 1937 to 2019, was used to calculate summary statistics given in Table 2-1. Based on the long-term percentiles statistics and annual rainfall data compiled for 2015-2019 shown in Table 2-2, the calibration and validation periods covered the range of all three hydrological conditions representing a mix of dry, average, and wet years.

Table 2-1 Percentile Statistics of Annual Rainfall around Lake Harris: 1937-2019

Statistics	Annual rainfall (inch)
Minimum	29.61
10 Percentile	45.62
25 Percentile	50.24
50 Percentile	55.89
Average	56.19
75 Percentile	61.86
90 Percentile	71.13
Maximum	76.06

Table 2-2 Hydrological Conditions of the Calibration and Validation Periods

Year	Annual rainfall (inch)	Hydrological condition
2015	58.28	Average
2016	37.21	Dry
2017	68.34	Wet
2018	63.70	Wet
2019	60.13	Average to wet

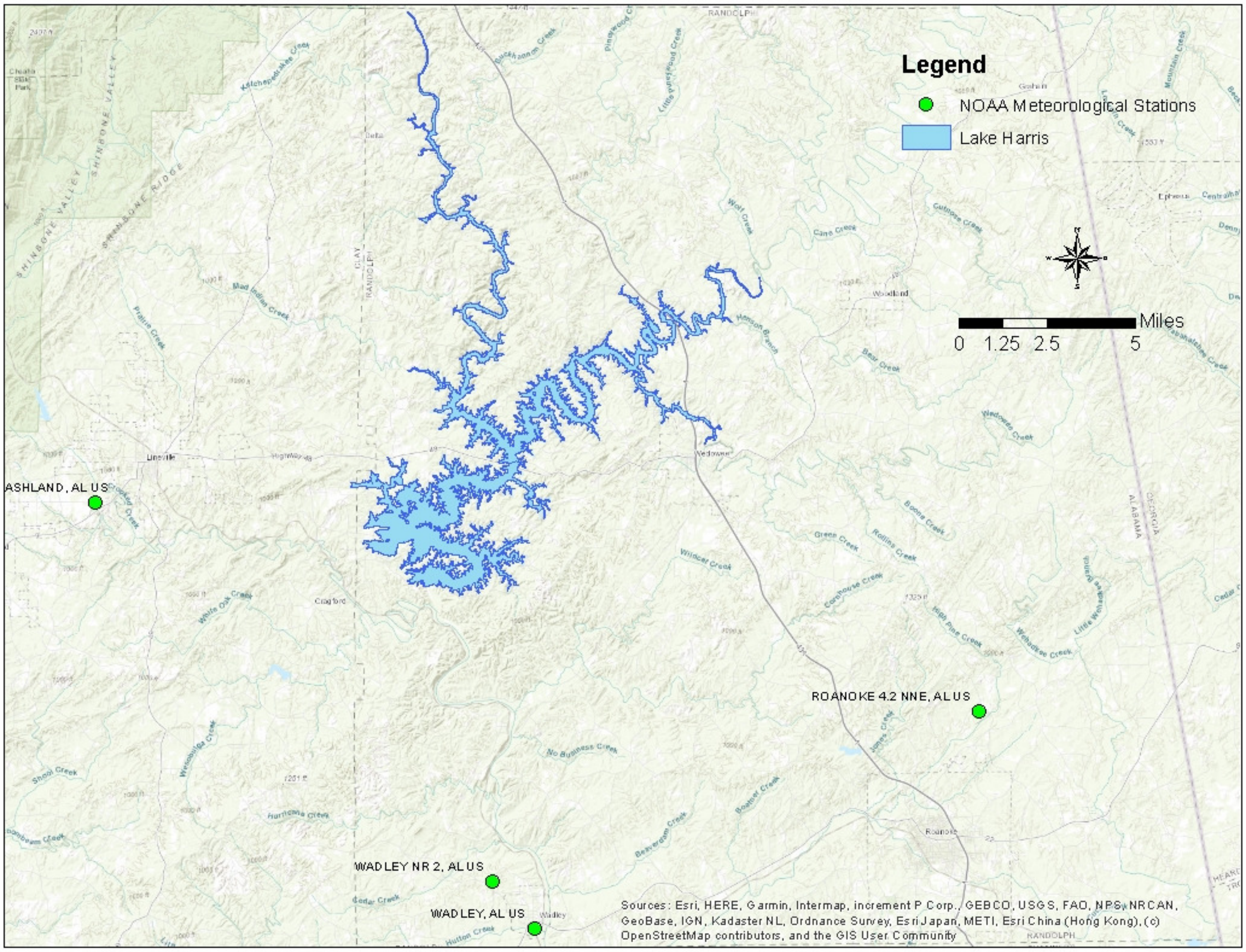

Figure 2-1 Location of the NOAA Meteorological Stations

The modeled state variable constituents for the Lake Harris EFDC hydrodynamic and water quality model are given below.

- **<u>Hydrodynamics</u>**
- Flow
- Water surface elevation
- Water temperature
- **<u>Sediment Transport and Water Quality</u>**
- Total suspended solids (TSS)
- Nitrogen (TN, NO_2+NO_3, Organic N, NH_3/NH_4)
- Phosphorus (TP, Organic P, Ortho-Phosphate)
- Total organic carbon (TOC)
- Phytoplankton (as Chl-a)
- Dissolved oxygen (DO)

2.3 Grid Development

Shoreline and bathymetry data available from aerial imagery and GIS data were used to generate the curvilinear orthogonal grid for the Lake Harris EFDC model. Data was transformed, as needed, to a horizontal coordinate system based on NAD1983 UTM Zone_16N (as meters). The computational grid is defined by a total of 912 horizontal grid cells covering a surface area of 8,948.6 acres as shown in Figure 2-2. Vertical layers for each grid cell were generated using the Sigma-Zed (SGZ) layering method. In the SGZ option for the EFDC model, the vertical layering scheme allows the number of layers to vary spatially over the model domain to differentiate shallow and deep areas of the lake. All bathymetry and water surface elevation data has been converted to NAVD88 with the units of meters to develop a consistent vertical datum, as shown in Figure 2-3. Due to the SGZ layering method, the bottom active cell can be associated with any layer in the model depending on the bathymetry. As water depth becomes shallower, the bottom active cell layer increases until only the top most layer in the model domain contains active cells in the shallower areas of the lake.

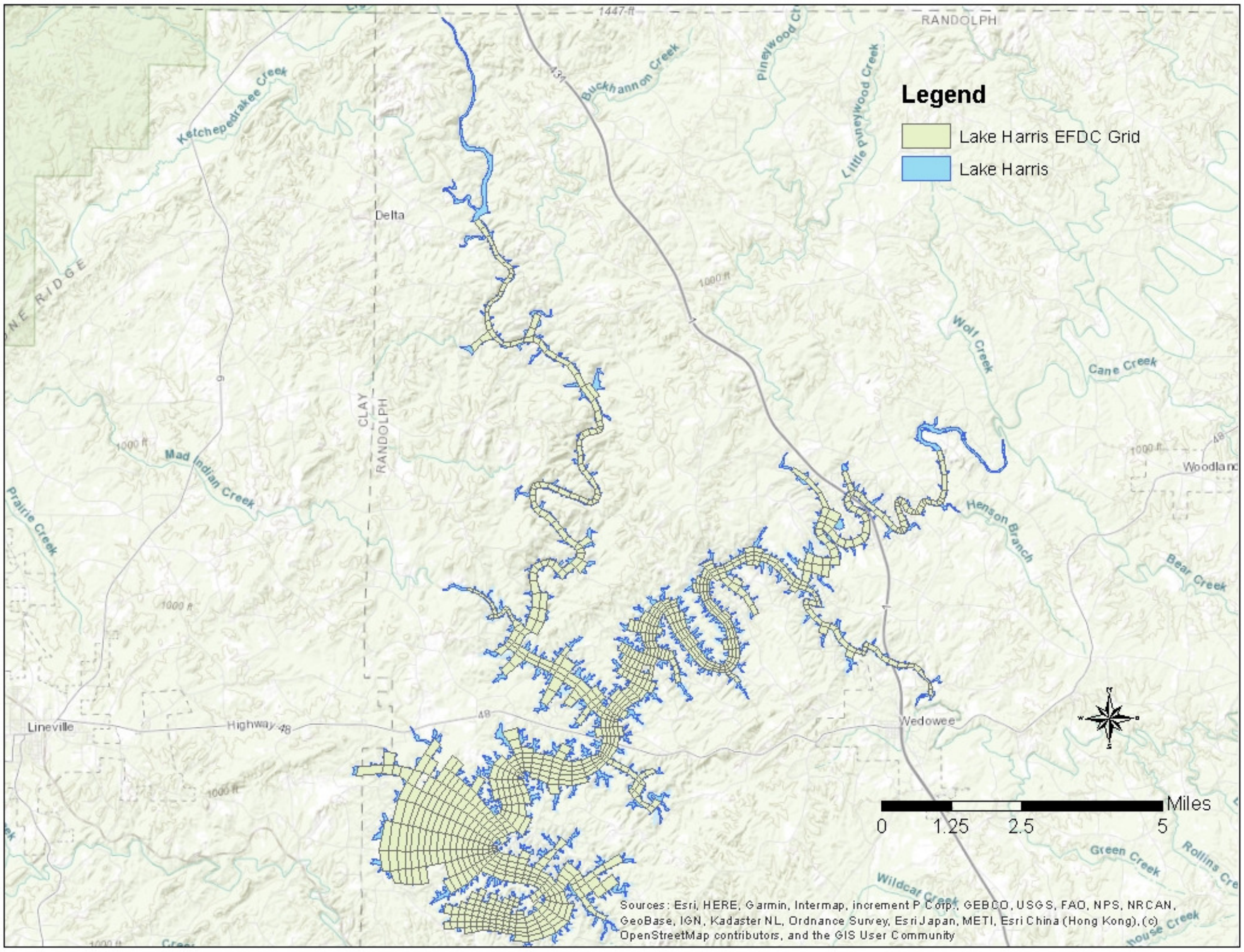

Figure 2-2 EFDC Model Grid for Lake Harris

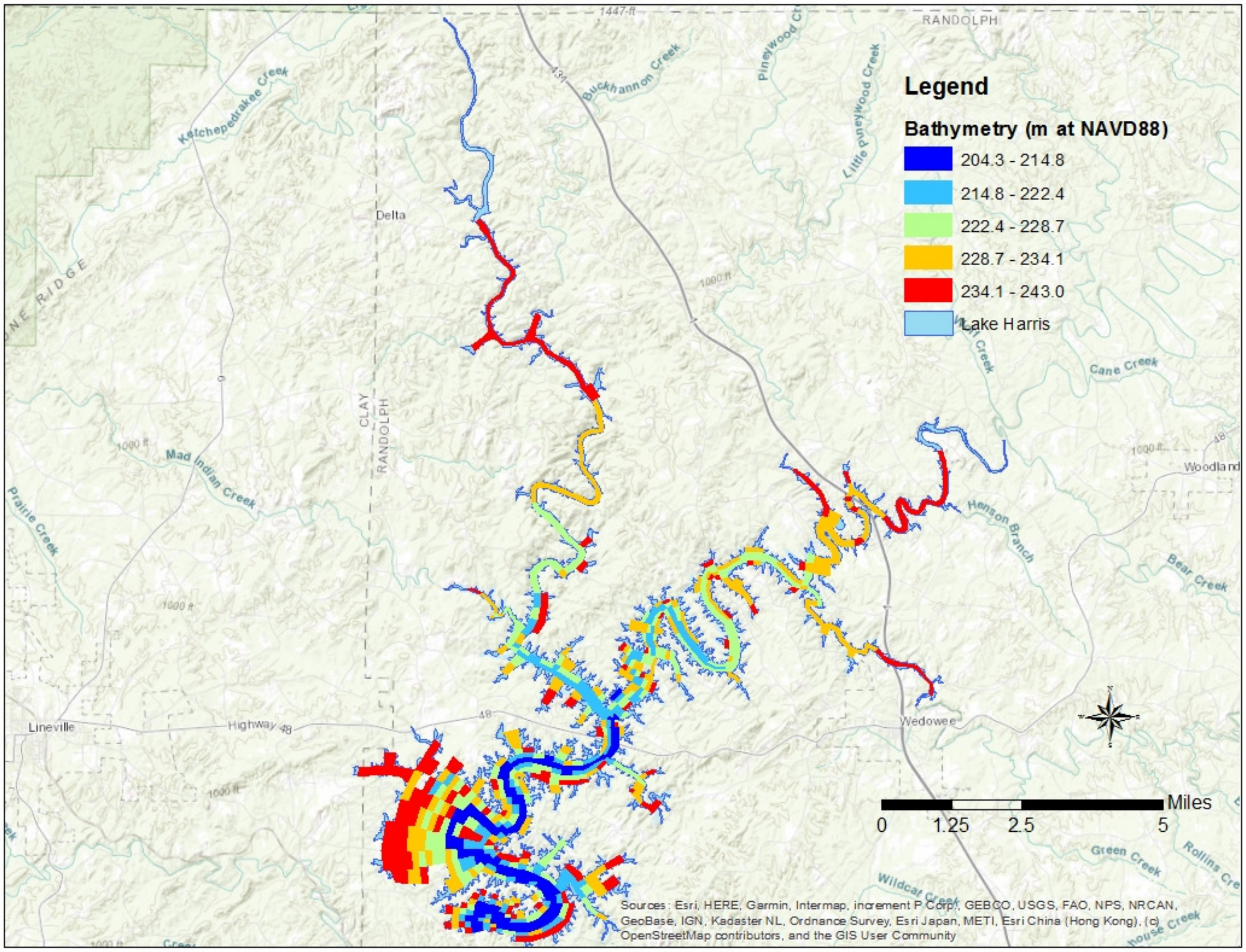

Figure 2-3 Bathymetry Data in the Lake Harris EFDC Model Domain

2.4 Meteorological Data

Meteorological data used in the EFDC hydrodynamic model included rainfall, wind speed and direction, relative humidity, atmospheric pressure, cloud cover, solar radiation, and air temperature. These data sets were used to calculate the impact of atmospheric forcing on water temperature and physical transport processes in the lake.

Hourly meteorological data was available at four NOAA meteorological stations, as shown in Figure 2-4. Anniston Metropolitan Airport is located in the west of Talladega National Forest while Lake Harris is located east of the Talladega National Forest in the valley. Thomas C Russell Field Airport has a more complete data set than does the stations located at the West Georgia Regional Airport and Lagrange Callaway Airport. The primary station used in the EFDC model to describe atmospheric forcing was, therefore, the Thomas C Russell Field Airport and the data sets from the other three stations were used to fill in missing data gaps from the records obtained for the Thomas C Russell Field Airport station. Short wave solar radiation data was estimated using a cloud-cover adjustment of latitude-dependent theoretical clear sky radiation. Evapotranspiration data used for input to the Lake Harris model was calculated internally by the EFDC model.

Table 2-3 Meteorological Stations Used in the EFDC Model

Station Name	Station ID	Agency	Latitude (N)	Longitude (W)
ANNISTON METROPOLITAN ARPT	WBAN 13871	NOAA	33.587	-85.856
WEST GEORGIA REGIONAL AIRPORT	WBAN 00249	NOAA	33.633	-85.150
THOMAS C RUSSELL FLD ARPT	WBAN 63833	NOAA	32.915	-85.963
LAGRANGE-CALLAWAY AIRPORT	WBAN 03821	NOAA	33.017	-85.067

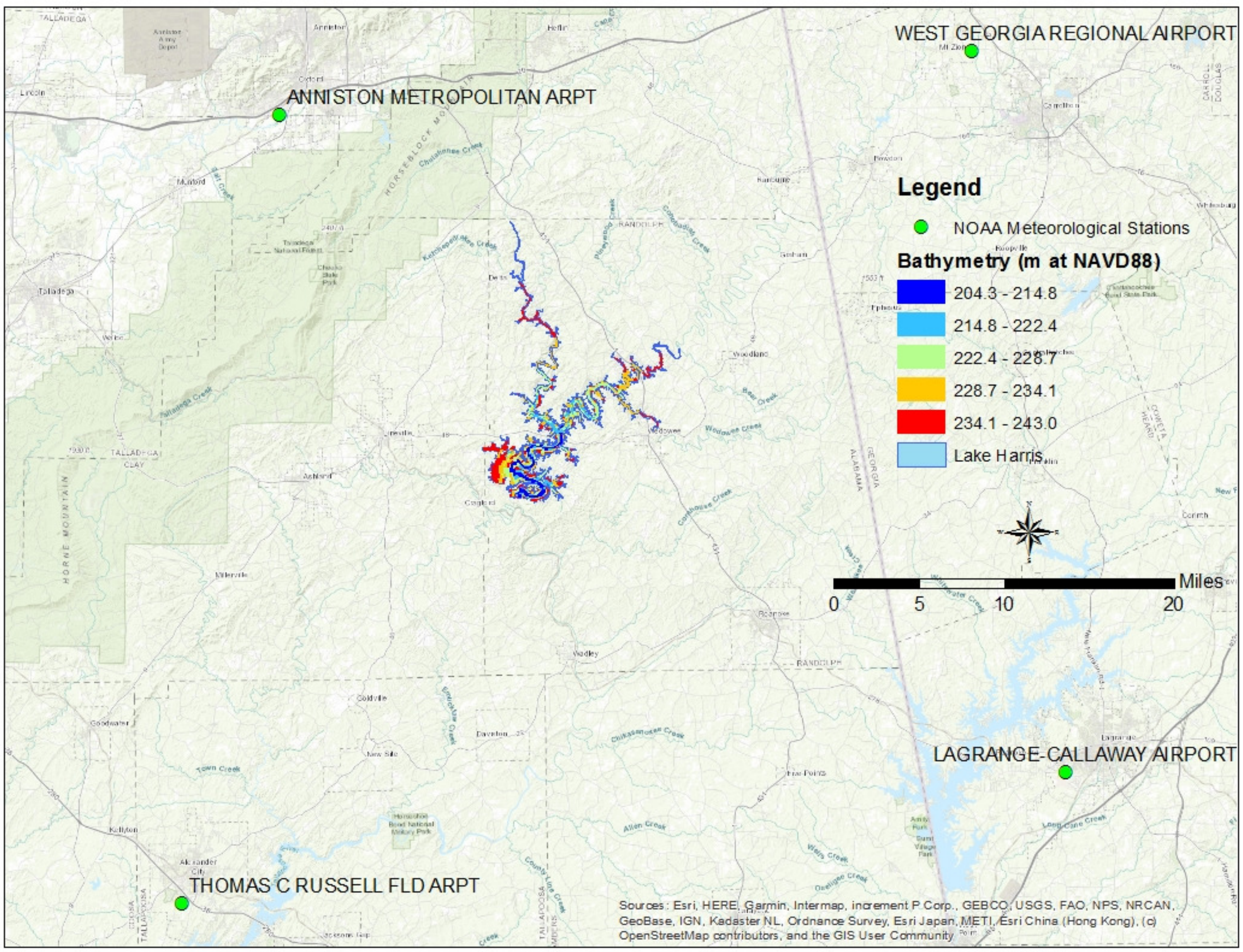

Figure 2-4 Location of the NOAA Meteorological Stations

2.5 Boundary Conditions

Boundary conditions for the EFDC model must be specified for flow boundary conditions to define external inflows of water and mass loading into the EFDC model domain. Flow boundary datasets required for input to EFDC include time series of flow, water temperature, suspended solids and water quality constituents to define mass loading inputs to the lake.

The Lake Harris EFDC model was developed with eleven (11) flow boundaries to define water coming into the lake from the tributaries, one (1) flow boundary to define release of water at the dam, and one (1) flow boundary to define a flow balance developed to account for water removed from the lake by water supply withdrawals and other unknown flows such as groundwater seepage and leakage from the dam. Table 2-4 listed the thirteen (13) model flow boundary indexes with the number of EFDC cells assigned to each boundary location. External flow boundary conditions were assigned to grid cells based on physical location and the specific boundary condition represented in the lake model (Figure 2-5).

Continuous observed flow data is available at two USGS gauge stations: (1) Tallapoosa River near Heflin (ID: USGS 02412000) and (2) Little Tallapoosa River near Newell (ID: USGS 02313300), as shown in Figure 2-5. The contributing areas of USGS 02412000 and USGS 02413300 stations are 448 and 406 square miles, respectively. The flow at each tributary, as shown in Figure 2-5, was estimated using a drainage area-weighted approach as follows. The ratio of the contributing area of each tributary to the target USGS gauge was first calculated (Table 2-5 and Table 2-6) and then the flow for each tributary was estimated as the product of the USGS flow and the drainage area ratio.

As a hydroelectric generating station, flow release records at the dam are maintained and were available from the APC. A flow balance was estimated using all inflows from rainfall and tributary flows and all outflows from evaporation and flow releases at the dam. As data for water supply withdrawals, groundwater seepage and leakage at the dam are either not readily available or are unknown, a flow balance is needed to account for these undocumented flows to ensure that the EFDC model simulated lake stage time series results match the observed lake stage.

Table 2-4 Lake Harris EFDC Model Flow Boundaries

BC	Boundary Group Name	Cells
1	Tallapoosa River	1
2	Little Tallapoosa River	1
3	Dam Discharge	1
4	Bear Creek	1
5	Copper Rock Creek	1
6	Wedowee Creek	1
7	Pineywoods Creek	1
8	Allen Branch	1
9	Dewberry Branch	2
10	Fox Creek	1
11	Mad Indian Creek	1
12	Gobbler Creek	2
13	Balance Flow	10

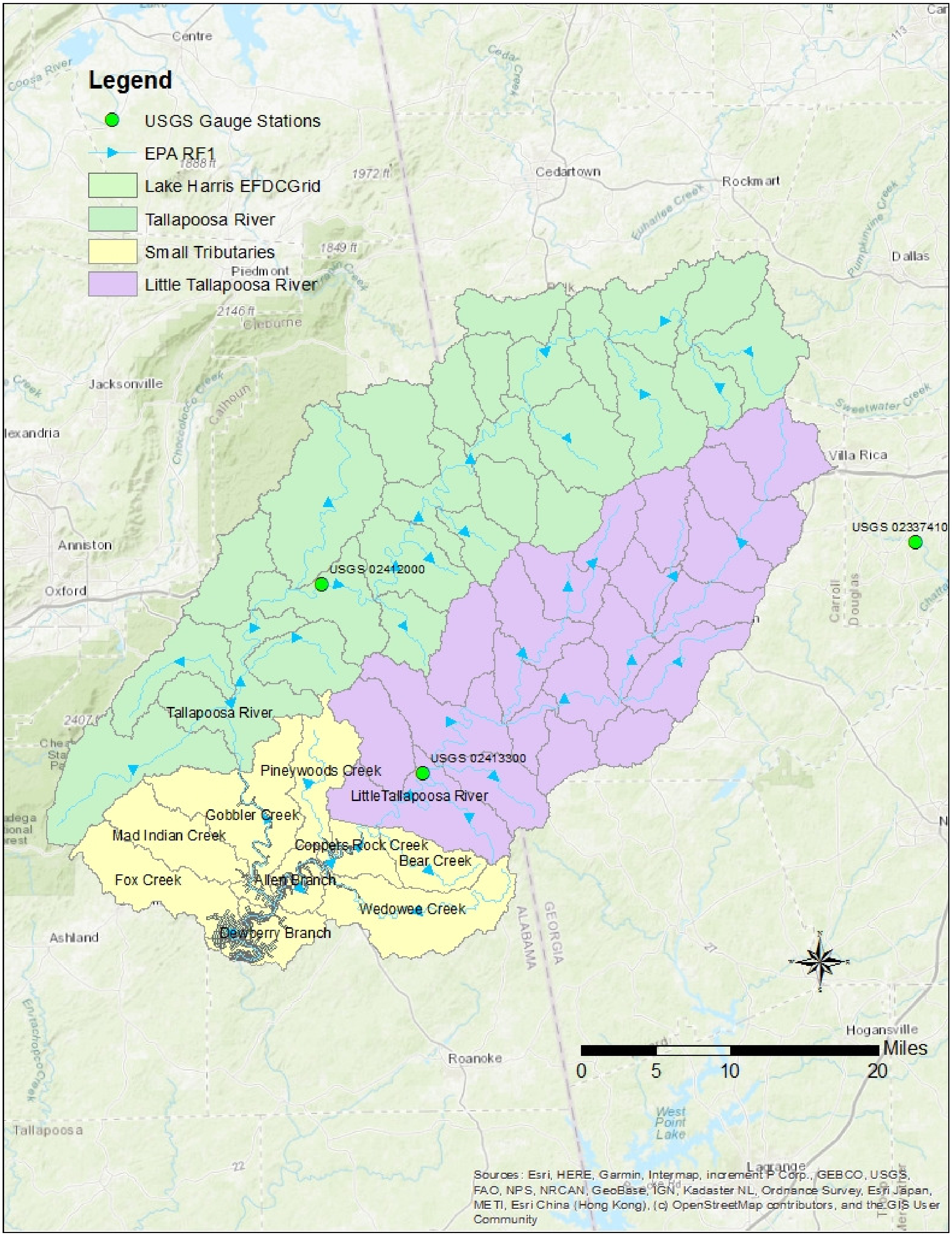

Figure 2-5 Location of the Tributary Boundary inflows to Lake Harris and USGS Stations

Table 2-5 Drainage Area Ratios of Tributary to Tallapoosa River USGS 02412000

Tributary Name	Contributing Area ($mile^2$)	Ratio
Tallapoosa River	705.528	1.574839
Gobbler Creek	54.654	0.121996
Fox Creek	36.043	0.080453
Mad Indian Creek	30.840	0.068839
Total	827.065	

Table 2-6 Drainage Area Ratios of Tributary to Little Tallapoosa River USGS 02413300

Tributary Name	Contributing Area ($mile^2$)	Ratio
Little Tallapoosa River	473.003	1.165032
Pineywoods Creek	27.636	0.068069
Bear Creek	19.344	0.047645
Wedowee Creek	50.628	0.124700
Allen Branch	10.316	0.025409
Dewberry Branch	15.280	0.037635
Coppers Rock Creek	14.646	0.036075
Total	610.853	

Observed water temperature data is available at two USGS gauge stations: (1) Tallapoosa River near Heflin (ID: USGS 02412000) and (2) Little Tallapoosa River near Newell (ID: USGS 02413300), as shown in Figure 2-5. The time interval of the observed temperature data set is 15-minute. The observed water temperature data, however, is only available from 5 December 2017 to the present at both USGS stations. The water temperature data prior to 5 December 2017 at both USGS stations, therefore, needs to be estimated to fill in this data gap.

The water temperature data at USGS 02412000 and USGS 02413300 prior to 5 December 2017 was estimated using a linear regression approach. Based on an assessment of the USGS stations close to Lake Harris, it was found that the water temperature data available from USGS gauge 02337410 (DOG RIVER AT GA 5, NEAR FAIRPLAY, GA) had the best linear relationship with the water temperature data recorded at USGS 02412000 and USGS 02413300, as shown in Figure 2-6 and Figure 2-7. The calculated regression coefficients (r^2) were higher than 0.97 demonstrating a strong relationship for both of these regressions. After filling in the data gaps in the long-term record, the complete water temperature time series data set from 2014 to 2019 was developed for both USGS 02412000 and USGS 02413300 stations. Water temperature boundary data associated with each tributary was then assigned to the USGS gauge data set as shown on Table 2-7.

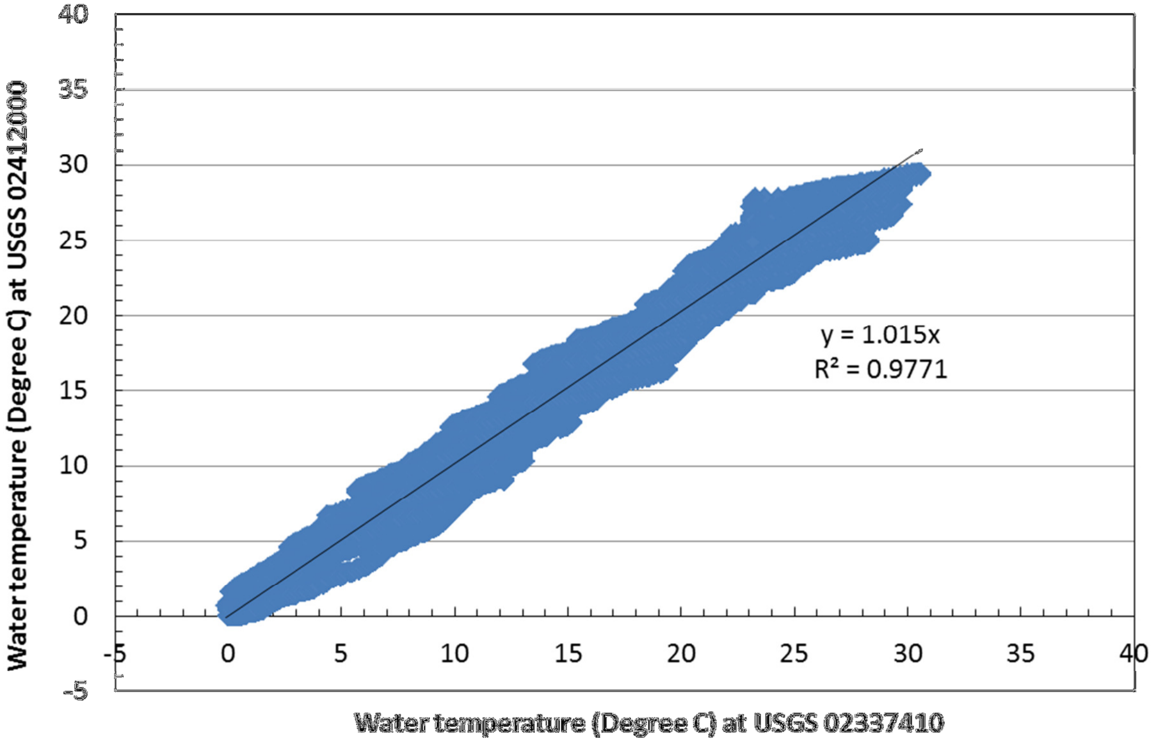

Figure 2-6 Linear Regression of Water Temperature Data between USGS 02412000 and USGS 02337410

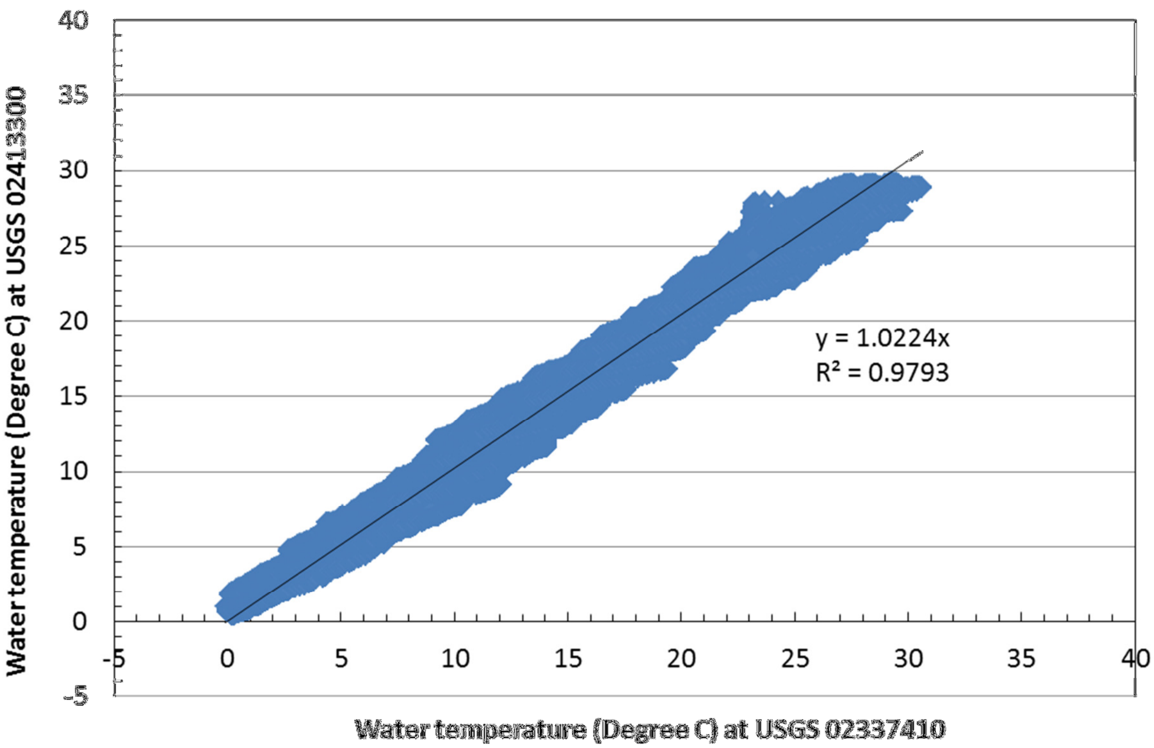

Figure 2-7 Linear Regression of Water Temperature Data between USGS 02413300 and USGS 02337410

Table 2-7 Assignment of Water Temperature Boundary

Tributary Name	Assigned Water Temperature Time Series
Tallapoosa River	USGS 02412000
Gobbler Creek	USGS 02412000
Fox Creek	USGS 02412000
Mad Indian Creek	USGS 02412000
Little Tallapoosa River	USGS 02413300
Pineywoods Creek	USGS 02413300
Bear Creek	USGS 02413300
Wedowee Creek	USGS 02413300
Allen Branch	USGS 02413300
Dewberry Branch	USGS 02413300
Coppers Rock Creek	USGS 02413300

Water quality constituent concentrations including total suspended solids, organic carbon, nutrients (nitrogen and phosphorus), and algae biomass at each of the flow boundary locations were estimated using the USGS LOAD ESTIMATOR (LOADEST) program, linear regression, and other approaches. More detailed information about how water quality boundary data sets were developed can be found in the next Section 2.6 (Estimation of Water Quality Boundaries) of this report.

2.6 Estimation of Water Quality Boundaries

Concentrations of all the water quality constituents at the flow boundaries, as shown in Figure 2-5, were first estimated using the USGS LOADEST program. LOADEST is a FORTRAN program for estimating water quality constituent loads in streams and rivers (Runkel et al., 2004). The LOADEST program assists the user in developing a regression model for the estimation of water quality constituent loads based on stream flow and water quality constituent concentration data. The LOADEST program provides eleven regression equations to estimate water quality constituent loadings. More detailed information about LOADEST, including regression model setup, calibration, and estimation, can be found in the USGS report by Runkel et al. (2004). The approach used for this study is described below as follows.

Paired flow and water quality data available for both the Tallapoosa River and the Little Tallapoosa River were collected and processed with observed water quality data downloaded from the Water Quality Portal website. Water quality stations in the Tallapoosa River and Little Tallapoosa River are given in Table 2-8, Table 2-9 and Figure 2-8. The processed flow-water quality data sets were used to prepare the LOADEST input file (calib.inp).

Paired flow and water quality data from both the Tallapoosa River and the Little Tallapoosa River stations were used to develop the regression model for each water quality constituent using USGS LOADEST with the option chosen for automated model selection. Regression equations developed with the LOADEST option were compared against the criteria to decide whether the developed regression models were acceptable or not based on criteria described below.

As recommended by Runkel et al. (2004), the criteria for acceptance of the regression model were: (1) Probability plot correlation coefficient (PPCC) should be close to a value of 1.0; (2) Absolute value of bias diagnostics (BP) should be close to or less than 25%; and (3) Nash-Sutcliffe efficiency index (E) value should be positive. The LOADEST method assumes a normal distribution of model residuals and a PPCC value close to 1.0 indicates that the model residuals follow a normal distribution. BP is the load bias as a percentage and positive values indicate over-estimation and negative values indicate under-estimation of the regression relationship. A Nash-Sutcliffe index value of E is equal to 1.0 represents a perfect match between observed and simulated data and a negative value of E (<0) indicates that the observed mean provides a better estimation than the LOADEST regression model. The LOADEST regression models for the Tallapoosa River and the Little Tallapoosa River that passed the above criteria for the water quality constituents are listed in Table 2-10 and Table 2-11.

As the final step in the estimation of the water quality boundary data sets, the accepted LOADEST regression models, as shown in Table 2-10 and Table 2-11 were used to estimate daily water quality loadings for the outlets of the Tallapoosa River and Little Tallapoosa River based on daily flow data records from 2014 to 2019. Time series of daily concentrations of the water quality constituent were then calculated from the daily load estimates and observed daily flow data.

Other approaches were used to estimate boundary conditions as time series for the water quality constituents which did not pass the LOADEST regression model criteria. The methods used to estimate water quality constituent daily concentrations for the Tallapoosa River and the Little Tallapoosa River are summarized in Table 2-12 and Table 2-13.

As phosphorus can adsorb to suspended sediment, Total Phosphorus can be significantly influenced by sorption/desorption and settling of suspended sediment. Total Suspended Solids (TSS) concentrations for the Little Tallapoosa River were estimated, therefore, based on a linear regression with Total Phosphorus (TP) data, as shown in Figure 2-9. Daily DO concentrations for both the Tallapoosa River and the Little Tallapoosa River were estimated as the 100% saturation concentration as a function of daily temperature data.

Once the complete water quality boundary conditions were developed at the outlets of the Tallapoosa River and Little Tallapoosa River, the assignment of water quality boundary for the small tributaries was based on Table 2-14.

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Table 2-8 Water Quality Stations in Tallapoosa River

Agency	**Data Source**	**Station_ID**	**Latitude N**	**Longitude W**
USGS	NWIS	USGS-02412000	33.623	-85.513
EPA	STORET	21AWIC-3132	33.623	-85.513
EPA	STORET	21AWIC-872	33.733	-85.372
EPA	STORET	21AWIC-873	33.606	-85.589
EPA	STORET	21AWIC-874	33.582	-85.592
EPA	STORET	21AWIC-875	33.556	-85.604
EPA	STORET	21AWIC-878	33.509	-85.625

Table 2-9 Water Quality Stations in Little Tallapoosa River

Agency	**Data Source**	**Station_ID**	**Latitude N**	**Longitude W**
USGS	NWIS	USGS-02413300	33.437	-85.399
EPA	STORET	21AWIC-1089	33.495	-85.338
EPA	STORET	21AWIC-2664	33.437	-85.399
EPA	STORET	21AWIC-4715	33.399	-85.439

Table 2-10 Regression Models Developed for Tallapoosa River

Constituents	**LOADEST Model selected**	**R^2**	**PPCC**	**BP**	**E**
BOD	#9	0.8658	0.9918	-1.80%	0.689
TKN	#3	0.6969	0.9892	-9.40%	0.509
NOX	#6	0.8126	0.9563	6.70%	0.467
TP	#6	0.795	0.9675	1.70%	0.964
TSS	#8	0.8772	0.9926	25.30%	0.787

Note: BP value for TSS is very close to 25% and is deemed to pass the criterion.

Table 2-11 Regression Models Developed for Little Tallapoosa River

Constituents	LOADEST Model selected	R^2	PPCC	Bp	E
BOD	#5	0.796	0.9892	-14.90%	0.454
NH4	#1	0.46	0.9826	5.40%	0.323
NO3	#9	0.9656	0.9678	1.10%	0.644
TKN	#6	0.8985	0.9984	6.40%	0.884
TP	#8	0.948	0.9547	-1.00%	0.648
TPO4	#2	0.8286	0.9742	0.60%	0.606

Table 2-12 Estimation of Concentrations of Water Quality Constituents in Tallapoosa River

Water Quality Parameter	Estimation Approach
TSS	LOADEST
TKN	LOADEST
NO3	LOADEST
TP	LOADEST
BOD	LOADEST
Chlorophyll a	a constant of 1.5 µg/L based on the observed data at station 21AWIC-878
NH4	Ratio of NH4:TKN = 0.16 based on the observed data at station 21AWIC-878
TON	TKN-NH4
TPO4	Ratio of TPO4:TP = 0.21 based on the observed data at station 21AWIC-878
TOP	TP – TPO4
TOC	Based on the LOADEST BOD5
DO	Based on water temperature and 100%saturation concentration

Table 2-13 Estimation of Concentrations of Water Quality Constituents in Little Tallapoosa River

Water Quality Parameter	Estimation Approach
TKN	LOADEST
NO3	LOADEST
NH4	LOADEST
TP	LOADEST
TPO4	LOADEST
BOD	LOADEST
Chlorophyll a	a constant of 3.0 µg/L based on the observed data at station 21AWIC-2664
TON	TKN – NH4
TOP	TP – TPO4
TOC	Based on the LOADEST BOD5
TSS	Based on the linear regression with TP
DO	Based on water temperature and 100%saturation concentration

Table 2-14 Assignment of Water Quality Boundary to Small Tributaries

Tributary Name	Assigned Water Temperature Time Series
Tallapoosa River	Tallapoosa River
Gobbler Creek	Tallapoosa River
Fox Creek	Tallapoosa River
Mad Indian Creek	Tallapoosa River
Little Tallapoosa River	Little Tallapoosa River
Pineywoods Creek	Little Tallapoosa River
Bear Creek	Little Tallapoosa River
Wedowee Creek	Little Tallapoosa River
Allen Branch	Little Tallapoosa River
Dewberry Branch	Little Tallapoosa River
Coppers Rock Creek	Little Tallapoosa River

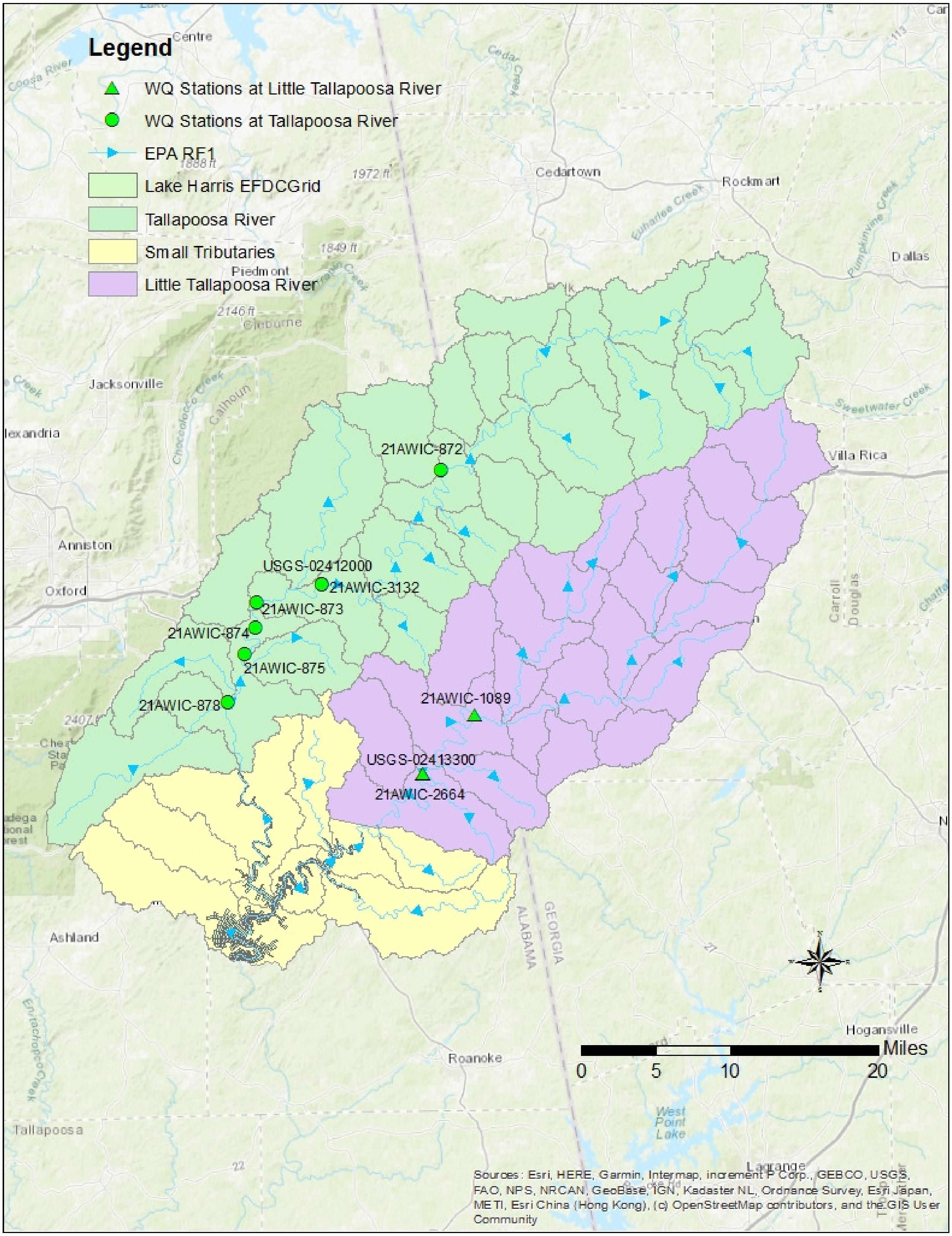

Figure 2-8 Location of Water Quality Stations

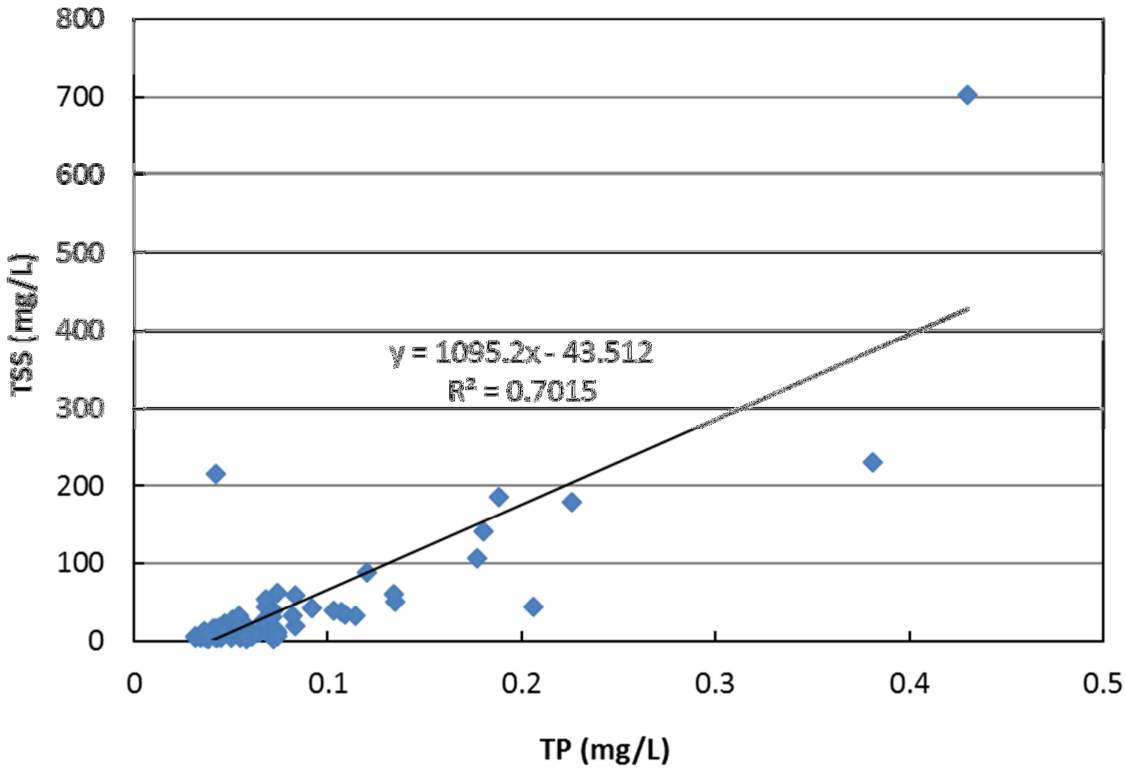

Figure 2-9 Linear Regression between TSS and TP at Little Tallapoosa River

3. Water Quality and Sediment Flux Model

3.1 Water Quality Model

For the Lake Harris EFDC model, the water quality model was internally coupled with the hydrodynamic model and a sediment transport model. The hydrodynamic model described circulation and physical transport processes including turbulent mixing, water column stratification during the summer months, and erosion of stratification during the winter months. The sediment transport model described the water column distribution of inorganic cohesive particles resulting from transport, settling, deposition, and resuspension processes.

State variables of the EFDC hydrodynamic model (water temperature) and sediment transport model (inorganic suspended solids) are internally coupled with the EFDC water quality model. State variables of the EFDC water quality model include one functional group of algae; organic carbon, inorganic phosphorus (orthophosphate), organic phosphorus; inorganic nitrogen (ammonium and nitrite + nitrate), organic nitrogen; chemical oxygen demand (COD) and dissolved oxygen. The state variables represented in the Lake Harris EFDC hydrodynamic and water quality model are listed in Table 3-1.

The formulations of the EFDC water quality model are based on the kinetic processes and interactions developed for the Chesapeake Bay model (Cerco and Cole, 1995; Cerco et al., 2002). An overview of the source and sink terms for each state variable is presented in this section and details of the state variable equations and kinetic terms for each state variable are presented in Park et al. (1995), Hamrick (2007) and Ji (2017).

Table 3-1 EFDC State Variables

	EFDC State Variable		EFDC UNITS	Used in Model
	Flow	FLOW	cms	Yes
	Water_Temperature	TEM	Deg-C	Yes
	Salinity	SAL	ppt	No
	Cohesive Suspended Solids	COH	mg/L	Yes
	Non-cohesive Suspended Solids	NONCOH	mg/L	No
1	BlueGreen_Algae	CHC	mgC/L	No
2	Diatoms_Algae	CHD	mgC/L	No
3	Green_Algae	CHG	mgC/L	Yes
4	Refractory_Particulate_Org_C	RPOC	mgC/L	Yes
5	Labile_Particulate_Org_C	LPOC	mgC/L	Yes
6	Dissolved_Org_C	DOC	mgC/L	Yes
7	Refractory_Particulate_Org_P	RPOP	mgP/L	Yes
8	Labile_Particulate_Org_P	LPOP	mgP/L	Yes
9	Dissolved_Org_P	DOP	mgP/L	Yes
10	Total_Phosphate (PO4_P)	TPO4	mgP/L	Yes
11	Refractory_Particulate_Org_N	RPON	mgN/L	Yes
12	Labile_Particulate_Org_N	LPON	mgN/L	Yes
13	Dissolved_Org_N	DON	mgN/L	Yes
14	Ammonia_N ($NH4^{+}$)	NH4	mgN/L	Yes
15	Nitrate_N (NO2 + NO3)	NO3	mgN/L	Yes
16	Particulate-Biogenic_Silica	PBSI	mgSi/L	No
17	Available_Silica	SI	mgSi/L	No
18	Chemical_Oxygen_Demand	COD	mg/L	Yes
19	Dissolved_Oxygen	OXY	mgO2/L	Yes
20	Total_Active_Metal	TAM	mg/L	No
21	Fecal_Coliform_Bacteria	FCB	# /100mL	No

Suspended Solids

Suspended solids in the EFDC model can be differentiated by multiple size classes of cohesive and non-cohesive solids. Suspended solids are represented as a single size class of cohesive particles in the Lake Harris model. Cohesive suspended solids are included in the model to account for the inorganic solids component of light attenuation in the water column. Since cohesive particles derived from silts and clays are characterized by a small particle diameter (< 62 microns) and a low settling velocity, cohesive particles can remain suspended in the water column for long periods of time and contribute to light attenuation that can influence algal production. Non-cohesive particles, consisting of fine to coarse size sands, by contrast, are characterized by much larger particles (> 62 microns) with rapid settling velocities that quickly remove any resuspended non-cohesive particles from the water column to the sediment bed.

The key processes that control the distribution of cohesive particles are transport in the water column, flocculation and settling, deposition to the sediment bed, consolidation within the bed, and resuspension or erosion of the sediment bed. In the EFDC model for Lake Harris, cohesive settling is defined by a constant settling velocity that is determined by model calibration. Deposition and erosion are controlled by the assignment of critical stresses for deposition and erosion and the bottom layer velocity and shear stress computed by the hydrodynamic model. Initial critical stresses for deposition and erosion of cohesive particles are taken from parameter values defined by Ji (2017) for a sediment transport model of Lake Okeechobee and then adjusted as needed during model calibration. Parameter values for deposition and erosion assigned for the calibration of cohesive solids are summarized in Table 3-2.

Table 3-2 EFDC Model Parameter Values for Cohesive Solids

Variable	Value	Description	Units
SDEN	3.7736E-07	Sediment Specific Volume	m^3/g
SSG	2.65	Sediment Specific Gravity	--
WSEDO	7.0E-06	Constant Sediment Settling Velocity	m/s
TAUD	3.00E-03	Critical Stress for Deposition	$(m/s)^2$
WRSPO	5.00E-06	Reference Surface Erosion Rate	$g/m^2/s$
TAUR	4.00E-03	Critical Stress for Erosion	$(m/s)^2$

Algae

Phytoplankton in the EFDC model can be represented by three different functional groups of algae as (1) blue-green cyanobacteria; (2) diatoms; and (3) green algae. The Lake Harris EFDC model was developed to simulate only green algae as a “generic” group since there was no observed data available to characterize seasonal phytoplankton composition. Kinetic processes represented for algal groups include photosynthetic production, basal metabolism (respiration and excretion), settling and predation. Photosynthetic production is described by a growth rate that is functionally dependent on a maximum growth rate, water temperature, the availability of sunlight at the surface, light extinction in the water column, the optimum light level for growth, and half-saturation dependent nutrient limitation by either nitrogen or phosphorus. Growth and basal metabolism are temperature dependent processes while settling and predation losses are assigned as constant parameter values.

Organic Carbon

Total organic carbon is represented in the model with three state variables as dissolved organic carbon (DOC) and refractory and labile forms of particulate organic carbon (RPOC and LPOC). The time scale for decomposition of particulate organic matter (POM) is used to differentiate refractory and labile POM with labile matter decomposing rapidly (weeks to months) while decay of refractory POM takes much longer (years). Although DOC is not termed "labile", DOC is considered to react with a rapid time scale for decomposition (weeks to months).

Kinetic processes represented in the model for particulate organic carbon (POC) include algal predation, dissolution of RPOC and LPOC to DOC, and settling. Kinetic processes for DOC include sources from algal excretion, predation and dissolution of POC and losses from decomposition and denitrification. With the exception of settling of POC, all the kinetic reaction processes are temperature dependent.

Phosphorus

The organic and inorganic forms of phosphorus are represented in the model. Total organic phosphorus is represented in the model with three state variables as dissolved organic phosphorus (DOP) and refractory and labile forms of particulate organic phosphorus (RPOP and LPOP). As with organic carbon, the time scale for decomposition of particulate organic matter (POM) is used to differentiate refractory and labile POP. Kinetic processes represented in the model for POP include algal metabolism, predation, dissolution of RPOP and LPOP to DOP, and settling. Kinetic processes for DOP include sources from algal metabolism, predation and dissolution of POP to DOP with losses of DOP from mineralization to phosphate. With the exception of settling of POP, the kinetic reaction processes are all temperature dependent.

Inorganic phosphorus is represented as a single state variable for total phosphate which accounts for both the dissolved and particulate sorbed forms of phosphate. Adsorption and desorption of phosphate is defined on the basis of equilibrium partitioning using an assigned phosphate partition coefficient for suspended solids. Kinetic terms for total phosphate include sources from algal metabolism, predation and mineralization from DOP while losses for phosphate include settling of the sorbed fraction of total phosphate and uptake by phytoplankton growth. Depending on the concentration gradient between the bottom layer of the water column and sediment bed porewater phosphate, the sediment-water interface can serve as either a source or a loss term for phosphate in the water column. With the exception of the partition coefficient and the settling of sorbed phosphate, the kinetic reaction processes for phosphate are all temperature dependent.

Nitrogen

The organic and inorganic forms of nitrogen are represented in the model. Total organic nitrogen is represented in the model with three state variables as dissolved organic nitrogen (DON) and refractory and labile forms of particulate organic nitrogen (RPON and LPON). As with organic carbon, the time scale for decomposition of particulate organic matter (POM) is used to differentiate refractory and labile PON. Kinetic processes represented in the model for PON include algal metabolism, predation, dissolution of RPON and LPON to DON, and settling. Kinetic processes for DON include sources from algal metabolism and predation, dissolution of PON to DON and losses of DON from mineralization of PON to ammonium. With the exception of settling of PON, the kinetic reaction processes are all temperature dependent.

Inorganic nitrogen is represented by two state variables as (1) ammonia and (2) nitrite+nitrate. In natural waters total ammonia exists in two forms as the ammonium ion ($NH4^+$) and as un-ionized (NH3) ammonia. The ammonium ion ($NH4^+$) is the form of ammonia that is oxidized by nitrifying bacteria to nitrite and nitrate and used by phytoplankton for photosynthetic growth. Un-ionized ammonia (NH3) is the form of ammonia that is toxic to fish and other aquatic species. The toxic level of ammonia (NH3) is water temperature and pH dependent and toxicity increases as water temperature and/or pH increase. In most natural waters, where pH is relatively stable (~6 to 8), the ionized form of ammonia ($NH4^+$) typically has a much larger concentration than the un-ionized form of ammonia (NH3) (Ji, 2017). In most water quality models, the ammonium ion ($NH4^+$) is the form of ammonia that is commonly simulated as shown in Table 3-1 (Cerco and Cole, 1994; Tetra Tech, 2007; Ji, 2017).

Kinetic terms for ammonia include sources from algal metabolism and predation and mineralization from DON. Losses for ammonia include bacterially mediated transformation to nitrite and nitrate by nitrification and uptake by phytoplankton growth. Depending on the concentration gradient between the bottom layer of the water column and sediment bed porewater ammonia, the sediment-water interface can serve as either a source or a loss term for ammonia in the water column. The kinetic reaction processes for ammonia are all temperature dependent.

Since the time scale for conversion of nitrite to nitrate is very rapid, the concentration of nitrite in natural waters is much smaller than nitrate concentrations. In almost all water quality models, nitrite and nitrate are combined as a single state variable representing the sum of these two forms of inorganic nitrogen (nitrite+nitrate). Kinetic terms for nitrite/nitrate include sources from nitrification from ammonia to nitrite and nitrate. Losses include photosynthetic uptake by phytoplankton and denitrification to nitrogen gas. Depending on the concentration gradient between the bottom layer of the water column and sediment bed porewater nitrite/nitrate, the sediment-water interface can serve as either a source or a loss term for nitrite/nitrate in the water column. The kinetic reaction processes for nitrite/nitrate are all water temperature dependent.

Chemical Oxygen Demand (COD)

In the EFDC water quality model, chemical oxygen demand (COD) represents the concentration of reduced substances that can be oxidized through inorganic processes. The principal source of COD in freshwater is methane released from oxidation of organic carbon in the sediment bed across the sediment-water interface. Since sediment bed decomposition is accounted for in the water quality model, the only source of COD to the water column is the flux of methane across the sediment-water interface. Sources from the open water boundaries and upstream flow boundaries are set to zero for COD. The loss term in the water column is defined by a temperature dependent first order oxidation rate.

Dissolved Oxygen

Dissolved oxygen is a key state variable in the water quality model since several kinetic processes interact with, and can be controlled by, dissolved oxygen. Kinetic processes represented in the dissolved oxygen model include sources from atmospheric reaeration in the surface layer and algal photosynthetic production. Kinetic loss terms include algal respiration, nitrification, decomposition of DOC, oxidation of COD, and in the bottom layer of the water column, consumption of dissolved oxygen from sediment oxygen demand. Sediment oxygen demand is internally simulated with the sediment flux model by coupling particulate organic carbon deposition from the water column and decomposition of organic matter in the sediment bed. The kinetic reaction processes for dissolved oxygen are all temperature dependent.

Kinetic Coefficients

Most of the water quality parameters and coefficients needed by the EFDC water quality model were initialized with default values as indicated in the user's manual (Hamrick, 2007). These default values are, in general, the same as the parameter values determined for the

Chesapeake Bay model (Cerco and Cole, 1995). Models developed for Lake Washington (Arhonditsis and Brett, 2005) and Chesapeake Bay tributaries (Cerco et al., 2002) also provided kinetic coefficients needed for the EFDC water quality model. Kinetic coefficients and model parameters were adjusted, as needed, within ranges reported in the literature, during model calibration to obtain the most reasonable agreement between observed and simulated water quality concentrations such as total suspended solids, algal biomass, organic carbon, dissolved oxygen and nutrients. A large body of literature is available from numerous advanced modeling studies developed over the past decade to provide information on reported ranges of parameter values that can be assigned for site-specific modeling projects (see Ji, 2017; Park et al, 1995; Hamrick, 2007; Dynamic Solutions, 2012; Dynamic Solutions, 2016).

Kinetic coefficients and model parameters assigned for the water quality model are assigned as either global or spatially dependent zone parameters for the Lake Harris EFDC model. Nine zones were used to represent the spatial variation in algae kinetics in the Lake Harris model (Figure 3-1).

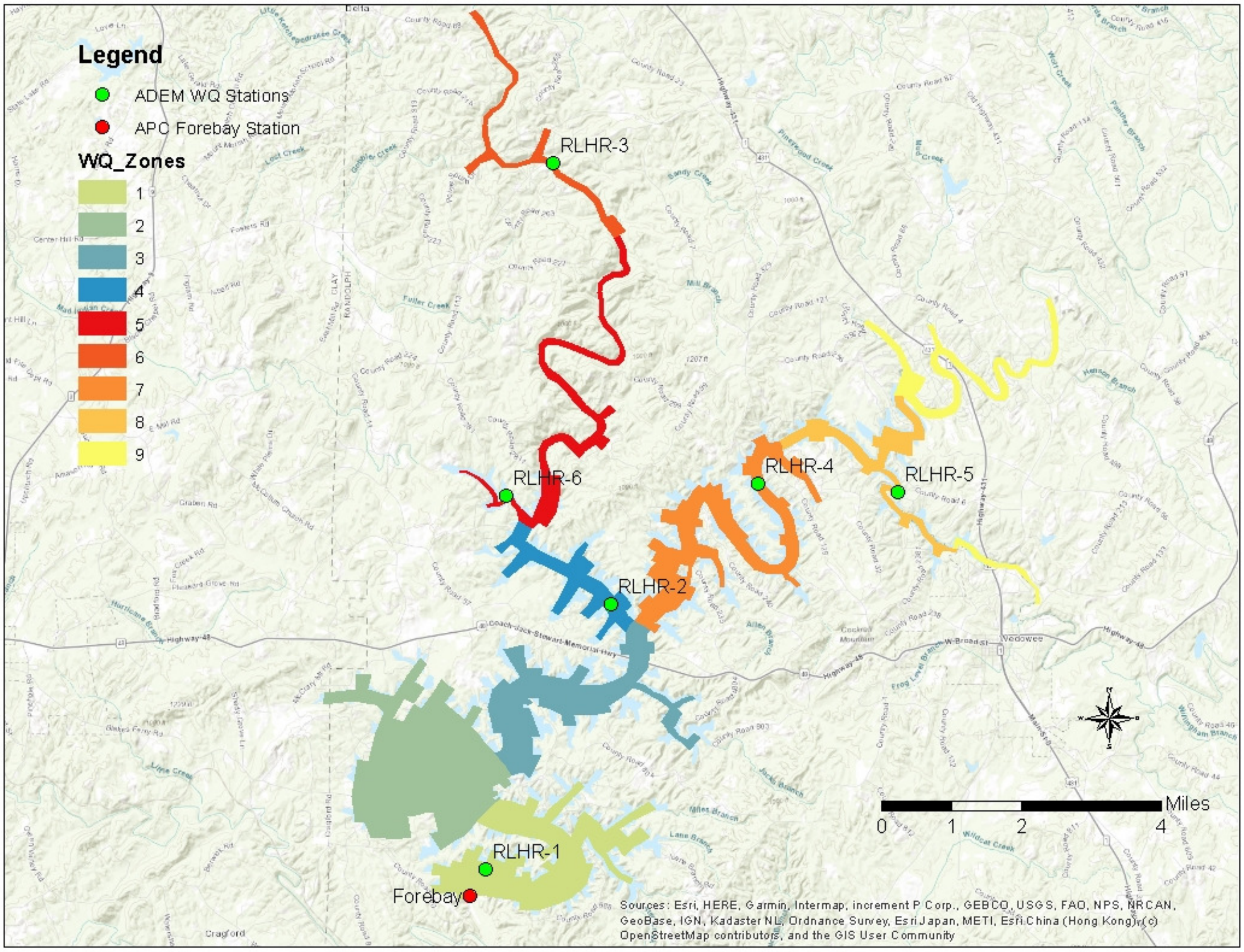

Figure 3-1 Spatial water quality kinetic zones defined for Lake Harris

Atmospheric Deposition

Atmospheric deposition is represented in the EFDC model with separate source terms for dry deposition and wet deposition. Dry deposition is defined by a constant mass flux rate (as g/m^2-day) for a constituent that settles out as dust or is deposited on a dry surface during a period of no precipitation. Wet deposition is defined by a constant concentration (as mg/L) of water quality constituents in rainfall and the time series of precipitation assigned for input to the hydrodynamic model. For the Lake Harris model, wet and dry deposition data (Table 3-3) was assigned as the average of annual data from 2015-2019 for ammonia and nitrate from the National Atmospheric Deposition Program (NADP) for Station GA41 (Georgia Station, Lat 33.18 N; Lon -84.41 W) and the Clean Air Status and Trends Network (CASTNET) Station GAS153 (Georgia Station, Lat 33.18 N; Lon -84.41 W) (Figure 3-2). As data was not available from the CASTNET and NADP sites for phosphate, dry deposition for phosphate was estimated using annual average N/P ratios for atmospheric deposition of N and P reported for 6 monitoring sites in Iowa (Anderson and Downing, 2006) and the ammonia and nitrate data obtained from the NADP and CASTNET data sources.

Table 3-3 Dry and Wet Atmospheric Deposition for Nutrients

	Dry	Wet	Data Source
	g/m^2-day	mg/L	
TPO4	6.00E-06	0.000566	Anderson & Downing (2006), Table VII
NH4	3.80E-05	0.175933	Dry (CASTNET, GAS 153); Wet (NADP, GA 41); average 2015-2019
NO3	7.80E-05	0.08531	Dry (CASTNET, GAS 153); Wet (NADP, GA 41); average 2015-2019

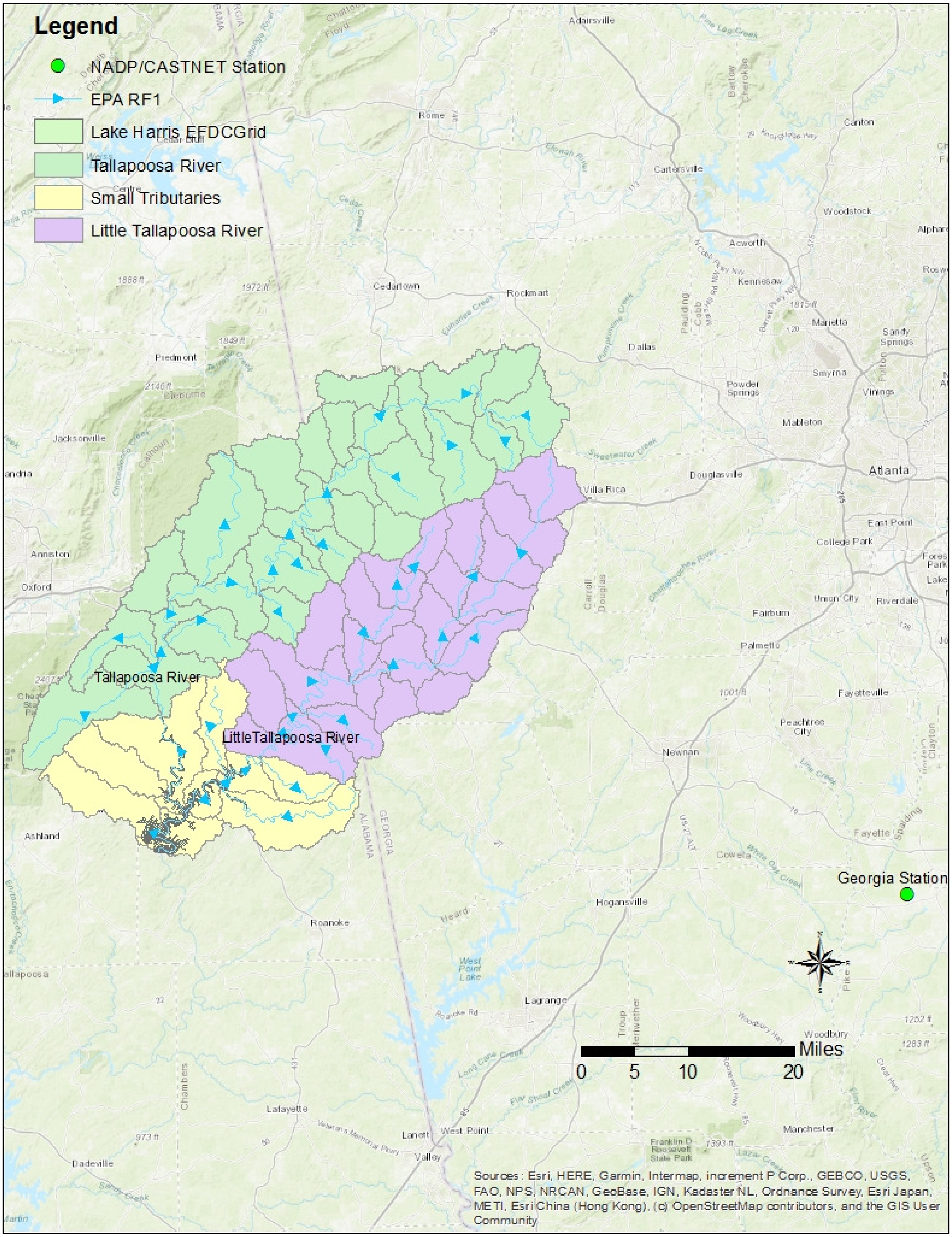

Figure 3-2 Locations of the EPA CASTNET Station and NADP/NTP Station

3.2 Sediment Flux Model

The EFDC water quality model provides three options for defining the sediment-water interface fluxes for nutrients and dissolved oxygen. The options are: (1) externally forced spatially and temporally constant fluxes; (2) externally forced spatially and temporally variable fluxes; and (3) internally coupled fluxes simulated with the sediment diagenesis model. The water quality state variables that are controlled by diffusive exchange across the sediment-water interface include phosphate, ammonia, nitrate, silica, chemical oxygen demand and dissolved oxygen. The first two options require that the sediment fluxes be assigned as spatial/temporal forcing functions based on either observed site-specific data from field surveys or best estimates based on the literature and sediment bed characteristics. The third option is the activation of the full sediment diagenesis model developed by Di Toro (2001).

For the Lake Harris EFDC model, the second option was selected because observed sediment bed chemistry data was not available. The initial sediment oxygen demand (SOD) values and nutrient fluxes (NH4 and PO4) for each spatial zone were based on measured SOD values in Weiss Lake in 2001 by the Environmental Protection Agency (EPA) (Tetra Tech, 2007). Location of the nine water quality zones is shown in Figure 3-1. During the calibration process, the SOD values and nutrient fluxes were adjusted as needed to best match the dissolved oxygen and nutrient observations. The seasonal pattern of SOD was initially based on the observed data reported by Cowan et al. (1996). The final calibrated data set for monthly SOD rates are given in Table 3-4. The highest monthly SOD value of 1.12 g/m^2-day determined by calibration was very close to the observed SOD values in Browns Lake in Mississippi collected by the USACE (Price et al., 1994).

Table 3-4 Monthly SOD Values Calibrated for Lake Harris EFDC Model (g/m^2-day)

Month	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
January	-0.65	-0.65	-0.65	-0.65	-0.65	-0.28	-0.65	-0.65	-0.28
February	-0.85	-0.85	-0.65	-0.65	-0.65	-0.28	-0.65	-0.65	-0.28
March	-0.85	-0.85	-0.65	-0.65	-0.65	-0.28	-0.65	-0.65	-0.28
April	-0.85	-0.85	-0.85	-0.85	-0.85	-0.28	-0.85	-0.85	-0.28
May	-1.00	-1.00	-1.00	-1.00	-1.00	-0.28	-1.00	-1.00	-0.28
June	-1.12	-1.12	-1.12	-1.12	-1.12	-0.28	-1.12	-1.12	-0.28
July	-1.12	-1.12	-1.12	-1.12	-1.12	-0.28	-1.12	-1.12	-0.28
August	-1.00	-1.00	-1.00	-1.00	-1.00	-0.28	-0.85	-0.85	-0.28
September	-0.85	-0.85	-0.85	-0.85	-0.85	-0.28	-0.85	-0.65	-0.28
October	-0.65	-0.65	-0.65	-0.65	-0.65	-0.28	-0.65	-0.65	-0.28
November	-0.65	-0.65	-0.65	-0.65	-0.65	-0.28	-0.65	-0.65	-0.28
December	-0.65	-0.65	-0.65	-0.65	-0.65	-0.28	-0.65	-0.65	-0.28

4. Calibration and Validation Stations

4.1 Stage Calibration and Validation Stations

The observed stage data in Lake Harris is available from APC at the forebay station shown in Figure 2-5.

4.2 Water Quality Calibration and Validation Stations

The Lake Harris EFDC model was calibrated and validated at one (1) APC station at the forebay and six (6) Alabama Department of Environmental Management (ADEM) stations: RLHR-1, RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6. Station identification information for these stations is listed in Table 4-1 and station locations are shown in Figure 4-1.

Table 4-1 Water Quality Calibration and Validation Stations for Lake Harris

Station Code	Location Description	Latitude (N)	Longitude (W)
Forebay	Dam site, most downstream site of the lake	33.25856	-85.6166
RLHR-1	Lower reservoir. Deepest point, main river channel, dam forebay	33.26406	-85.6127
RLHR-2	Mid reservoir. Deepest point, main river channel, immediate upstream of Tallapoosa River/Little Tallapoosa River confluence.	33.31843	-85.5811
RLHR-3	Upper reservoir. Deepest point, main river channel, immediate downstream of Randolph Co. Hwy 82 bridge.	33.41002	-85.5939
RLHR-4	Deepest point, Little Tallapoosa River channel, immediate downstream of Randolph Co. Hwy 29.	33.34314	-85.5444
RLHR-5	Deepest point, main creek channel, Wedowee Creek embayment, approx. 0.5 miles upstream of lake confluence.	33.34083	-85.5097
RLHR-6	Deepest point, main creek channel, Mad Indian Creek embayment, approx. 0.5 miles upstream of lake confluence.	33.34139	-85.6064

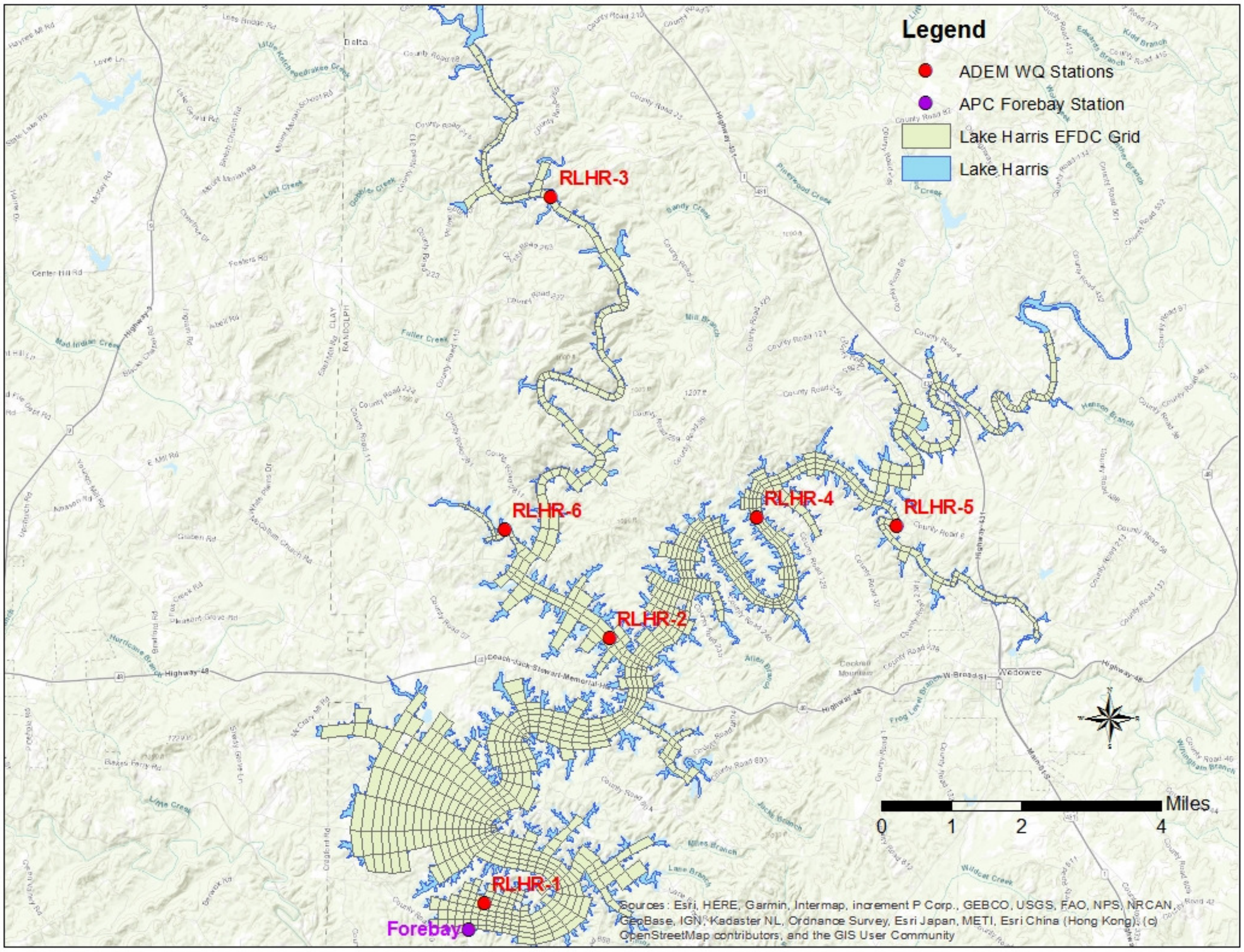

Figure 4-1 Locations of the APC and ADEM Water Quality Stations in Lake Harris

5. Model Performance Statistics

Observed station data was processed to define time series for each station location for the surface layer and bottom layer of the water column. Observed data was assigned to a vertical layer based on surface water elevation, station bottom elevation and the total depth of the water column estimated for the sampling date and time. Station locations were overlaid on the model grid to define a set of discrete grid cells that correspond to each monitoring site for extraction of model results.

The model-data model performance statistic selected for calibration of the hydrodynamic and water quality model was the Root Mean Square Error (RMSE). The units of the RMSE are defined by the units of each state variable of the model.

The equation for the RMSE is,

$$\text{RMSE} = \sqrt{\frac{1}{N}\Sigma(O-P)^2} \qquad \text{Equation (1)}$$

Where

N is the number of paired records of observed measurements and EFDC model results,

O is the observed water quality measurement,

P is the predicted EFDC model result.

6. Hydrodynamic Model Calibration and Validation

6.1 Lake Stage Calibration

The hydrodynamic model was calibrated for the 2-year time period from 1 January 2018 to 31 December 2019. Figure 6-1 shows the comparison of observed lake water surface elevation at the APC forebay station and simulated water surface elevation extracted from a grid cell at that location. Water level data for the lake were based on the NAVD88 vertical datum with units of meters.

Simulated lake elevation was in excellent agreement with the measured lake elevation for the calibration period from January 2018 through December 2019. The summary of model performance statistics between observed and simulated water surface elevation for the calibration period is given in Table 6-1. The simulated average stage was 240.613 m, which was very close to the averaged observed stage of 240.612 m. The calculated RMS error was 0.016 m (Table 6-1).

Table 6-1 Model Performance Statistics for Hydrodynamic Model for Lake Stage (NAVD88, m)

Station ID	Parameter	Simulation Periods	Starting	Ending	# Pairs	RMS (m)	Data Average (m)	Model Average (m)
Forebay	Stage (m)	Calibration	1/1/2018 0:00	12/31/2019 0:00	17,473	0.016	240.612	240.613
Forebay	Stage (m)	Validation	1/1/2015 0:00	12/31/2017 0:00	26,297	0.019	240.603	240.606

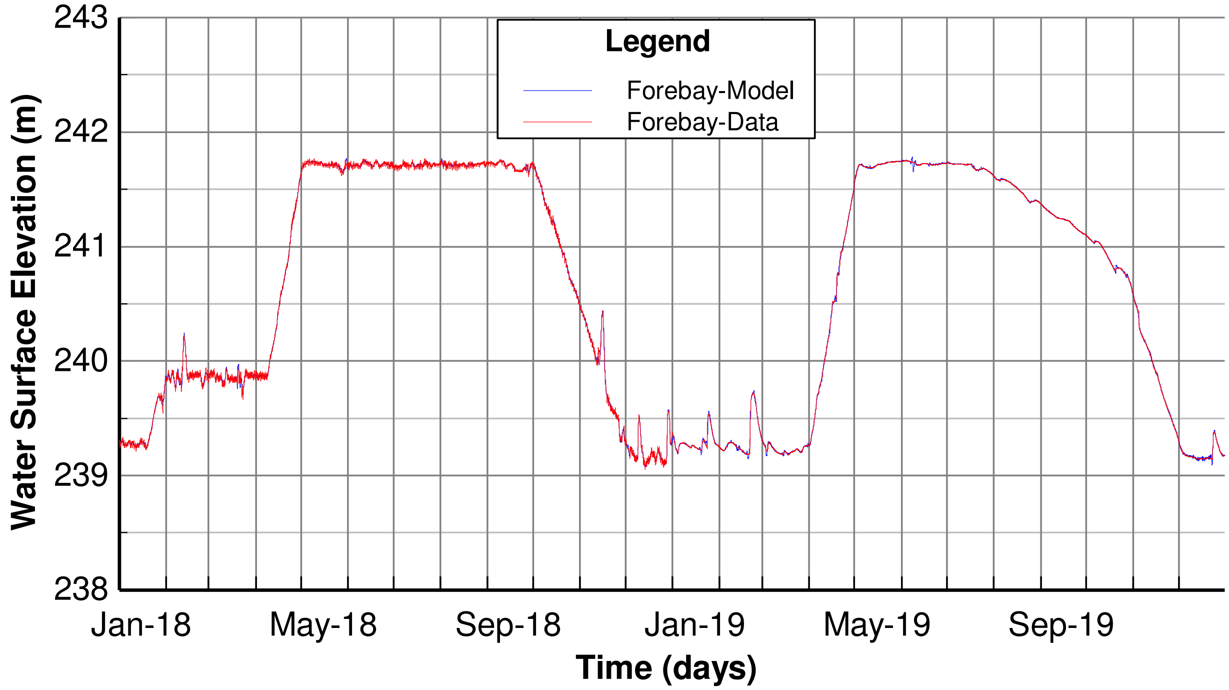

Figure 6-1 Calibration Plot of Water Surface Elevation at APC Forebay Station

6.2 Lake Stage Validation

The Lake Harris EFDC model was validated for the 3-year time period from 1 January 2015 to 31 December 2017. The validation plot for surface water elevation at the APC forebay station (NAVD88) is shown in Figure 6-2. The summary of model performance statistics between observed and simulated water surface elevation for the validation period is given in Table 6-1. Simulated lake elevation was again in excellent agreement with the measured lake elevation for the entire validation period. The simulated average stage was 240.606 m, which, again, was very close to the averaged observed stage of 240.603 m. The calculated RMS error was 0.019 m (Table 6-1).

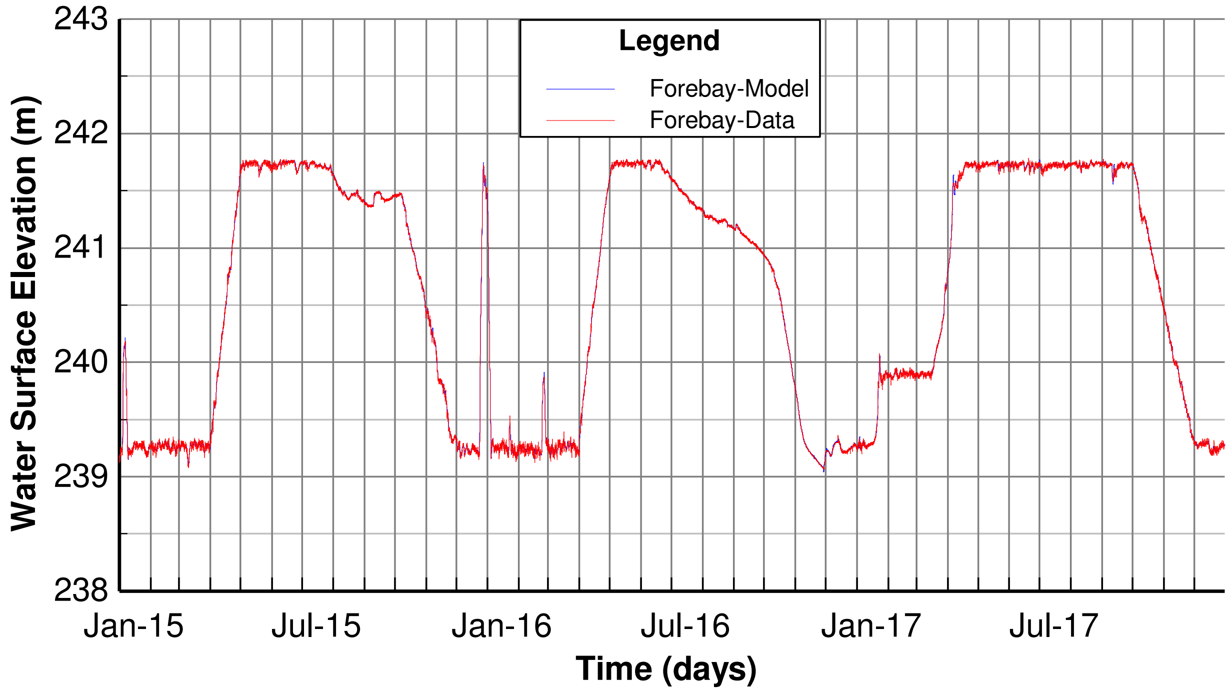

Figure 6-2 Validation Plot of Water Surface Elevation at APC Forebay Station

7. Water Quality Model Calibration and Validation

Prior to model calibration and validation, a one-year model spin-up run was conducted to eliminate the impact of initial water quality conditions on model results. Calibration of the lake model is demonstrated with model-data comparisons for water temperature, total suspended solids, secchi depth, dissolved oxygen, nutrients, and algae biomass as station time series. Vertical profiles are presented for water temperature and dissolved oxygen.

Observed data collected near the surface was compared to lake model results for the EFDC surface layer and data collected near the bottom was compared to model results for the EFDC bottom layer. Observed data at the bottom layer was available only for water temperature and dissolved oxygen (DO). Station results are presented in this section to show model calibration and validation for the selected water quality stations in Lake Harris as shown in Figure 4-1.

During the calibration and validation periods, the availability of observed data sets were very limited. In many cases the sample size of the observed data set for either the calibration period or validation period was less than 10 records. Hence, summary statistics for model performance were computed for the entire calibraton and validation periods. Model-data comparison plots are, however, shown separately for the calibration and validation periods.

7.1 Water Temperature Calibration and Validation

Procedures used to calibrate water temperature included: (1) check the boundary conditions assigned for water temperature; (2) check the meteorological data to make sure that the solar radiation data are in a reasonable range; and (3) adjust the key parameters within reasonable ranges to best match the observed water temperature data.

Modeled water temperature results are presented for comparison to the observed data for the surface layer and bottom layer. Water temperature calibration plots at the APC forebay station are shown in Figure 7-1 and Figure 7-2 and water temperature validation plots at the APC forebay station are shown in Figure 7-3 and Figure 7-4. The water temperature surface and bottom layer calibration and validation plots at the ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are presented in Appendix A. Summary statistics for model performance for water temperature are given in Table 7-1.

As can be seen in the model-data plots, the model results for the surface and bottom layer are in very good agreement with measured water temperature for both the calibration and validation periods. Modeled water temperature closely followed the seasonal trends of the observed data in both the surface and bottom layers. The calculated RMS errors ranged from 0.71 ºC in the bottom layer for station RLHR-4 to 1.98 ºC in the bottom layer for station RLHR-3, as shown in Table 7-1.

Table 7-1 Hydrodynamic Model Performance Statistics for Time Series of Water Temperature (℃)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
Forebay	Surface	5/25/2016 13:59	10/2/2019 13:15	37	1.35	25.00	24.53
Forebay	Bottom	5/25/2016 13:59	10/2/2019 13:15	37	0.96	10.18	9.44
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	1.02	26.20	26.25
RLHR-2	Bottom	4/29/2015 7:47	10/24/2018 9:51	11	0.84	9.26	9.05
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	16	1.23	24.72	25.22
RLHR-3	Bottom	4/29/2015 8:25	10/24/2018 10:42	11	1.98	23.59	22.05
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	1.03	26.40	26.67
RLHR-4	Bottom	4/29/2015 9:35	10/24/2018 11:26	13	0.71	12.68	13.00
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	1.05	26.52	27.02
RLHR-5	Bottom	4/29/2015 9:56	10/24/2018 11:46	9	1.74	17.23	18.64
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	1.03	26.16	26.26
RLHR-6	Bottom	4/29/2015 9:05	10/24/2018 10:15	12	1.61	17.45	16.75

Vertical profiles comparisons of water temperature at the APC forebay station are shown in Figure 7-5 through Figure 7-9 while comparisons of the water temperature vertical profiles at the ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix B. Vertical profiles show the model results extracted as “snapshots” for a time interval of the simulation that matches the observed date and time records for the hydrographic survey profile. As can be seen in the model-data vertical profile plots, the simulated water temperature profiles are in excellent agreement with the observed temperature measurements in most cases. Summary statistics for model performance of the set of water temperature vertical profiles are given in Table 7-2. Calculated RMS errors ranged from 0.95 ºC at station RLHR-4 to 1.17 ºC at APC forebay station, as shown in Table 7-2.

Table 7-2 Hydrodynamic Model Performance Statistics for Vertical Profiles of Water Temperature (℃)

Station ID	Starting	Ending	# Pairs	RMS	Data Average	Model Average
Forebay	5/25/2016	10/2/2019	518	1.17	17.74	17.73
RLHR-2	4/29/2015	10/24/2018	413	1.03	17.54	17.49
RLHR-3	4/29/2015	10/24/2018	161	1.08	24.06	23.73
RLHR-4	4/29/2015	10/24/2018	298	0.95	20.68	20.82
RLHR-5	4/29/2015	10/24/2018	207	1.10	23.16	23.64
RLHR-6	4/29/2015	10/24/2018	220	0.96	22.79	22.62

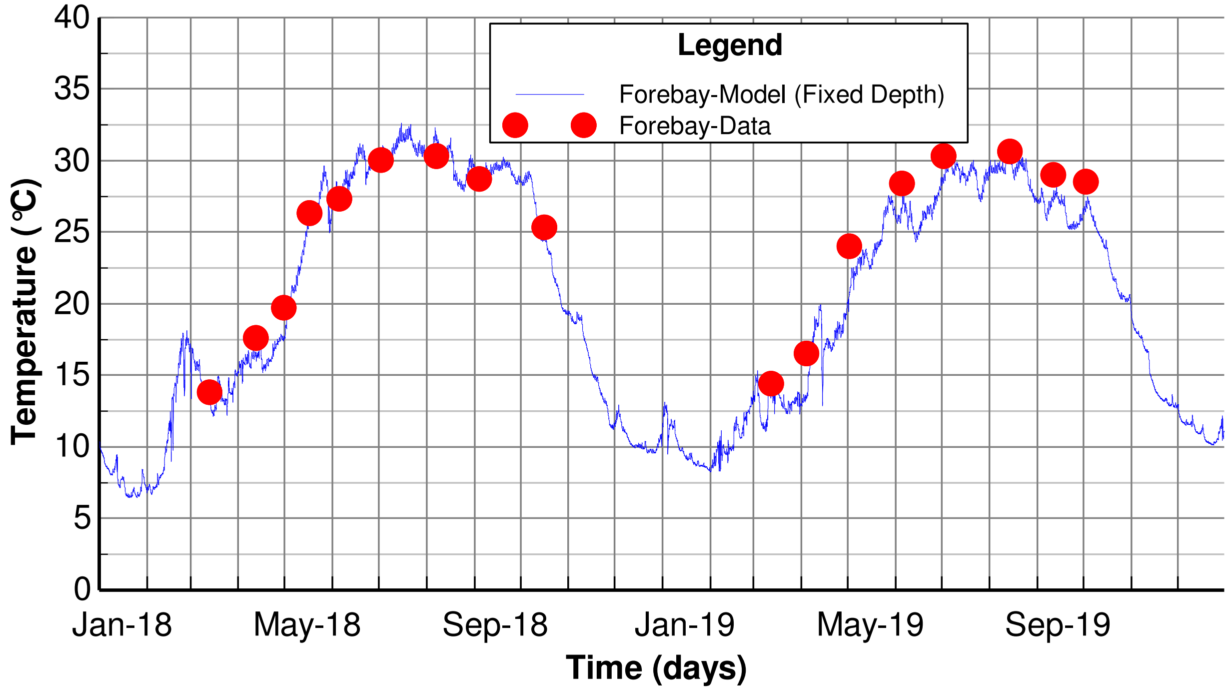

Figure 7-1 Calibration Plot of Surface Layer Water Temperature at APC Forebay Station

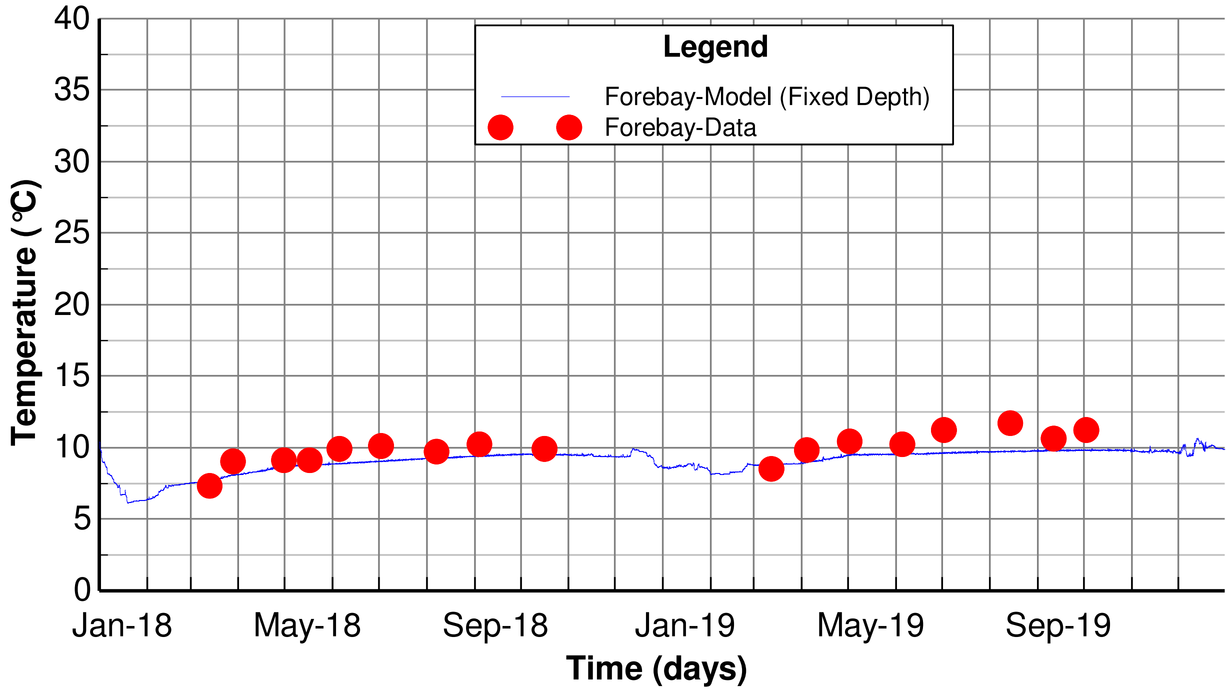

Figure 7-2 Calibration Plot of Bottom Layer Water Temperature at APC Forebay Station

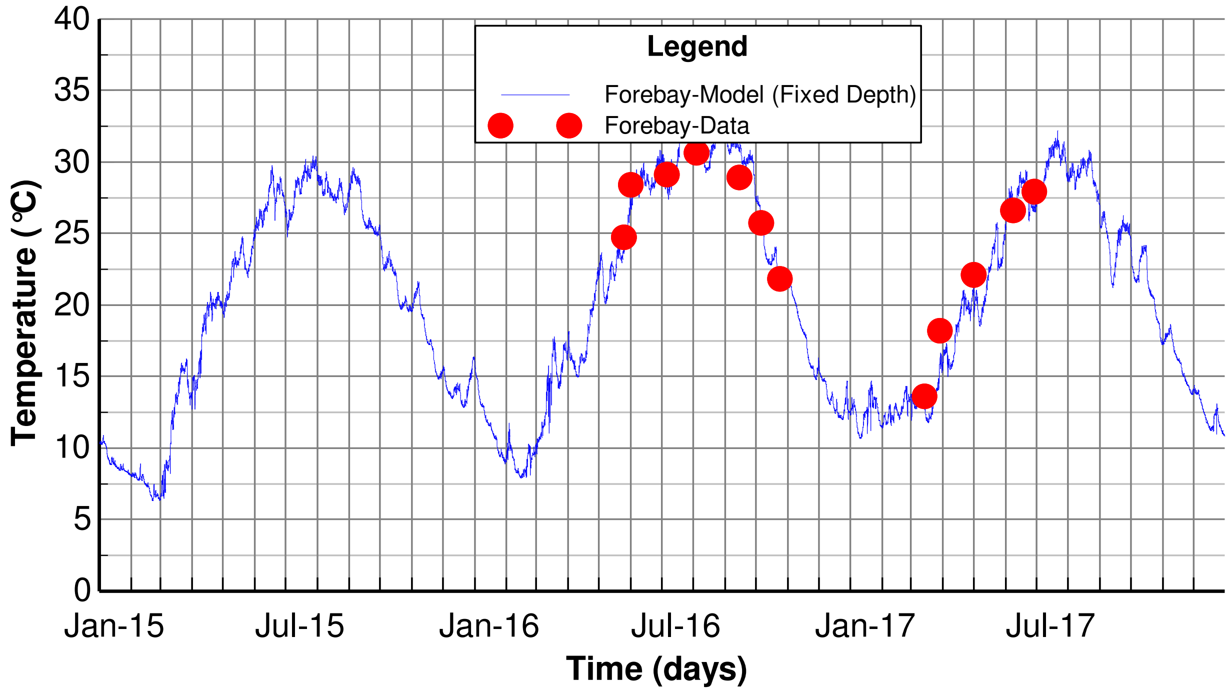

Figure 7-3 Validation Plot of Surface Layer Water Temperature at APC Forebay Station

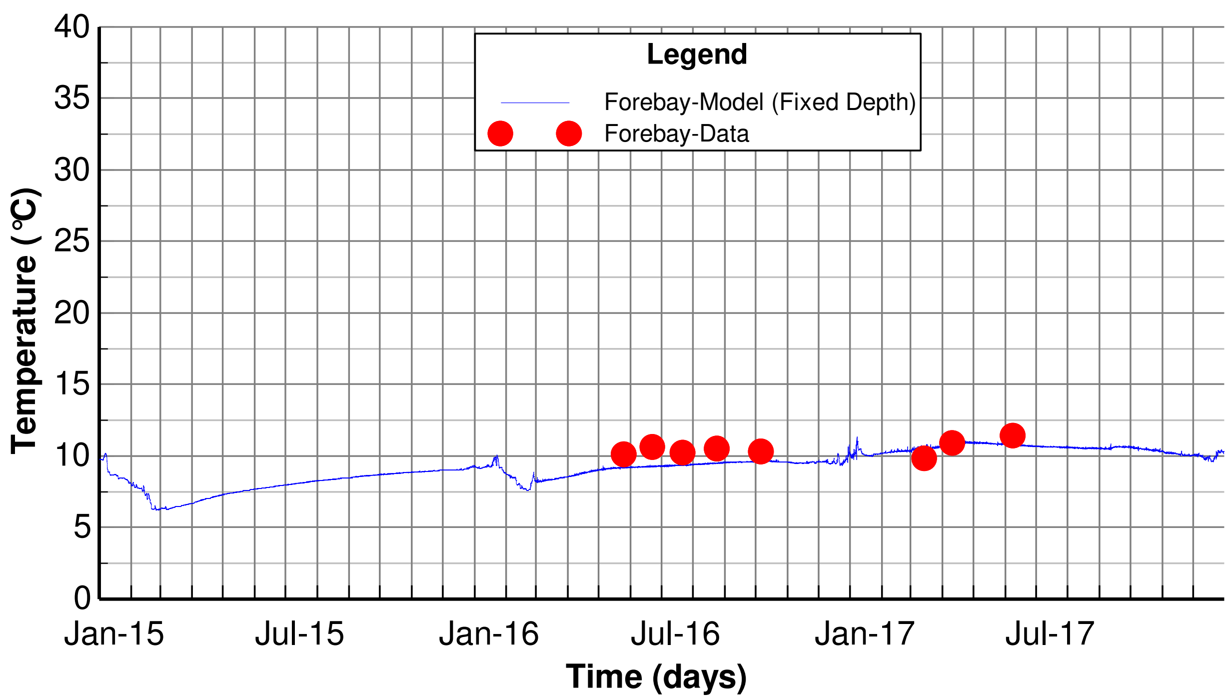

Figure 7-4 Validation Plot of Bottom Layer Water Temperature at APC Forebay Station

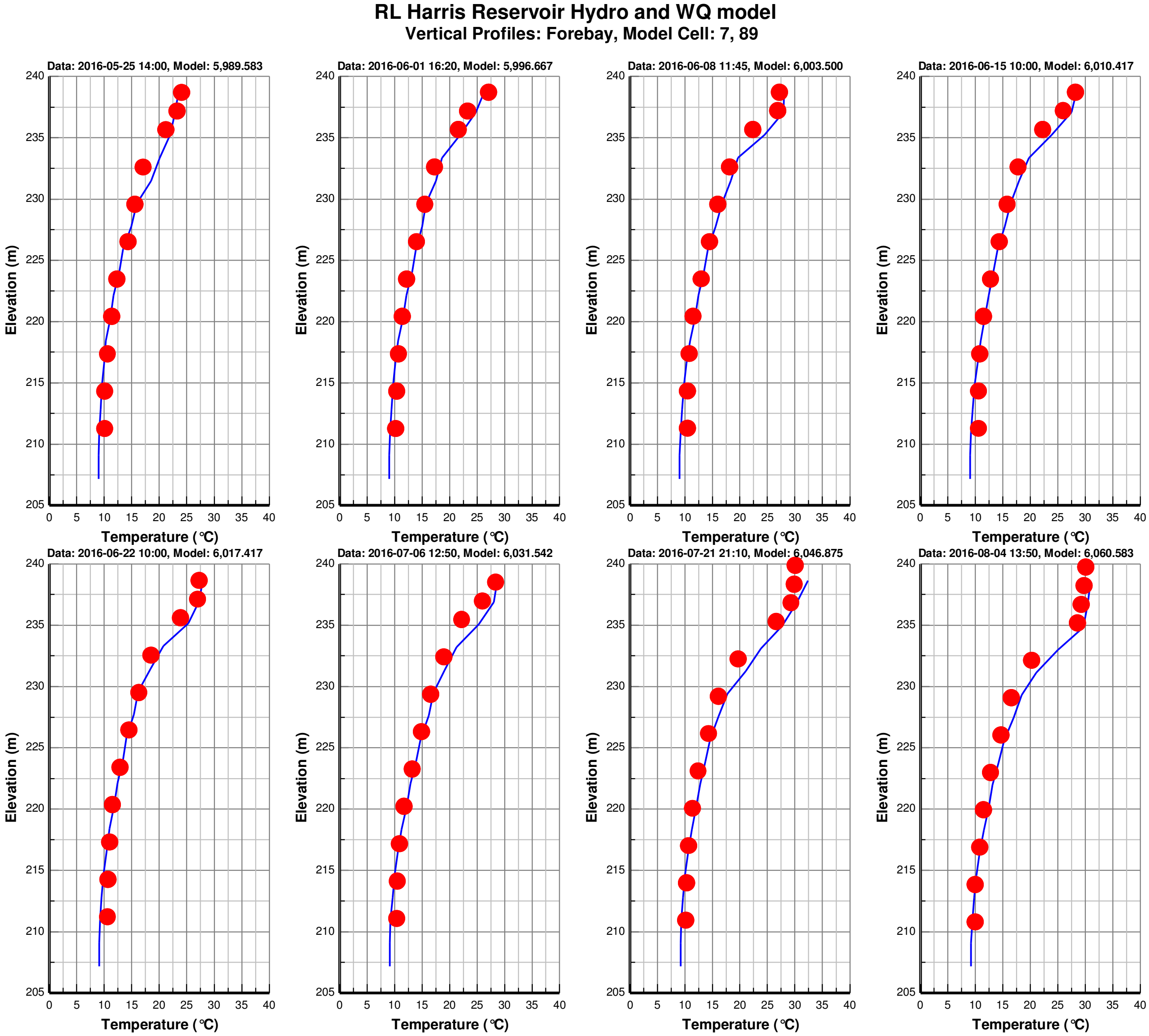

Figure 7-5 Water Temperature Vertical Profile Comparison Plot at APC Forebay Station (25 May 2016 – 4 August 2016)

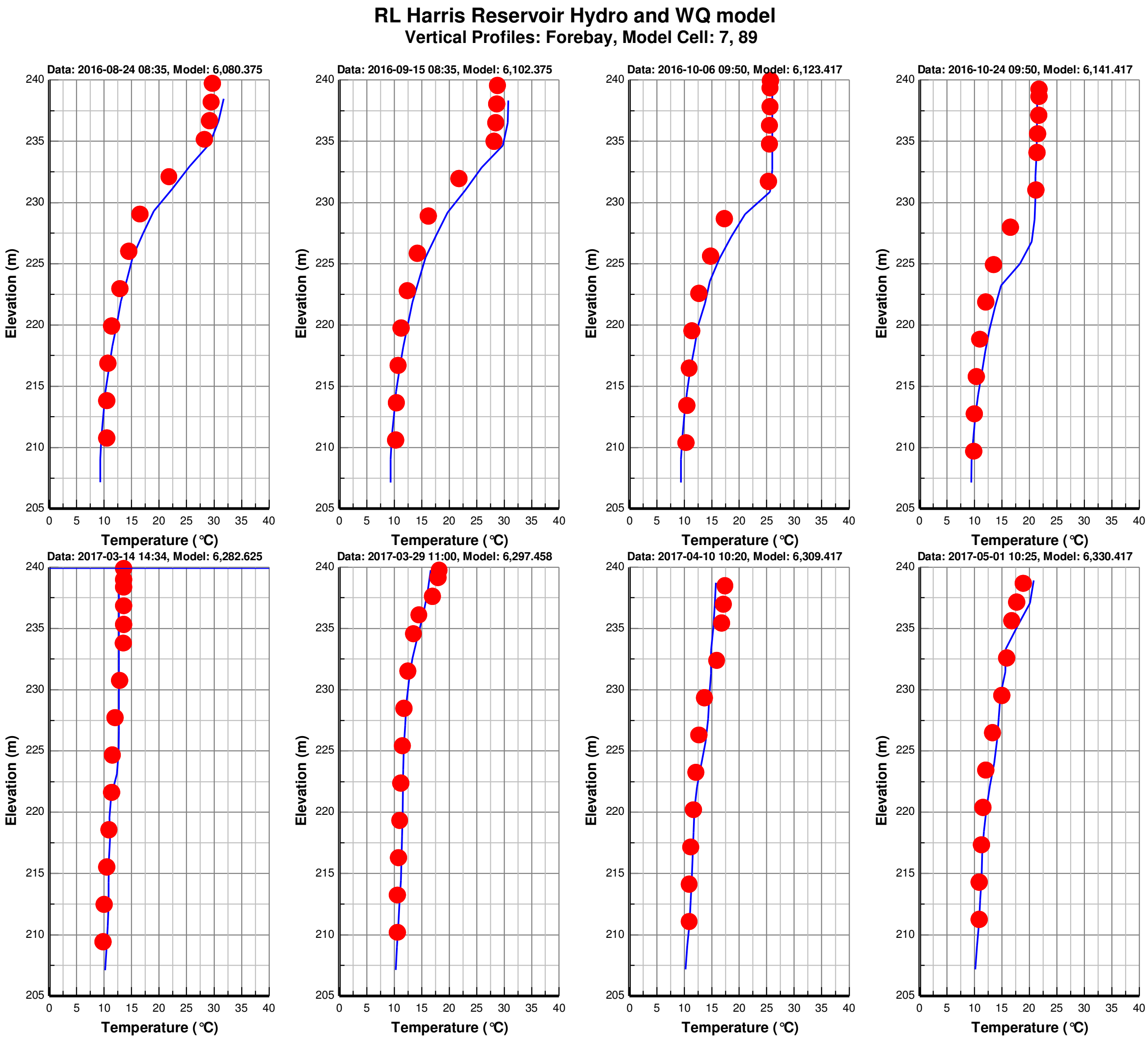

Figure 7-6 Water Temperature Vertical Profile Comparison Plot at APC Forebay Station (24 August 2016 – 1 May 2017)

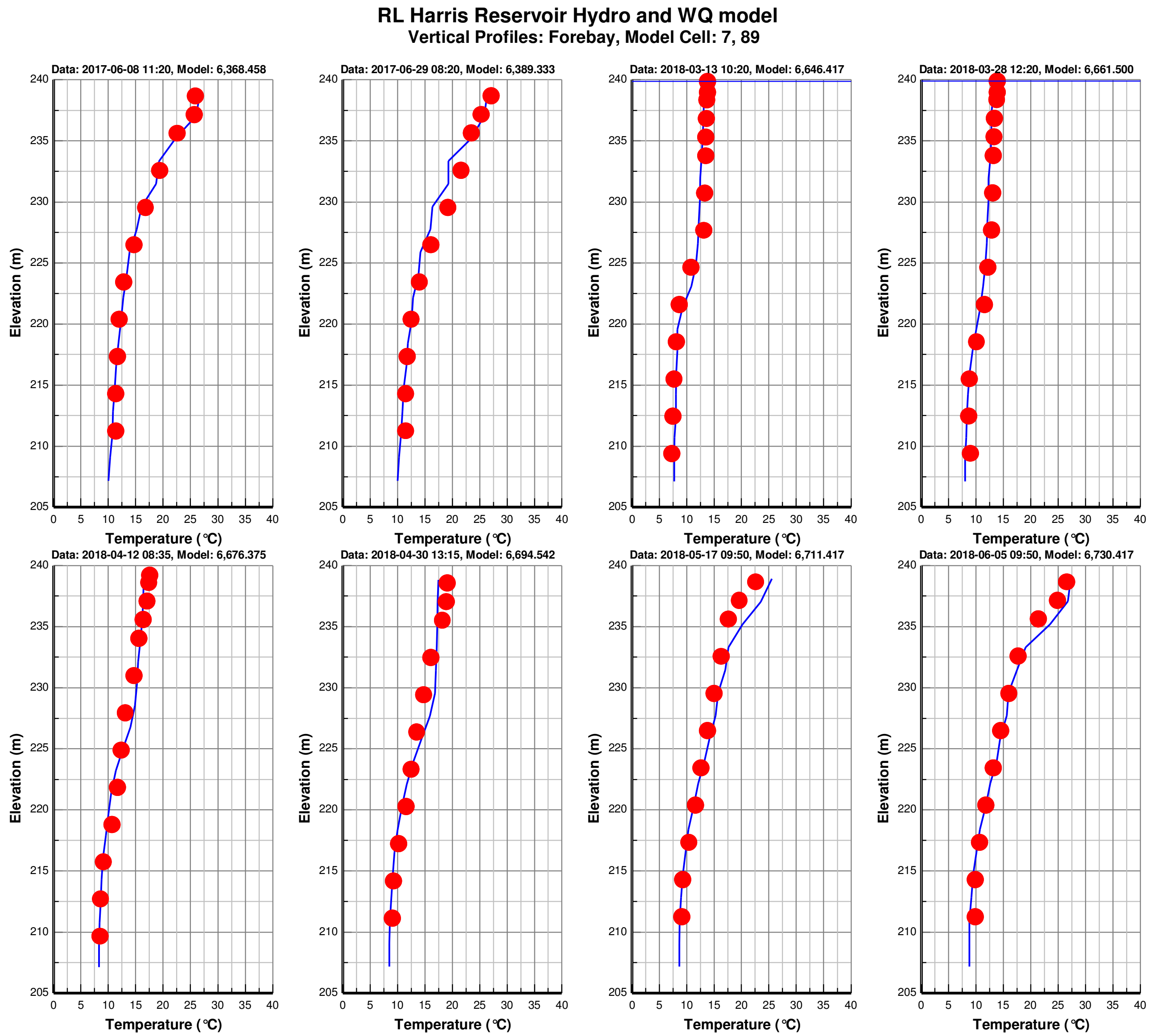

Figure 7-7 Water Temperature Vertical Profile Comparison Plot at APC Forebay Station (8 June 2017 – 5 June 2018)

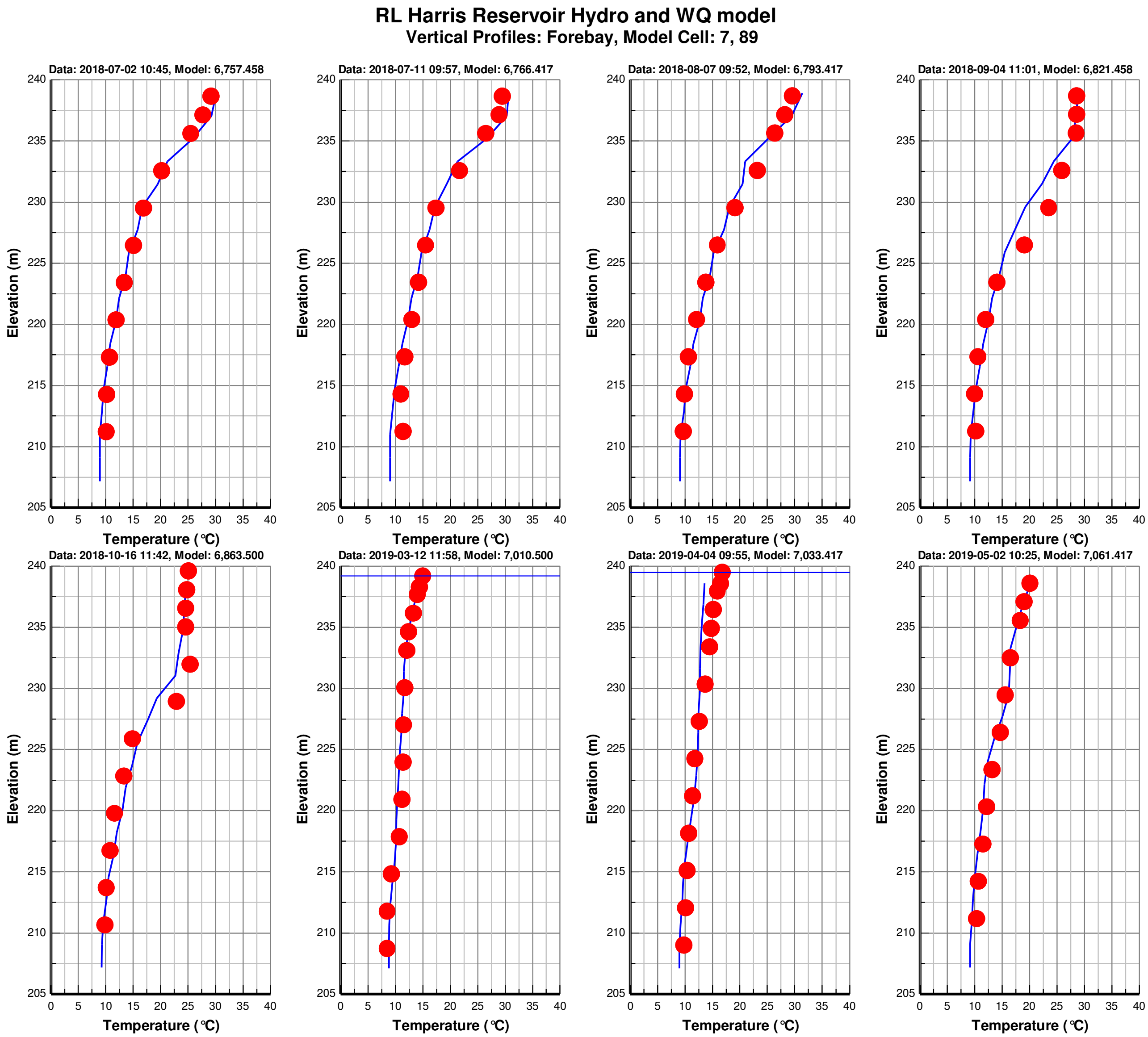

Figure 7-8 Water Temperature Vertical Profile Comparison Plot at APC Forebay Station (2 July 2018 – 2 May 2019)

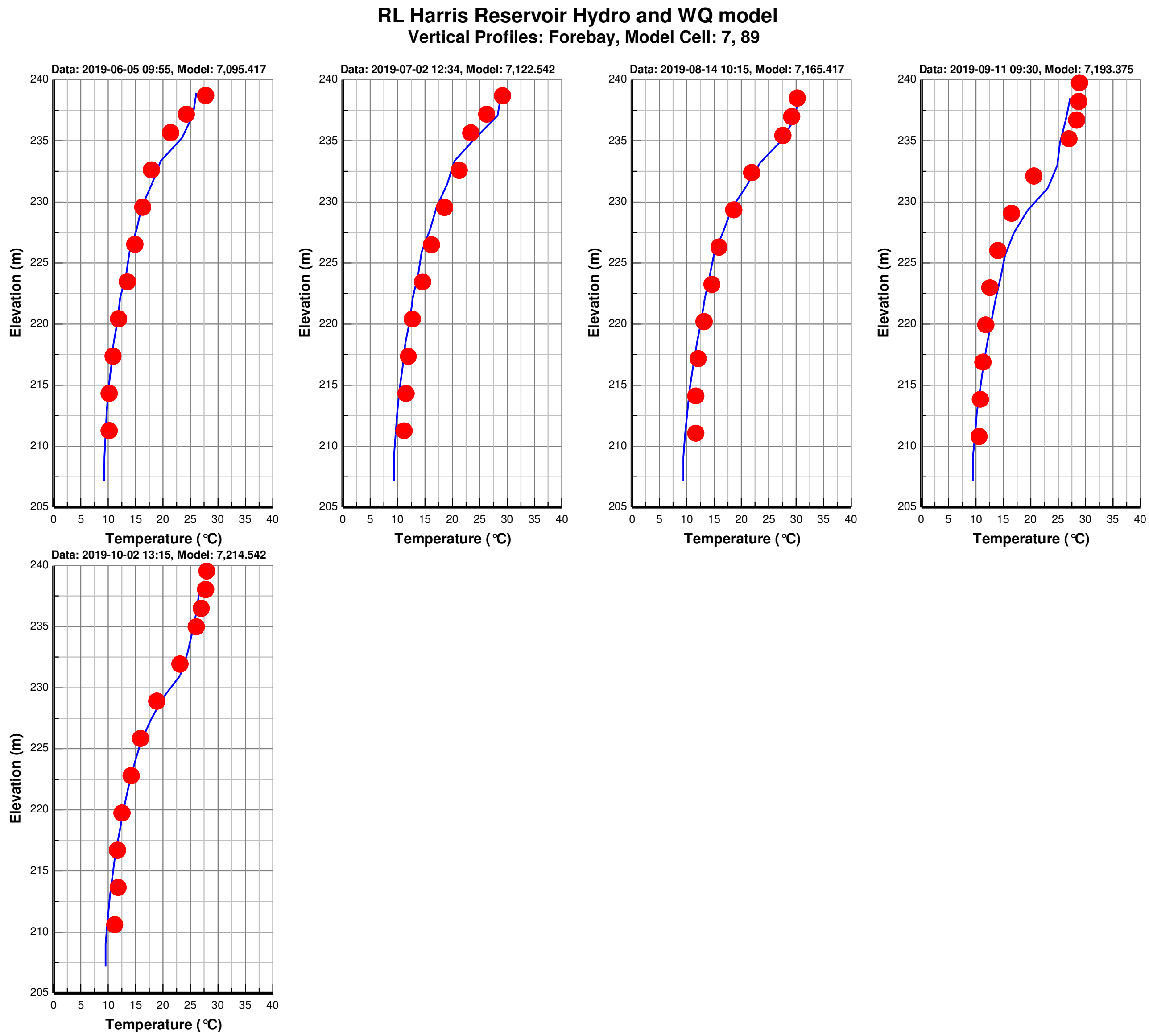

Figure 7-9 Water Temperature Vertical Profile Comparison Plot at APC Forebay Station (5 June 2019 – 2 October 2019)

7.2 Total Suspended Solids Calibration and Validation

Procedures used to calibrate total suspended solids included: (1) check the TSS boundary conditions; and (2) adjust the key parameters within reasonable ranges to best match the observed data.

As observed TSS data was available only for the surface layer, modeled TSS results were presented for comparison to the observed data only for the surface layer. Total suspended solids calibration and validation plots at ADEM Station RLHR-1 are given in Figure 7-10 and Figure 7-11, respectively. Total suspended solids calibration and validation plots at ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix A. Summary statistics for model performance of total suspended solids are given in Table 7-3.

As can be seen in these model-data plots, the model results for the surface layer are in reasonable agreement with observed TSS. The calculated RMS errors for model performance ranged from 1.91 mg/L at station RLHR-1 to 7.01 mg/L at station RLHR-6. In most of the cases, the Lake Harris EFDC model results overestimated the observed data with the exception of station RLHR-1 (Table 7-3).

The purpose of the total suspended solids calibration was to simulate a reasonable amount of suspended solids in the water column to ensure that light extinction due to inorganic suspended solids provides a good representation of the effects of light attenuation on both water temperature and water clarity. As suspended solids were reasonably well simulated and the model performance of water temperature was very good, the sediment transport model results based on TSS calibration were deemed to be acceptable.

Table 7-3 Model Performance Statistics for Total Suspended Solids (mg/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	1.91	1.86	0.65
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	6.27	1.96	3.59
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	9.87	4.93	10.17
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	6.04	2.61	4.17
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	6.89	2.75	4.13
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	7.01	2.50	4.89

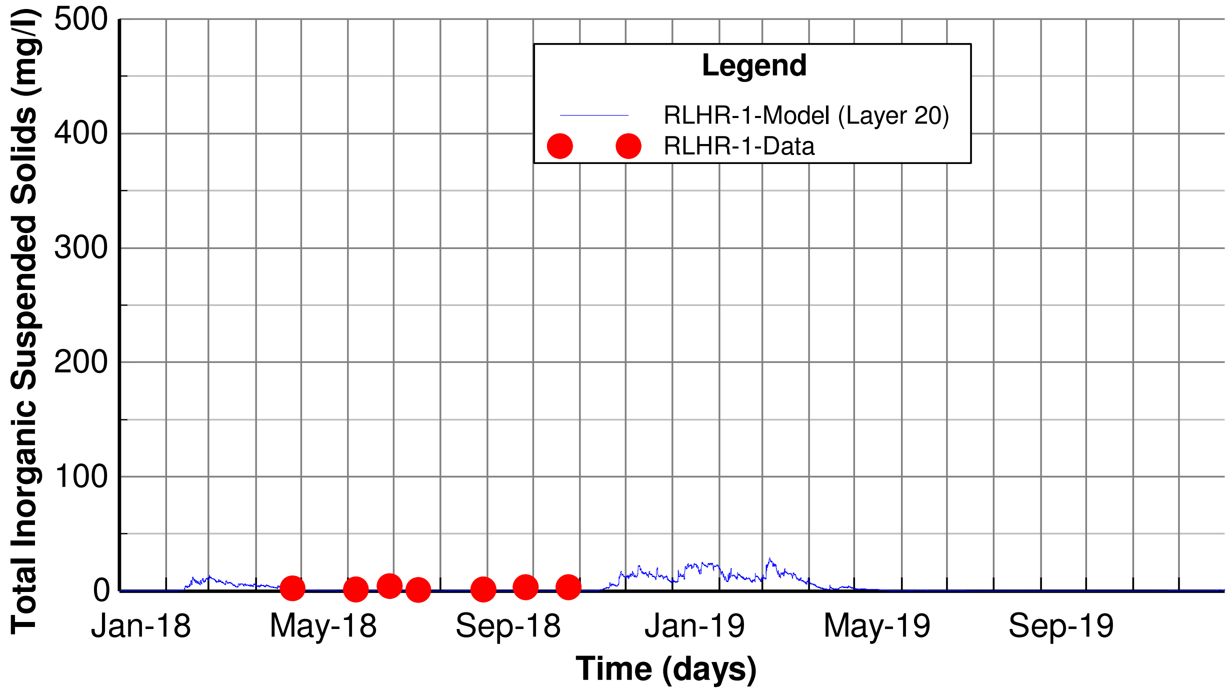

Figure 7-10 Calibration Plot of Surface Layer Total Suspended Solids at Station RLHR-1

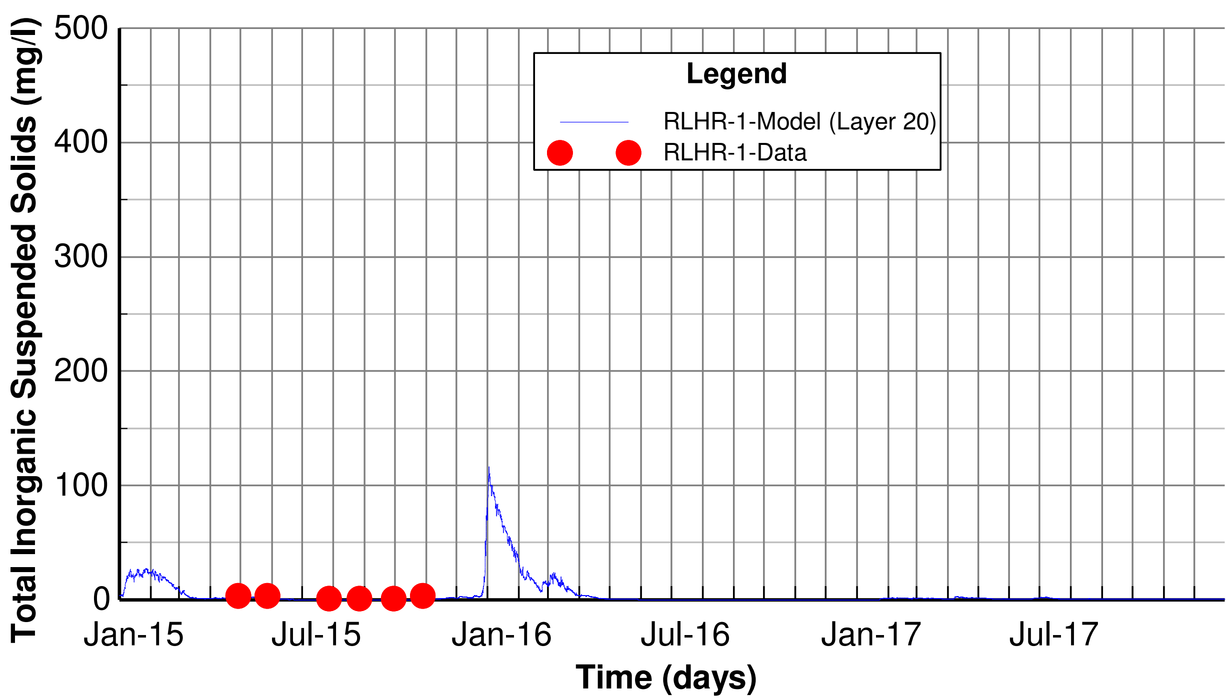

Figure 7-11 Validation Plot of Surface Layer Total Suspended Solids at Station RLHR-1

7.3 Secchi Depth Calibration and Validation

Secchi depth provides simple yet very meaningful measurements to characterize water clarity in a waterbody such as Lake Harris. In the EFDC model, Secchi depth is a derived output variable that represents the overall effect of light extinction by algal biomass (as chlorophyll a) and the concentrations of inorganic suspended solids, POC, DOC, and background effects of light attenuation not related to these state variables. In the EFDC hydrodynamic and water quality model, water quality-dependent light extinction in the water column also strongly impacts the simulation of water temperature in the hydrodynamic model.

Modeled Secchi depth results compared to the observed data sets collected during the calibration and validation periods at ADEM station RLHR-1 are shown in Figure 7-12 and Figure 7-13. Secchi depth calibration and validation plots at ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix A. Summary statistics for model performance of Secchi depth are given in Table 7-4.

As can be seen in the model-observed data plots, the modeled Secchi depth results fell within the range of the measured Secchi depth records. The calculated RMS errors ranged from 0.30 m at ADEM station RLHR-3 to 0.67 m at ADEM station RLHR-1. In addition, as suspended solids and Secchi depth were both reasonably well simulated and the model performance of water temperature was very good, it was deemed that the Secchi depth simulation provided an acceptable representation of light attenuation in Lake Harris.

Table 7-4 Model Performance Statistics for Secchi Depth (meter)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.67	2.69	2.53
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.55	2.19	1.81
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.30	1.34	1.16
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.50	1.99	1.72
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.47	1.82	1.50
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.39	1.96	1.70

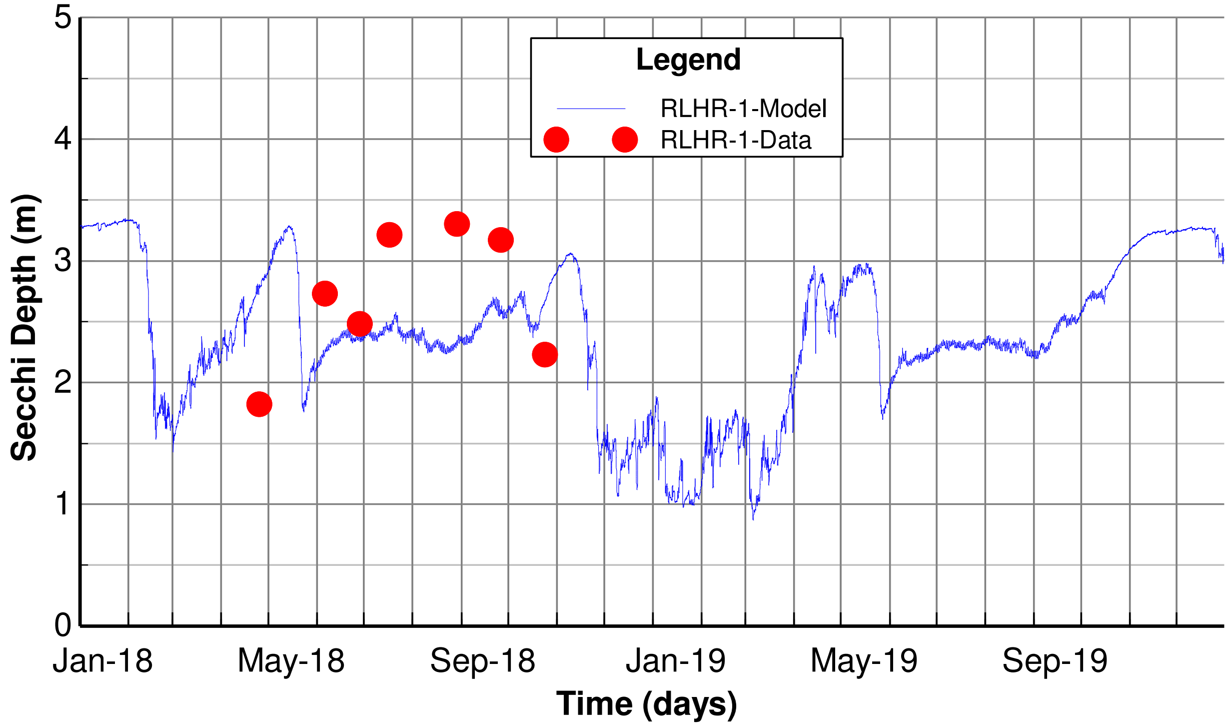

Figure 7-12 Calibration Plot of Modeled and Observed Secchi Depth at Station RLHR-1

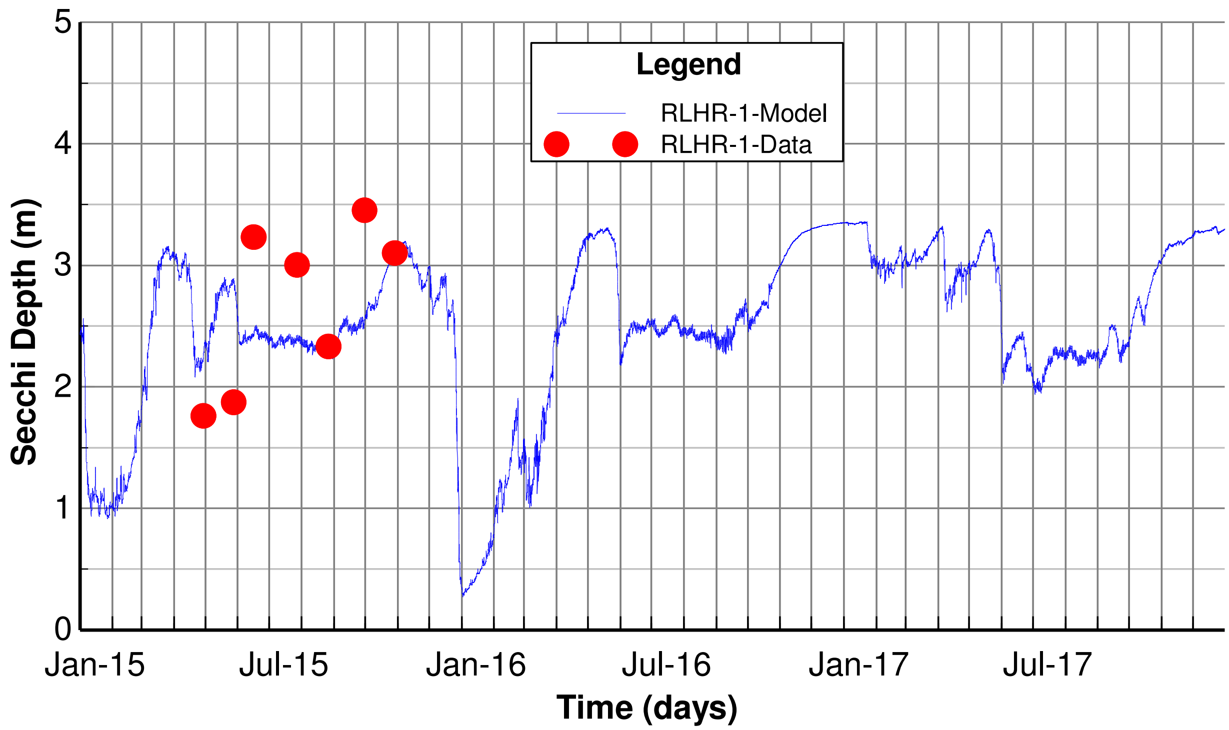

Figure 7-13 Validation Plot of Modeled and Observed Secchi Depth at Station RLHR-1

7.4 Dissolved Oxygen Calibration and Validation

Procedures used to calibrate dissolved oxygen included: (1) check the dissolved oxygen boundary conditions asigned for the EFDC model; and (2) adjust the key parameters within reasonable ranges to obtain the best match with the observed data.

Modeled oxygen results are presented for comparison to the observed data for the surface layer and bottom layer. Dissolved oxygen time series calibration plots at the APC forebay station are shown in Figure 7-14 and Figure 7-15, respectively. Dissolved oxygen time series validation plots at the APC forebay station are shown in Figure 7-16 and Figure 7-17, respectively. The dissolved oxygen surface and bottom layer calibration and validation plots at ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix A. In general, the model results for both the surface and bottom layers followed the seasonal patterns of the measured dissolved oxygen data reasonably well as can be seen in the model-data plots.

The model results for calibration and validation of the bottom layer, for the most part, demonstrate good agreement with the observed seasonal depletion of dissolved oxygen to summer hypoxic and anoxic levels in response to water column stratification. The exception to the good agreeement, however, are the model validation results for spring-summer months of 2017 where the model results, although decreasing because of stratification,.are about 2-3 mg/L higher than the observed oxygen measurements (see Figure 7-17). The over-estimation of bottom DO concentrations in 2017 might be caused by the APC operating procedures that were implemented to deal with the the drought conditions of 2016 (annual rainfall of 37.21 inch).

Following the drought of 2016, Lake Harris was filled 2 ft higher than the normal operation schedule starting in mid-January 2017 which led to reduced dam release discharges in March. Full summer pool elevation (793 ft NGVD29) was then reached almost a month early in 2017. This could have ended up storing more oxygen-consuming organic matter that would have been discharged downstream out of the lake during a normal spring. In addition, the Lake EFDC sediment flux model used the same assigned monthly SOD values for each year of the calibration and validation periods, as discussed in Section 3.2. This approach was considered to be reasonable because observed sediment bed chemistry data was not available for application of the fully coupled water column-bed sediment diagenesis module. Confirmation of the this empirical approach was demonstrated with the EFDC model results for bottom DO concentrations that compared very well with observations for the 2018-2019 calibration period and the 2015-2016 validation period, as shown in Figure 7-15 and Figure 7-17.

Summary statistics for model performance for dissolved oxygen are given in Table 7-5. The calculated RMS errors ranged from 0.39 mg/L at the bottom layer of ADEM station RLHR-4 to 2.65 mg/L at the bottom layer of ADEM station RLHR-5, as shown in Table 7-5. If the 2017 observed data was excluded from the model performance analysis, the calculated RMS error for bottom DO at APC forebay station would have decreased considerably from 1.66 to 1.04 mg/L.

Table 7-5 Model Performance Statistics for Time Series of Dissolved Oxygen (mg/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
Forebay	Surface	5/25/2016 13:59	10/2/2019 13:15	37	0.82	8.83	8.46
Forebay	Bottom	5/25/2016 13:59	10/2/2019 13:15	37	1.66	2.00	2.63
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	1.04	8.12	7.94
RLHR-2	Bottom	4/29/2015 7:47	10/24/2018 9:51	11	0.42	0.63	0.48
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	16	1.00	8.19	8.67
RLHR-3	Bottom	4/29/2015 8:25	10/24/2018 10:42	11	1.64	4.48	4.65
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	1.16	8.55	8.08
RLHR-4	Bottom	4/29/2015 9:35	10/24/2018 11:26	13	0.39	0.28	0.00
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	1.24	8.71	8.08
RLHR-5	Bottom	4/29/2015 9:56	10/24/2018 11:46	9	2.65	1.27	1.94
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.82	8.45	8.09
RLHR-6	Bottom	4/29/2015 9:05	10/24/2018 10:15	12	1.79	1.57	1.88

The model-data comparisons for dissolved oxygen vertical profiles at the APC forebay station are given in Figure 7-18 through Figure 7-22. The comparisons for vertical profiles of dissolved oxygen at ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix B. Vertical profiles show the model results extracted as “snapshots” for a time interval of the simulation that matches the observed date and time records for the hydrographic survey profile. As can be seen in these model-data plots of vertical profiles, the model results were reasonably consistent with the observed dissolved oxygen in most cases, especially for the well-mixed winter conditions. Similar to the time series plot comparison of bottom DO, the vertical profile comparisdn of DO in 2017 was not as good as the other years. Summary statistics for model performance of the vertical profiles for dissolved oxygen are given in Table 7-6. The calculated RMS errors ranged from 1.45 mg/L at ADEM station RLHR-2 to 2.14 mg/L at ADEM station RLHR-5, as shown in Table 7-6.

Table 7-6 Model Performance Statistics for Vertical Profiles of Dissolved Oxygen (mg/L)

Station ID	Starting	Ending	# Pairs	RMS	Data Average	Model Average
Forebay	5/25/2016	10/2/2019	518	2.06	5.23	6.28
RLHR-2	4/29/2015	10/24/2018	413	1.45	3.28	3.91
RLHR-3	4/29/2015	10/24/2018	161	1.80	6.63	7.96
RLHR-4	4/29/2015	10/24/2018	298	1.73	3.57	4.43
RLHR-5	4/29/2015	10/24/2018	207	2.14	4.77	5.89
RLHR-6	4/29/2015	10/24/2018	220	1.27	5.64	5.89

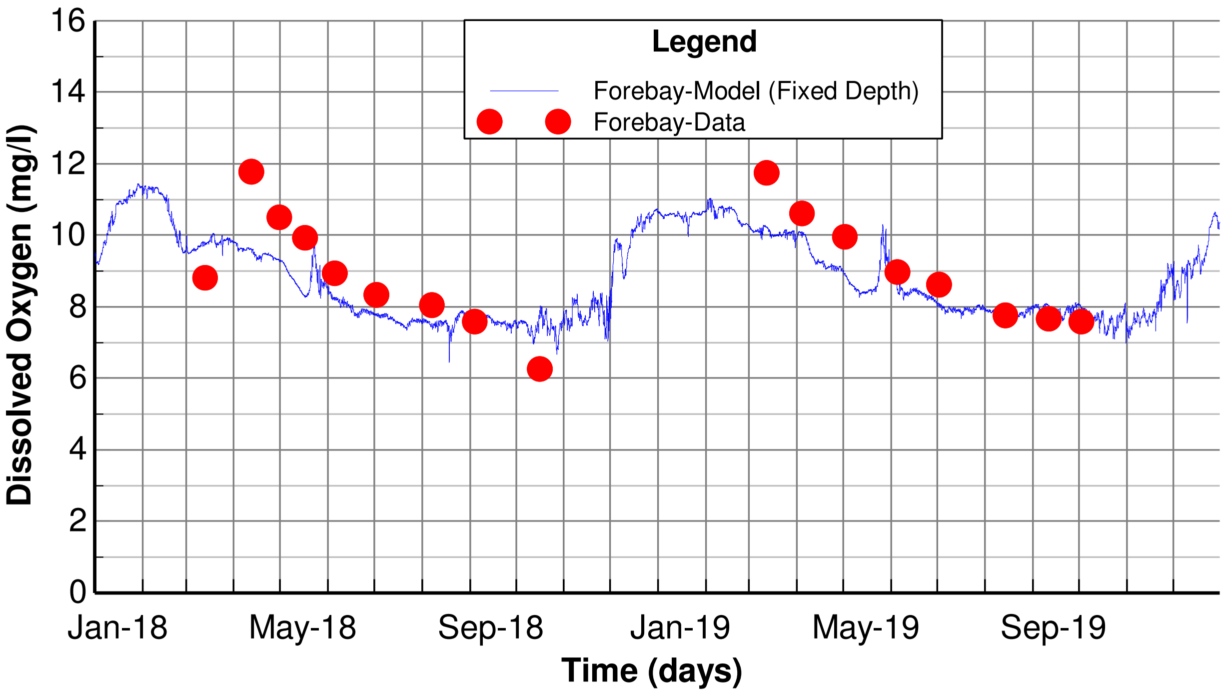

Figure 7-14 Calibration Plot of Surface Layer Dissolved Oxygen at APC Forebay Station

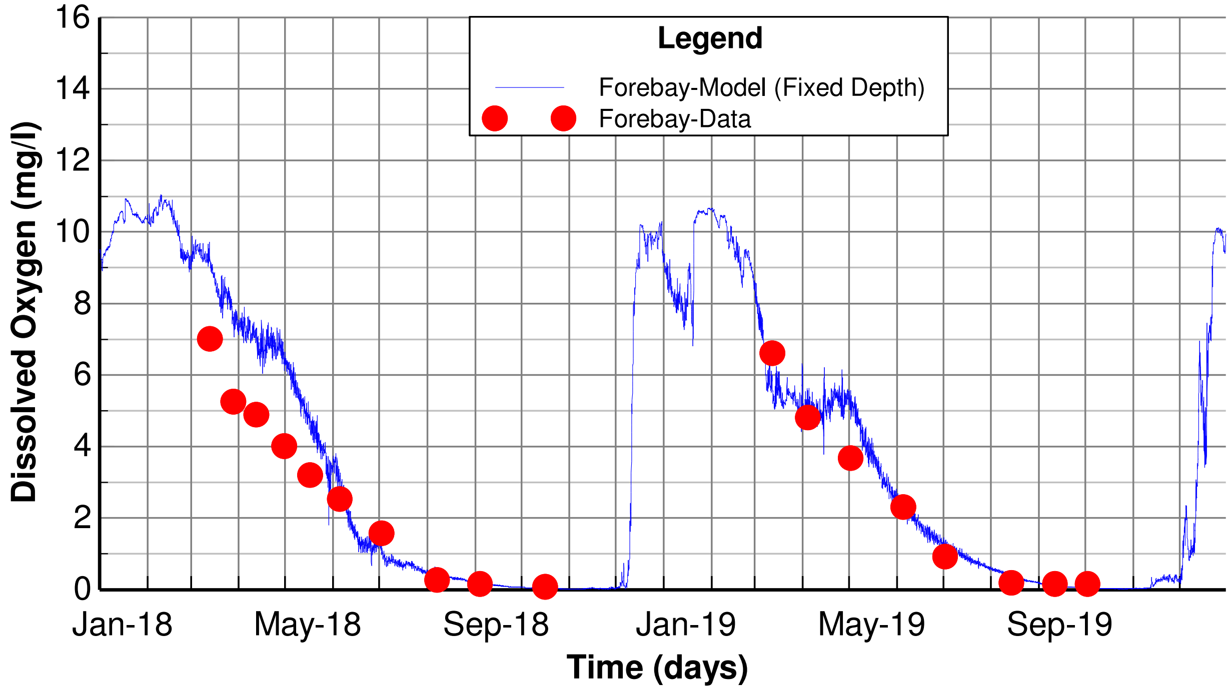

Figure 7-15 Calibration Plot of Bottom Layer Dissolved Oxygen at APC Forebay Station.

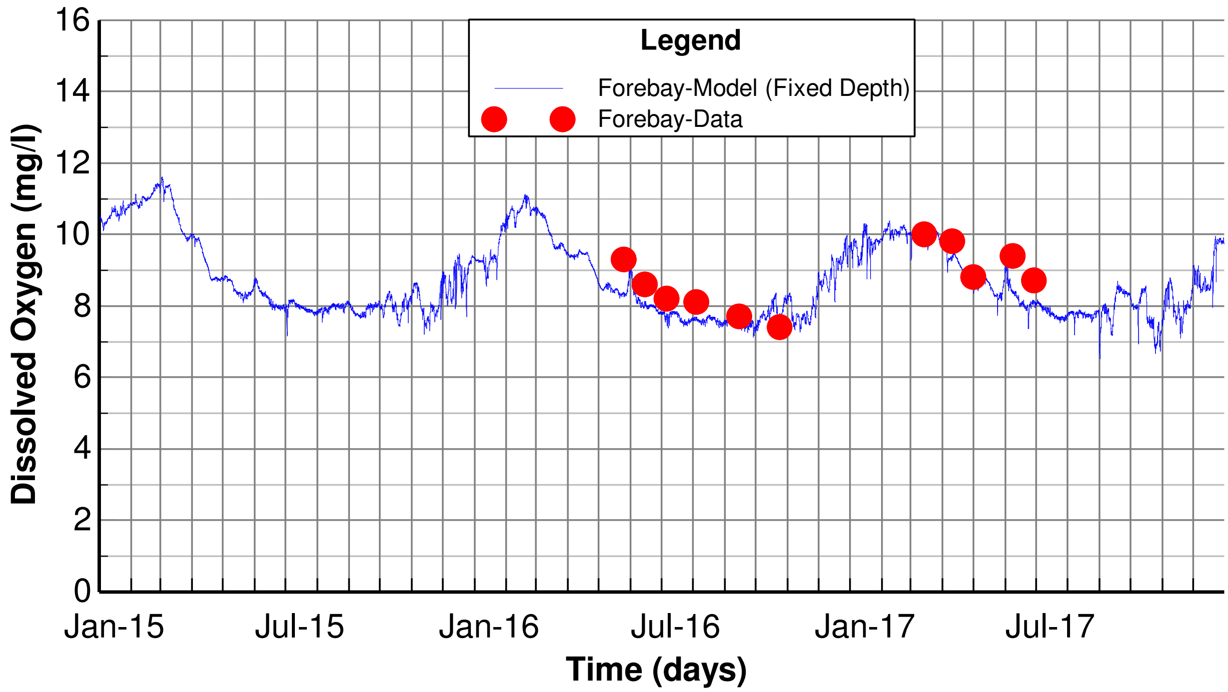

Figure 7-16 Validation Plot of Surface Layer Dissolved Oxygen at APC Forebay Station

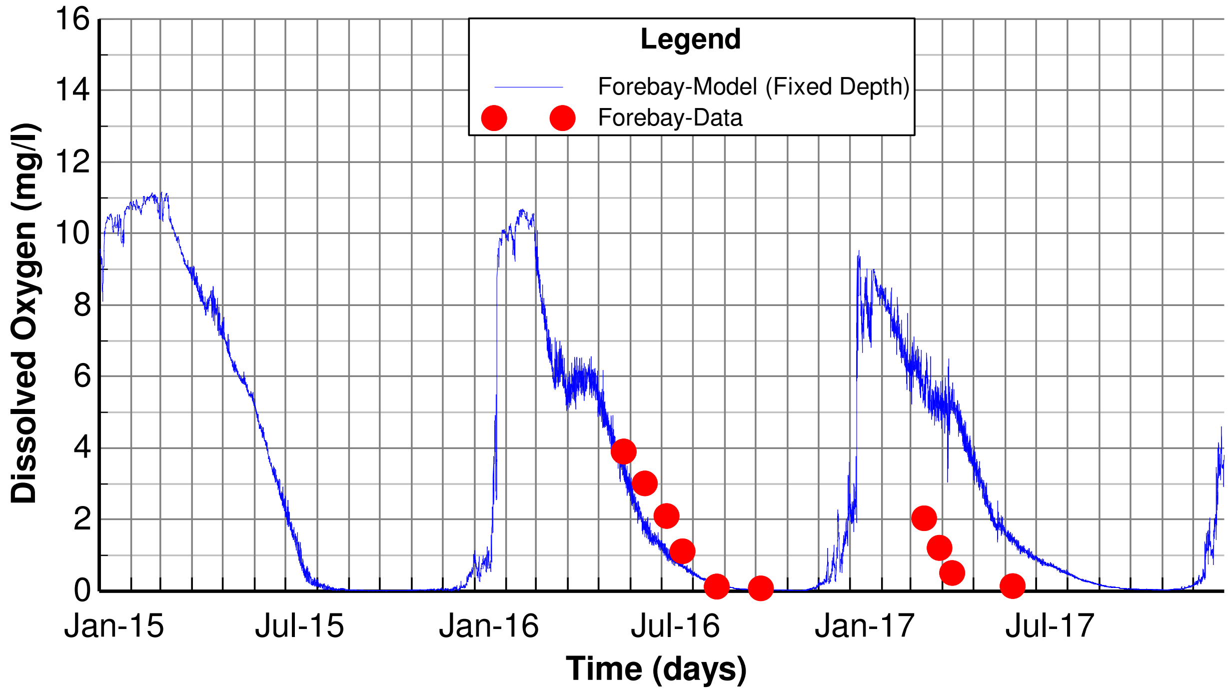

Figure 7-17 Validation Plot of Bottom Layer Dissolved Oxygen at APC Forebay Station

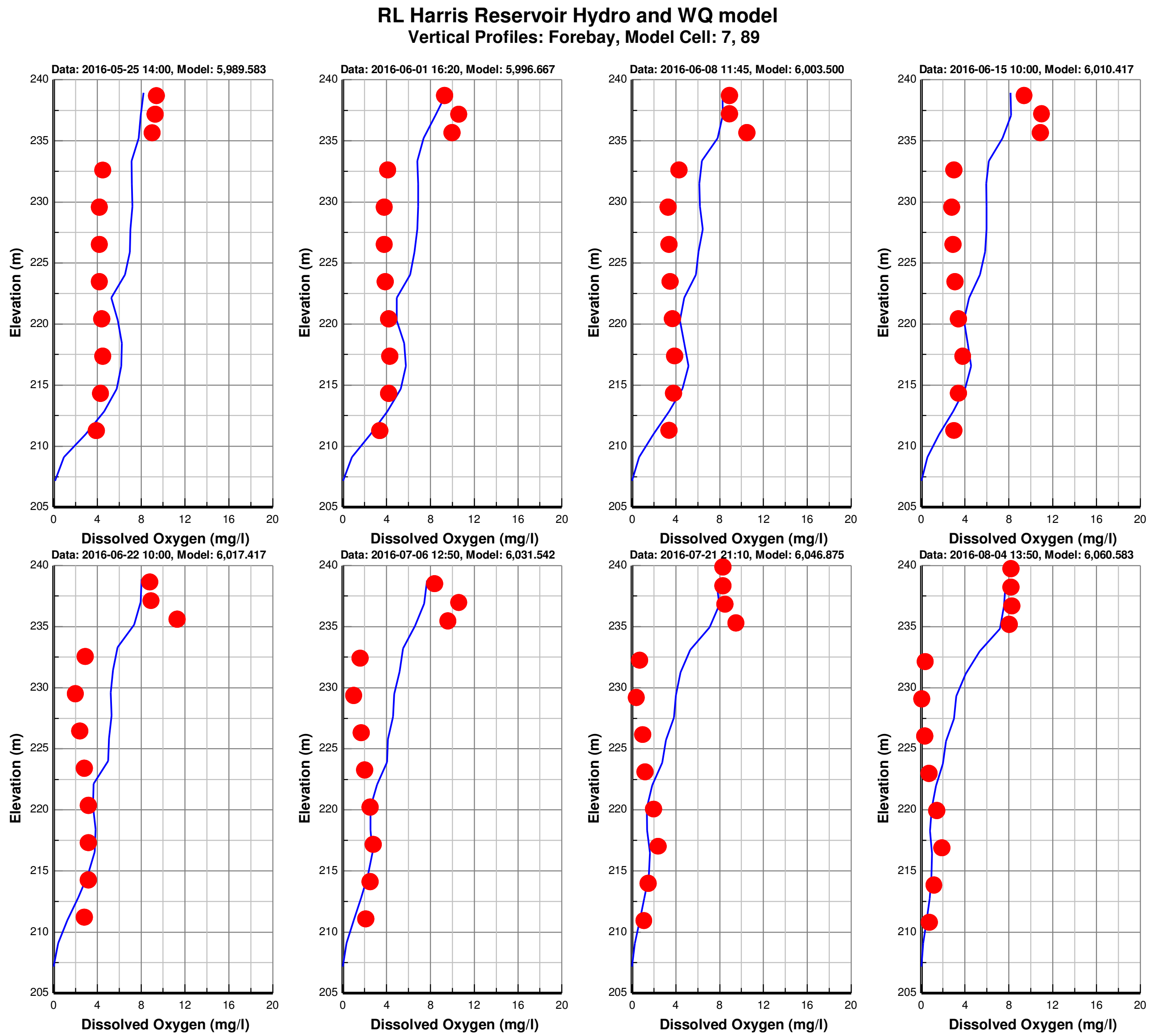

Figure 7-18 Dissolved Oxygen Vertical Profile Comparison Plot at APC Forebay Station (25 May 2016 – 4 August 2016)

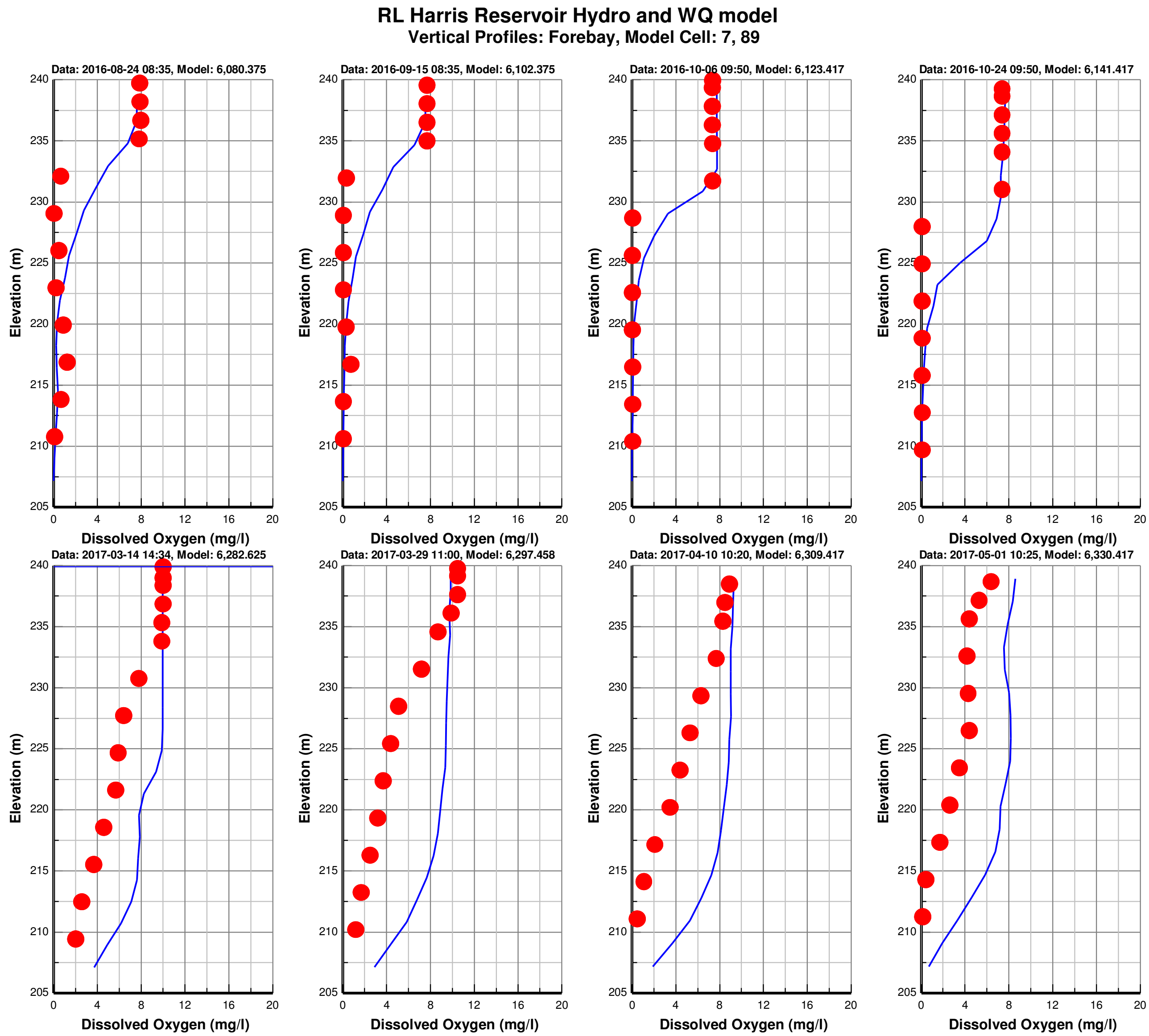

Figure 7-19 Dissolved Oxygen Vertical Profile Comparison Plot at APC Forebay Station (24 August 2016 – 1 May 2017)

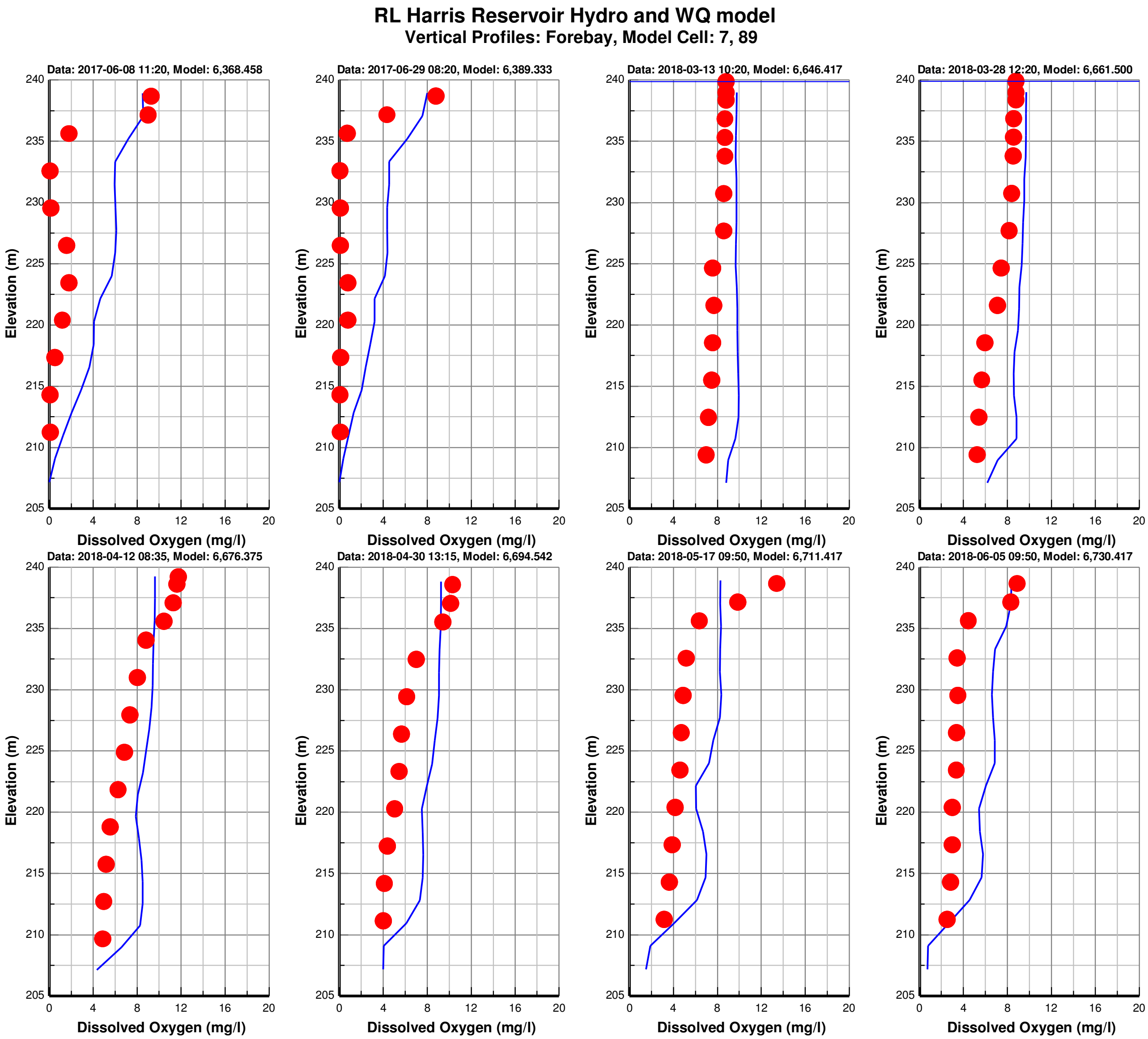

Figure 7-20 Dissolved Oxygen Vertical Profile Comparison Plot at APC Forebay Station (8 June 2017 – 5 June 2018)

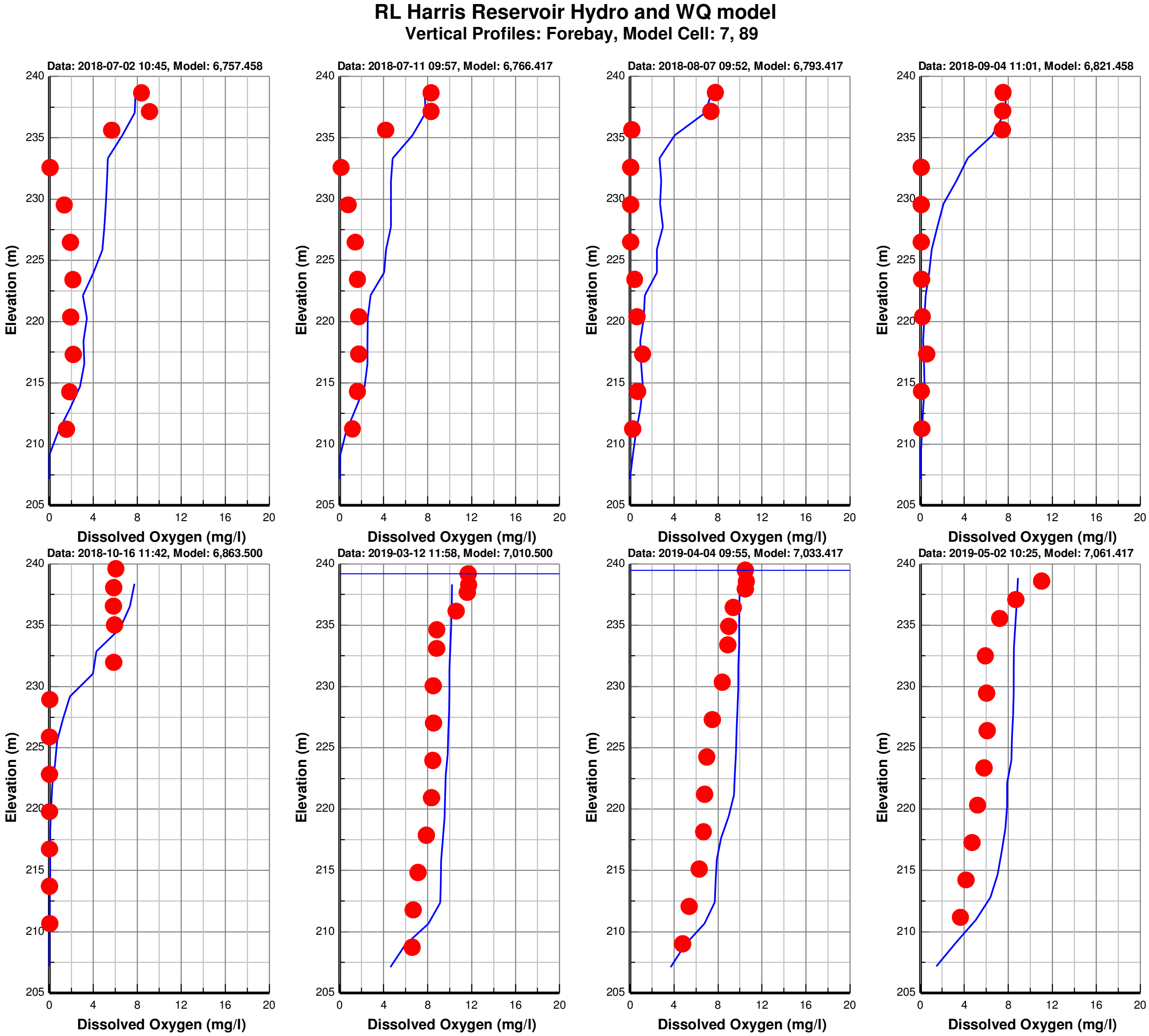

Figure 7-21 Dissolved Oxygen Vertical Profile Comparison Plot at APC Forebay Station (2 July 2018 – 2 May 2019)

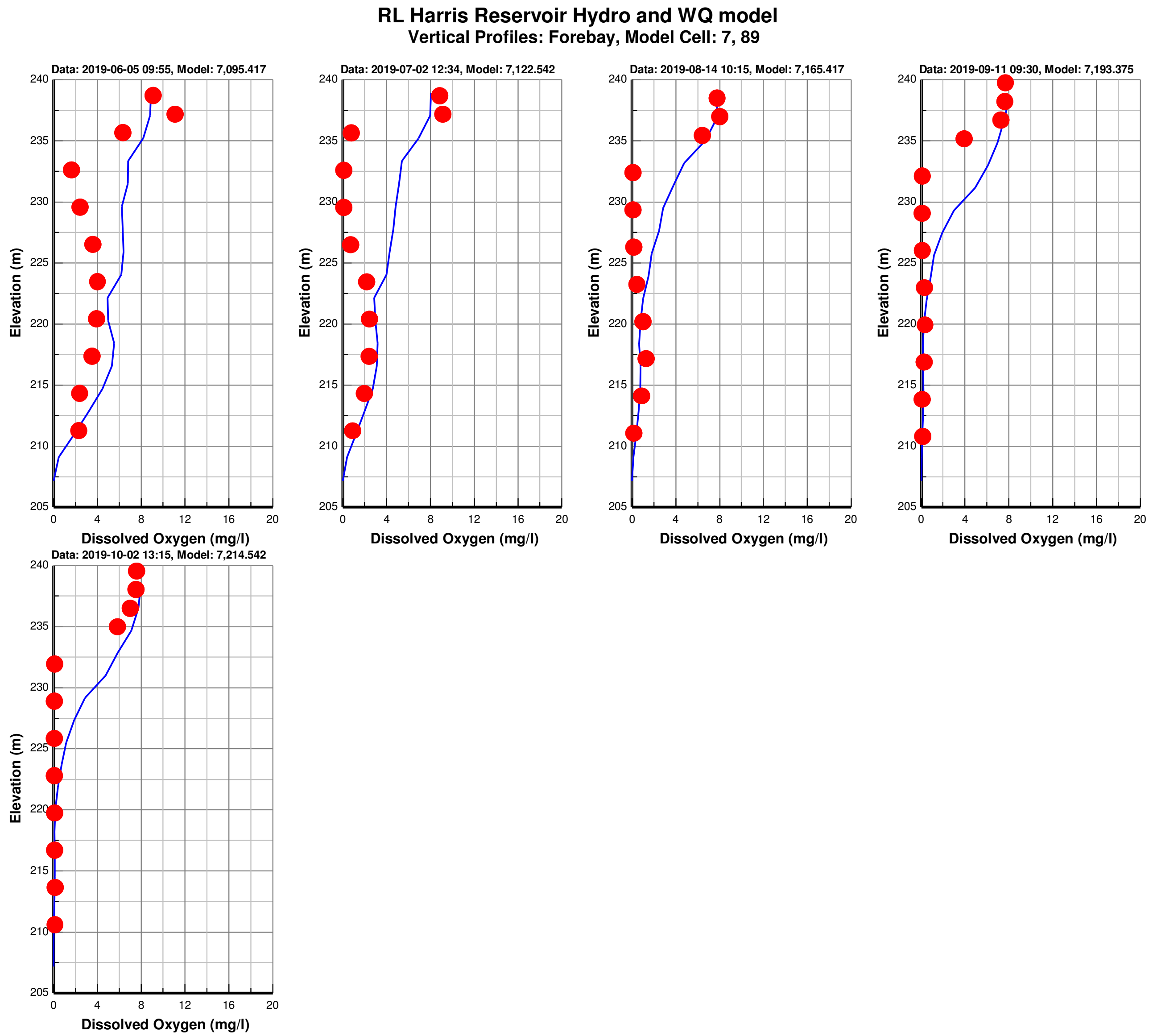

Figure 7-22 Dissolved Oxygen Vertical Profile Comparison Plot at APC Forebay Station (5 June 2019 – 2 October 2019)

7.5 Algae Calibration and Validation

Procedures used to calibrate algae (as chlorophyll a) included: (1) check the algae boundary conditions of the EFDC model; and (2) adjust the key parameters within reasonable ranges to match the observed data.

Modeled algae biomass results (as chlorophyll a) were presented for comparison to the observed data for the surface layer. In the Lake Harris model, green algae was simulated as a the functional group to derive total algae biomass for comparison to chlorophyll a observations. Chlorophyll a calibration and validation plots at ADEM station RLHR-1 are given in Figure 7-23 and Figure 7-24, respectively. The chlorophyll a surface layer calibration and validation plots at ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix A. As can be seen in these model-data plots, the model results are in fairly good agreement with measured algal biomass. In particular, the EFDC-simulated chlorophyll a concentrations followed the seasonal trend of observed chlorophyll a at these ADEM monitoring stations.

Summary statistics for model performance for chlorophyll a are given in Table 7-7. The calculated RMS errors ranged from 2.30 µg/L at the surface layer of ADEM station RLHR-3 to 8.16 µg/L at the surface layer of ADEM station RLHR-6, as shown in Table 7-7.

Table 7-7 Model Performance Statistics for Chlorophyll a (µg/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	5.94	5.24	4.60
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	4.52	4.06	5.61
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	2.30	11.02	7.28
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	5.81	7.51	8.23
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	7.08	6.81	8.33
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	8.16	5.46	6.26

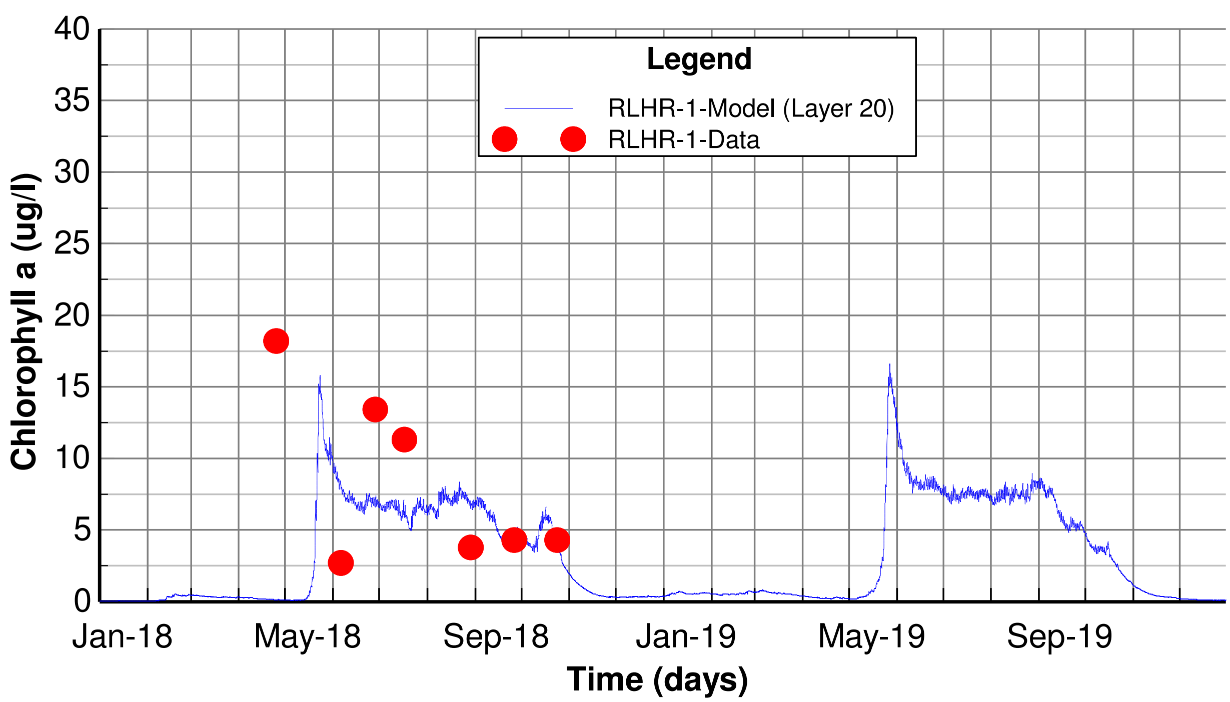

Figure 7-23 Calibration Plot of Surface Layer Chlorophyll a at Station RLHR-1

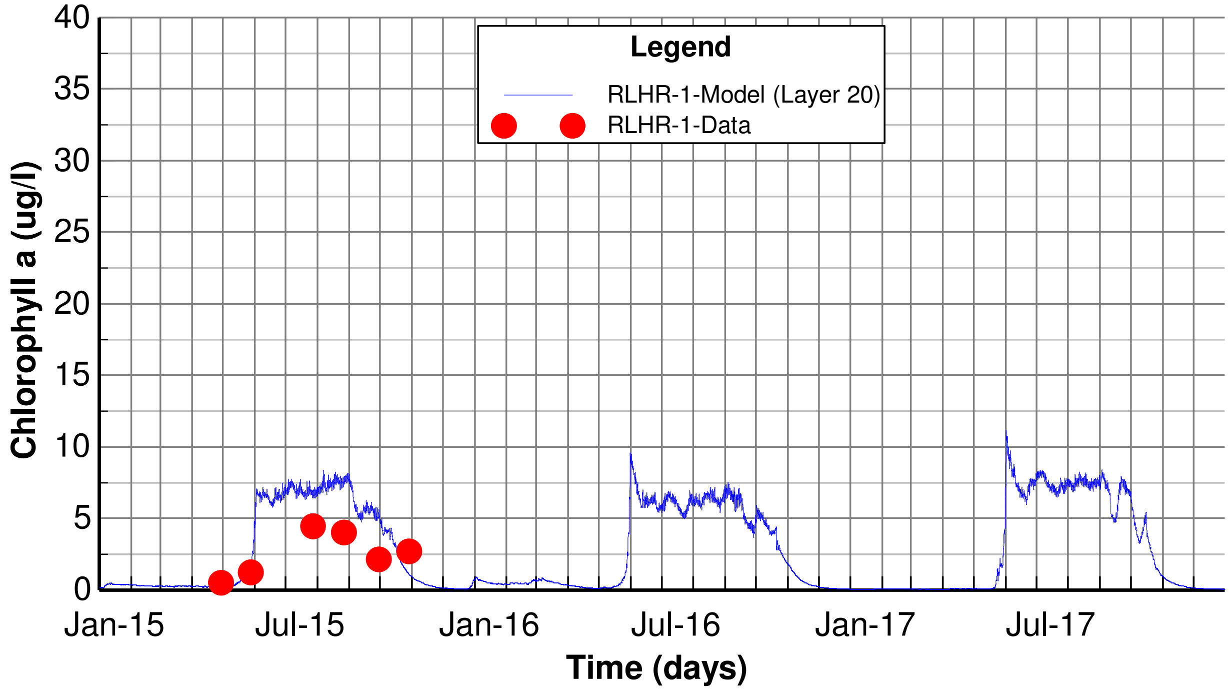

Figure 7-24 Validation Plot of Surface Layer Chlorophyll a at Station RLHR-1

7.6 Nitrogen Calibration and Validation

Procedures used to calibrate nitrogen state variables included: (1) check the boundary conditions of the EFDC model; and (2) adjust the key parameters within reasonable ranges to match the observed data.

Ammonia-N ($NH4^{+}$), nitrate-N (NO2+NO3), total organic nitrogen (TON) and total nitrogen (TN) model results at ADEM station RLHR-1 are presented for comparison to the observed data for the surface layer. The ammonia calibration and validation plots are given in Figure 7-25 and Figure 7-26, respectively. The nitrite/nitrate calibration and validation plots are given in Figure 7-27 and Figure 7-28, respectively. The TON calibration and validation plots are given in Figure 7-29 and Figure 7-30, respectively and the TN calibration and validation plots are given in Figure 7-31 and Figure 7-32, respectively. The ammonia, nitrite/nitrate, TON and TN surface layer calibration and validation plots at ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix A.

The summary statistics for model performance of ammonia are given in Table 7-8.The calculated RMS errors ranged from 0.043 mg/L at the surface layer of ADEM station RLHR-4 to 0.075 mg/L at the surface layer of ADEM station RLHR-2, as shown in Table 7-8.

Table 7-8 Model Performance Statistics for Ammonia (mg N/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.072	0.04	0.031
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.075	0.043	0.022
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.064	0.044	0.027
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.043	0.022	0.023
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.047	0.022	0.023
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.072	0.035	0.019

The summary statistics for model performance of nitrate are given in Table 7-9. The calculated RMS errors ranged from 0.039 mg/L at the surface layer of ADEM station RLHR-6 to 0.054 mg/L at the surface layer of ADEM station RLHR-3 as shown in Table 7-9.

Table 7-9 Model Performance Statistics for Nitrate (mg N/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.029	0.022	0.02
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.046	0.023	0.021
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.054	0.045	0.078
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.05	0.066	0.046
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.042	0.062	0.048
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.039	0.021	0.022

The summary statistics for model performance of Total Organic Nitrogen are given in Table 7-10. The calculated RMS errors ranged from 0.027 mg/L at the surface layer of ADEM station RLHR-3 to 0.336 mg/L at the bottom layer of ADEM station RLHR-4 as shown in Table 7-10.

Table 7-10 Model Performance Statistics for Total Organic Nitrogen (mg N/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.229	0.244	0.433
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.28	0.278	0.454
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.207	0.325	0.379
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.336	0.344	0.614
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.318	0.409	0.631
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.222	0.319	0.42

The summary statistics for model performance of total nitrogen are given in Table 7-11. The calculated RMS errors ranged from 0.213 mg/L at the surface layer of ADEM station RLHR-3 to 0.32 mg/L at the surface layer of ADEM station RLHRL-4, as shown in Table 7-11.

Table 7-11 Model Performance Statistics for Total Nitrogen (mg N/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.228	0.306	0.483
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.246	0.343	0.497
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.213	0.412	0.483
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.32	0.433	0.683
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.315	0.494	0.702
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.179	0.375	0.461

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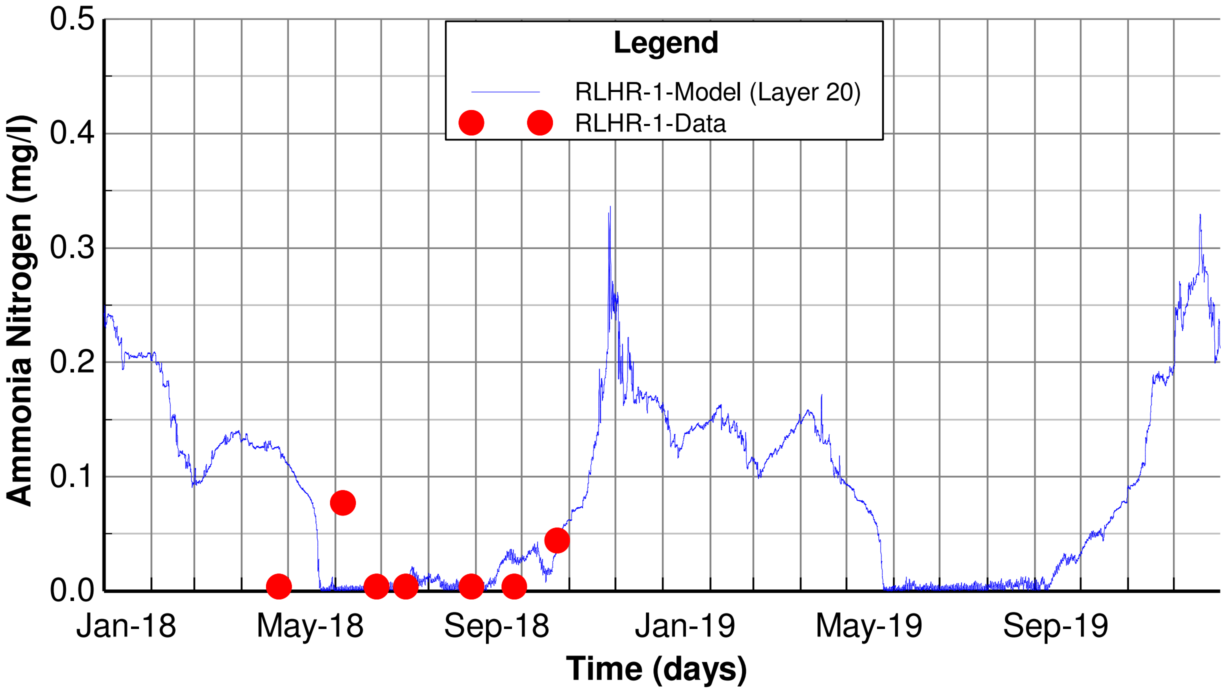

Figure 7-25 Calibration Plot of Surface Layer Ammonia at Station RLHR-1

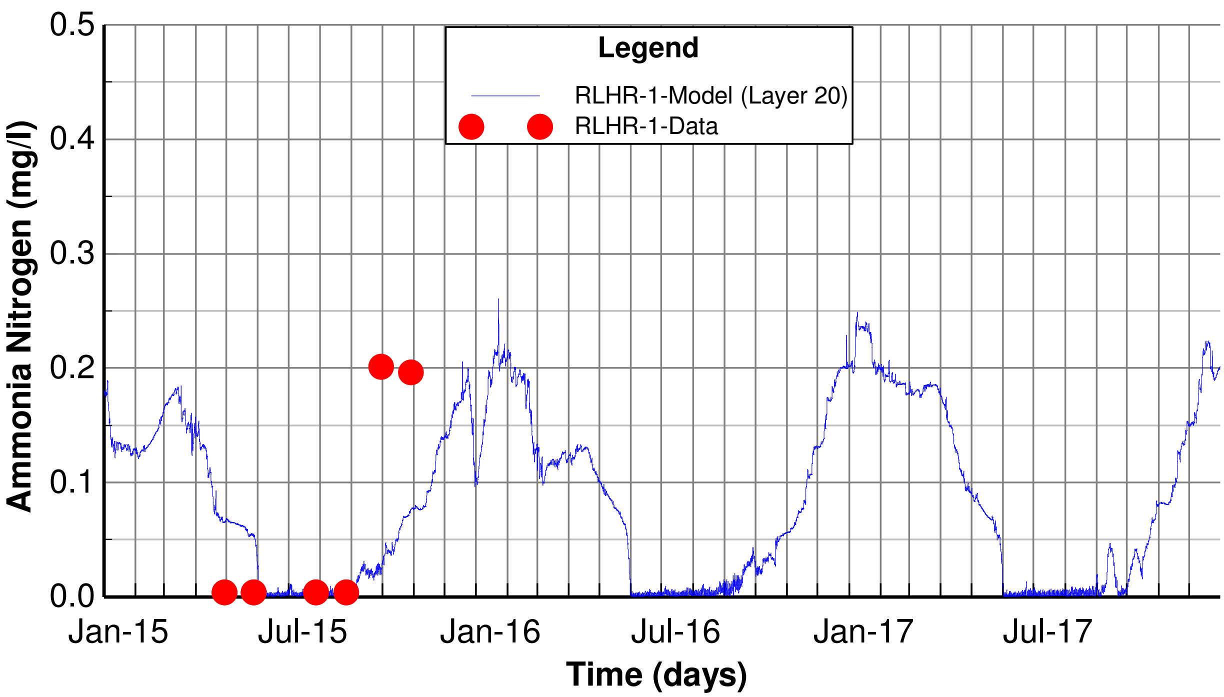

Figure 7-26 Validation Plot of Surface Layer Ammonia at Station RLHR-1

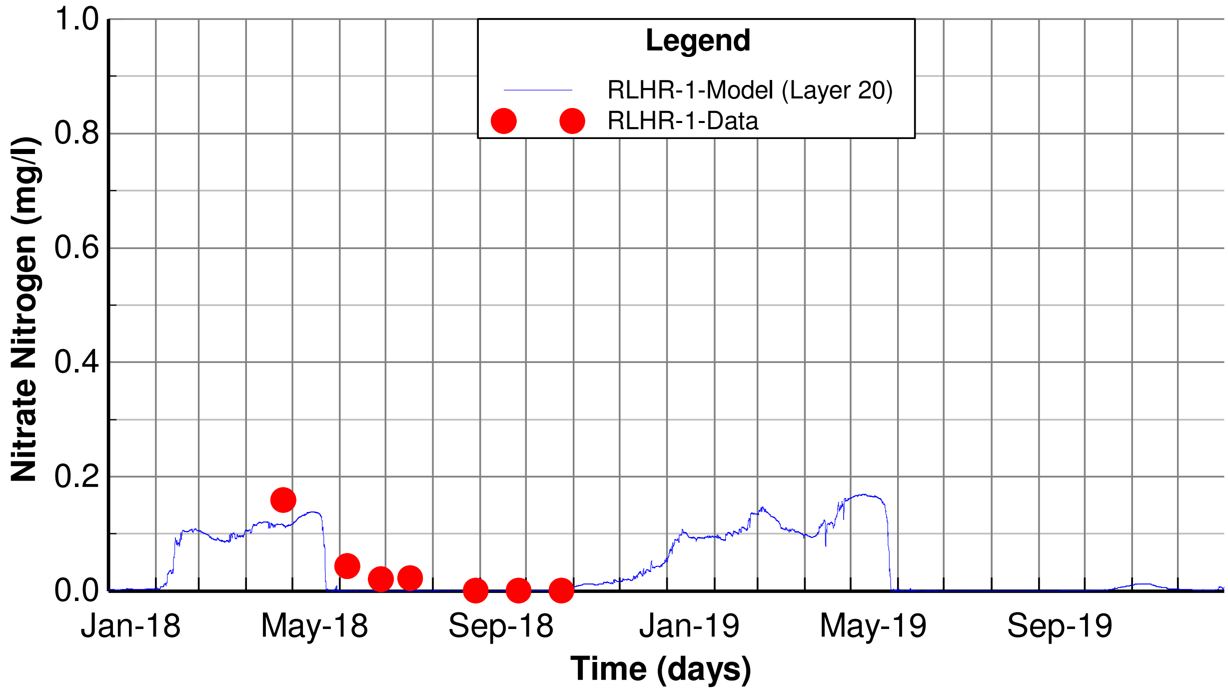

Figure 7-27 Calibration Plot of Surface Layer Nitrate at Station RLHR-1

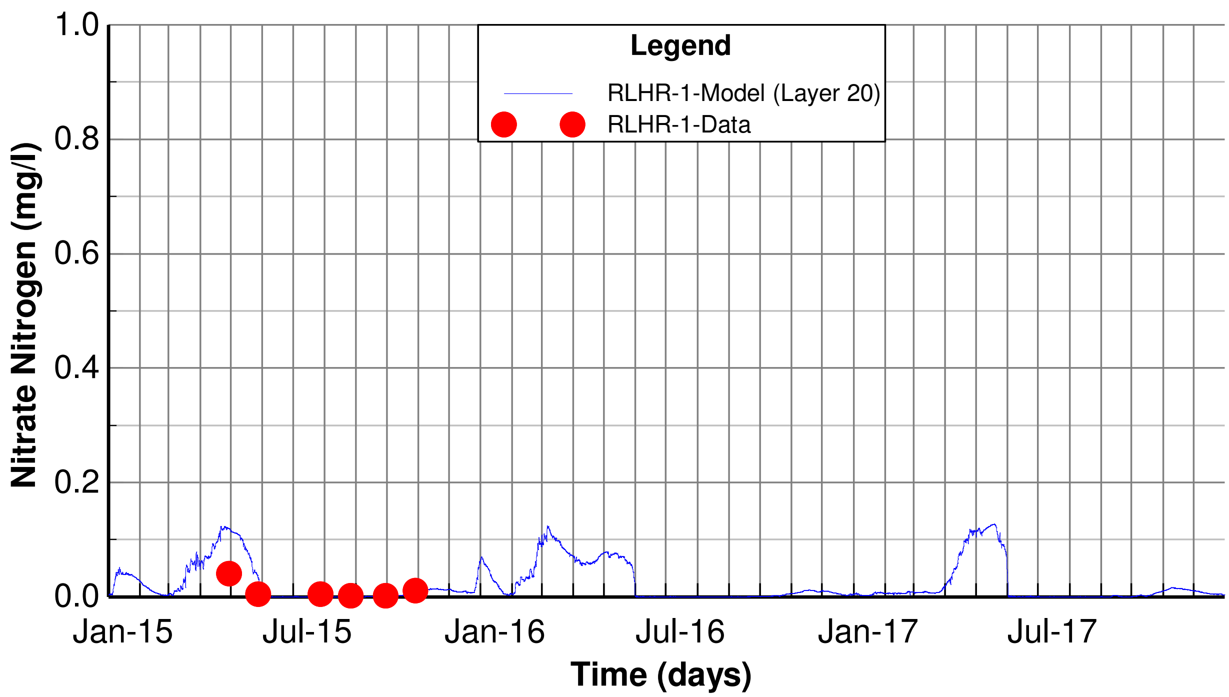

Figure 7-28 Validation Plot of Surface Layer Nitrate at Station RLHR-1

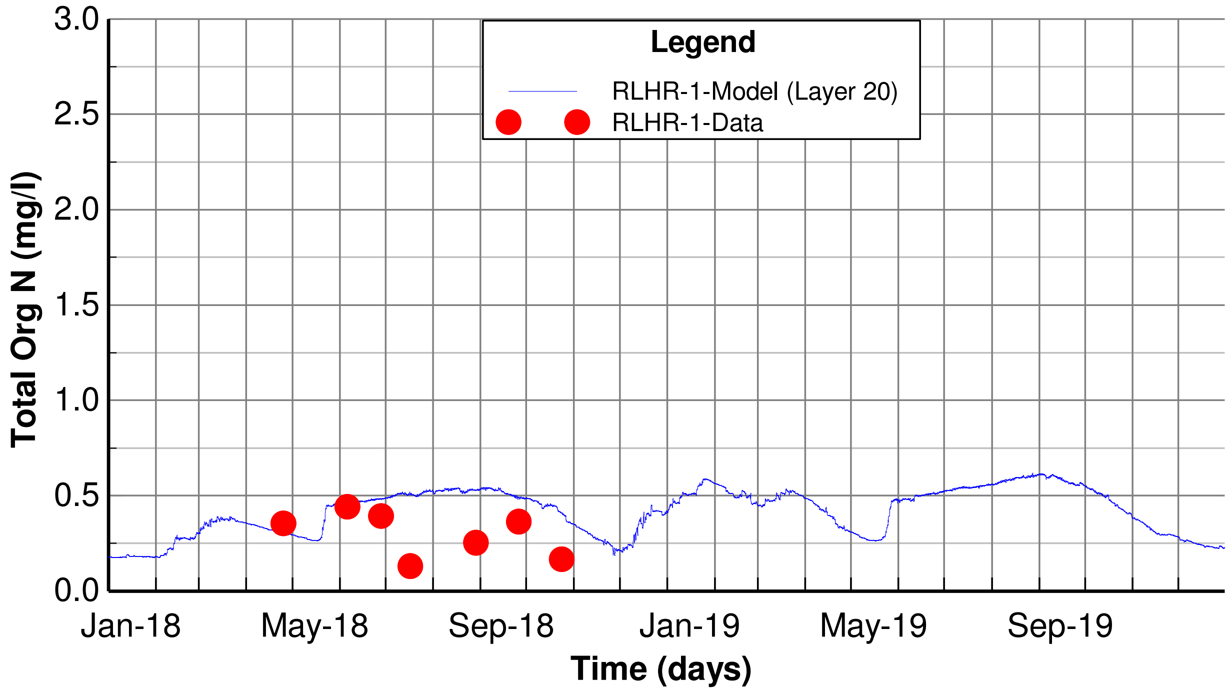

Figure 7-29 Calibration Plot of Surface Layer Total Organic Nitrogen at Station RLHR-1

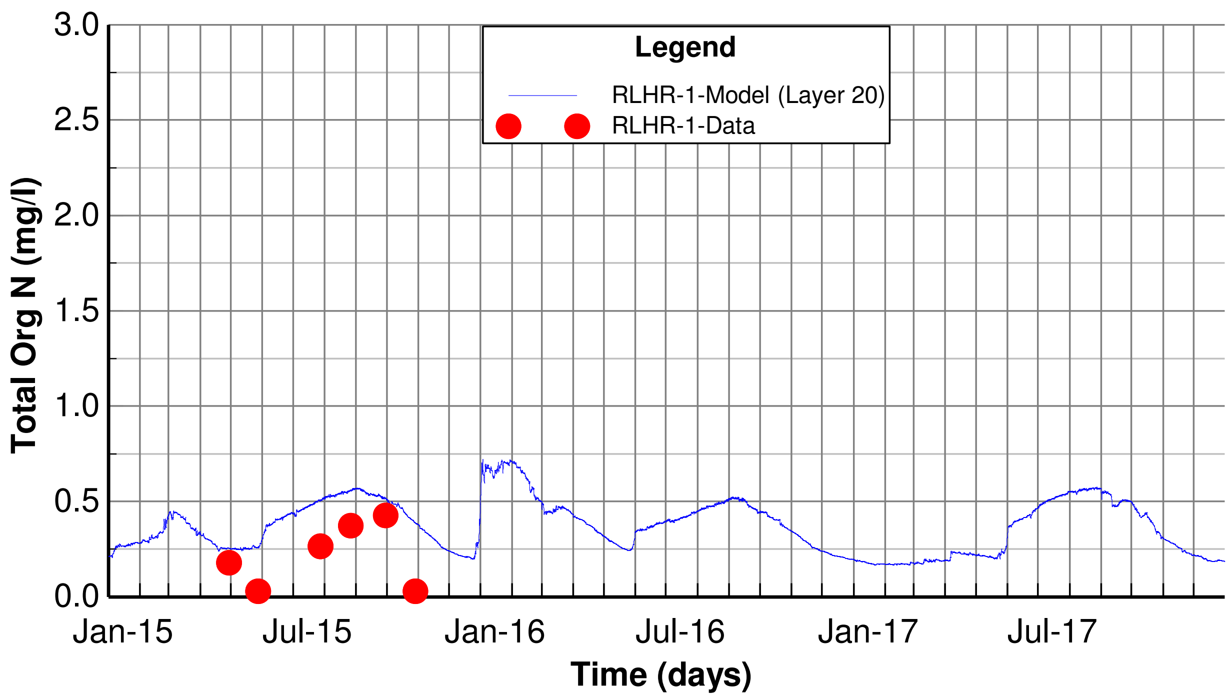

Figure 7-30 Validation Plot of Surface Layer Total Organic Nitrogen at Station RLHR-1

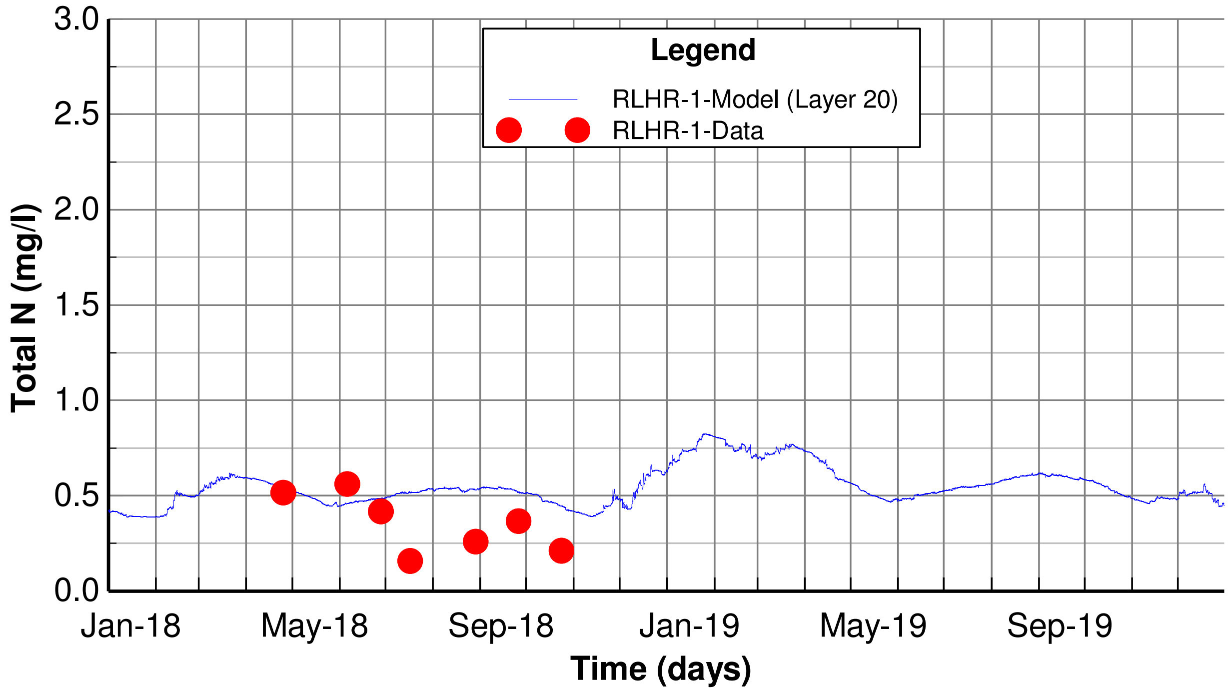

Figure 7-31 Calibration Plot of Surface Layer Total Nitrogen at Station RLHR-1

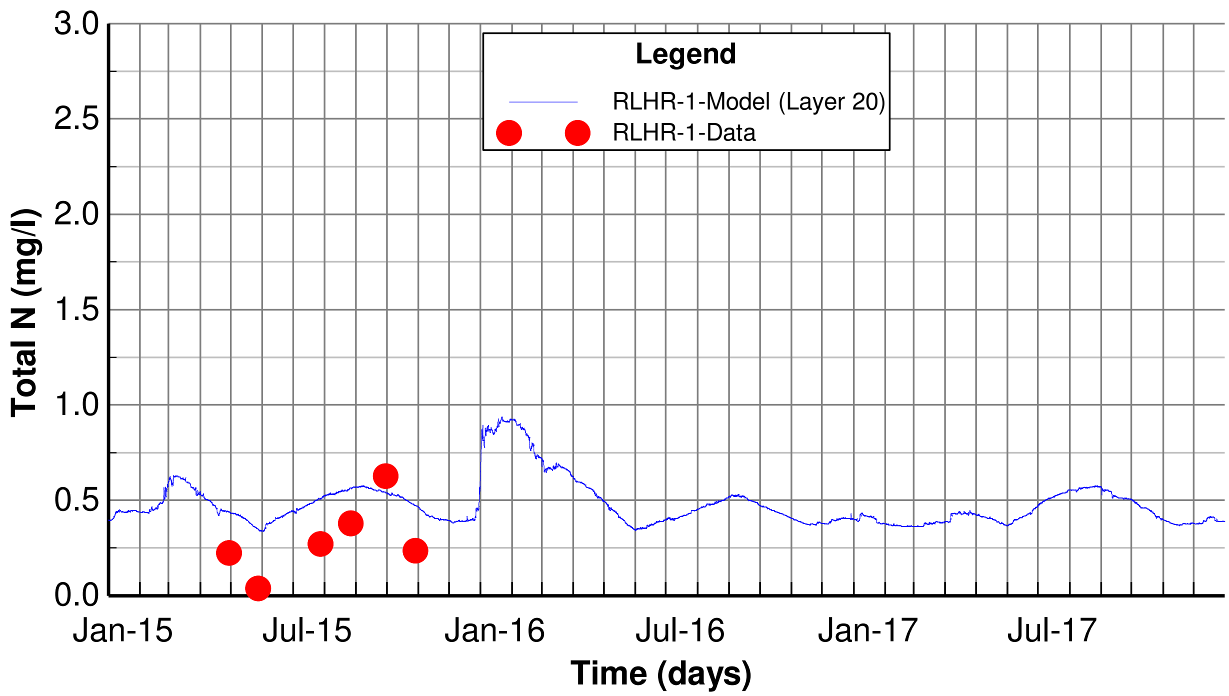

Figure 7-32 Validation Plot of Surface Layer Total Nitrogen at Station RLHR-1

7.7 Phosphorus Calibration and Validation

Procedures used to calibrate phosphorus state variables include: (1) check the phosphorus boundary conditions of the EFDC model; and (2) adjust the key parameters within reasonable ranges to match the observed data.

Total phosphate (TPO4), total organic phosphorus (TOP), and total phosphorus (TP) model results at ADEM station RLHR-1 are presented for comparison to the observed data for the surface layer. The TPO4 calibration and validation plots are given in Figure 7-33 and Figure 7-34, repectviely. The TOP calibration and validation plots are given in Figure 7-35 and Figure 7-36, respectively. The TP calibration and validation plots are given in Figure 7-37 and Figure 7-38, respectively. The total phosphate, total organic phosphorus, and total phosphorus surface layer calibration and validation plots at ADEM stations RLHR-2, RLHR-3, RLHR-4, RLHR-5, and RLHR-6 are given in Appendix A.

The summary statistics for model performance of total phosphate are given in Table 7-12. The calculated RMS errors ranged from 0.008 mg/L at the surface layer of ADEM station RLHR-3 to 0.01 mg/L at the surface layer of ADEM stations RLHR-4 and RLHR-5, as shown in Table 7-12.

Table 7-12 Model Performance Statistics for Total Phosphate (mg P/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.009	0.002	0.006
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.009	0.002	0.007
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.008	0.003	0.007
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.01	0.002	0.007
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.01	0.002	0.006
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.009	0.002	0.007

The summary statistics for model performance of total organic phosphorus are given in Table 7-13. The calculated RMS errors ranged from 0.008 mg/L at the surface layer of ADEM station RLHR-4 to 0.028 mg/L at the surface layer of ADEM station RLHR-3, as shown in Table 7-13.

Table 7-13 Model Performance Statistics for Total Organic Phosphorus (mg P/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.005	0.009	0.01
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.01	0.011	0.015
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.021	0.02	0.03
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.008	0.014	0.018
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.01	0.018	0.018
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.012	0.011	0.019

The summary statistics for model performance of total phosphorus are given in Table 7-14. The calculated RMS errors ranged from 0.008 mg/L at the surface layer of ADEM station RLHR-1 to 0.028 mg/L at the bottom layer of ADEM station RLHR-3, as shown in Table 7-14.

Table 7-14 Model Performance Statistics for Total Phosphorus (mg P/L)

Station ID	Layer	Starting	Ending	# Pairs	RMS	Data Average	Model Average
RLHR-1	Surface	4/29/2015 7:05	10/24/2018 9:11	14	0.008	0.01	0.016
RLHR-2	Surface	4/29/2015 7:47	10/24/2018 9:51	14	0.018	0.013	0.022
RLHR-3	Surface	4/29/2015 8:25	10/24/2018 10:42	15	0.028	0.023	0.037
RLHR-4	Surface	4/29/2015 9:35	10/24/2018 11:26	14	0.015	0.016	0.024
RLHR-5	Surface	4/29/2015 9:56	10/24/2018 11:46	14	0.017	0.02	0.024
RLHR-6	Surface	4/29/2015 9:05	10/24/2018 10:15	14	0.019	0.014	0.025

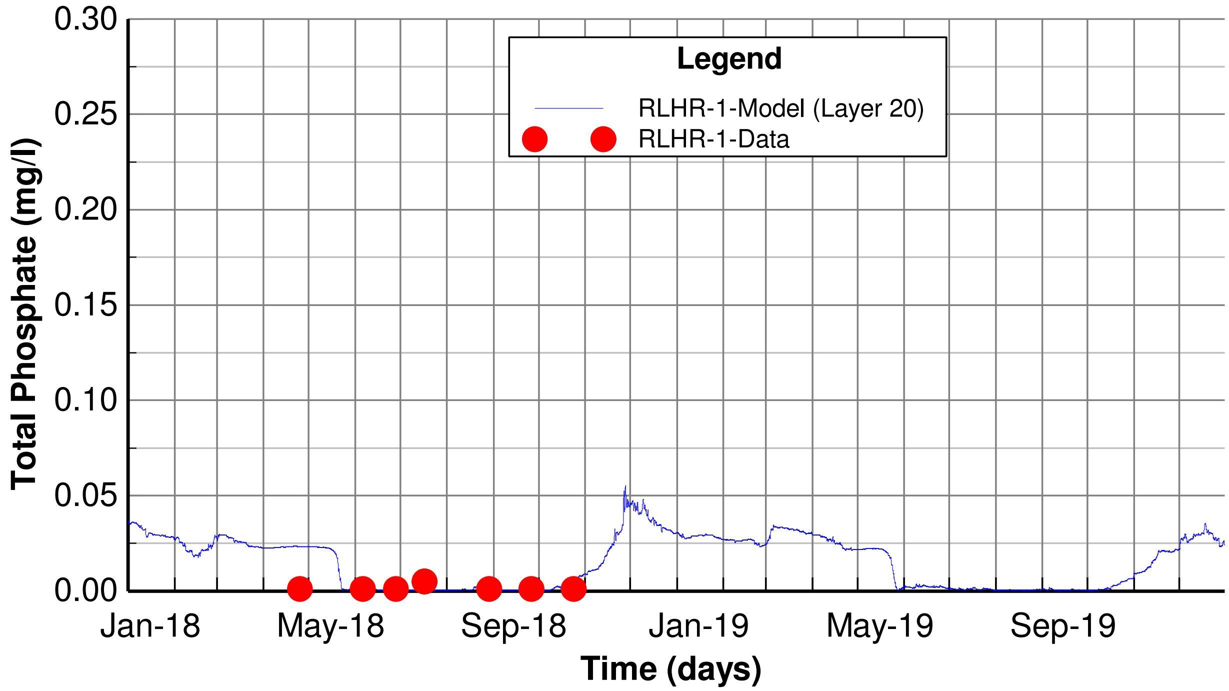

Figure 7-33 Calibration Plot of Surface Layer Total Phosphate at Station RLHR-1

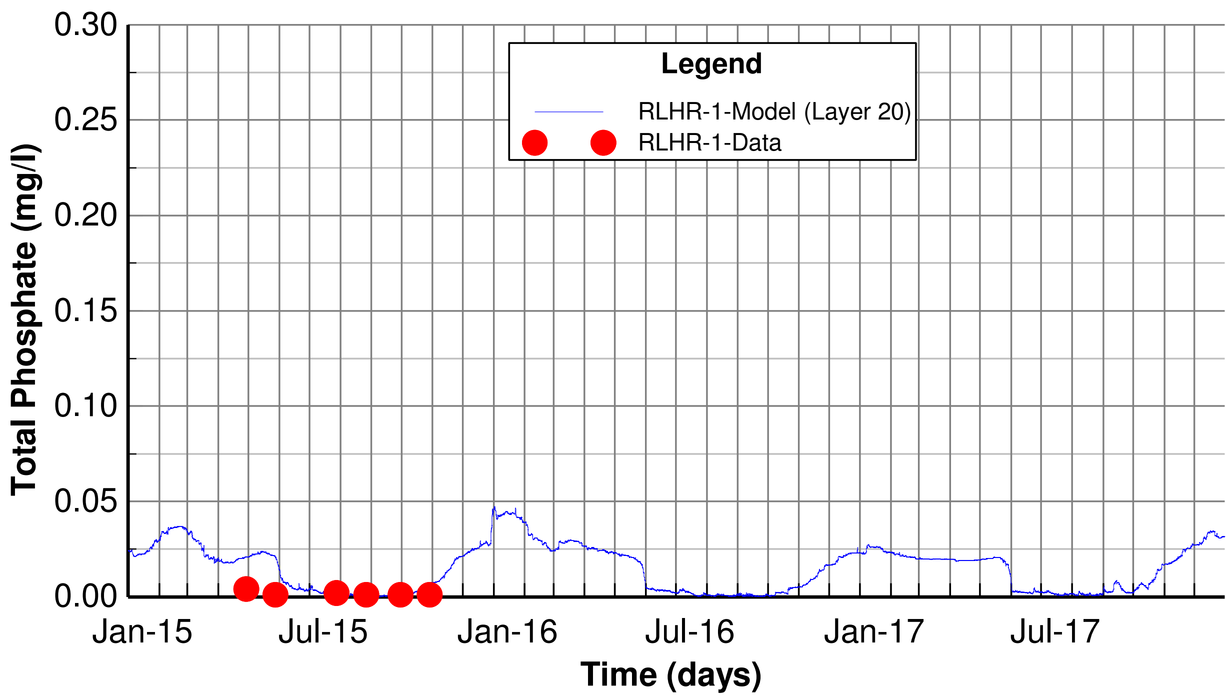

Figure 7-34 Validation Plot of Surface Layer Total Phosphate at Station RLHR-1

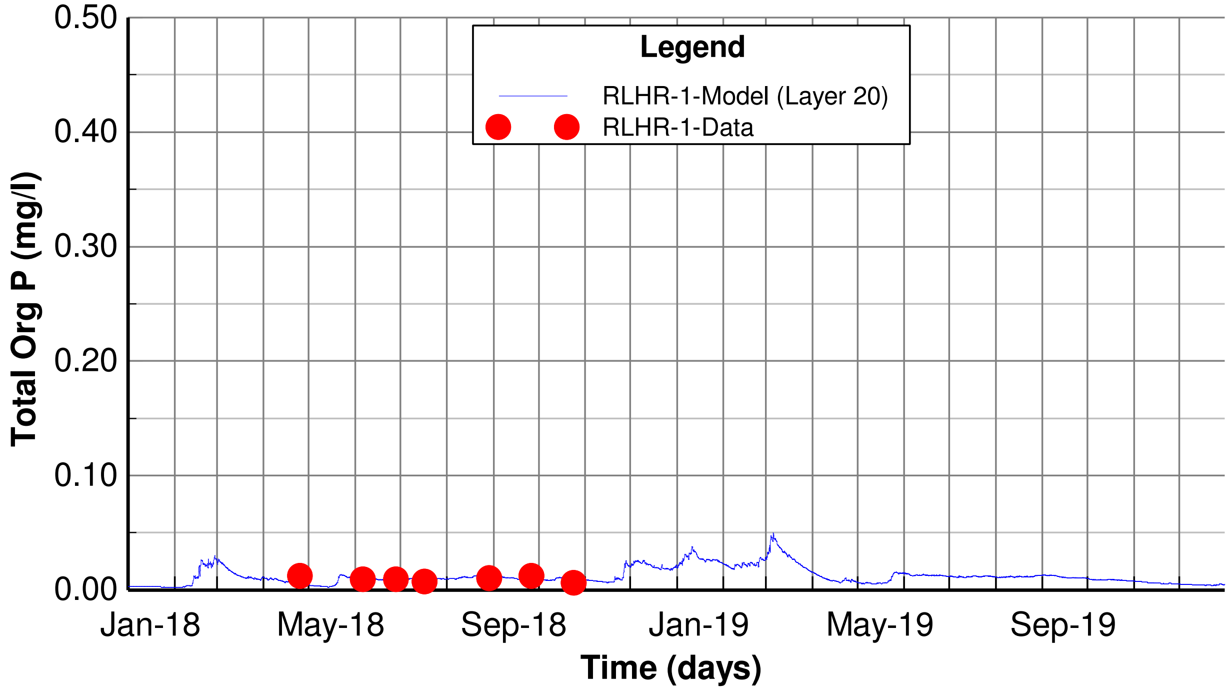

Figure 7-35 Calibration Plot of Surface Layer Total Organic Phosphorus at Station RLHR-1

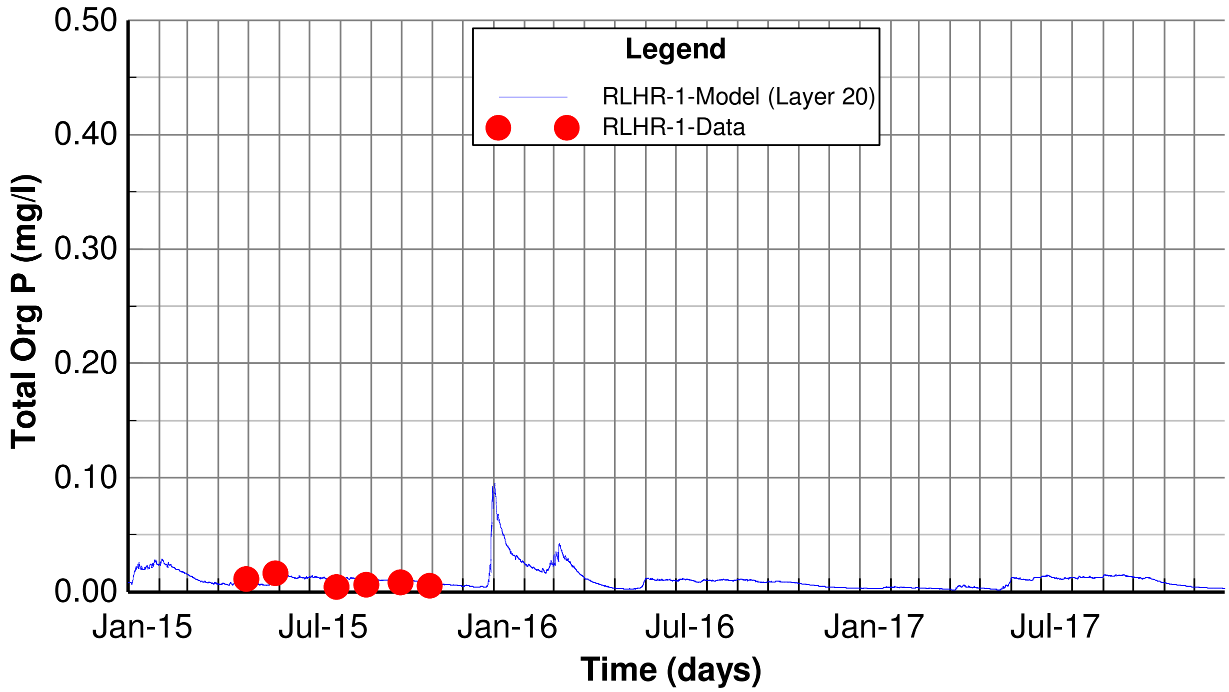

Figure 7-36 Validation Plot of Surface Layer Total Organic Phosphorus at Station RLHR-1

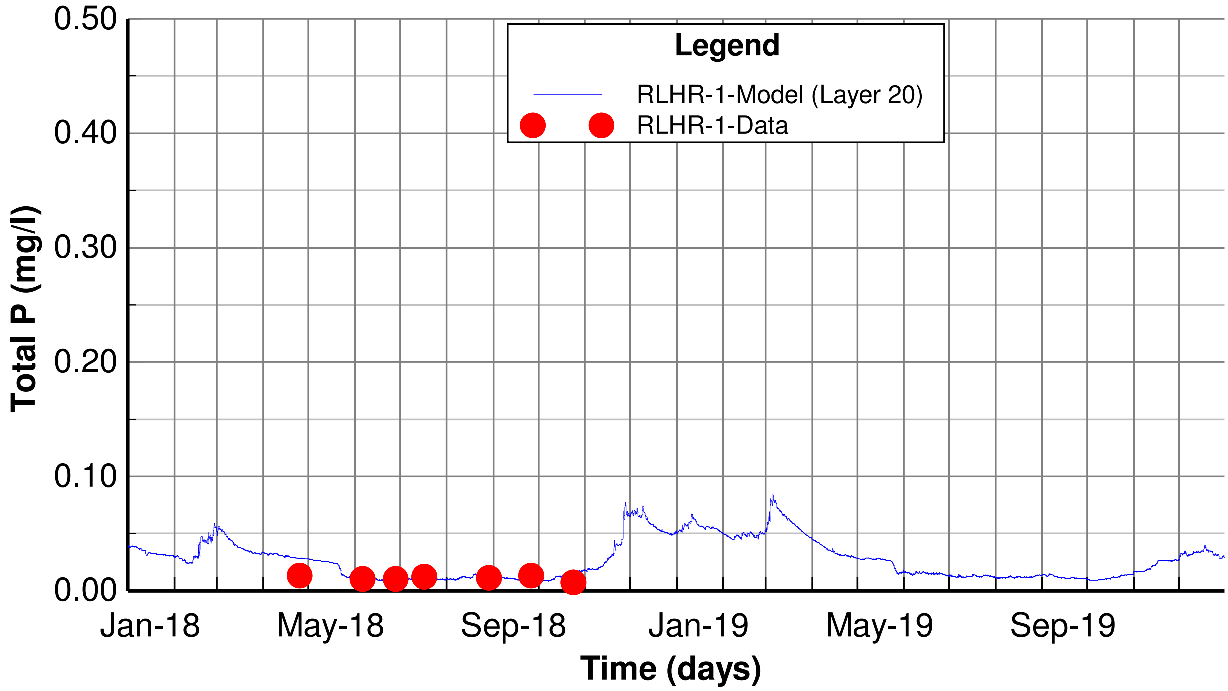

Figure 7-37 Calibration Plot of Surface Layer Total Phosphorus at Station RLHR-1

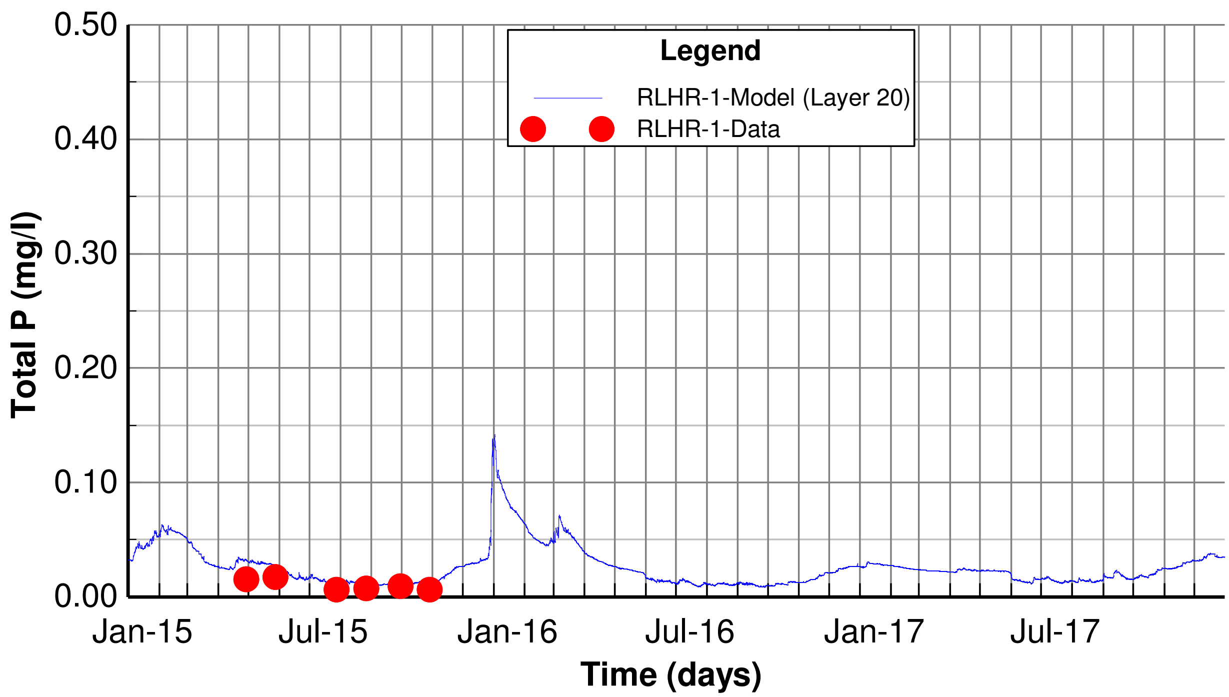

Figure 7-38 Validation Plot of Surface Layer Total Phosphorus at Station RLHR-1

8. Scenario Analysis

The calibrated and validated EFDC model of Lake Harris was used to evaluate the effects of a range of scenarios designed to raise the winter pool elevation by up to four feet on water temperature and dissolved oxygen in the forebay area of Lake Harris. The operating curves of the lake stages are shown in Table 8-1 and Figure 1-2.

Table 8-1 Operating Curves of Lake Harris Dam

Scenarios	Winter Pool Elevation (ft NGVD29)
Baseline	785
Scenario 1	786
Scenario 2	787
Scenario 3	788
Scenario 4	789

For each scenario run, the initial water surface elevation was adjusted and a scenario flow balance was re-calculated to make sure the simulated water surface elevation at the forebay followed the scheduled operation curves. For all four scenarios, the EFDC model of Lake Harris was run for the 6-year period from 1 January 2014 to 31 December 2019.

Since the dam discharge was released from the top four layers of the model, water temperature and dissolved oxygen data simulated in the top four layers were extracted for the period from 2015 to 2019 for all four scenarios and the baseline simulation. The baseline EFDC model refers to the calibrated and validated EFDC model results that represent the existing operating schedule. Data from the top four layers were pooled to compute average values for water temperature and dissolved oxygen for each of the four scenarios and the baseline run. Average water temperature and dissolved oxygen scenario results were then compared with the baseline results.

The simulated water surface elevation at the forebay area for the four scenarios and baseline run are shown in Figure 8-1. The simulated water surface elevation results for all four scenarios followed the scheduled operation curves, as specified in Table 8-1 and shown in Figure 1-2. The comparison of the time series plots of simulated water temperature and dissolved oxygen concentration of the dam discharge between the baseline and scenarios are shown in Figure 8-2 and Figure 8-3, respectively. Hourly water temperature and dissolved oxygen results for baseline and scenarios were also extracted from the EFDC models to calculated the statistics including minimum, 10 percentile, 25 percentile, 50 percentile, 75 percentile, 90 percentile, maximum, and mean values. The summary statistics of water temperature and dissolved oxygen for the baseline and scenarios are given in Table 8-2 and Table 8-3, respectively. As can be seen, there are only small differences in simulated water temperature and dissolved oxygen between the baseline run and the four scenarios. The model simulation results clearly indicate that raising the winter pool water level by up to 4 ft would lead to only minor differences in water temperature and dissolved oxygen in the dam discharge flow.

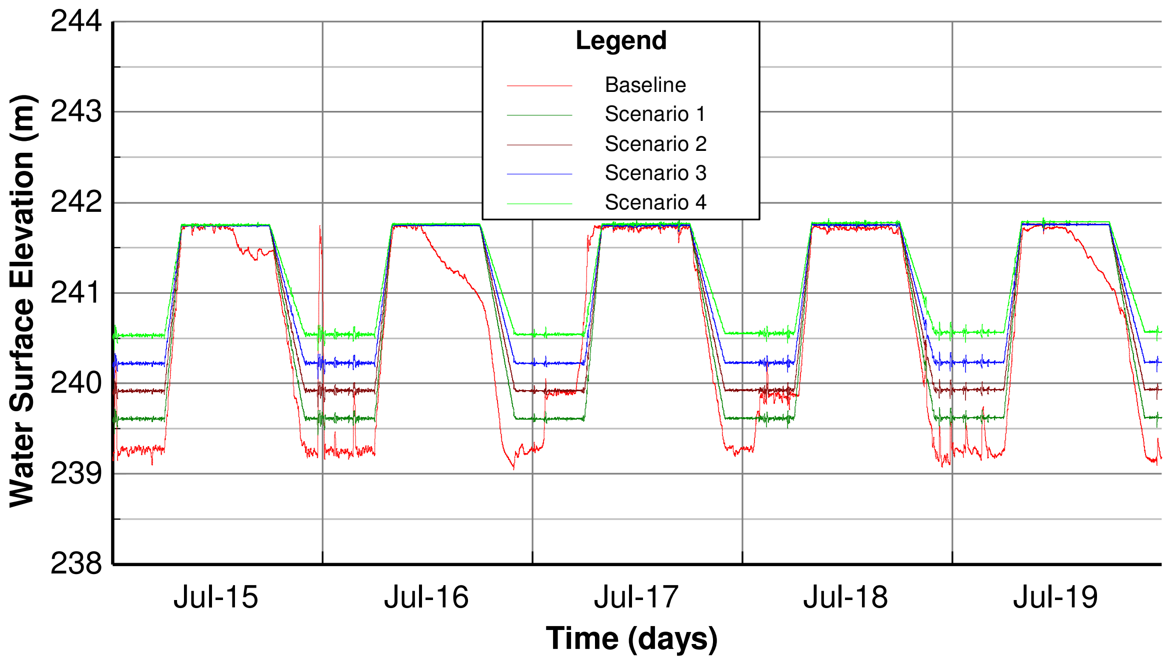

Figure 8-1 Comparison of Simulated Water Surface Elevation at the APC Forebay Station between Baseline and Scenarios

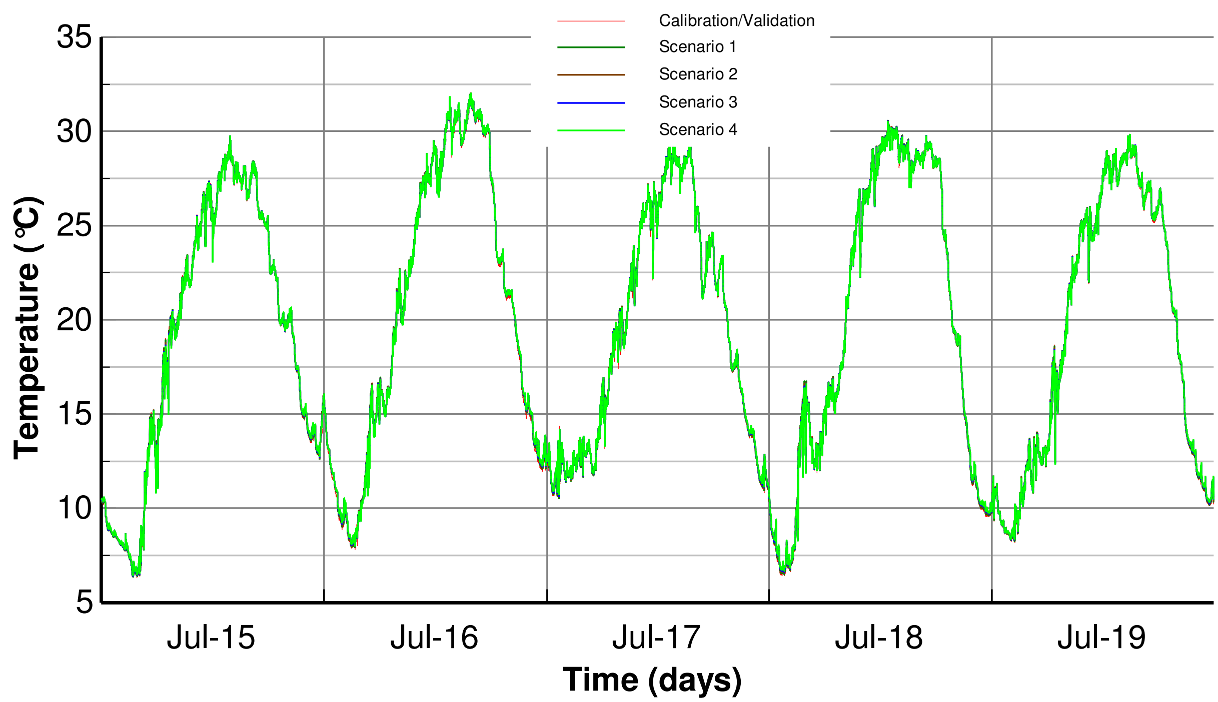

Figure 8-2 Comparison of Water Temperature of Dam Discharge between Baseline and Scenarios

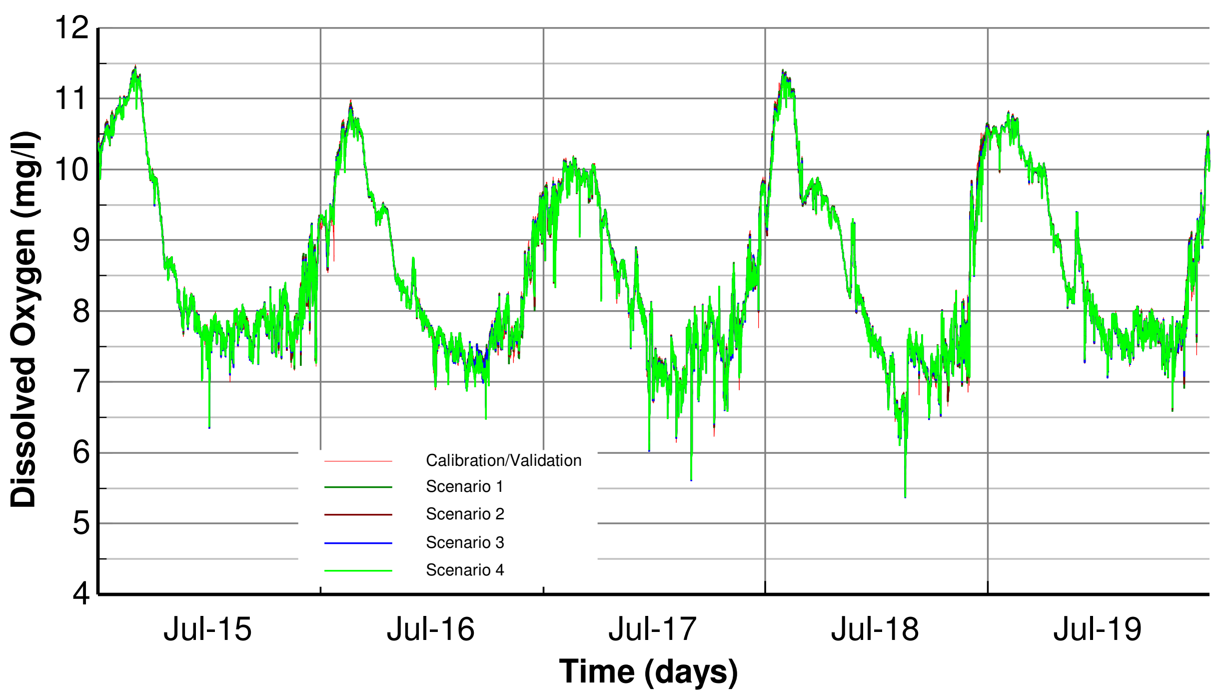

Figure 8-3 Comparison of Dissolved Oxygen of Dam Discharge between Baseline and Scenarios

Table 8-2 Summary Statistics of Water Temperature for Baseline and Scenarios

Statistics	Calibration/Validation	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Minimum	6.322	6.360	6.395	6.395	6.439
10 percentile	9.749	9.802	9.823	9.840	9.882
25 percentile	12.978	13.013	13.027	13.035	13.053
50 percentile	19.688	19.709	19.691	19.684	19.677
75 percentile	26.566	26.586	26.568	26.557	26.545
90 percentile	28.680	28.704	28.693	28.686	28.680
Maximum	31.998	32.028	32.031	32.018	32.038
Mean	19.493	19.534	19.535	19.535	19.541

Table 8-3 Summary Statistics of Dissolved Oxygen for Baseline and Scenarios

Statistics	Calibration/Validation	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Minimum	5.385	5.385	5.408	5.358	5.369
10 percentile	7.288	7.296	7.291	7.287	7.272
25 percentile	7.623	7.625	7.621	7.625	7.626
50 percentile	8.197	8.191	8.184	8.187	8.188
75 percentile	9.602	9.600	9.596	9.592	9.585
90 percentile	10.495	10.478	10.464	10.454	10.443
Maximum	11.480	11.462	11.445	11.433	11.423
Mean	8.587	8.584	8.577	8.573	8.569

9. References

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APPENDIX D

EROSION AND SEDIMENTATION SITES IDENTIFIED IN EROSION AND SEDIMENTATION STUDY

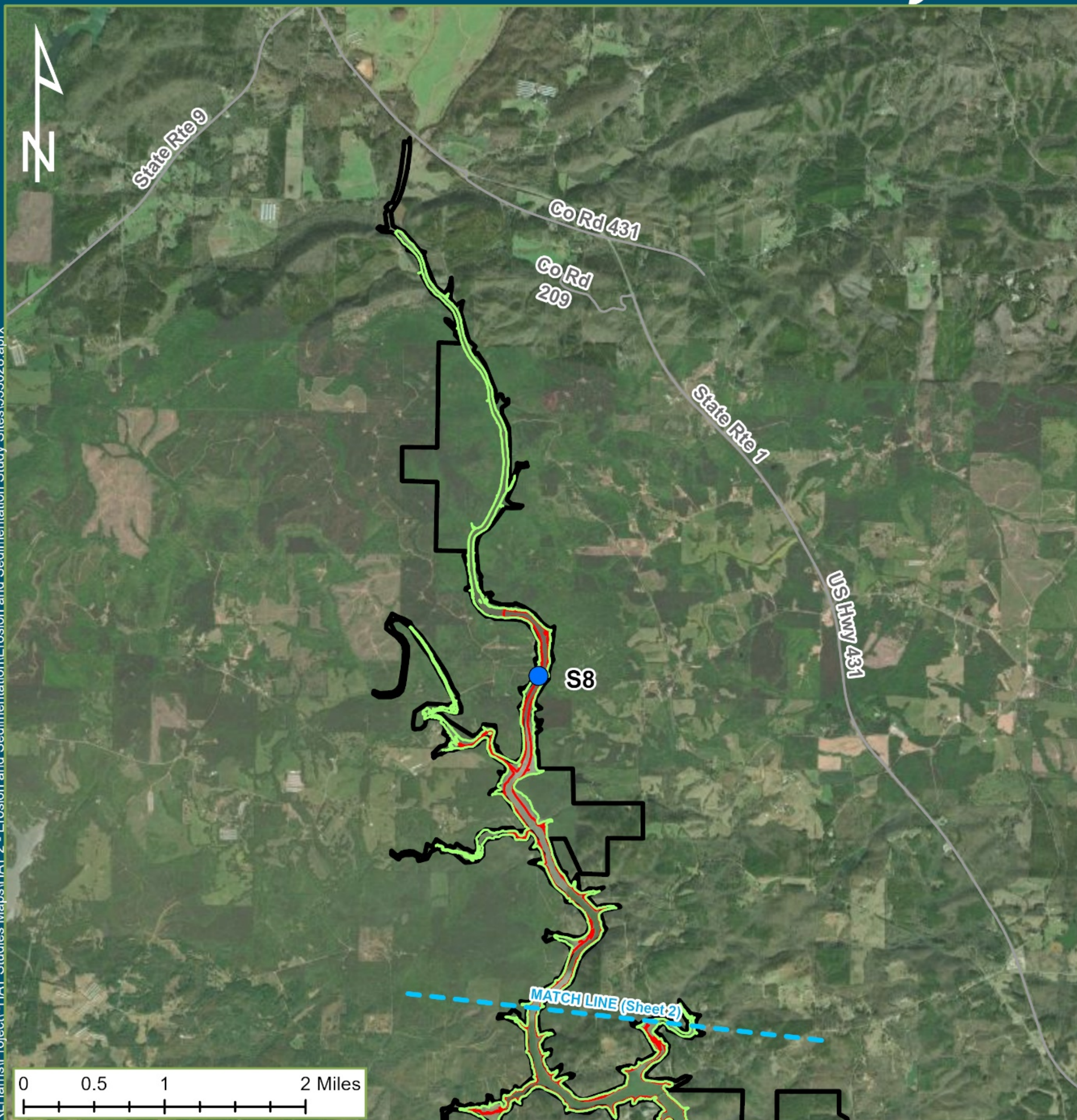
Erosion Site	Latitude	Longitude	Potential Cause of Erosion/ Sedimentation	Length (feet)	Width (feet)	Description of Exposed Soils	Adjacent Land Use
E1	33.39649	-85.44412	Natural Factor Independent of Operations, Land Use	100	20	Oc, Ochlockonee fine sandy loam	Agricultural, Exposed Roots or Root Undercutting, Leaning or Fallen Trees
E2	33.39618	-85.44512	Natural Factor Independent of Operations, Land Use	150	20	Oc, Ochlockonee fine sandy loam	Agricultural
E3	33.39448	-85.44763	Land Use	50	30	Oc, Ochlockonee fine sandy loam	Agricultural
E4	33.39253	-85.44797	Land Use	varying	N/A	Oc, Ochlockonee fine sandy loam	Early Successional Vegetation, Developed, Residential
E5	33.38870	-85.44677	Anthropogenic	100	10	Oc, Ochlockonee fine sandy loam	Unvegetated, Exposed Roots or Root Undercutting, Leaning or Fallen Trees, Residential
E6	33.38817	-85.45264	No active erosion	N/A	N/A	Oc, Ochlockonee fine sandy loam	N/A
E7	33.38399	-85.45285	Natural Factor Independent of Operations, Land Use	75	5	Bu, Buncombe loamy sand	Undeveloped Wooded, Exposed Roots or Root Undercutting, Leaning or Fallen Trees
E8	33.37972	-85.45260	Natural Factor Independent of Operations, Land Use	100	10	Bu, Buncombe loamy sand	Undeveloped Grassy
E9	33.37732	-85.45879	Natural Factor Independent of Operations, Land Use	450	5	LtE, Louisa stony sandy loam	Early Successional Vegetation, Exposed Roots or Root Undercutting, Leaning or Fallen Trees, Residential

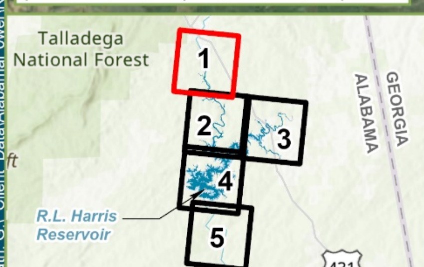
Erosion Site	Latitude	Longitude	Potential Cause of Erosion/ Sedimentation	Length (feet)	Width (feet)	Description of Exposed Soils	Adjacent Land Use
E10	33.37785	-85.45851	Natural Factor Independent of Operations, Land Use	150	5	Oc, Ochlockonee fine sandy loam	Early Successional Vegetation, Exposed Roots or Root Undercutting, Leaning or Fallen Trees, Residential
E11	33.38727	-85.47761	No active erosion	N/A	N/A	Mt, Mantachie fine sandy loam	N/A
E12	33.36759	-85.47331	No active erosion	N/A	N/A	Oc, Ochlockonee fine sandy loam	Developed
E13	33.36509	-85.47680	No active erosion	N/A	N/A	MaD3, Madison gravelly clay loam	Undeveloped Grassy, Roadway Embankment
E14	33.36407	-85.47728	Natural Factor Independent of Operations, Anthropogenic	N/A	N/A	Oc, Ochlockonee fine sandy loam	Undeveloped Wooded, Roadway Embankment
E15	33.37197	-85.49914	No active erosion	N/A	N/A	LgE, Louisa gravelly sandy loam	Developed, Wooded and Grassy, Residential
E16	33.37216	-85.50173	No active erosion	N/A	N/A	LtE, Louisa stony sandy loam	Undeveloped Grassy
E17	33.37371	-85.50122	No active erosion	N/A	N/A	Mt, Mantachie fine sandy loam	Undeveloped Grassy, Exposed Roots or Root Undercutting, Power Line Crossing
E18	33.35833	-85.49693	Land Use, Anthropogenic	300	5	LtE, Louisa stony sandy loam	Developed, Grassy
E19	33.35334	-85.50611	Land Use, Anthropogenic	150	3	LtE, Louisa stony sandy loam	Early Successional Vegetation, Exposed Roots or Root Undercutting, Developed Grassy
E20	33.35544	-85.51280	No active erosion			LtE, Louisa stony sandy loam	Undeveloped Grassy
E21	33.33941	-85.55814	Anthropogenic	100	2	MdC2, Madison gravelly fine sandy loam	Exposed Roots or Root Undercutting, Residential Grass Cutting

Erosion Site	Latitude	Longitude	Potential Cause of Erosion/ Sedimentation	Length (feet)	Width (feet)	Description of Exposed Soils	Adjacent Land Use
E22*	33.19603	-85.57649	Natural Factor Independent of Operations, Land Use	30	4	Oc, Ochlockonee fine sandy loam	Developed, Grassy, Early Successional Vegetation, Exposed Roots or Root Undercutting, Leaning or Fallen Trees
E23*	33.18490	-85.58503	Land Use	400	10	Oc, Ochlockonee fine sandy loam	Agricultural, Grassy, Early Successional Vegetation, Exposed Roots or Root Undercutting, Leaning or Fallen Trees
E24	33.34779	-85.51483	Anthropogenic	30	5	DaD3, Davidson gravelly clay loam	Undeveloped Wooded, Exposed Roots or Root Undercutting, Leaning or Fallen Trees

* Located downstream of Harris Dam

Erosion and Sedimentation Study Sites





Legend

- Project Boundary
- Match Line
- 785' Contour
- Study Sites
- 793' Contour
- Erosion
- Major Roads
- Sedimentation

Alabama Power

FERC No. 2628

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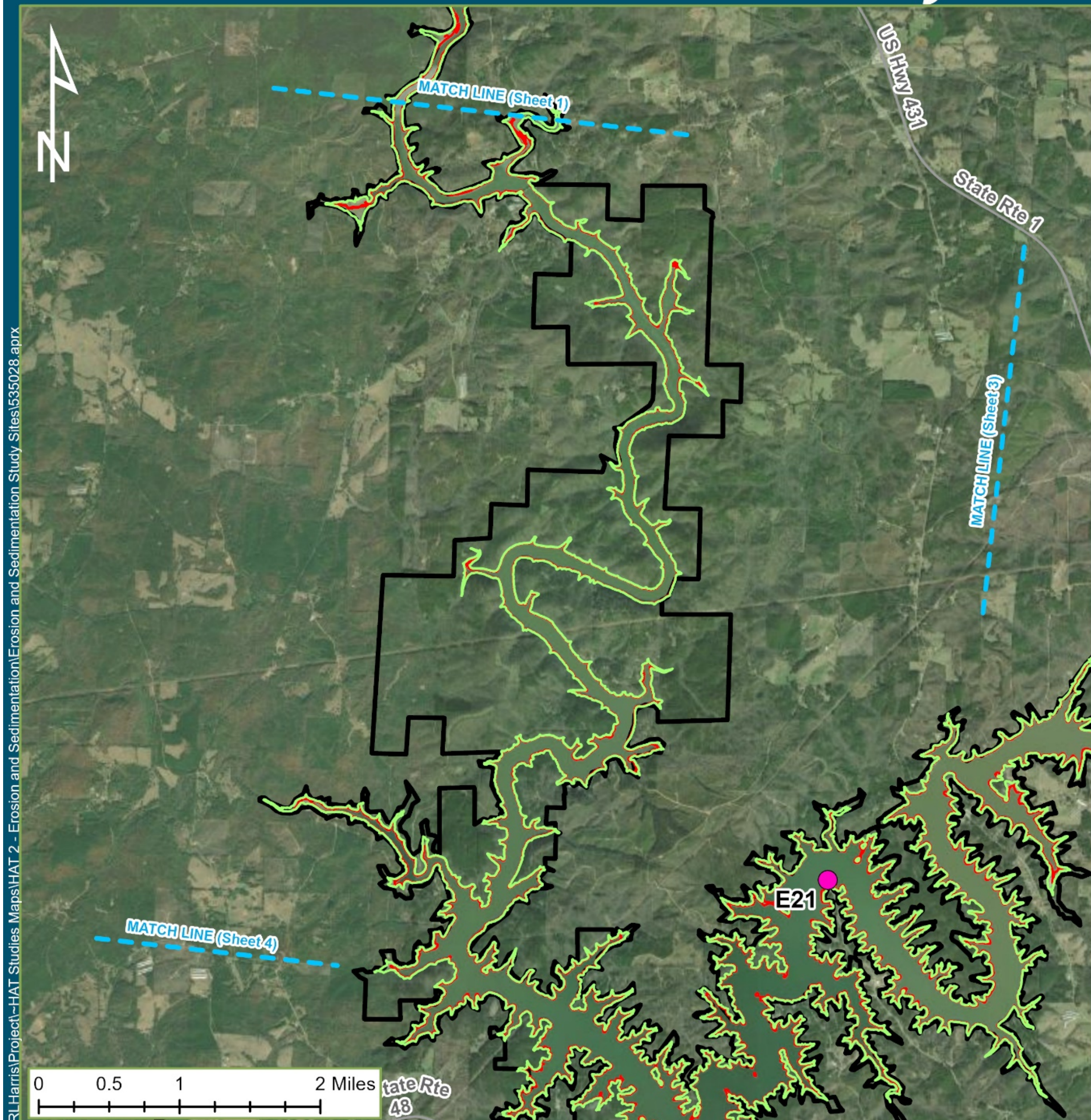
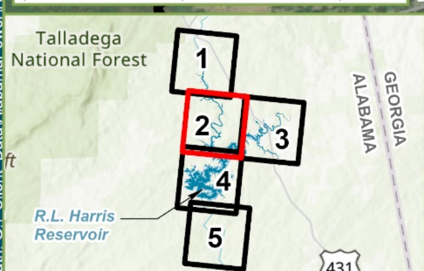
Date Printed: 7/22/2021

Source: Erosion/Sedimentation Locations (Alabama Power, 2019), Project Boundary (Alabama Power, 2019), Aerial Imagery (ESRI, 2020)

PN: 535028.01

Erosion and Sedimentation Study Sites





Legend

Project Boundary

Match Line

785' Contour

793' Contour

Major Roads

Study Sites

Erosion

Sedimentation

Alabama Power

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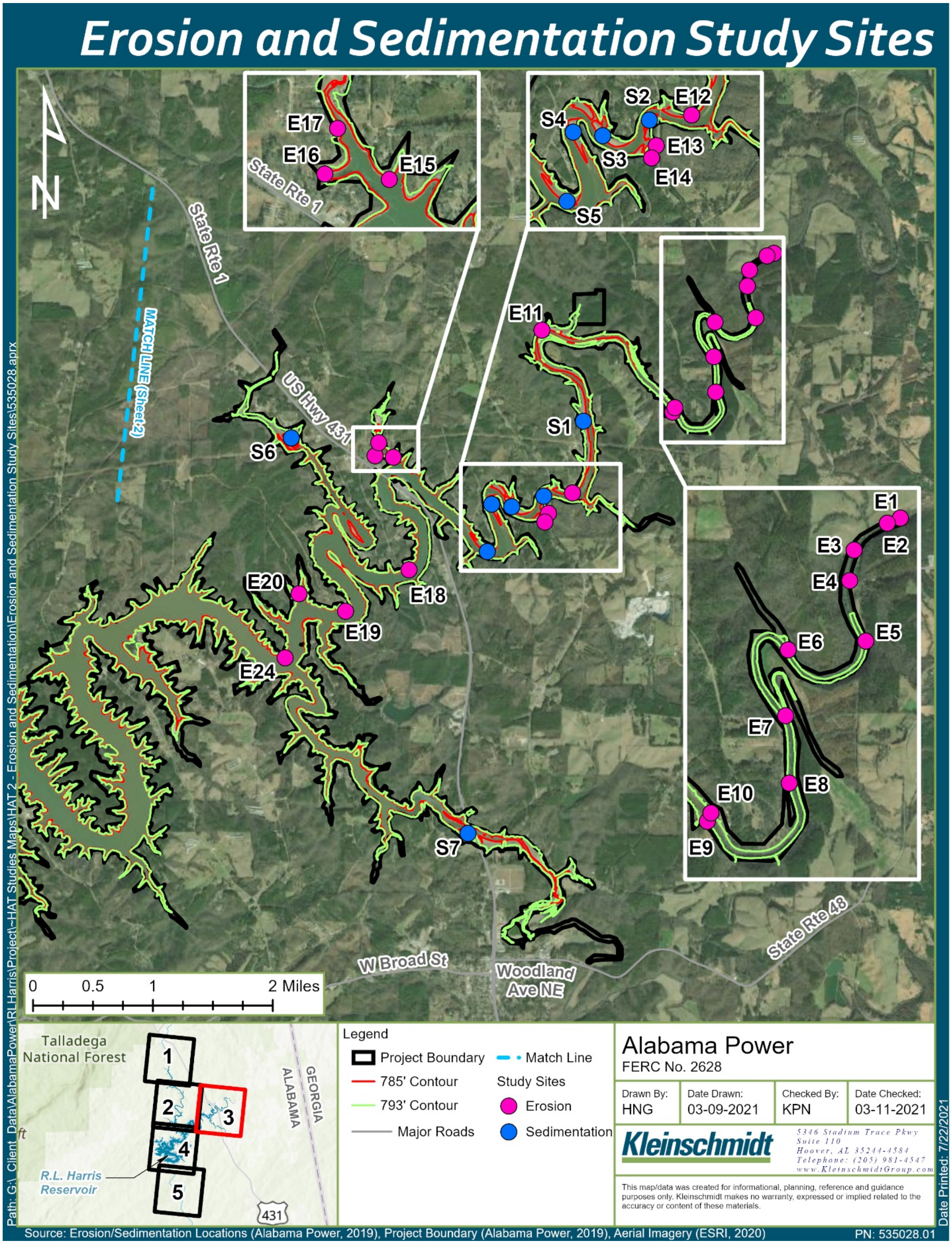

Erosion and Sedimentation Study Sites
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MATCH LINE (Sheet 2)
State Rte 1
US Hwy 431
State Rte 48
W Broad St
Woodland Ave NE
E1
E2
E3
E4
E5
E6
E7
E8
E9
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E12
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S6
S7
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Talladega National Forest
R.L. Harris Reservoir
ALABAMA
GEORGIA
431
1
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Legend
Project Boundary
Match Line
785' Contour
793' Contour
Major Roads
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Erosion
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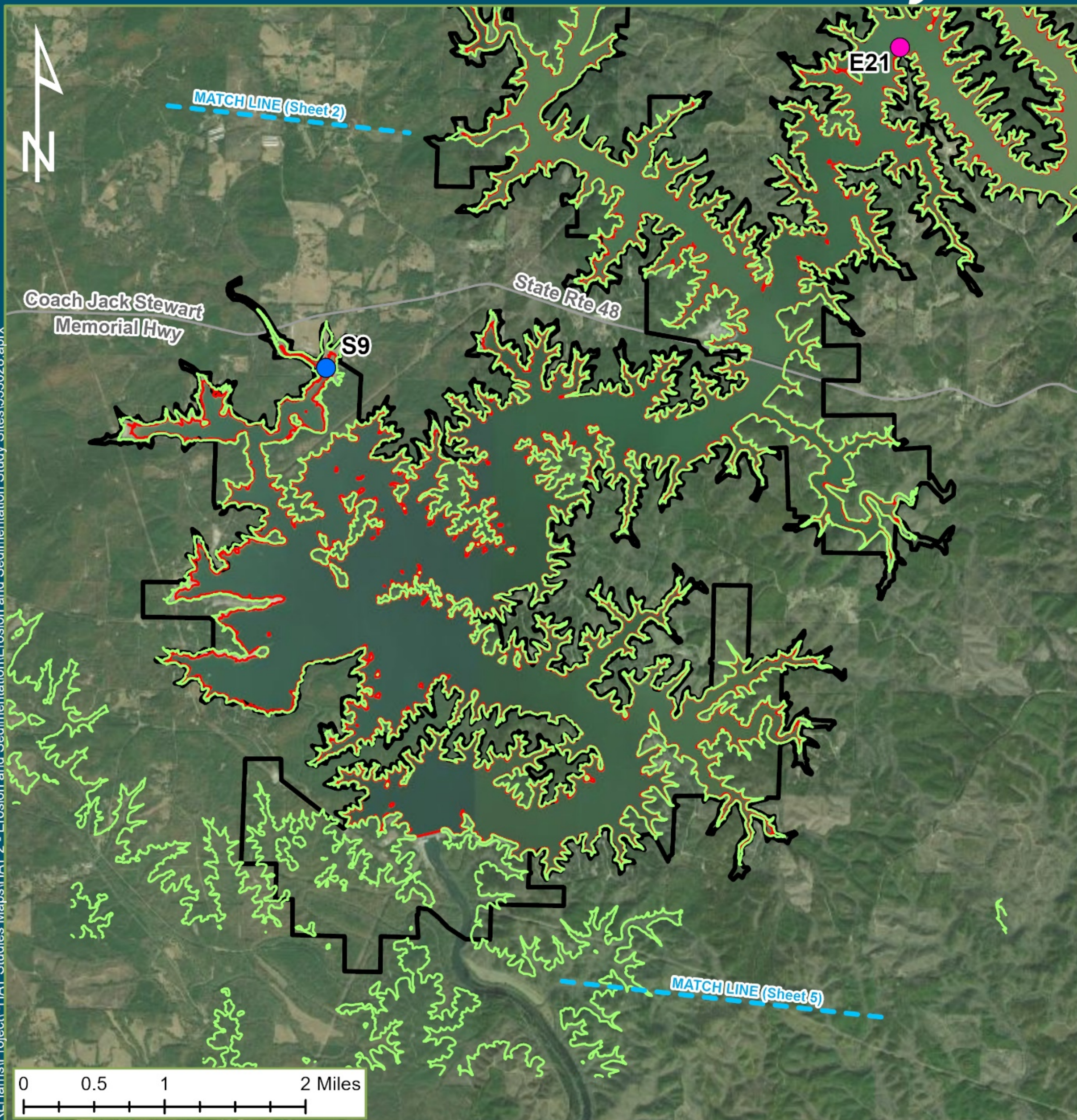

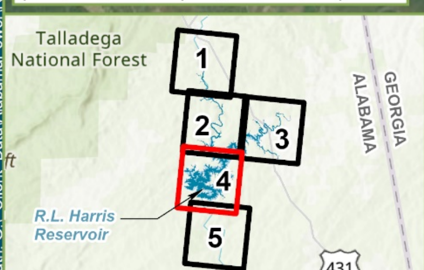

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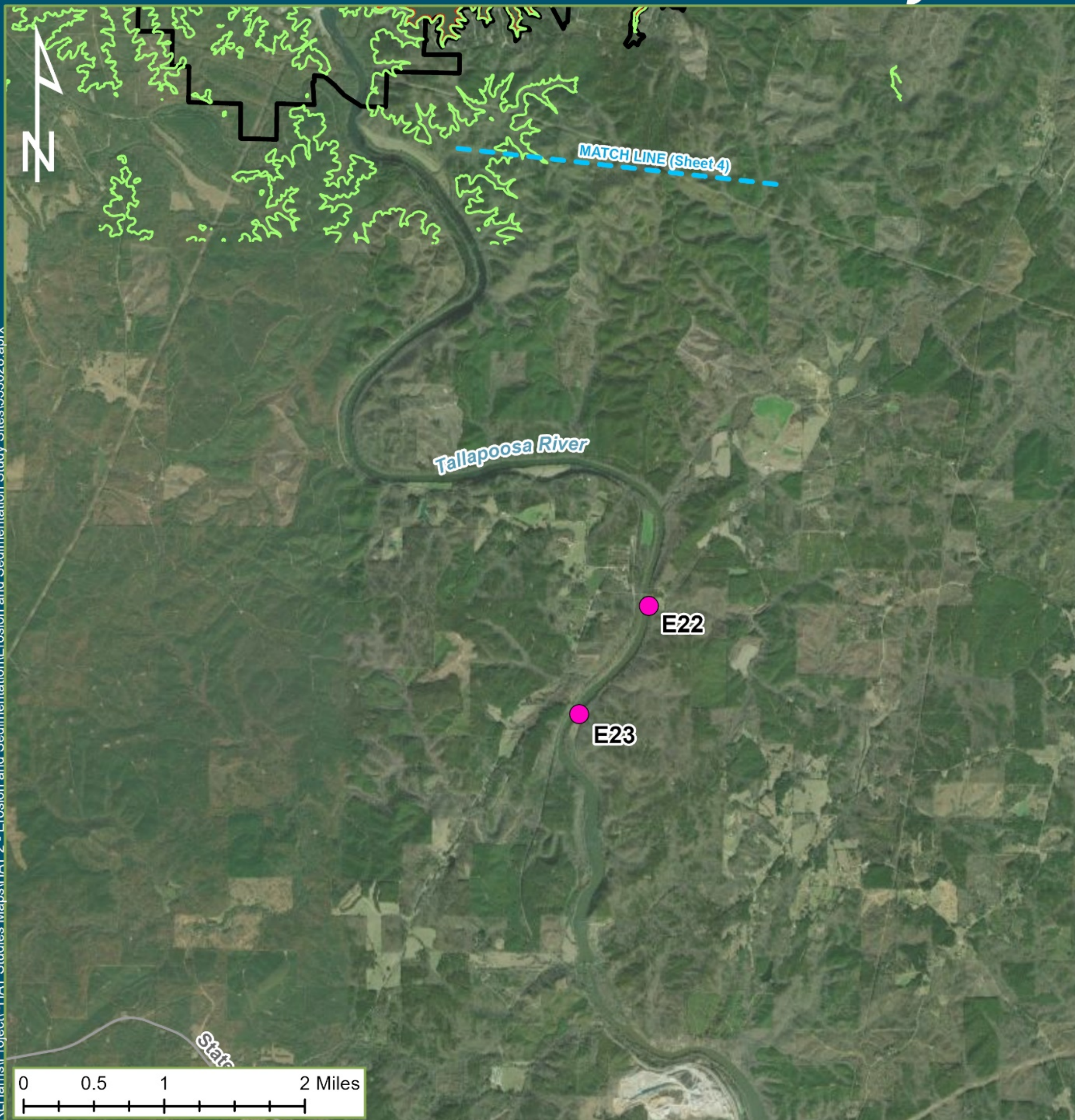

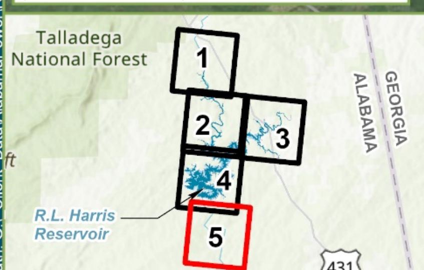

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APPENDIX E

WADING AND/OR OVERWINTERING BIRD SPECIES POTENTIALLY OCCURRING IN THE HARRIS PROJECT VICINITY

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Anatidae	Canada Goose	*Branta Canadensis*	X	Fairly common in all seasons	Freshwater marshes, agricultural fields, and on lakes
Anatidae	Wood Duck	*Aix sponsa*	X	Common in all seasons	Wooded swamps, beaver ponds, bottomlands, creeks, and lakes
Anatidae	Gadwall	*Anas strepera*		Fairly common in winter and uncommon in fall and spring	Shallow freshwater ponds and lakes with abundant aquatic vegetation
Anatidae	American Wigeon	*Anas Americana*		Fairly common in winter, spring, and fall	Shallow freshwater ponds and lakes with abundant aquatic vegetation
Anatidae	Mallard	*Anas platyrhynchos*	X	Common in winter, fairly common in spring and fall, and uncommon in summer	Shallow water of ponds, lakes, and flooded fields
Anatidae	Blue-winged Teal	*Anas discors*		Common to fairly common in spring and fall	Shallow freshwater ponds, sloughs, creeks, and on lake mudflats
Anatidae	Northern Shoveler	*Anas clypeata*		Common in winter, spring, and fall	Freshwater ponds, swamps, and on lakes
Anatidae	Northern Pintail	*Anas acuta*		Fairly common in winter, spring, and fall	Freshwater marshes, agricultural fields, and shallow portions of lakes, ponds, and rivers
Anatidae	Green-winged Teal	*Anas cerci*		Common in winter, spring, and fall	Shallow freshwater marshes, and on creeks, lakes, and mudflats
Anatidae	Ring-necked Duck	*Aythya collaris*		Common in winter, early spring, and late fall	Shallow, wooded, freshwater ponds, swamps, and lakes
Anatidae	Lesser Scaup	*Aythya affinisthrus*		Fairly common in winter, spring, and fall	Larger lakes and rivers
Anatidae	Bufflehead	*Bucephala albeola*		Common in winter, early spring, and late fall	Larger lakes and slow-moving rivers
Anatidae	Hooded Merganser	*Lophodytes cucullatus*	X	Fairly common in winter, spring, and fall, and rare in summer	Wooded freshwater ponds, lakes, and slow water river systems
Anatidae	Ruddy Duck	*Oxyura jamaicensis*		Fairly common in winter	Freshwater ponds, lakes, and slow-moving rivers

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Phasianidae	Wild Turkey	*Meleagris gallopavo*	X	Fairly common in all seasons	Forested and partially forested habitats
Odontophoridae	Northern Bobwhite	*Colinus virginianus*	X	Fairly common in all seasons in early successional habitats	Farms, along woodland edges, recently cut-over forest land, and in open country habitats dominated by old fields
Podicipedidae	Pied-billed Grebe	*Podilymbus podiceps*	X	Fairly common in spring, winter, and fall	Lakes and marshy ponds
Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*		Fairly common in fall, winter, and spring and uncommon in summer	Larger lakes, ponds, and rivers
Ardeidae	Great Blue Heron	*Ardea herodias*	X	Common in all seasons	Shallow water of ponds, lakes, and rivers
Ardeidae	Great Egret	*Ardea alba*	X	Common to fairly common in spring, summer, but uncommon to rare in winter	Shallow water of ponds, lakes, and rivers
Ardeidae	Little Blue Heron	*Egretta caerulea*	X	Rare to uncommon in spring to mid-summer, but fairly common in late summer and early fall	Shallow water of ponds, lakes, and rivers
Ardeidae	Green Heron	*Butorides virescens*	X	Common in spring, summer, and fall, but rare in winter	Edge of ponds, lakes, and rivers
Cathartidae	Black Vulture	*Coragyps atratus*	X	Common throughout year	Agricultural and livestock areas
Cathartidae	Turkey Vulture	*Cathartes aura*	X	Common in all seasons and regions	Wooded as well as open areas
Accipitridae	Northern Harrier	*Circus cyaneus*		Fairly common in winter, spring, and fall	In and over old fields, marshes, meadows, and grasslands
Accipitradae	Red-shouldered Hawk	*Buteo lineatus*	X	Fairly common in all seasons	Moist woodlands and swamps
Accipitradae	Red-tailed Hawk	*Buteo jamaicensis*	X	Common winter and fairly common in spring, summer, and fall	Open country and woodland edges
Falconidae	American Kestrel	*Falco sparverius*	X	Common in winter, fairly common in spring and fall, but rare in summer	Open fields and woodland edges

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Rallidae	American Coot	*Fulica Americana*		Common in winter, common to uncommon in spring and fall, and rare in summer	Rivers, ponds, lakes, and swamps
Charadriidae	American Golden-Plover	*Pluvialis dominica*		Fairly common in spring and uncommon to rare in fall	Short grasslands, flooded fields and on mudflats of lakes, ponds, and rivers
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*		Fairly common in spring and fall, and occasional in early winter	Mudflats of lakes, ponds, and rivers
Charadriidae	Killdeer	*Charadrius vociferous*	X	Common in all seasons	Short-grass fields, and mudflats and shorelines of lakes, ponds, and rivers
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*		Fairly common in spring and fall, but uncommon in winter and late summer	Along shorelines of shallow ponds and lakes, marsh edges, in flooded fields, and on mudflats
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*		Common in spring and fall, rare in winter, uncommon to rare in summer	Along shorelines of shallow ponds and lakes, marsh edges, in flooded fields and on mudflats
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	X	Common in spring, late summer, and fall, but rare in winter	Along pond and lake margins, stream banks, and on mudflats
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*		Common in spring, late summer, and fall	Along lake borders, stream banks, ponds, and marsh edges
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*		Fairly common in spring and fall, and uncommon in late summer	On mudflats, and along pond edges and lakeshores
Scolopacidae	Least Sandpiper	*Calidris minutilla*		Common in spring, fairly common in fall, uncommon in winter and late summer, and occasional in early summer	On mudflats, and along pond edges and lakeshores
Scolopacidae	Pectoral Sandpiper	*Calidris melanotos*		Common in spring and fall, and uncommon in late summer	Wet meadows, flooded fields, on mudflats, and along shores of ponds, pools, and lakes
Scolopacidae	Common Snipe	*Gallinago*		Common in winter, spring, and fall	Marshes and wet grassy areas
Scolopacidae	American Woodcock	*Scolopax minor*	X	Fairly common in fall and winter, and occasional in spring	Moist shrubby woods, floodplains, thickets, and at edges of swamps

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Laridae	Ring-billed Gull	*Larus delawarensis*		Fairly common in winter, spring, and fall, and occasional in summer	Summer rivers, lakes, irrigated and plowed fields, and garbage dumps
Columbidae	Rock Pigeon	*Columba livia Exotic*	X	Common in all seasons	In cities, and on farms, bridges, cliffs
Columbidae	Mourning Dove	*Zenaida macroura*	X	Common in all seasons	Farms, and in towns, woodlots, agricultural fields, and grasslands
Strigidae	Eastern Screech-Owl	*Megascops asio*	X	Common in all seasons	Woodlands, especially near open areas
Strigidae	Great Horned Owl	*Bubo virginianus*	X	Fairly common in all seasons	Woodlands, parklands, and occasionally in wooded suburbs
Strigidae	Barred Owl	*Strix varia*	X	Common in all seasons	Moist woodlands and wooded swamps
Alcedinidae	Belted Kingfisher	*Ceryle alcyon*	X	Common in all seasons	Along wooded rivers, streams, lakes, ponds, and in marshes
Picidae	Red-bellied Woodpecker	*Melanerpes carolinus*	X	Common in all seasons	Woodlands
Picidae	Yellow-bellied Sapsucker	*Sphyrapicus varius*		Fairly common in winter, spring, and fall	Mixed hardwood and conifer forests
Picidae	Downy Woodpecker	*Picoides pubescens*	X	Common in all seasons	Woodlands, orchards, suburban areas, parks, and farm woodlots
Picidae	Red-cockaded Woodpecker	*Picoides borealis*	X	Rare and isolated in all seasons	Old growth pine with open mid-story
Picidae	Northern Flicker	*Colaptes auratus*	X	Fairly common in all seasons and regions	Open woodlands and fields, and on lawns and open meadows with large trees
Picidae	Pileated Woodpecker	*Dryocopus pileatus*	X	Fairly common in all seasons	Mature woodlands with coniferous and hardwood trees
Tyrannidae	Eastern Wood-Pewee	*Contopus virens*	X	Common to fairly common in spring, summer, and fall	Open woodlands, parks, and along forest edges
Tyrannidae	Eastern Phoebe	*Sayornis phoebe*	X	Common in winter, spring, and fall	Open deciduous woodlands near bridges, cliffs, and eaves

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Laniidae	Loggerhead Shrike	*Lanius ludovicianus*	X	Fairly common in winter, spring, and fall, and uncommon in summer	Open country with scattered trees and shrubs, and in hedgerows along agricultural fields
Corvidae	Blue Jay	*Cyanocitta cristata*	X	Common in all seasons	Forests, open woodlands, wooded residential areas, and parks
Corvidae	American Crow	*Corvus brachyrhynchos*	X	Common	All woodlands, farmlands, and suburban areas
Corvidae	Fish Crow	*Corvus ossifragus*	X	Fairly common to locally common in all seasons	Around swamplands, riverine areas, large lakes, urban and suburban areas, and farmlands
Hirundinidae	Tree Swallow	*Tachycineta bicolor*	X	Common in fall, fairly common in spring, and rare in winter and summer	Open areas, and over ponds and lakes; nests in cavities in dead, standing timber and boxes
Paridae	Carolina Chickadee	*Poecile carolinensis*	X	Common in all seasons	Woodlands and wooded suburbs
Paridae	Tufted Titmouse	*Baeolophus bicolor*	X	Common in all seasons	Woodlands and wooded suburbs
Sittidae	Brown-headed Nuthatch	*Sitta pusilla*	X	Locally common in all seasons	Open pine forests
Troglodytidae	Carolina Wren	*Thryothorus ludovicianus*	X	Common in all seasons	Thickets in woodlands, farmlands, and suburbs
Troglodytidae	House Wren	*Troglodytes aedon*	X	Fairly common in fall, uncommon in spring, and rare in winter and summer	Farmlands, thickets, and suburban yards with dense hedgerows
Regulidae	Golden-crowned Kinglet	*Regulus satrapa*		Common in winter, spring, and fall	Woodlands, especially with conifers
Regulidae	Ruby-crowned Kinglet	*Regulus calendula*		Common in winter, spring, and fall	Woodlands
Sylviidae	Blue-gray Gnatcatcher	*Polioptila caerulea*	X	Common in spring, summer, and fall, and rare in winter	Open woodlands, forest edges, and tree-lined fence rows

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Turdidae	Eastern Bluebird	*Sialia sialis*	X	Common in all seasons	Open rural areas, farmlands, fence rows, open suburban areas, and parks with scattered trees
Turdidae	Hermit Thrush	*Catharus guttatus*		Common in winter, spring, and fall	Woodlands with dense undergrowth
Turdidae	American Robin	*Turdus migratorius*	X	Common in all seasons	Short grass areas with scattered trees
Mimidae	Northern Mockingbird	*Mimus polyglottos*	X	Common in all seasons	Openings with short grass, scattered shrubs, and trees
Mimidae	Brown Thrasher	*Toxostoma rufum*	X	Common in all seasons	Short ground cover vegetation near dense thickets, hedgerows, and shrubs
Motacillidae	American Pipit	*Anthus rubescens*		Fairly common in winter, spring, and fall	Open country, especially on plowed fields and mudflats
Bombycillidae	Cedar Waxwing	*Bombycilla cedrorum*	X	Common in winter, spring, and fall, and occasional in summer	Areas with trees and shrubs that produce fruits, such as hackberry, mulberry, cedar, cherry, and holly
Parulidae	Yellow-throated Warbler	*Dendroica dominica*	X	Fairly common in spring, summer, and fall, and occasional in winter	Older pine forests, and woodlands with sycamores, especially near water; in migration, found in woodlands
Parulidae	Pine Warbler	*Dendroica pinus*	X	Common in all seasons	Mature pine woodlands
Parulidae	Prairie Warbler	*Setophaga discolor*	X	Common in spring, summer, and fall, and occasional in winter	Brushy early successional growth, particularly regenerating clear cuts
Parulidae	Palm Warbler	*Dendroica palmarum*		Common in spring, fairly common in fall, and rare in winter	Open areas with scattered shrubs and trees
Parulidae	Common Yellowthroat	*Geothlypis trichas*	X	Common in spring, summer, and fall, and rare in winter	Along woodland edges, and in hedgerows, thickets, marshes, and wet meadows
Parulidae	Yellow-breasted Chat	*Icteria virens*	X	Common in spring, summer, and fall, and occasional in winter	Early successional growth areas
Thraupidae	Summer Tanager	*Piranga rubra*	X	Common in spring, summer, and fall, and occasional in winter	In breeding season, found in open, mixed hardwood-coniferous forests and along forest edges

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Emberizidae	Eastern Towhee	*Pipilo erythrophthalmus*	X	Common in all seasons	Brushy woodlands and early successional growth
Emberizidae	Chipping Sparrow	*Spizella passerine*	X	Common in all seasons	Open areas with short grass and scattered trees, especially conifers
Emberizidae	Field Sparrow	*Spizella pusilla*	X	Common to fairly common in all seasons	Early successional growth areas, especially with dense ground cover
Emberizidae	Savannah Sparrow	*Passerculus sandwichensis*		Common in winter, spring, and fall	Open grassy fields
Emberizidae	Song Sparrow	*Melospiza melodia*	X	Common in winter, spring, and fall, and uncommon to rare in summer	Open brushy and weedy areas
Emberizidae	Swamp Sparrow	*Melospiza Georgiana*		Common to fairly common in winter, spring, and fall	Freshwater marshes, and shrubby and weedy areas, especially near water
Emberizidae	White-throated Sparrow	*Zonotrichia albicollis*		Common in winter, spring, and fall, and rare in summer	Thickets and shrubby areas
Emberizidae	Dark-eyed Junco	*Junco hyemalis*		Common in winter, spring, and fall, and occasional in summer	Open woodlands, and brushy and grassy areas
Cardinalidae	Northern Cardinal	*Cardinalis*	X	Common in all seasons	Shrubby areas, hedgerows, thickets, and suburban gardens
Cardinalidae	Indigo Bunting	*Passerina cyanea*	X	Common in spring, summer, and fall, and occasional in winter	Brushy and weedy area, in early successional stages and woodland openings, and along woodland and field borders
Icteridae	Red-winged Blackbird	*Agelaius phoeniceus*	X	Common in all seasons	Marshes, and brushy, weedy, and grassy areas, especially when wet
Icteridae	Eastern Meadowlark	*Sturnella magna*	X	Common in all seasons	Grassy, weedy fields, especially high grass
Icteridae	Common Grackle	*Quiscalus quiscula*	X	Common in all seasons	Open woodlands, especially those with pines and grassy areas; also fields with short grasses or in cultivated fields
Icteridae	Brown-headed Cowbird	*Molothrus ater*	X	Common in all seasons	Open areas, especially with livestock

Family	Common Name	Scientific Name	Breeds in Project Area	Abundance/ Seasonality	Habitat
Icteridae	Baltimore Oriole	*Icterus galbula*	X	Fairly common in spring and fall, but rare in summer and winter	In breeding season, found in open areas, with scattered trees, especially near water. In migration, found in woodlands
Fringillidae	House Finch	*Carpodacus mexicanus*	X	Common in all seasons	Open woodlands
Fringillidae	American Goldfinch	*Carduelis tristis*	X	Common in winter, spring, and fall	Open woodlands, brushy areas, and willow thickets
Passeridae	House Sparrow	*Passer domesticus Exotic*	X	Common in all seasons	Urban and suburban areas, and open farmland

Source: Alabama Power and Kleinschmidt 2018

APPENDIX F

AMPHIBIAN SPECIES POTENTIALLY OCCURRING IN THE HARRIS PROJECT VICINITY

Family	Common Name	Scientific Name	Abundance in Project Area	Habitat
Amphibians				
Bufonidae	American Toad	*Bufo americanus*	Common	Upland forests, suburban areas
Bufonidae	Fowler's Toad	*Bufo woodhousii*	Common	Sandy areas around shores of lakes, or in river valleys
Hylidae	Northern Cricket Frog	*Acris crepitans*	Common	Creekbanks, lakeshores, and mudflats
Hylidae	Cope's Gray Treefrog	*Hyla chrysoscelis*	Common	Small trees or shrubs, typically over standing water; on ground or at water's edge during breeding season
Hylidae	Green Treefrog	*Hyla cinerea*	Moderately common	Permanent aquatic habitats
Hylidae	Mountain Chorus Frog	*Pseudacris brachyphona*	Moderately common	Forested areas in most of northern Alabama
Hylidae	Northern Spring Peeper	*Pseudacris crucifer*	Common	Ponds, pools, and swamps
Hylidae	Upland Chorus Frog	*Pseudacris triseriata feriarum*	Moderately common	Grassy swales, moist woodlands, river-bottom swamps, and environs of ponds, bogs, and marshes
Microhylidae	Eastern Narrow-mouthed Toad	*Gastrophyrne carolinensis*	Common	Variety of habitats providing suitable cover and moisture, including under logs and or leaf litter
Pelobatidae	Eastern Spadefoot Toad	*Scaphiopus holbrooki*	Moderately	Forested areas of sandy or loose soil
Ranidae	Bullfrog	*Rana catesbeiana*	Common	Permanent aquatic habitats
Ranidae	Bronze Frog	*Rana clamitans spp.*	Moderately common	Rocks, stumps, limestone crevices of stream environs, bayheads and swamps
Ranidae	Wood Frog	*Rana sylvatica*	Uncommon	Moist wooded areas
Ranidae	Southern Leopard Frog	*Rana pipiens sphenocephala*	Moderately common, believed to be declining	All types of aquatic to slightly brackish habitats
Ambystomatidae	Spotted Salamander	*Ambystoma maculatum*	Moderately common, believed to be declining	Bottomland hardwoods, woodland pools
Ambystomatidae	Marbled Salamander	*Ambystoma opacum*	Common	Bottomland hardwoods, woodland pools

Family	Common Name	Scientific Name	Abundance in Project Area	Habitat
Plethodontidae	Spotted Dusky Salamander	*Desmongnathus conanti*	Common	Damp habitats, seepage areas
Plethodontidae	Southern Two-lined Salamander	*Eurycea cirrigera*	Common	Shaded aquatic habitats
Plethodontidae	Three-lined Salamander	*Eurycea guttolineata*	Common	Shaded aquatic habitats, forested floodplains
Plethodontidae	Webster's Salamander	*Plethodon websteri*	Moderately common	Damp deciduous forest
Plethodontidae	Northern Slimy Salamander	*Plethodon glutinosus*	Common	Wide variety of habitats
Plethodontidae	Northern Red Salamander	*Pseudotriton ruber*	Common	Aquatic margins in forested areas
Salamandridae	Eastern Newt	*Notophthalmus viridescens louisianensis*	Moderately common	Terrestrial or aquatic habitats, depending on life stage
Salamandridae	Central Newt	*Notophthalmus viridescens*	Moderately common	Terrestrial or aquatic habitats, depending on life stage

Source: Alabama Power and Kleinschmidt 2018

APPENDIX G

QUALITATIVE DISCUSSION OF "EXTENDED SUMMER POOL" ALTERNATIVES

In an October 1, 2021 letter[1], FERC staff requested that Alabama Power provide a qualitative analysis of two additional operating curve alternatives in order to facilitate their review of stakeholder-recommended summer pool scenarios. The alternatives, as requested by FERC are:

(1) modify the operating curve to maintain the summer pool elevation of 793 feet from March 1 through October 31 (7 months) with adjusted winter pool elevation between January 1 and February 28 (2 months) at: (a) 785 feet; (b) 786 feet; (c) 787 feet; (d) 788 feet; and (e) 789 feet; and

(2) modify the operating curve to maintain the summer pool elevation of 793 feet from April 1 through October 31 (6 months) with adjusted winter pool elevation between January and March 31 (3 months) at: (a) 785 feet; (b) 786 feet; (c) 787 feet; (d) 788 feet; and (e) 789 feet.

FERC further requested that Alabama Power address the effects of these alternatives on: (1) structures downstream of Harris Dam; (2) water quality; (3) water use; (4) erosion and sedimentation; (5) aquatic resources; (6) wildlife and threatened and endangered species; (7) terrestrial wetlands; (8) recreation; and (9) cultural resources. Finally, FERC requested that the information be presented in an appendix to the Final *Operating Curve Change Feasibility Analysis (Phase 2) Report*.

As described by FERC in these two alternatives, the winter pool would last until February 28 and March 31, respectively and be full the following day, March 1 and April 1, respectively, which is not hydrologically possible. Therefore, for the following analysis, it is assumed that FERC intended the winter pool duration to be from December 1 until February 1 for the first alternative and December 1 until March 1 for the second alternative.

Figure 1 depicts the first alternative for an operating curve where the summer pool elevation of 793-ft msl is maintained from March 1 (begin filling on February 1) through October 31, along with a winter pool elevation of 785-ft msl through 789-ft msl (in 1-foot increments). The first alternative would result in a higher reservoir level compared to baseline during the month of February, as well as two additional months (March and April) when the reservoir would be maintained at its summer pool elevation. In addition, there

[1] Accession No. 20211001-3009.

would be a higher reservoir level for October through November, with reservoir levels declining during the month of November.

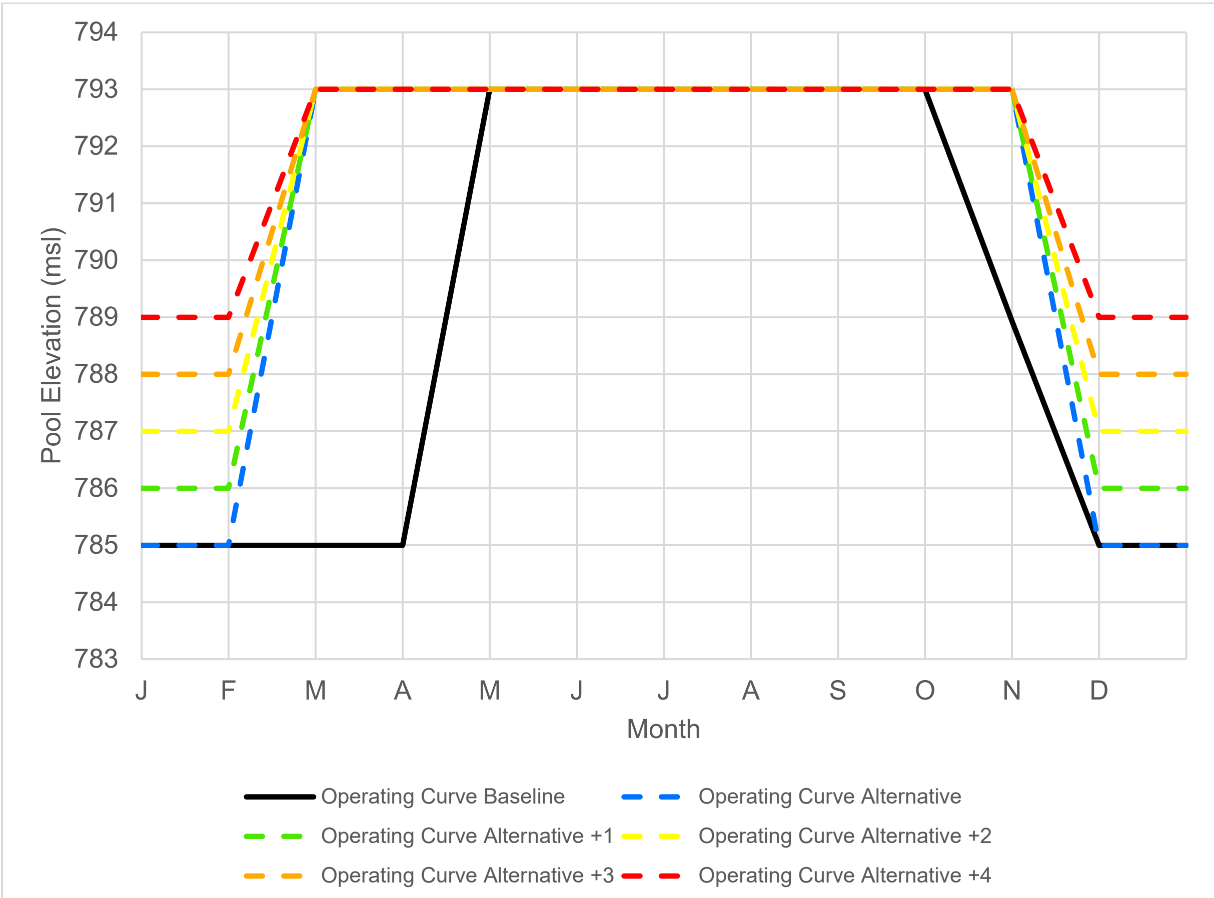

Figure 1 Summer Pool Extension Operating Curve Alternative 1

Figure 2 depicts the second alternative for an operating curve where the summer pool elevation of 793-ft msl is maintained from April 1 (begin filling on March 1) through October 31, along with a winter pool elevation of 785-ft msl through 789-ft msl (in 1-foot increments). The second alternative would result in a higher reservoir level compared to baseline reservoir elevation during the month of March, as well as one additional month (April) when the reservoir would be maintained at its summer pool elevation. In addition, there would be a higher reservoir level for October through November, with reservoir levels declining during the month of November.

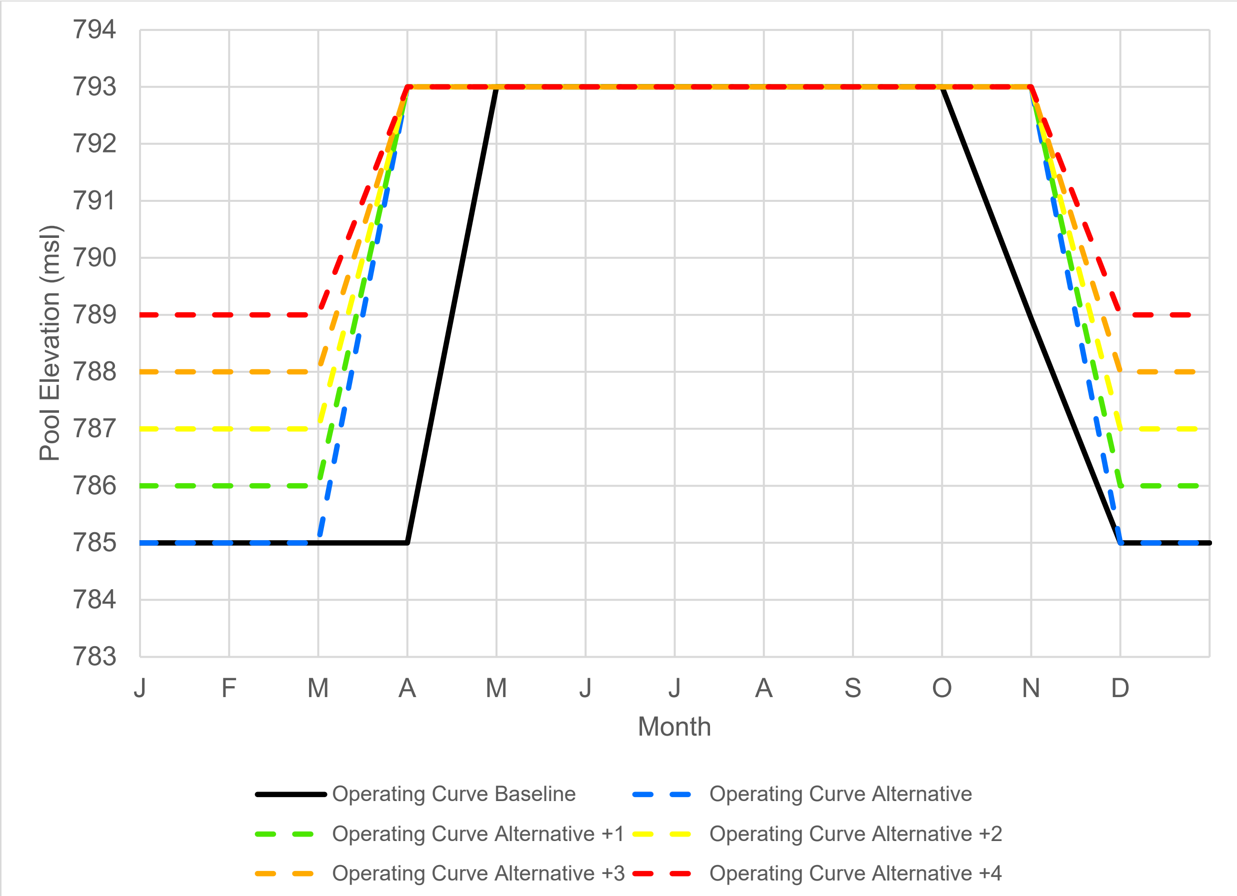

Figure 2 Summer Pool Extension Operating Curve Alternative 2

Filling the Harris Reservoir earlier in the year is problematic for two reasons: increased magnitude of flooding below Harris Dam and decreased ability of the reservoir to accommodate high flow events, resulting in an increase in the frequency of spillway operations and/or operating at plant capacity (i.e., 16,000 cfs or greater). During the months of March and April, the 1 percent chance of exceedance flow[2] is over 17,000 cfs. February and March also have the highest average monthly rainfall in the Tallapoosa River Basin (Figure 3). Approximately 80 percent of the flood-producing storms in the Tallapoosa Basin occur in the winter and spring months, of which approximately 27 percent occur in the month of March (Alabama Power 2020). Further, three of the largest storms on record, as recorded at the Heflin gage, occurred during March (see Appendix B of *the Operating Curve Feasibility Analysis Phase 1 Report*). Therefore, because in both alternatives the reservoir starts at a higher elevation during a spring rain event, there is a

[2] This refers to a flood level or peak that has a one in a hundred, or 1%, chance of being equaled or exceeded in any year.

greater probability of increased frequency of spillway operations and/or operating at plant capacity than would occur under the existing operating curve. Therefore, effects on downstream resources would be more likely to occur more frequently for these extended summer reservoir elevation alternatives compared to baseline. For example, downstream erosion could be exacerbated due to increased scour from higher channelized flows that would occur more frequently with Alternative 1 or 2.

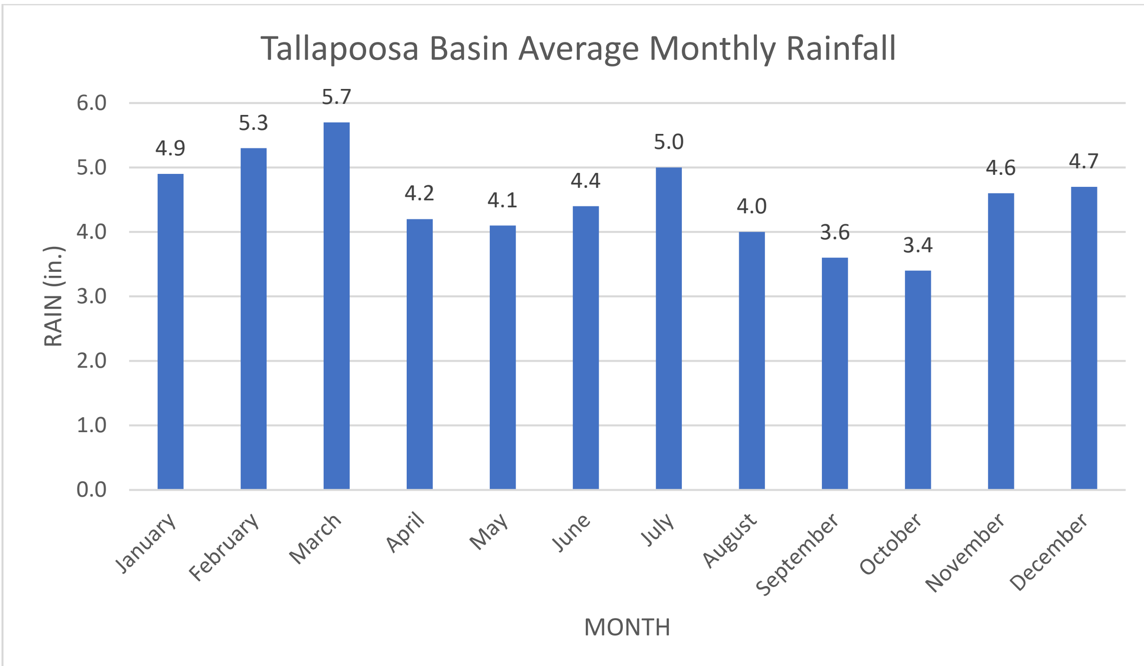

Figure 3 Tallapoosa Basin Average Monthly Rainfall

In the Operating Curve Change Feasibility Analysis Study, downstream flooding effects were calculated using the 100-Year Design Flood and the reservoir being at each of the higher winter pool alternatives. (786, 787, 788, and 789-ft msl). This design flood resulted in increased area, depth, and duration of flooding at points downstream of Harris Dam for each of these winter pool alternatives. If the design flood were to occur in February, March, or April (or October or November), when the reservoir would be higher due to an earlier fill or extended summer pool, the downstream flooding effects would be worse with additional acres inundated and potentially more structures affected. In other words, if the reservoir is higher than the highest starting reservoir elevation (789-ft msl), the downstream flooding effects would be worse than those modeled and calculated as part of the Study.

Holding the reservoir higher through October 31 may provide some benefit to reservoir related recreation. However, it is unlikely that, even if the operating curve was extended, the actual reservoir elevation in most years would be higher during the month of October due to the lack of inflow in the basin during July through September. In fact, September and October have the lowest average monthly rainfall for the Tallapoosa River Basin. Even with a higher winter operating curve, modeled average daily elevations were identical on October 1, as shown in Figure 4. Note that in higher inflow years, Alabama Power does maintain Harris reservoir at full pool until October 1. However, shortening the drawdown period to only one month (November 1 to December 1) may not allow adequate time to ensure the winter pool level is met by December 1, particularly in high inflow years.

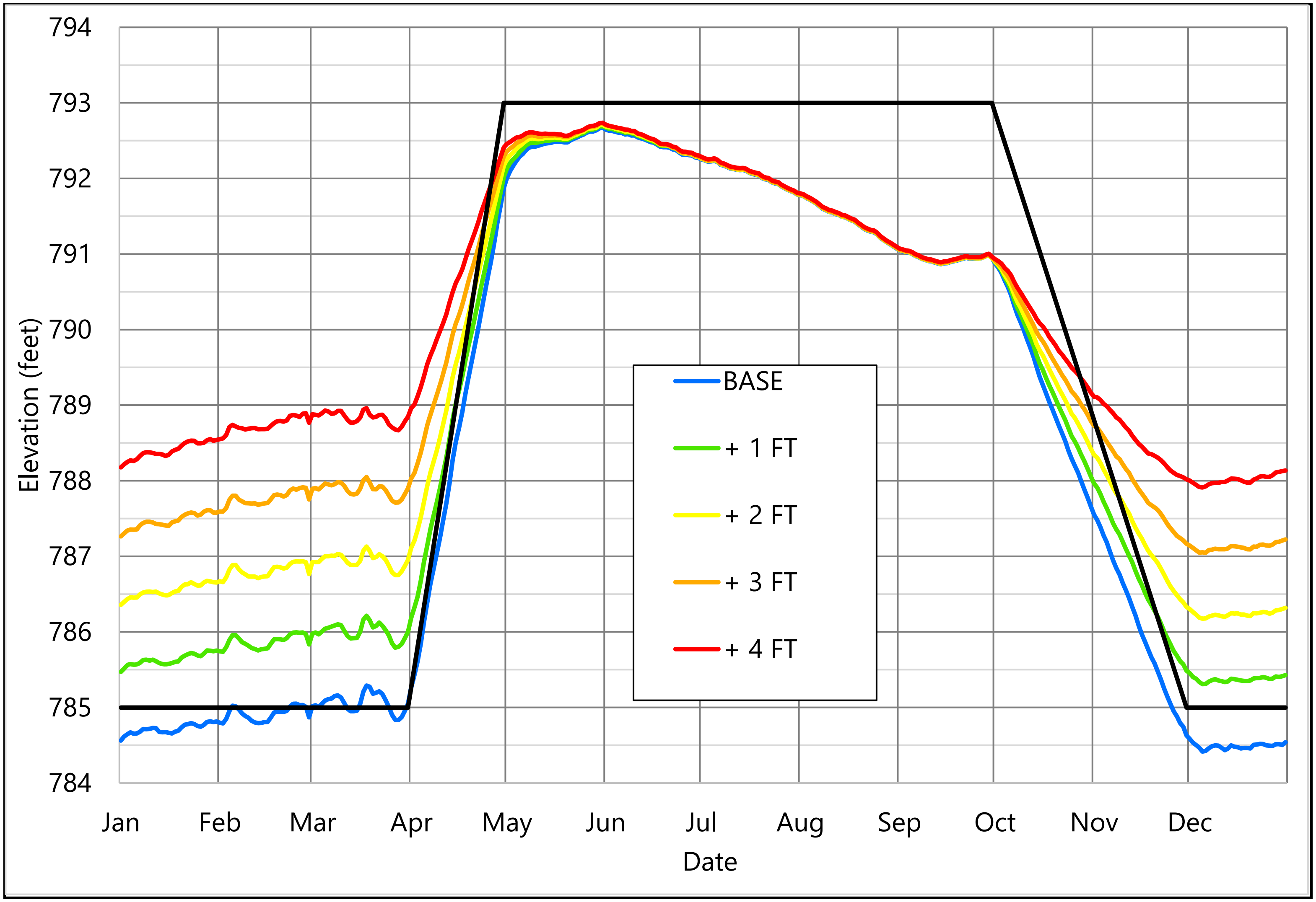

Figure 4 Average Daily Elevations for Operating Curve Alternatives

For all of these extended summer pool alternatives, the effects on resources would be the same as those analyzed and described in the *Operating Curve Change Feasibility Analysis Phase 1 and Phase 2 Reports*; however, these effects would be more likely to occur more frequently because the reservoir elevation would be higher during the wetter months of the year, resulting in an increase in the frequency of spillway operations and/or operating at plant capacity. A summary of the effects on resources from these extended summer pool alternatives is provided in Table 2.

Table 1 Effects on Resources from Extended Reservoir Elevation Alternatives

RESOURCE	SUMMARY OF EFFECT ON HARRIS RESERVOIR	SUMMARY OF EFFECT ON TALLAPOOSA RIVER DOWNSTREAM OF HARRIS DAM
Structures Downstream of Harris Dam	N/A	Additional acres inundated and potentially more structures affected during 100-Year Design Flood if starting reservoir elevation is higher than 789-ft msl
Water Quality	An increase in pool or extension of time at the full pool elevation could raise or keep the thermocline higher in the reservoir for longer compared to baseline.	An increase in elevation of the thermocline over baseline in the reservoir could result in the average temperature of the discharge being lower. This could also result in lower dissolved oxygen in releases from the Project.
Water Use	Increase in pool would mean more water is available during the winter and spring and could help reach full pool in the summer in dry years (e.g., years where the water level is low because of low flow or drought conditions).	No effect
Erosion and Sedimentation	Potential increase in boating in the winter and spring months may result in additional erosion; could increase size of sedimentation areas over time due to decreased "flushing" effect; an increase in sedimentation would also provide "habitat" for aquatic vegetation, some of which may be nuisance aquatic vegetation	Increased potential for scour associated with decreased ability of the reservoir to accommodate high flow events, resulting in an increase in the frequency of spillway operations and/or operating at plant capacity; no effect on sedimentation
Aquatic Resources	Increase in wetted area of reservoir could lead to increased productivity	The decreased ability of the reservoir to accommodate high flow events during the spring months, resulting in an increase in the frequency of spillway

RESOURCE	SUMMARY OF EFFECT ON HARRIS RESERVOIR	SUMMARY OF EFFECT ON TALLAPOOSA RIVER DOWNSTREAM OF HARRIS DAM
		operations and/or operating at plant capacity, could impact spawning sites and spawning behavior.
Wildlife and Threatened and Endangered Species	Increase in shallow littoral habitats	No effect
Terrestrial Wetlands	Could alter composition of existing wetlands and increase their size	No effect
Recreation	Increase in usable structures during February, March, April, October, and November depending on reservoir elevation	Maximum depth of inundation at formal recreation sites would increase; duration of time above baseline ground elevation would decrease (during 100-Year Design Flood if starting reservoir elevation is higher than 789-ft msl)
Cultural Resources	Otherwise exposed cultural resources would be inundated at higher reservoir elevations and less susceptible to water fluctuation, wind erosion, recreational activities, and looting (vandalism), but more susceptible to erosion from variations in currents, general flow pattern fluctuations, and aquatic species nesting activities	Based on the decreased ability of the reservoir to accommodate high flow events during the spring months, results in an increase in the frequency of spillway operations and/or operating at plant capacity; known cultural resources could experience scour and removal of overlying protective vegetation due to increased inundation

References

Alabama Power Company (Alabama Power). 2020. R.L. Harris Hydro Electric Plant Supporting Technical Information Revision 3 – September 2020. Alabama Power Company, Birmingham, AL.

APPENDIX H

STAKEHOLDER COMMENT TABLE

Commenting Entity	Date of Comment & FERC Accession Number	Comment – Phase 2 Operating Curve Change Feasibility Analysis	Alabama Power Response
Lake Wedowee Property Owners Association (LWPOA) Note: footnotes included in the original letter have been omitted from this table	5/19/2021 20210519-5060	The LWPOA asks that Alabama Power and FERC approve raising the winter pool from the current 785’ to 786’ msl. a. A winter pool of 786’ would result in an increase of 193 usable private lakeshore structures, from 449 to 642 (Table 3.13, pg 74 of DRA), and make one additional public launch (Lonnie White ramp) available (Table 3.14, pg 74 of DRA) at winter pool. Further, many LWPOA members report that a rise of one foot would make their private structure far more usable, though not technically meeting Alabama Power’s definition of usable. b. As LWPOA reads the data, the only potential negative environmental impact at 786’ is Submerged Aquatic Vegetation in the reservoir. According to the study results SAV is largely non-existent in sedimentation areas now after nearly 40 years of reservoir operations (Section 3.5.7, pg 28, OCCA) so a threat of vegetation increasing at a one foot higher winter pool is assumed to be low. c. Fish spawning in the reservoir would be enhanced (Section 3.6.2, pg 32, OCCA). d. Raising the winter level one foot to 786’ would have negligible impact on the river environment or downstream landowners in the event of a 100 year flood. Table 3-2, pg 14, OCCA shows no more inundated structures downstream at 786’ than 785’. Table 3-4 pg 15, OCCA shows the duration of inundation downstream actually decreases, since flood releases would end earlier at a higher pool level.	Any increase in the winter operating curve would result in an increase in downstream flooding, including both an increase in downstream acres inundated and an increase in downstream flood depth. Alabama Power determined from the modeled 100-Year Design Flood that increases in downstream flooding were not reasonable; therefore, Alabama Power eliminated these operating alternatives from further consideration.
LWPOA		While it is not the official position of the LWPOA, many property owners around R.L. Harris reservoir support raising the winter level two feet to 787’. Table 3-2, pg 14, OCCA shows that at 787’ four additional structures downstream would be inundated during a 100 year flood event for a shorter duration. Benefits of raising the winter pool two feet are the same as raising the level one foot as detailed above, making even more lakeshore structures and recreational opportunities available year round. Table 3-13, pg 73, DRA shows the number of usable lakeshore structures increases by 377, from 449 to 826.	Any increase in the winter operating curve would result in an increase in downstream flooding, including both an increase in downstream acres inundated and an increase in downstream flood depth. Alabama Power determined from the modeled 100-Year Design Flood that increases in downstream flooding were not reasonable; therefore, Alabama Power eliminated these operating alternatives from further consideration.
LWPOA		The Lake Wedowee Property Owners Association supports the tenet that everyone has equal rights to Tallapoosa River waters, and desires to be a good neighbor to the entire basin community. Based on the data in the referenced study reports, the Association asks for nothing that would substantially harm any other stakeholder group with whom it shares the Tallapoosa River system.	Comment noted.

Commenting Entity	Date of Comment & FERC Accession Number	Comment – Phase 2 Operating Curve Change Feasibility Analysis	Alabama Power Response
Alabama Department of Conservation and Natural Resources (ADCNR) Note: footnotes included in the original letter have been omitted from this table	05/27/2021 20210527-5024	ADCNR has no additional comments or recommendations at this time other than to reiterate our support of having combinations of operating curve scenarios and downstream release alternatives modeled together for further analyses.	Comment noted.
Federal Energy Regulatory Commission (FERC) Note: footnotes included in the original letter have been omitted from this table	06/09/2021 20210609-3045	The HEC-ResSim Model developed during Phase 1 of the Operating Curve Change Feasibility Analysis includes a minimum release provision that is based on flow at the upstream Heflin gage, which is located on the mainstem Tallapoosa River. There is also a streamflow gage (Newell) located on the Little Tallapoosa River Arm of Lake Harris, which was not used to develop the minimum release provision. Alabama Power's response to a Commission staff's additional information request regarding these streamflow gages, indicates that during the development of the Green Plan, the stakeholders involved in the process considered the Heflin gage "the gage that best mimicked the unregulated, natural flow of the Tallapoosa River;" thus the Newell gage was not considered in developing the Green Plan and the minimum release provision. However, it remains unclear how flow from the Little Tallapoosa River is accounted for by the HEC-ResSim Model developed during Phase 1 of the study and its relationship to the minimum release provision. Because the HEC-ResSim Model is a mass balance model, it should account for all inflow coming into Lake Harris (i.e., the output from the HEC-SSP model). Therefore, to better understand how the HEC-ResSim Model works, please revise the Draft Operating Curve Change Feasibility Analysis (Phase 2) Report to include an explanation for how flow from the Little Tallapoosa River is accounted for in the model, including describing (a) the model's assumptions related to the Little Tallapoosa River and its flow entering the R.L. Harris Project, and (b) the relationship between the Little Tallapoosa River flow and the minimum release requirement included in the HEC ResSim model.	As discussed in the Phase 1 report, the HEC-ResSim Model accounts for all flow coming into Harris Reservoir (i.e., inflows) through its use of the ACT unimpaired flow database, including inflows into the Little Tallapoosa River Arm. The use of the unimpaired flow dataset as a model input is different from the rule contained in the HEC-ResSim Model related to the Green Plan, which uses the upstream Heflin gage only to determine Green Plan releases for daily operations. As indicated in Section 2.0, the details regarding the HEC-ResSim Model, both data inputs and rules, are contained in the Phase 1 Report and Alabama Power does not see the need to repeat that information in the Phase 2 Report.
Alabama Rivers Alliance (ARA) Note: footnotes included in the original letter have been omitted from this table	06/11/2021 20210611-5096[1]	The Operating Curve Change Feasibility Analysis Draft Phase 2 Report ("Operative Curve Phase 2 Report") applies the hydrologic models and modeling results developed for the Phase 1 Report to quantitatively and qualitatively describe possible impacts to resources that would result from raises in the winter pool level. Under the current operating curve, winter pool elevation is 785 feet msl, and the Phase 2 Report evaluates raising the winter pool level to either 786, 787, 788, or 789 feet msl.	Alabama Power disagrees with the assertion that "since beginning operations, the Harris Project has highly altered hydrologic processes and flow regime characteristics and created frequent large flow fluctuations that can lead to more intense flooding than the ecosystem would experience in its natural state." One of the primary purposes of the Harris Project is to provide flood control to for the downstream Tallapoosa River. Based on pre-

[1] In addition to comments filed with FERC concerning the Operating Curve Feasibility Analysis Phase 2 Report, ARA provided similar comments to Alabama Power via email dated 05/27/2021. The 05/27/2021 comments are included within the stakeholder consultation record for reference.

Commenting Entity	Date of Comment & FERC Accession Number	Comment – Phase 2 Operating Curve Change Feasibility Analysis	Alabama Power Response
		Elevating the winter pool level could benefit recreation on Lake Wedowee in the winter months by making some structures and boat ramps more accessible, however, increased recreation opportunities must be weighed against exacerbated downstream flooding that could result from a raise in the winter pool elevation. As the Operating Curve Phase 2 Report summarizes: "The primary adverse effect of raising the winter pool is on downstream resources in the form of an increase in flooding….The primary beneficial effect of raising the winter pool is in the number of reservoir recreational structures (boat slips, docks, etc.) that are available for private recreational use/access during the winter months." Impacts to Downstream Residents and River Users The modeling results summarized in Table 3-2 and Table 3-3 of the Operating Curve Phase 2 Report show that once the winter pool is raised by two feet and reaches 787 feet msl, more downstream structures become inundated during the 100-year design flood, including single family and mobile homes. With any amount of raise in the winter pool level, flooding becomes shorter in duration, but more intense in magnitude with a more rapid rise due to less storage being available in the reservoir and a quicker release of water. Throughout the relicensing, many river users and downstream property owners have voiced concern about unpredictable flooding, property damage, and risks to personal safety caused by rapid and unannounced rises in river levels. ARA highly recommends that Licensee pay careful attention to these very real concerns of people living below Harris and those who recreate on the river. These flood events not only harm property but also present a threat to public safety. Recreation downstream of Harris could also suffer with a higher winter pool level. Table 3-16 of the Operating Curve Phase 2 Report shows that the seven existing recreation sites below the dam would have a greater maximum depth of inundation, ranging from roughly 0.5 foot of depth increase with a 1-foot raise up to approximately 2.5 feet of depth increase with a four-foot raise in the winter pool. This additional inundation could make the recreation access points below the dam less accessible. Impacts to Aquatic Resources and Habitat Periodic flooding on the Tallapoosa River, particularly in the spring, is part of natural riverine processes. However, since beginning operations, the Harris Project has highly altered hydrologic processes and flow regime characteristics and created frequent large flow fluctuations that can lead to more intense flooding than the ecosystem would experience in its natural state. The modeling in the Operating Curve Phase 2 Report	Harris Dam flow records, the Project has reduced the magnitude and frequency of flood events as shown at the Wadley gage. Alabama Power agrees that the effects of raising the winter pool on Harris Reservoir to downstream resources are not reasonable and has eliminated these operating alternatives from further consideration.

Commenting Entity	Date of Comment & FERC Accession Number	Comment – Phase 2 Operating Curve Change Feasibility Analysis	Alabama Power Response
		shows that raising the winter pool level "results in greater outflow from Harris Dam and subsequent flooding" due to increases in spill frequency and the amount of time spent at turbine capacity. While the percentage increases may appear small, more time spent at turbine capacity could have further repercussions on downstream aquatic resources and affect fish spawning sites and spawning behavior. Infrequent but intense flood events can have considerable negative effects on spawning success. Erosion could also be worsened by raising the winter pool level. Due to steep streambanks and soil conditions, the Operating Curve Phase 2 Report notes that "[i]ncreased scour would occur as velocities increase with the higher channelized flows resulting from the decreased storage in Harris Reservoir associated with higher winter operating curve elevations." Issues of erosion and sedimentation have been frequently cited by river users and property owners downstream of Harris, and any operational changes that could lead to increased erosion should be carefully considered and only adopted with robust mitigation and protection efforts. In deciding whether to change the operating curve to raise the winter pool, Licensee, FERC, and stakeholders must weigh the potential benefits of increased recreation on the reservoir during winter months against possible exacerbated flooding below the dam, increased erosion, and further negative impacts to aquatic life and habitat. Without detailed and robust protection and mitigation plans, ARA would not support a change in the operating curve to raise the winter pool level. Either way, protection and mitigation measures should be taken downstream of Harris to reduce flooding impacts, restore eroded and impaired streambank segments, and provide safer conditions for recreationists and residents.	

Commenting Entity	Date of Comment & FERC Accession Number	Comment – Phase 2 Operating Curve Change Feasibility Analysis	Alabama Power Response
Chris Lunsford	06/11/2021 20210611-5096	Thank you for the opportunity to comment on this proposed change to the RL Harris Reservoir. As a 29 year resident on RL Harris Reservoir, I have observed the entities in charge of it's operation. They have done a good job servicing the needs of those around the reservoir and those downstream. The options of retaining a higher water level through winter months is a good idea. While I would support as much as a 4 foot increase in winter pool levels, I understand the concerns of downstream flood control but I believe a revised winter level combined with any increases due to heavier than normal rains can be managed. In my 29 years of residing here, there have been only a few incidents of major flooding, one of which was Hurricane Opal. I did notice a lesser amount of floating debris in the reservoir this spring compared to previous springs. This was avoided by a more stationary winter level prohibiting objects from becoming dislodged along shorelines. An idea to consider is testing each of the potential winter increases over the next 4 years whereby each 1 foot increase can be experienced and tested for abilities to support each increase. This would provide credible data for each of the potential level increases. I appreciate the open mindedness of all the entities involved with this possible change. Making common sense decisions with the updating of the water control manuals can satisfy everyone's needs for this important water resource. Thank you again for allowing public input on this proposed change.	Any increase in the winter operating curve would result in an increase in downstream flooding, including both an increase in downstream acres inundated and an increase in downstream flood depth. Alabama Power determined from the modeled 100-Year Design Flood that increases in downstream flooding were not reasonable; therefore, Alabama Power eliminated these operating alternatives from further consideration. Even if these alternatives were "tested", these adverse effects could be seen.
FERC	12/23/2021 20211223-3032	The values for the effects of potential changes to the operating curve and alternative downstream releases on generation across the entire Alabama Power fleet, and generation and revenue specific to Harris Dam were clarified and revised at two places in the license application, (i.e., Page 56, table 4-1 in the Draft Operating Curve Change (Phase 2) Study Report and pages 20 and 21, figures 3-11 through 3-14 in the Draft Downstream Release Alternatives (Phase 2) Study Report). In addition to the revisions in the license application, please make similar revisions to provide the effect on generation and revenue of the potential changes/alternatives presented in: a. Table 4-1 in the Final Operating Curve Change (Phase 2) Study Report [i.e., In the left "Resource" column, revise the top 4 cells to read "Change in Hydro Generation (Revenue)", "Change in Hydro Generation (Megawatt Hours)", etc. Also, add a brief explanation of how more generation results in less revenue (e.g. more generation, but less peak), etc.]	These changes have been made in the revised final report dated June 2022.

Commenting Entity	Date of Comment & FERC Accession Number	Comment – Phase 2 Operating Curve Change Feasibility Analysis	Alabama Power Response
FERC	02/15/2022 20220215-3039	Section 3.3.2, Results – Tallapoosa River Downstream of Harris Dam, of the final Operating Curve Change Feasibility Analysis Phase 2 Report indicates that the results of the EFDC (or Environmental Fluid Dynamics Code) model show only "small differences" in simulated water temperature and DO in the withdrawal zone of the forebay between the baseline condition and the four winter pool alternatives. In order for Commission staff to understand how the four winter pool curve alternatives affect water temperature and DO in the withdrawal zone, please describe (i.e., quantify) what is characterized as "small differences."	This change has been made in the revised final report dated June 2022.
FERC	02/15/2022 20220215-3039	Table 4-1 in section 4, Summary, of the final Operating Curve Change Feasibility Analysis Phase 2 Report provides a summary of effects associated with the winter pool alternatives. The table shows that for the Harris Project, the loss in hydro generation and revenue diminishes with each incremental increase in the winter pool elevation from +1 foot to +3 feet. However, instead of having the smallest loss consistent with the aforementioned trend, the +4 feet alternative shown in table 4-1 results in the greatest loss of hydro generation and revenue. Therefore, please review the figures in table 4-1 for all of the alternatives for accuracy and correct if necessary. If the figures are accurate, please explain why the +4 feet alternative does not fit the observed trend.	An explanation has been added to Table 4-1 of the revised final report dated June 2022.