DRAFT LICENSE APPLICATION

Volume II of V
Exhibit E – Environmental Report

Bad Creek Pumped Storage Project
(FERC No. 2740)

February 2025

Prepared by:

Prepared for:

Duke Energy Carolinas, LLC

DRAFT LICENSE APPLICATION

BAD CREEK PUMPED STORAGE PROJECT (FERC NO. 2740)

EXHIBIT E

ENVIRONMENTAL REPORT

BAD CREEK PUMPED STORAGE PROJECT
FERC PROJECT NO. 2740
DRAFT LICENSE APPLICATION

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
ADCP	Acoustic Doppler Current Profiler
ANOVA	analysis of variance
APE	area of potential effect
APLIC	Avian Power Line Interaction Committee
Bad Creek Project or Project	Bad Creek Pumped Storage Project (existing Project)
Bad Creek II	Bad Creek II Power Complex (proposed)
BCE	Before Common Era
BCC	Birds of Conservation Concern
BCRA	Bad Creek Relicensing Agreement
BGEPA	Bald and Golden Eagle Protection Act
BMP	Best Management Practice
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHEOPS	Computer Hydro-Electric Operations and Planning Software
cm	centimeter
CUI // PRIV	Controlled Unclassified Information // Privileged Information
CVSZ	Central Virginia Seismic Zone
CWA	Clean Water Act
D2SI-ARO	FERC Division of Dam Safety and Inspections Atlanta Regional Office
DLA	Draft License Application
DO	dissolved oxygen
Duke Energy	Duke Energy Carolinas, LLC
EJ	Environmental Justice
EPC	Engineering, Procurement, and Construction
ESA	Endangered Species Act
ESC	Erosion and Sedimentation Control
ETSZ	East Tennessee Seismic Zone
FEMA	Federal Emergency Management Agency
FERC or Commission	Federal Energy Regulatory Commission
FLA	Final License Application
fps	feet per second
ft	feet/foot
ft msl	feet above mean sea level
FTC	Foothills Trail Conservancy
GPS	Global Positioning System
HPMP	Historic Properties Management Plan
HUC	Hydrologic Unit Code
I/O	inlet/outlet
ILP	Integrated Licensing Process
IPaC	Information for Planning and Consultation
ISR	Initial Study Report
kg	kilogram
km	kilometer
KT Project	Keowee-Toxaway Hydroelectric Project (FERC No. 2503)
kV	kilovolt
kW	kilowatt
lf	linear feet
LiDAR	light detection and ranging
LIP	Low Inflow Protocol
LOD	limits of disturbance

m	meter
Ma	million years
MBTA	Migratory Bird Treaty Act of 1918
MEP	Maintenance and Emergency Protocol
Mft^3	million cubic feet
mg/l	milligrams per liter
mi^2	square miles
MOU	Memorandum of Understanding
MW	megawatt
MWh	megawatt hour
NCSAM	North Carolina Stream Assessment Methods
NCWRC	North Carolina Wildlife Resources Commission
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act of 1966
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NTU	Nephelometric turbidity units
ORW	Outstanding Resources Waters
PAD	Pre-Application Document
PGA	Peak Ground Acceleration
PM&E	protection, mitigation, and enhancement
PSP	Proposed Study Plan
RBP	Rapid Bioassessment Protocol
REMI	Reservoir Environmental Management, Inc.
RM	river mile
RMP	Recreation Management Plan
ROW	Right-of-way
rpm	revolutions per minute
RSP	Revised Study Plan
RTE	rare, threatened, and endangered
RUN	Recreation Use and Needs
SCDES	South Carolina Department of Environmental Services
SCDNR	South Carolina Department of Natural Resources
SCPRT	South Carolina Department of Parks, Recreation and Tourism
SCORP	State Comprehensive Outdoor Recreation Plan
SCNHP	South Carolina National Heritage Preserve
SD1	Scoping Document 1
SD2	Scoping Document 2
SEPA	Southeastern Power Administration
SHPO	State Historic Preservation Office
SMP	Shoreline Management Plan
SMS	Scenery Management System
SPD	Study Plan Determination
SR	State Route
SWAP	State Wildlife Action Plan
TFF	Tallulah Falls Formation
TGn	Toxaway Gneiss
TN	Trout Natural
TNW	Traditional Navigable Waters
TPGT	Trout Put, Grow, and Take
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture

USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USR	Updated Study Report
μS	microsiemens
V	volt
VRMP	Visual Resources Management Plan
WQC	Water Quality Certification
WQMP	Water Quality Monitoring Plan

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Exhibit E - Environmental Report (18 CFR §5.18(b))

E.1 Introduction

Duke Energy Carolinas, LLC (Duke Energy or Licensee) is the Licensee, owner, and operator of the Bad Creek Pumped Storage Project (Bad Creek Project or Project) (Federal Energy Regulatory Commission [FERC or Commission] Project No. 2740), located in Oconee County, South Carolina, approximately eight miles north of Salem. Figure E.1-1 provides an overview of the Project setting and the proposed FERC Project Boundary[1].

The Bad Creek Reservoir (or upper reservoir) was formed from the damming of Bad Creek and West Bad Creek and serves as the Project's upper reservoir. Lake Jocassee, licensed as part of Duke Energy's Keowee-Toxaway Hydroelectric Project (KT Project) (FERC Project No. 2503), serves as the lower reservoir. The Project is operated by Duke Energy under the terms of an Original License issued by the FERC on August 1, 1977, as subsequently amended. The construction of Bad Creek took roughly 10 years, and the Project began operating in 1991. The structures and features included in the Bad Creek Project license include the upper reservoir and dams, inlet/outlet (I/O) structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, and an approximately 9.25-mile-long transmission line corridor extending from Bad Creek to the KT Project's Jocassee switchyard.

The existing Bad Creek powerhouse is built within a large cavern inside a mountain. Similar to other hydroelectric stations, the engineering design of the Project involves the flow of water to produce electricity, however, because about 1,200 vertical feet (ft) separate the upper and lower reservoirs, Bad Creek is better able to take advantage of gravity to produce larger quantities of electricity. The now over 30-year-old Project is one of the most powerful and flexible energy generation and storage assets in Duke Energy's system. Built primarily to store surplus energy from baseload nuclear and fossil fuel power plants during times of low energy demand, today Bad Creek is used to balance an increasingly complex energy grid. Pumping water from Lake Jocassee up to the Bad Creek Reservoir provides a means of storing energy from surplus baseload generation during low demand periods and other non-dispatchable renewables generation (e.g., solar photovoltaic) during certain periods. Project

1 Duke Energy is proposing an expanded Project Boundary (i.e., proposed Project Boundary) to encompass the Bad Creek II Power Complex (Bad Creek II). Refer to Exhibit G for a comparison of the proposed Project Boundary to the existing one provided in original license Exhibits J and K and described in the original license order.

operation in turbine mode, from the Bad Creek Reservoir to Lake Jocassee, provides power back to the grid when energy demand is higher or non-dispatchable renewables generation is not available.

The Project is currently licensed by the FERC under the authority granted to FERC by Congress through the Federal Power Act, 16 United States Code (USC) §791(a), et seq., to license and oversee the operation of non-federal hydroelectric projects on jurisdictional waters and/or federal land. The Project received an Original License on August 1, 1977, and the current operating license for the Project expires on July 31, 2027. Accordingly, Duke Energy is pursuing a new license for the Project pursuant to the Commission's Integrated Licensing Process (ILP), as described at 18 Code of Federal Regulations (CFR) Part 5. In accordance with FERC's regulations at 18 CFR §16.9(b), the Licensee must file its final application for a new license with FERC no later than July 31, 2025.

Given the need for additional energy storage and renewable energy generation across Duke Energy's service territories over the Project's new 40 to 50-year license term, Duke Energy is proposing additional pumping and generating capacity at the Project. Additional energy storage and generation capacity would be developed by constructing a new power complex (including a new underground powerhouse) adjacent to the existing Bad Creek powerhouse. Therefore, the effects of construction and operation of the 1,400-megawatt Bad Creek II Power Complex (Bad Creek II) are being evaluated by Duke Energy in conjunction with Project relicensing. The proposed expanded Project Boundary including lands necessary for the construction and operation of Bad Creek II is shown on Figure E.1-1.

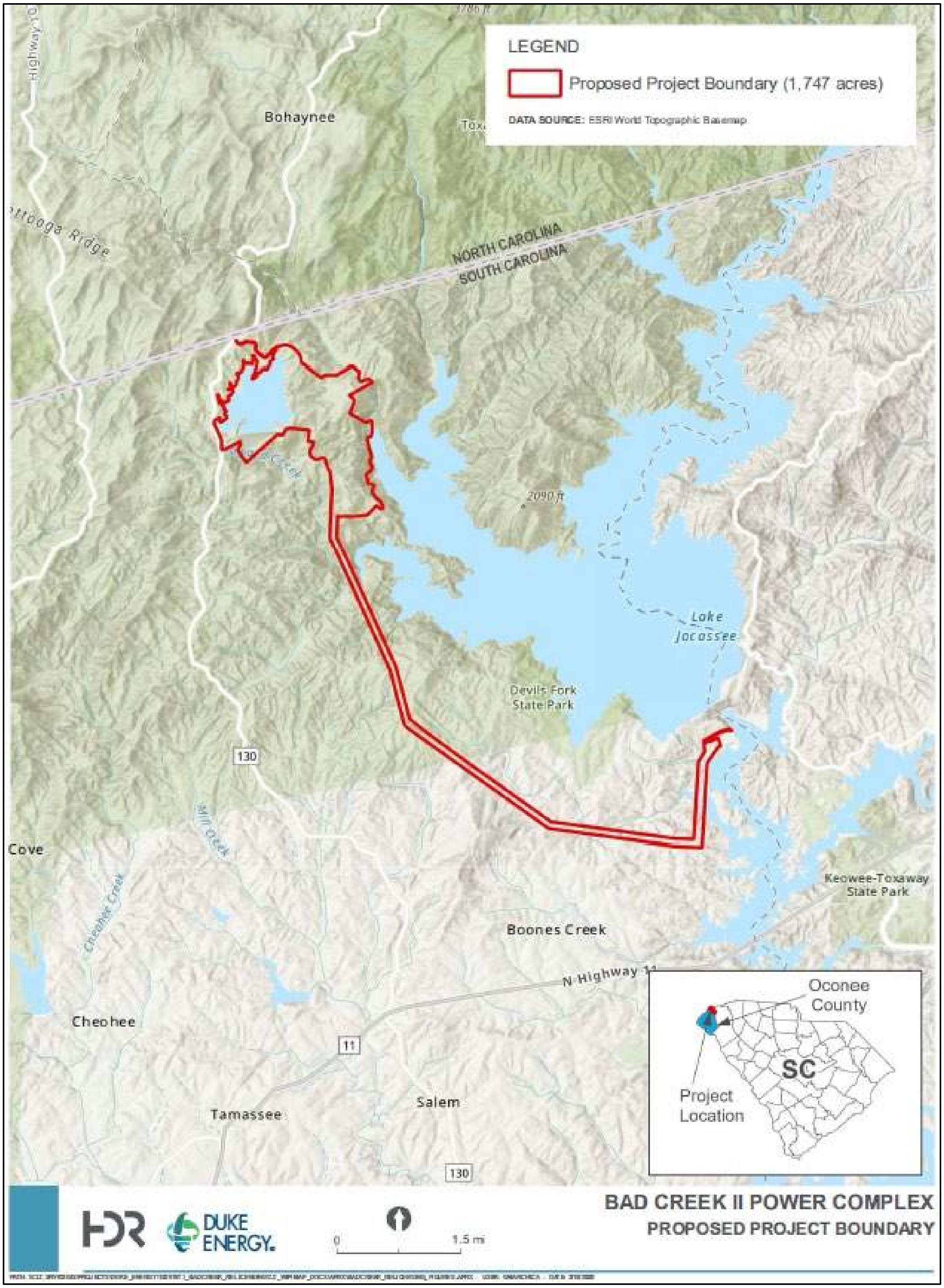


Figure E.1-1. Project Location Map and Proposed Project Boundary

E.1.1 Pre-Filing Consultation

Duke Energy filed a Pre-Application Document (PAD) and associated Notice of Intent (NOI) with the Commission on February 23, 2022, to initiate the ILP. The Commission issued Scoping Document 1 (SD1) for the Project on April 22, 2022. As provided in 18 CFR §5.8(a) and §5.18(b), the Commission issued a notice of commencement of the relicensing proceeding concomitant with SD1. On May 16 and 17, 2022, the Commission held two virtual public scoping meetings due to concerns with large gatherings related to COVID-19. During these meetings, FERC staff presented information regarding the ILP and details regarding the study scoping process and how to request a relicensing study, including the Commission's study criteria. In addition, FERC staff solicited comments regarding the scope of issues and analyses for the Environmental Assessment or Environmental Impact Statement. Due to construction activities at the Project associated with unit upgrades (FERC 2018), the remote location of the Project, and the COVID-19 pandemic, Duke Energy prepared an overview video orientation of the Project for general viewing by interested parties in lieu of an on-site environmental review site visit. The virtual environmental site review presentation was given by Duke Energy one hour prior to each scoping meeting, pursuant to 18 CFR §5.8(d).

Resource agencies, Indian Tribes, non-governmental organizations, and other interested parties were afforded a 60-day period to request studies and provide comments on the PAD and SD1. The comment period was initiated with the Commission's April 22, 2022 notice of commencement and concluded on June 23, 2022. During the comment period, eight stakeholders filed letters with the Commission providing general comments and comments regarding the PAD/NOI and SD1. FERC also submitted comments during the comment period. The Commission was the only entity to file a formal study request during the comment period related to Environmental Justice (EJ).

The ILP required Duke Energy to file the Proposed Study Plan (PSP) within 45 days from the close of the June 23, 2022, comment period (i.e., on or before August 7, 2022), therefore Duke Energy submitted the PSP on August 5, 2022. The PSP presented the methodology and details of the studies proposed by Duke Energy and addressed, as appropriate, the comments and study requests submitted by resource agencies and other stakeholders.

On the same day of the PSP filing (August 5th), FERC issued Scoping Document 2 (SD2) to provide information on the proposed action and alternatives, the environmental analysis process FERC staff will follow to prepare the National Environmental Policy Act (NEPA) document, and a list of issues to be addressed in the NEPA document. On August 16, 2022, Duke Energy held a site visit at the Project for relicensing Resource Committee participants and provided a tour of the powerhouse and upper reservoir.

Pursuant to 18 CFR §5.11(e), Duke Energy held a PSP Meeting in Greenville, SC on September 7, 2022, for the purpose of clarifying the PSP, explaining initial information gathering needs, and addressing outstanding issues associated with the PSP. A summary of the PSP meeting was prepared by Duke Energy and filed with FERC and the Project mailing list on October 19, 2022. Comments on the PSP were due 90 days from filing, therefore, the commenting period closed on November 5, 2022. Duke Energy received formal comments on the PSP from Commission staff, the South Carolina Department of Natural Resources (SCDNR), Foothills Trail Conservancy (FTC), and Upstate Forever. Duke Energy also held a virtual meeting with Resource Committee members on November 17, 2022 to review and discuss the comments received.

In accordance with 18 CFR §5.11, Duke Energy developed a Revised Study Plan (RSP) for the Project, which incorporated comments and study requests considered in developing the PSP, the Commission's SD2, and comments on the PSP, and it was filed with the Commission and made available to stakeholders on December 5, 2022. On January 4, 2023, FERC issued the Study Plan Determination (SPD), with modifications to the Recreational Resources Study. The SPD required six studies to be performed in support of issuing a new license for the Project, as listed below:

1. Water Resources Study
2. Aquatic Resources Study
3. Visual Resources Study
4. Recreational Resources Study
5. Cultural Resources Study
6. Environmental Justice Study

Duke Energy filed the Initial Study Report (ISR) on January 4, 2024, conducted an ISR Meeting on January 17, 2024, and filed the ISR Meeting summary with the Commission on February 1, 2024. Duke Energy received written comments on the ISR and ISR Meeting summary from the SCDNR on February 28, 2024, and from both Upstate Forever and FERC on March 1, 2024. Duke Energy filed a response to comments on the ISR on April 1, 2024. On May 9, 2024, FERC filed an Additional Information Request regarding the ISR. Duke Energy responded to the AIR on June 12, 2024.

Duke Energy conducted a second year of studies in 2024, submitted an Updated Study Report (USR) on January 3, 2025, and filed the USR Meeting summary with the Commission on January 29, 2025.

Since March 2023, either by separate filing or in conjunction with the filings described above, Duke Energy has provided FERC and relicensing participants with quarterly ILP study progress reports describing study activities completed by Duke Energy, updates to the study schedule, and variances from the RSP due to field conditions or other developments. Copies of FERC consultation documentation are provided in Appendix A and documents associated with ILP filing are provided on the Project's public relicensing website. [2]

In addition to the ILP-required stakeholder consultation, throughout the relicensing process, Duke Energy consulted extensively with relicensing stakeholders, many of whom joined the Bad Creek Relicensing Agreement (BCRA) team beginning in 2024, culminating with the development of the BCRA signed by thirteen organizations in January 2025. The signed BCRA is provided in Appendix B. The BCRA is a comprehensive agreement addressing the environmental, recreation, aesthetic, and cultural resources potentially affected by continued operation of the Project as well as the proposed construction and operation of Bad Creek II.

E.1.2 Resource Areas and Environmental Analysis Addressed in this Exhibit

As required by FERC's ILP regulations at 18 CFR § 5.18(b), this exhibit presents effects of the Project on environmental resources using the information filed in the Licensee's PAD, information developed through the Licensee's FERC-approved study plan, and other information developed or obtained by the Licensee. Duke Energy has included the most important and relevant information, and by reference this Exhibit accounts for and reflects other relicensing filings, in particular the study reports that were filed with the ISR and the USR.

This environmental report contains information about the affected environment; analysis of anticipated continuing or new environmental impacts due to Project operation or proposed changes thereto, based on existing information and the results of relicensing studies; proposed environmental measures and measures recommended by relicensing participants; unavoidable adverse impacts that may occur despite recommended or proposed environmental measures; and impacts to the environment associated with the construction of Bad Creek II.

[2] www.badcreekpumpedstorage.com

E.2 General Description of the River Basin

E.2.1 Savannah River Basin

The Project is located in the headwaters of the Savannah River Basin (Hydrologic Unit Code [HUC] 030601), which has an area of approximately 10,577 square miles (mi^2) and drains portions of the Blue Ridge, Piedmont, and Coastal Plain (Figure E.2-1). Approximately 55 percent of the Savannah River Basin is in Georgia (5,821 mi^2), 43 percent is in South Carolina (4,581 mi^2), and 2.0 percent (175 mi^2) is in North Carolina. The Project, along with the other two Duke Energy reservoirs associated with the KT Project (i.e., Lake Jocassee and Lake Keowee) drain approximately 439 mi^2 or just 4 percent of the entire Savannah River Basin.

Lake Jocassee, which operates as the lower reservoir for the Bad Creek Project, was formed by impounding the Keowee River at river mile (RM) 343.6, just downstream of the confluence of the Whitewater and Toxaway rivers. Lake Jocassee has a drainage area of 145 mi^2, a surface area of approximately 7,980 acres, and approximately 92 miles of shoreline at full pond (1,110 ft above mean sea level [ft msl]) (HUC 0306010101). Water from Lake Jocassee flows directly into Lake Keowee, which was formed by impounding the Keowee River and the Little River, and the two impoundments are connected through an excavated canal creating one large impoundment. Jocassee is also a pumped storage facility, utilizing Lake Keowee as its lower reservoir. Lake Keowee has approximately 388 miles of shoreline with a surface area of approximately 17,660 acres at full pond (800 ft msl). Lake Keowee provides municipal water to the cities of Seneca, Walhalla, and Greenville, South Carolina, and cooling water for Duke Energy's 2,538-megawatt (MW) Oconee Nuclear Station, which is located on the shores of Lake Keowee immediately west of Keowee Dam.

Downstream of Lake Keowee is the Hartwell Dam (RM 289). Annual average inflows to the KT Project account for 28 percent of inflows into Lake Hartwell (Duke Energy 2014a). There are several Georgia Power dams located in North Georgia on tributaries that flow into Lake Hartwell as well as other smaller impoundments on tributaries within the Savannah River Basin that contribute to the overall water resources of the Savannah River Basin. Other major dams on the mainstem Savannah River including the Richard B. Russel Dam (RM 259) and the J. Strom Thurmond Dam (RM 222), along with other smaller dams and diversion structures, are located downstream of the Bad Creek and KT Projects along the Savannah River before the river terminates at the Atlantic Ocean near Savannah, Georgia, approximately 220 miles downstream of J. Strom Thurmond Dam and Lake (also known as Clarks Hill Lake) near Augusta, Georgia.

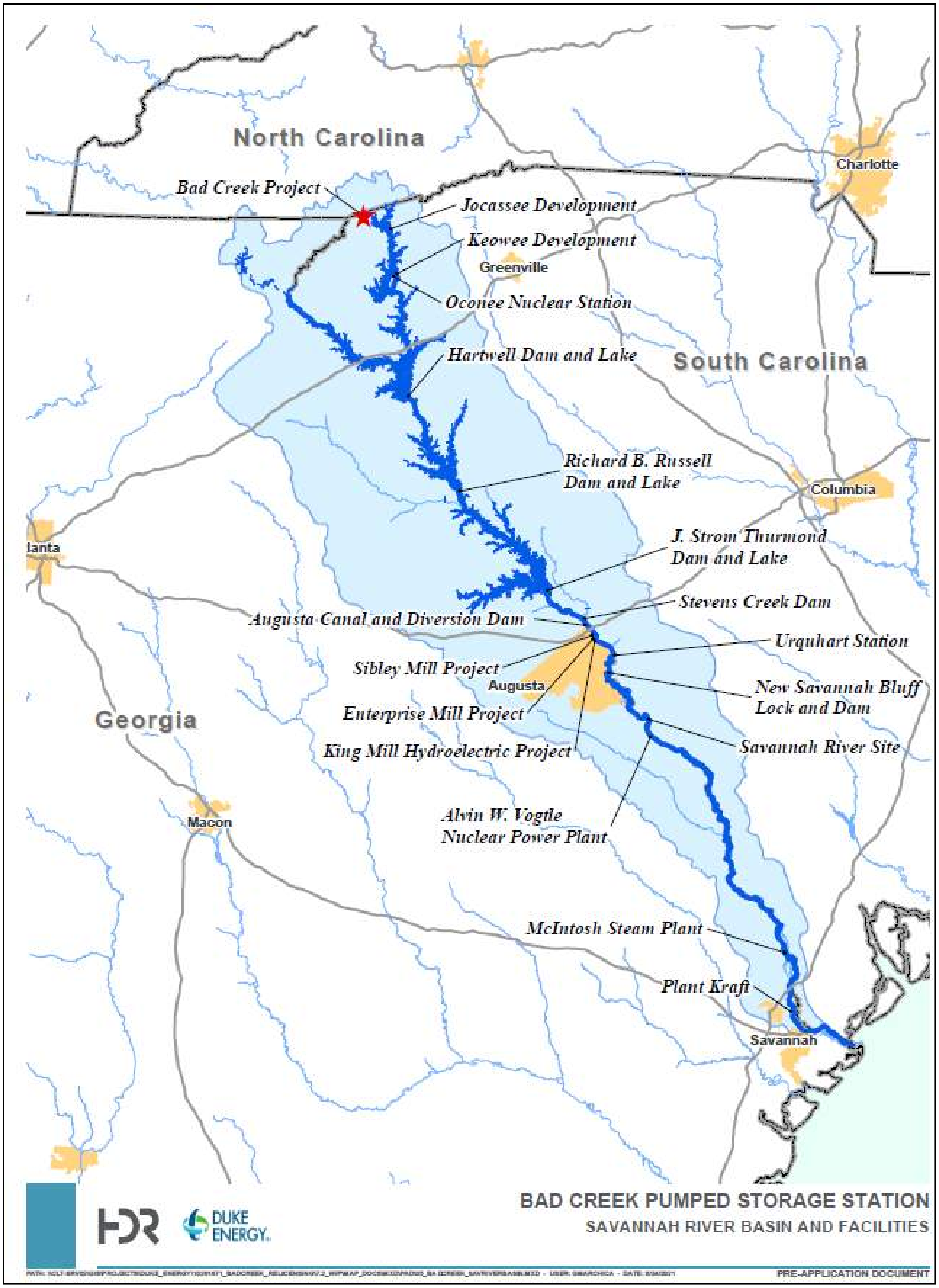


Figure E.2-1. Savannah River Basin and Project Location

The Project, Project facilities, and the western portion of Lake Jocassee are situated in the Whitewater River watershed (HUC 030601010104), which has an area of 80.3 mi^2. The Whitewater River is approximately 14.6 miles long from its headwaters in Transylvania County, North Carolina to its confluence with Lake Jocassee in South Carolina. The elevation near the headwaters is approximately 3,550 ft msl and the mouth is at 1,108 ft msl; the large elevation difference between the headwaters and the river mouth has helped to form two of the region's tallest waterfalls, the Upper Whitewater Falls and the Lower Whitewater Falls. The Upper Whitewater Falls in North Carolina near Cashiers is the highest waterfall east of the Rocky Mountains with a height of approximately 411 ft. The Lower Whitewater Falls, located just downstream of the upper falls in South Carolina, drops another 400 ft. The average flow at the mouth of the Whitewater River is approximately 76 cubic ft per second (cfs) (U.S. Environmental Protection Agency [USEPA] 2019a).

The eastern portion of Lake Jocassee is fed primarily by the Toxaway River, which originates in Transylvania County, North Carolina, at an elevation of approximately 4,000 ft msl. The Toxaway River is approximately 21 miles long, and discharges into the lake at approximately 508 cfs (USEPA 2019b). Similar to the Whitewater River Basin, the terrain is rugged and significant elevation drops over the length of the river result in waterfalls and cascades (e.g., Mill Creek Falls, Laurel Fork Falls). The Horsepasture River is also a major tributary to Lake Jocassee (HUC 030601010103) with a drainage area of 36 mi^2 and an average discharge of approximately 141 cfs (USEPA 2019c).

The Project transmission line corridor extends through a small portion of the Upper Little River-Lake Keowee watershed (HUC 030601010302) and terminates at a grid intertie station at the Jocassee Pumped Storage Station in the Cane Creek-Lake Keowee watershed (HUC 030601010201) (Figure E.2-2). These three watersheds are located within the northwestern portion of the Seneca sub-basin (HUC 03060101) (1,028 m^2) within the larger Savannah River Basin (see Figure E.2-1).

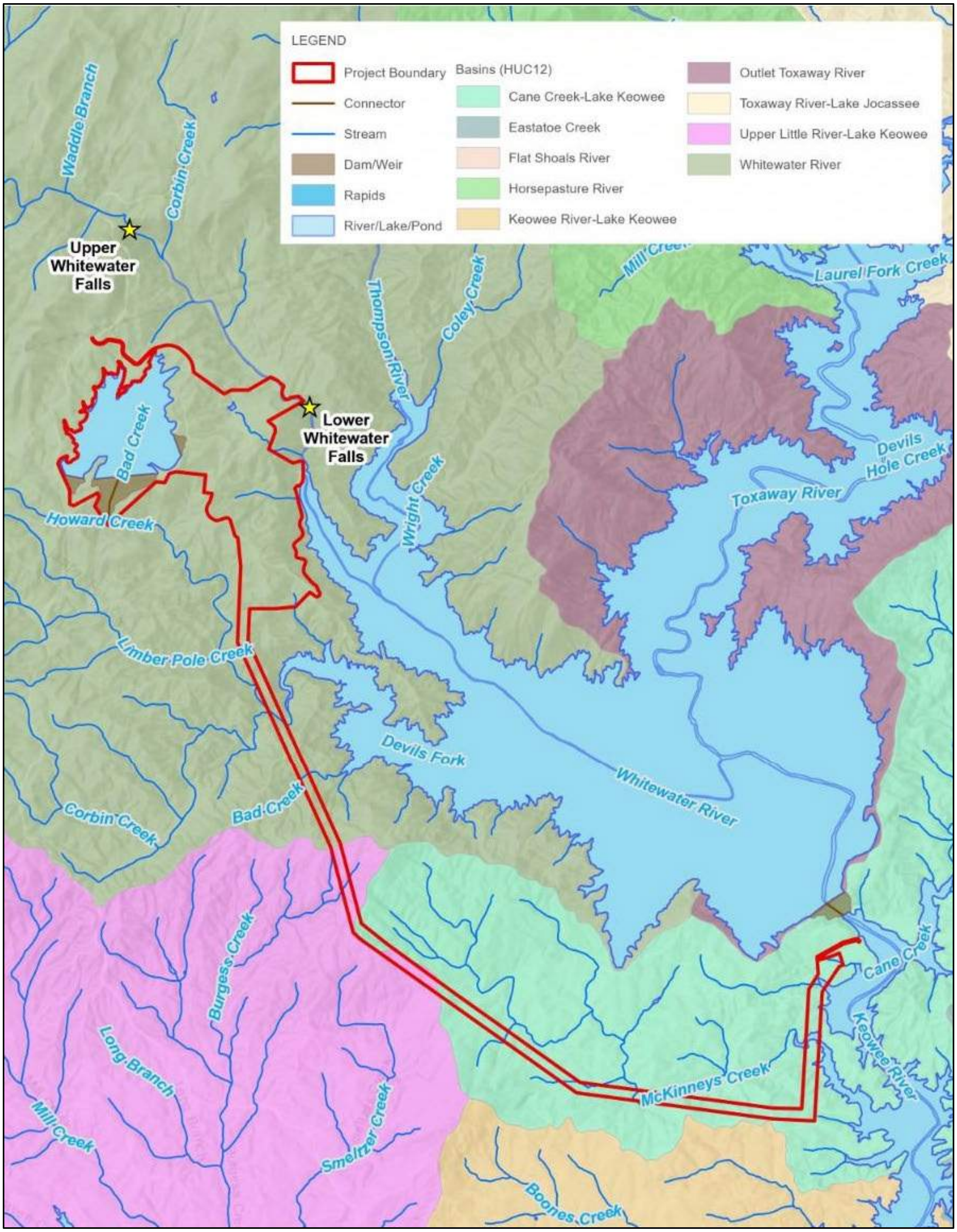


Figure E.2-2. Watersheds of the Project Area

E.2.2 Geography, Topography, and Climate

The Project is located in the Blue Ridge physiographic province, a mountainous zone extending northeast-southwest from southern Pennsylvania to central Alabama, varying in width from less than 15 miles up to 70 miles. It is characterized by rugged terrain with valleys ranging from 1,000 ft msl in the south to greater than 1,500 ft msl in the north. Several mountain peaks have elevations greater than 6,000 ft msl with relief of up to 3,500 ft msl. The highest peak is Mt. Mitchell in North Carolina at 6,684 ft msl.

The climate in the Savannah River Basin varies due to the differences in the topography from the headwaters near the Project to the river mouth at the Atlantic Ocean. Upstate South Carolina has four distinct seasons and the climate of the entire state is classified as humid subtropical. The climate at the Project is affected by the presence of the Blue Ridge Mountains, the relative location of the state in the northern mid-latitudes, and elevation; the mountains protect the area from cold air masses from the northwest, which helps keep the winters relatively warm.

The National Weather Service maintains a weather station at the Oconee County regional airport in Clemson, SC, about 3 miles southeast of Lake Keowee. At this location, average July high temps are about 91 degrees Fahrenheit (ºF) and average lows are about 70ºF. The average high temperature for January is 54ºF, and the average low is about 34ºF with limited snowfall. The Upstate region has the highest average annual precipitation in the state. Average annual precipitation at this location is about 53 inches with average monthly values relatively evenly distributed. Smaller watersheds draining the headwaters above Lake Jocassee may receive as much as 100 inches of precipitation per year. The 30-year climate normals for Oconee County (recorded at Walhalla, SC) are presented in Table E.2-1.

Appendix C includes the report titled *Summary of Climate Data and Future Operations on Water Resources,* which has been developed in support of this Draft License Application (DLA) in response to stakeholder comments on the RSP regarding climate change and potential effects of future operations on water resources. This report provides a detailed discussion of climate in South Carolina and the Upstate region, including past and future climate trends, and information on future operations of the Project (including Bad Creek II) and modeled effects on water resources. Attachments to Appendix C include reports relevant to climate change and future operations developed during the KT Project relicensing as well as a table of raw climate data (precipitation, temperature, drought conditions) for Oconee County over the last 50 years.

Table E.2-1. 30-Year Climate Normals[1] for Oconee County, South Carolina

Years	Max Temp (ºF)	Mean Temp (ºF)	Min Temp (ºF)	Precipitation (inches)
1971-2000	72.4	58.8	45.1	60.65
1981-2010	71.8	59.5	47.1	57.81
1991-2020	71.0	59.2	47.7	61.10

Source: SCDNR 2024

[1] Climate normals are 30-year averages of climate data (i.e., temperature and precipitation) used to show typical climate conditions for a given location. Climate normals are updated every ten years to provide information on observed climate conditions.

E.2.3 Dams and Diversions in the Watershed

The dams and diversion structures associated with the Bad Creek Project are described in Exhibit A of this DLA. The KT Project immediately downstream of the Bad Creek Project also has several dams and diversion structures including the Jocassee Dam, spillway and associated saddle dikes (Saddle Dike #1 and #2), Keowee Dam, spillway, saddle dikes A-D, and Oconee Nuclear Station Intake Dike, and the Little River Dam.

Since the Bad Creek and KT projects are in the headwaters of the Savannah River Basin, there are no upstream dams, however, there are numerous dams and projects downstream of the Project affected by Bad Creek and KT project operations. In 1968, the U.S. Army Corps of Engineers (USACE) and the Southeastern Power Administration (SEPA) entered into an Operating Agreement (1968 Operating Agreement) with Duke Energy's predecessor company, Duke Power Company. The purpose of this agreement was to ensure the uppermost projects (KT Project) were operated such that the USACE and SEPA would be able to meet their hydropower generating requirements at the time. Although there were many changes in both the USACE and Duke Energy systems since its inception, the 1968 Operating Agreement had never been modified. Therefore, a New Operating Agreement was signed in 2014 by the USACE, SEPA, and Duke Energy (2014 Operating Agreement), which incorporated the modified conditions of the KT Project operations and superseded the 1968 Operating Agreement with the goal of determining how water would be managed between the uppermost projects and the lowermost projects on the Savannah River.

The 2014 Operating Agreement is described in detail in Section E.8.1.5.2 (*Existing Instream Flow Uses).* The power generation projects and dams (power and non-power dams) in the Savannah River Basin downstream of the Project include:

1. Jocassee Pumped Storage Station (Duke Energy);
2. Keowee Hydroelectric Station (Duke Energy);
3. Oconee Nuclear Station (Duke Energy);
4. Hartwell Dam and Lake (USACE);
5. Richard B. Russell Dam and Lake (USACE);
6. J. Strom Thurmond Dam and Lake (USACE);
7. Stevens Creek Dam (Dominion Energy SC [formerly SCE&G]);
8. Augusta Canal and Diversion Dam (City of Augusta, GA);
9. Sibley Mill Project (August Canal Authority);
10. Enterprise Mill Project (Augusta Canal Authority);
11. King Mill Hydroelectric Project (Augusta Canal Authority);
12. Urquhart Station (coal plant decommissioned and now the site of natural gas power plant) (Dominion Energy SC);
13. New Savannah Bluff Lock and Dam (USACE);
14. Savannah River Site (Department of Energy);
15. Alvin W. Vogtle Nuclear Power Plant (Southern Nuclear Operating Company-Operator); and
16. Plant McIntosh (Southern Company)

E.2.4 Tributary Rivers and Streams

There are no tributaries upstream of the Bad Creek Project. Significant tributaries draining directly into Lake Jocassee include the Whitewater, Thompson, Horsepasture and Toxaway rivers, and Bad and Coley creeks. The major tributaries of the Whitewater River include Silver Run, Happy Hollow, Democrat Creek, Waddle Branch, and Corbin Creek (river left); the only tributary on river right is the Little Whitewater Creek. The major tributaries to the Toxaway River include the Indian Creek, Panther Branch, Auger Fork, Toxaway Creek, Rock Creek, Laurel Fork Creek and the Devils Hole Creek (river left) and the Mill Creek, Deep Ford Creek, Bear Meadow Creek, Cobb Creek, and Horsepasture River (river right).

E.2.5 General Land and Water Use

E.2.5.1 Land Cover

The Project vicinity includes mature deciduous forests with some pine forests on open steep south and southwest facing slopes. The area around Lake Jocassee is dominated by mature growth forested land with parts of the KT Project bordering but not including the Sumter National Forest; however, portions of the Devils Fork State Park occupy lands at Lake Jocassee. The Bad Creek Reservoir has no residential development, and Lake Jocassee has minor residential development (compared to Lake Keowee). The primary reason for this is that Duke Energy, in partnerships with SCDNR, South Carolina Department of Parks, Recreation and Tourism (SCPRT), and the State of North Carolina has designated a significant amount of the land adjoining Lake Jocassee for public recreation and resource conservation.

The total Project Boundary encompasses approximately 1,747 acres (Table E.2-2). The Project Area excluding the transmission line corridor is dominated by forested areas (53.0 percent), followed by open water and developed areas (28.9 and 14.8 percent, respectively). The open water area largely consists of Bad Creek Reservoir (Figure E.2-3). The transmission line corridor is mainly herbaceous (47.6 percent) and forested cover (43.0 percent). Herbaceous areas are primarily within the existing transmission line right-of-way (ROW), and forested areas in the expanded ROW and access roads (Figure E.2-4).

Table E.2-2. Land Use in the Proposed Project Boundary

Land Use Type	Acres	Percent of Total
Project Boundary Excluding Transmission Line Corridor		
Forest	647.4	53.0
Open Water	353.8	28.9
Developed	181.0	14.8
Manicured Lawn	19.5	1.6
Herbaceous	9.3	0.8
Shrub/Scrub	7.4	0.6
Barren	3.9	0.3
Total	**1,222.3**	**100.0**
Transmission Line Corridor		
Herbaceous	249.7	47.6
Forest	225.6	43.0
Shrub/Scrub	25.7	4.9
Developed	14.3	2.7
Open Water	9.8	1.9
Total	**525.1**	**100.0**

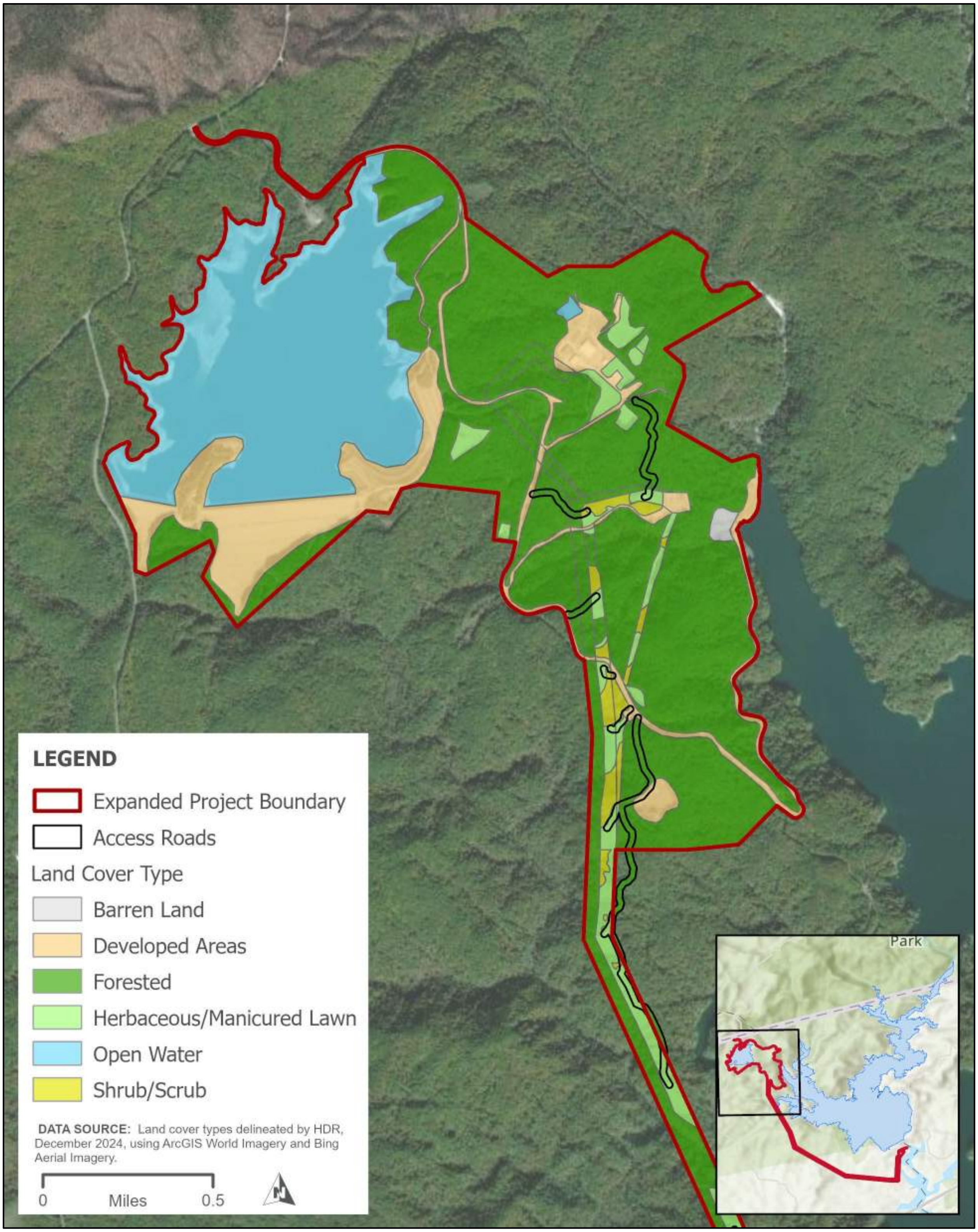


Figure E.2-3. Land Use Map of Project Boundary

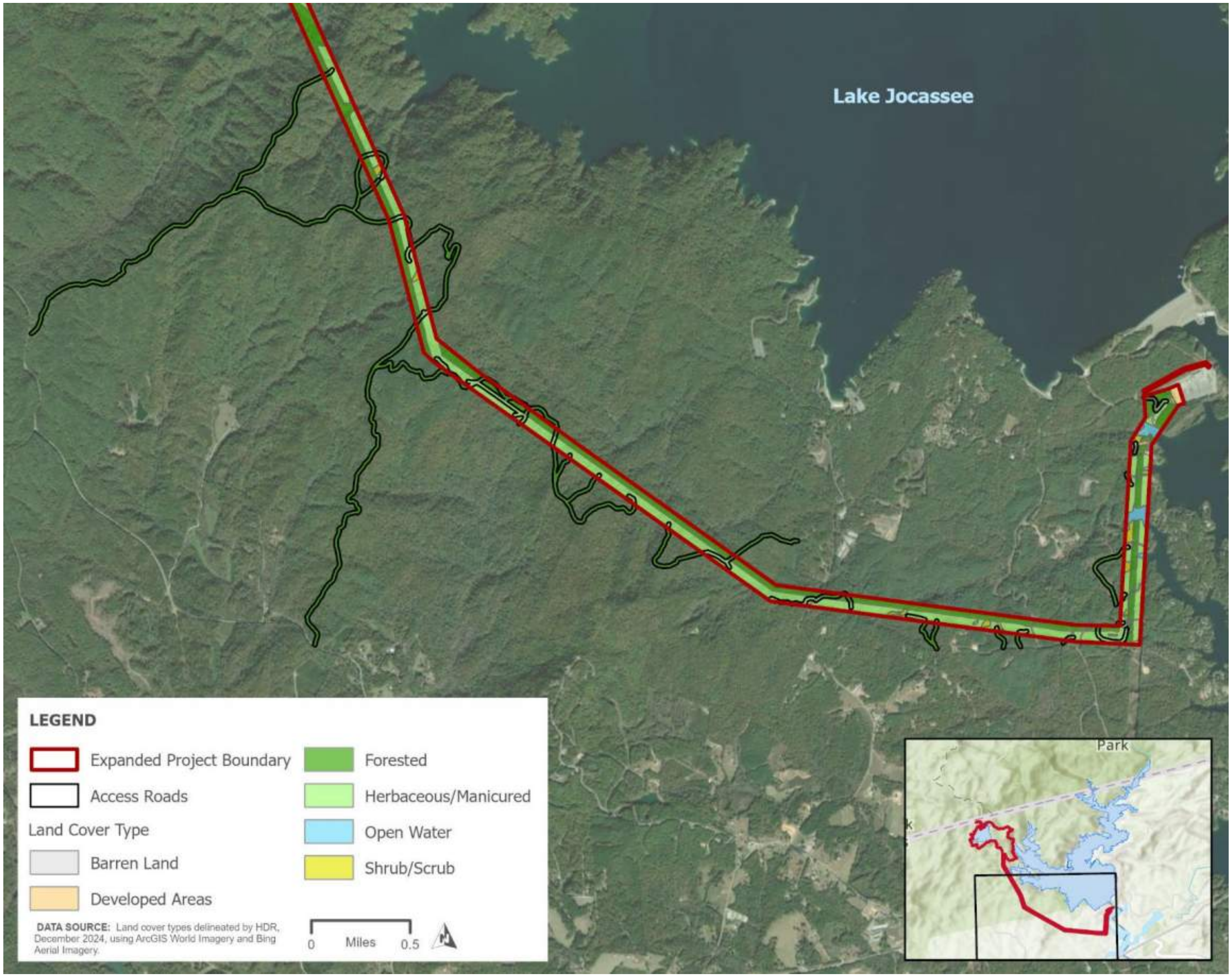


Figure E.2-4. Land Use Map of Project Boundary (Transmission Line Corridor)

E.2.5.2 Water Use

Both North Carolina and South Carolina have assigned state water quality standards commensurate with a designated use of a water body and both states have similar categories of designated use; however, the waters of the Bad Creek Reservoir are not included in state-assigned water quality standards or water use designations, therefore, description of water use in this section is limited to Lake Jocassee and its tributaries.

Some of the tributaries flowing into Lake Jocassee are wholly within North Carolina, some are wholly within South Carolina, and some flow through both states. Variations of sub-sets of general classifications between the two states exist; however, both states have recognized and distinguished between general use to maintain and support aquatic life and general contact recreation, trout habitats, and high value resource areas.

Under the authority of the South Carolina Pollution Control Act, the South Carolina Department of Environmental Services (SCDES) Water Classification & Standards is responsible for establishing appropriate water uses and protection classifications, as well as general rules and specific water quality criteria in order to protect existing water uses, establish anti-degradation rules, protect public welfare, and maintain and enhance water quality. Streams with the following Water Classifications are found within the Project vicinity: Outstanding Resources Waters (ORW); Trout Natural (TN); and Trout Put, Grow, and Take (TPGT). The Whitewater River is classified as ORW, Howard Creek is classified as TN, and Whitewater River tributaries are classified as ORW and TPGT (SCDES 2025; North Carolina Department of Environmental Quality 2021). Lake Jocassee is designated as TPGT. TPGT are freshwaters suitable for supporting growth of stocked trout populations and a balanced indigenous aquatic community of fauna and flora. These waters are also suitable for contact recreation and as a drinking water supply source after conventional treatment. A summary of the designated use classification for the Lake Jocassee watershed is provided in Table E.2-3 and depicted on Figure E.2-5. These waters are subject to SCDES's anti-degradation rules and activities such as discharges to these waters may be prohibited to maintain their classification.

Table E.2-3. Designated Use Classifications of Waterbodies within the Lake Jocassee Watershed

Name	State	Description	Surface Water Classification
Bear Camp Creek	NC	From source to state line	C; TR
Bear Creek	NC	From source to state line	C; TR
Bear Creek	SC	Portion of the creek from state line to Lake Jocassee	TN
Corbin Creek	SC	The entire creek tributary to Devils Fork	ORW (TPGT)
Devils Fork Creek	SC	Portion of the creek from confluence of Corbin Creek and Howard Creek to Lake Jocassee	TN
Horsepasture River	NC	From a point approximately 0.60 miles downstream of N.C. Hwy 281 (Bohaynee Rd) to state line	B; TR, ORW
Howard Creek	SC	Portion of the creek from its headwaters to 0.3 miles below Hwy 130 upstream of the flow augmentation system at the Bad Creek main dam	ORW (TPGT)
Howard Creek	SC	The portion below Bad Creek dam to Lake Jocassee	TN
Lake Jocassee	SC	The entire lake	TPGT
Laurel Fork Creek	SC	The entire creek tributary to Lake Jocassee	TN
Limber Pole Creek	SC	The entire creek tributary to Devils Fork	TN
Rock Creek	SC	Portion of the creek within South Carolina	TN
Thompson River	NC	From source to state line	C, TR
Thompson River	SC	Portion of the river from state line to Lake Jocassee	TN
Toxaway River	NC	From dam at Lake Toxaway Estates, Inc. to state line	C
Whitewater River	NC	From Little Whitewater Creek to state line	C, TR, HWQ
Whitewater River	SC	Portion of the river from state line to Lake Jocassee	ORW (TPGT)
Write Creek	SC	The entire creek tributary to Lake Jocassee	ORW (TPGT)
Coley Creek	SC	The portion of the creek in SC	TPGT
Devils Hole Creek	SC	The entire creek tributary to Lake Jocassee	TPGT
Jackie's Branch	SC	The entire creek tributary to Lake Jocassee	TN
Mill Creek	SC	The entire creek tributary to Lake Jocassee	TPGT

B - Primary Recreation, Fresh Water; C - Aquatic Life, Secondary Recreation, Fresh Water; HQW - High Quality Waters; ORW - Outstanding Resource Waters; TN - Trout-Natural; TPGT - Trout-Put, Grow, and Take; TR - Trout Waters.

Sources: SCDES 2025; NCDEQ 2021

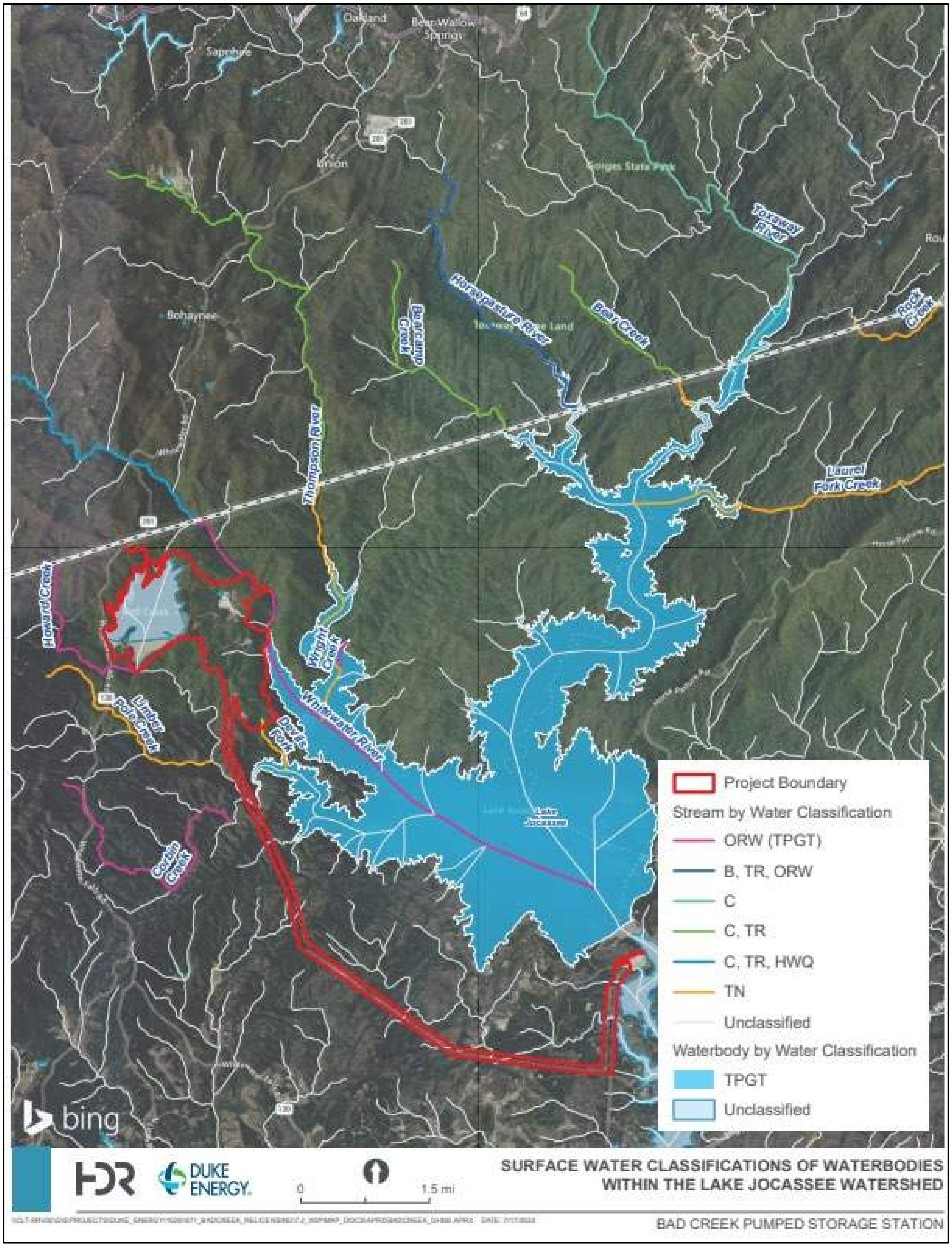


Figure E.2-5. SCDES Surface Water Classifications in Project Vicinity

E.2.6 Downstream Reach Gradients

The only downstream reach directly affected by the Project is Lake Jocassee, which is not included in the Project license. This section is, therefore, not applicable for the Bad Creek Project.

E.3 Cumulative Effects

According to the Council on Environmental Quality's regulations for implementing NEPA, 40 CFR § 1508.1(i)(3), cumulative effects are the effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative effects can result from actions with individually minor but collectively significant actions taking place over a period of time, including hydropower and other land and water development activities.

Based on preliminary staff analysis, FERC identified in its SD2 geology and soil resources, water quality, water quantity, and fishery resources as resources that could be cumulatively affected by the proposed continued operation and maintenance of the Bad Creek Project, in combination with other hydroelectric projects and other activities in the Savannah River Basin. Resource issues also address the effects of potential construction and operation of a second powerhouse during the New License term for Bad Creek II.

E.3.1 Geographic Scope

FERC's geographic scope for the cumulative effects analyses associated with the Project are defined by the physical limits or boundaries of the proposed action's effect on given resources and contributing effects from other hydropower and non-hydropower activities in the Savannah River Basin.

For geology and soil resources, water quality, water quantity, and fishery resources, FERC has tentatively identified the geographic scope to include the Lake Jocassee watershed, including the tributaries to Lake Jocassee as the upstream geographic scope of analysis. In addition, FERC preliminarily identified the downstream geographic scope of analysis as extending to the mouth of the Savannah River. In SD2, FERC explained that this geographic scope was preliminarily chosen because the collective operation and maintenance of the Project, in combination with other developmental and non-developmental uses, may cumulatively affect geology and soil resources, water quality, water quantity, and fishery resources in the Savannah River.

The Licensee agrees with the upstream geographic scope as the Lake Jocassee watershed, though including only those tributaries in the Whitewater River watershed. Based on the results of relicensing studies performed for the Project and Duke Energy's experience and obligations for operating the Bad Creek and KT Projects in accordance with the 2014 Operating Agreement, the Licensee disagrees that the downstream geographic scope extends to the mouth of the Savannah River, as operational or environmental impacts of the Project are attenuated by Lake Jocassee, such that Lake Keowee should reasonably serve as the downstream geographic scope for FERC's cumulative effects analyses.

E.3.2 Temporal Scope

The temporal scope of Duke Energy's cumulative effects analysis includes a brief discussion of past, present, and reasonably foreseeable future actions, to the extent feasible. Based on the potential term of a new license, the temporal scope would extend 40 to 50 years into the future, with a focus on the effects of reasonably foreseeable future actions. The effects of historical activities are generally evaluated in the discussion of the affected environment and are, by necessity, limited to the amount of information available for each resource.

E.3.3 Potential Resource Issues

Many projects and activities occurring in the Project vicinity may contribute to cumulative impacts to natural resources in the Savannah River Basin. Although there are no hydroelectric projects upstream of the Bad Creek Project, there are several hydroelectric projects and diversion structures downstream and on tributaries to the Savannah River. Duke Energy is a party to the following agreements which determine many of the management strategies to maintain the multiple uses throughout the watershed and provide structure around which water and resources are managed:

- **2014 Operating Agreement:** The 2014 Operating Agreement with the USACE and SEPA outlines how water will be managed between the various projects on the Savannah River.
- **KT Relicensing Agreement:** The KT Relicensing Agreement was developed during KT Project relicensing and sets forth actions by Duke Energy and the other signatory parties regarding operation of the KT Project as well as off-License activities.
- **Bad Creek Fisheries Resources Memorandum of Understanding (MOU)**: The Bad Creek Fisheries Resources MOU with the SCDNR provides for the long-term management of high-quality fishery resources in Lake Keowee, Lake Jocassee, and their tributaries. (Refer to Section E.9.1.2 for additional discussion of this agreement covering the existing license term.)

These agreements require review of resource use and potential impacts to minimize both direct and cumulative impacts between projects. Additionally, Duke Energy's continued compliance with the existing KT Project FERC license reduces cumulative impacts.

There are no additional projects or activities that take place on the Bad Creek Reservoir, but Lake Jocassee and downstream areas support diverse recreational activities, including boating and fishing, which may cumulatively contribute to impacts on natural resources. Climate change sensitivities may also affect resources in the Savannah River Basin; Appendix C (*Summary of Climate Data and Future Operations on Water Resources)* includes a discussion of climate and project operations on water resources at the Project.

In SD 2, FERC identified geology and soil resources, water quality, water quantity, and fishery resources as resources for consideration of cumulative impacts. The specific resource issues being evaluated for cumulative impacts include:

- Effects of Project operation on shoreline erosion along the lower reservoir.
- Effects of Project operation on water levels in Lake Jocassee.
- Effects of Project operation on water quality in Lake Jocassee including water temperature, dissolved oxygen (DO) concentrations, and vertical mixing of DO.
- Effects of reservoir fluctuations associated with Project operation on aquatic habitat and biota in Lake Jocassee.
- Effects of Project induced impingement[3], entrainment, and turbine mortality on fish populations in Lake Jocassee.

Duke Energy conducted studies to evaluate these and other potential resource issues. Conclusions from these studies related to the potential resource issues identified by FERC are described in Sections E.3.3.1 and E.3.3.2, below. Detailed analysis of direct impacts to resources are provided in Sections E.7 through E.15

E.3.3.1 Geology and Soils Resources

Sources of shoreline erosion along the Lake Jocassee shoreline include physical weathering, concentrated runoff, and non-Project development along the shoreline, with the majority of erosion attributed to wave action from wind and recreational boating. Approximately 75 percent of the Lake Jocassee shoreline is either bedrock or shows no signs of erosion (Orbis 2012).

Increased flows associated with Bad Creek II generation would add to the overall outflow through the conduits discharging into the Whitewater River cove of Lake Jocassee. Associated potential effects on shoreline erosion along the opposite (eastern) bank in the Whitewater River cove due to a second powerhouse were assessed during a Bad Creek II feasibility study using a computational fluid dynamics (CFD) model developed for the Bad Creek Project. The final report (*Bad Creek II Power Complex Feasibility Study Lower Reservoir CFD Flow Modeling Report* [HDR 2022]) was filed with the

[3] Not applicable; relevant studies for the Project assume impingement is unlikely due bar rack spacing of six inches (Kleinschmidt Associates 2018).

RSP[4] and results indicated higher velocities and/or changes in the location of higher velocities would not affect existing bank conditions/erosion assuming the geology of the east bank is consistent along the shoreline (i.e., predominantly exposed competent bedrock). The modeled velocities were approximately equivalent to the physical model study velocities, which are representative of the existing conditions. Additional CFD modeling for the relicensing is further discussed in Section E.8.2.1.3 and the final report (*Velocity Effects and Vertical Mixing in Lake Jocassee duke to a Second Powerhouse Final Report)* is included in Appendix D; results from that modeling effort provide a detailed description of modeled operational scenarios on flow patterns and velocities in the Whitewater River cove with the addition of Bad Creek II. Water level fluctuations in Lake Jocassee will not increase in magnitude under Bad Creek II operations, therefore, continued operation of the Project or new operations at Bad Creek II is not expected have cumulative impacts on shoreline erosion at Lake Jocassee.

E.3.3.2 Water and Aquatic Resources

Effects of Project operations are not expected to have significant cumulative impacts on water or aquatic resources at Lake Jocassee or in the Savannah River Basin.

Bad Creek II operations would have limited impacts on water levels in Lake Jocassee or Lake Keowee. The effects of Bad Creek II are constrained by Duke Energy's continued compliance with the existing KT Project FERC license, including the 2014 Operating Agreement. These requirements would not be modified with the relicensing of the Project or the construction and operation of Bad Creek II, so there would be little to no effects to the downstream[5] USACE hydroelectric projects. Bad Creek II will not affect the total quantity of water pumped or discharged or impoundment levels or the ultimate magnitude of fluctuations of the upper and lower reservoirs. The Lake Jocassee reservoir level fluctuations over a 24-hour period would generally be less under Bad Creek II than would occur under the Baseline Scenario. The 24-hour fluctuations would be two ft or less approximately 90 percent of the time under the Bad Creek II scenario, compared with 75 percent of the time under the Baseline Scenario as discussed in Section E.8.2.1.4 as well as the *Water Exchange Rates and Lake Jocassee*

[4] FERC eLibrary Docket P-2740, Accession Number 20221205-5088: Bad Creek Pumped Storage Station Revised Study Plan.

[5] Bad Creek releases directly into Lake Jocassee, so the elevation of Lake Jocassee is the controlling factor for Bad Creek's tailwater elevation. Likewise, the Jocassee powerhouse releases directly into Lake Keowee, so the elevation of Lake Keowee is the controlling factor for Lake Jocassee's tailwater elevation computation. Although the Keowee powerhouse discharges into Hartwell Lake, backwater effects in the upstream lake channel minimize effects to Hartwell Lake elevations or limitations to Lake Keowee discharges.

Reservoir Levels Final Report in Appendix D. There are no projects upstream of Bad Creek and cumulative impacts are not anticipated.

Project operations are not expected to have cumulative impacts on water quality in Lake Jocassee, including water temperature, DO concentrations, or vertical mixing of DO. Duke Energy has monitored water quality in Lake Jocassee since the 1970's and carried out a comprehensive desktop analysis of historic water quality in Lake Jocassee including DO concentration, DO saturation, water temperature, conductivity, phosphorus, and nitrogen data from 12 water quality monitoring stations. Field work was also carried out over two summers (2023 and 2024) to assess water quality and vertical mixing in Lake Jocassee under 3-unit and 4-unit operations and CFD modeling was conducted to estimate future flows under combined discharge from the existing Project and Bad Creek II in Lake Jocassee and also considers the submerged weir[6] downstream of the Project discharge. Results from the (1) desktop review, (2) field work, and (3) modeling efforts show water upstream of the submerged weir is well-mixed due to Project operations and inflow from the Whitewater River, while water downstream of the weir remains stratified under all pumping and generation scenarios, indicating the weir is functioning as it was designed and is effective in dissipating energy from the I/O structure, limiting vertical mixing to the upstream portion of Whitewater River cove. Therefore, continued operation of the existing Project and future operation of Bad Creek II is not anticipated to have cumulative impacts on water quality in Lake Jocassee. The Licensee's proposed Water Quality Monitoring Plan (WQMP) to be implemented during construction of Bad Creek II and for a specified period of time after Bad Creek II is commissioned will support compliance with water quality standards (turbidity) in Lake Jocassee; therefore, cumulative impacts are not anticipated for tributaries or downstream waterbodies. The final study reports supporting water quality are provided in Appendix D and include the *Summary of Existing Water Quality Data and Standards Final Report*, *Water Quality Monitoring in the Whitewater River Arm Final Report*, and *Velocity Effects and Vertical Mixing in Lake Jocassee duke to a Second Powerhouse Final Report.*

Cumulative impacts to aquatic habitat and biota are not anticipated from reservoir fluctuations associated with Project operations. Although stable water surface elevations are important for species that use the littoral zone for spawning, impacts to pelagic trout habitat resulting from increased vertical mixing due to operations from Bad Creek II are not expected based on historical lake dynamics, trout habitat monitoring, and hydraulic modeling. The addition of Bad Creek II would not reduce littoral zone

[6] During original Project construction, Duke Energy constructed a submerged weir 1,800 ft downstream of the Project discharge. The crest of the weir, built out of nearly half a million cubic yards of rock excavated during Project construction, extends to within approximately 40 ft of full pond elevation of Lake Jocassee and was installed to help minimize the effects of Bad Creek operations on the natural stratification of Lake Jocassee and to dissipate the energy of the discharging water.

habitat as compared to current conditions under the Baseline Scenario in Lake Jocassee, while some conditions (e.g., spawning success) would improve with the addition of Bad Creek II operations, as described in the *Water Exchange Rates and Like Jocassee Reservoir Levels Final Report* in Appendix D.

There are multiple projects that may contribute to cumulative impacts to fish populations in the Savannah River Basin, as discussed in Section E.2.3, including the Hartwell Dam, several dams on tributaries that flow into Lake Hartwell, as well as the Richard B. Russel Dam and the J. Strom Thurmond Dam on the mainstem Savannah River. The estimated rates of entrainment mortality at the Project or proposed Bad Creek II are not expected to affect the long-term sustainability of Lake Jocassee fish populations based on intrinsic population growth rates, as documented in the *Desktop Entrainment Analysis Final Report* in Appendix D. The species that experience the greatest amount of entrainment, blueback herring and threadfin shad, are highly fecund species, such that population-level compensatory mechanisms would likely offset the entrainment losses. In addition, while some level of entrainment mortality will inevitably occur, many natural populations have excess reproductive capacity that will compensate for some losses of individuals. Although entrainment impacts to fish populations at Lake Jocassee are not significant, there may be cumulative impacts in the Savannah River Basin.

Climate change may affect the availability of water in the Savannah River Basin and contribute to cumulative impacts to water resources. To maintain water levels and reduce potential cumulative impacts, the Low Inflow Protocol for the KT Project (LIP) included in the current license, determines operating procedures during drought (USACE 2014; Duke Energy 2014a).

E.4 Compliance with Applicable Laws

E.4.1 Clean Water Act

Under Section 401 of the Clean Water Act (CWA) (33 USC § 1251 et seq.), a federal agency may not issue a license or permit to conduct any activity that may result in any discharge into waters of the United States unless the state or authorized tribe where the discharge would originate either issues a Section 401 Water Quality Certification (WQC) finding compliance with existing water quality requirements or waives the certification requirement. The SCDES administers WQCs pursuant to S.C. Code Ann. § 48-1-10, et seq.

Duke Energy is preparing a joint permit application for a WQC for the continued operation of the Project, including the addition of the Bad Creek II Bad Creek II, in parallel with the FERC licensing process and intends, to the extent possible, to use licensing documents including but not limited to study reports and the license application exhibits to satisfy this parallel regulatory process. Pursuant to 18 CFR § 5.23(b), Duke Energy will file an application for WQC with SCDES no later than 60 days of the Commission's Notice of Acceptance and Ready for Environmental Analysis. The SCDES must act on the request for WQC within the one-year timeframe allowed under the CWA.

Duke Energy will also seek a WQC from SCDES for the construction of Bad Creek II and as part of the separate CWA Section 404 permitting process. Section 404 of the CWA (33 USC § 1344) establishes a program to regulate the discharge of dredged or fill material into "waters of the United States" requires a permit from the USACE before any such activity can occur. Both permanent and temporary impacts to waters of the U.S. require permitting under Sections 404 and 401 of the CWA. In parallel with the relicensing process, Duke Energy has initiated pre-filing consultation with and is planning to file an application with USACE for an individual permit to authorize the discharge of dredged or fill materials in waters of the U.S., including wetlands and surface waters (i.e., streams) in spoil areas and other areas associated with the construction of proposed Bad Creek II infrastructure, including the lower reservoir I/O structure. The USACE Charleston District administers Section 404 permitting and the SCDES administers 401 water quality certifications in South Carolina.

An Individual Section 404 permit will only be issued if the USACE District Engineer makes a determination that a proposed discharge (e.g., impact) complies with applicable provisions of 40 CFR part 230 (i.e., the CWA Section 404(b)(1) Guidelines), including the requirement of an applicant to first take all appropriate and practicable steps to avoid and minimize adverse impacts to waters of the U.S. (e.g., alternatives analysis). Based on this provision, the applicant is required in every case to evaluate opportunities for use of non-aquatic areas and other aquatic sites that would result in less adverse impact on the aquatic ecosystem. The purpose of the alternatives analysis is to reach the Least Environmentally Damaging Practicable Alternative ("LEDPA") that meets the Purpose and Need of a project. Compensatory mitigation for unavoidable impacts may be required to ensure that an activity requiring a Section 404 permit complies with the Section 404(b)(1) Guidelines. USACE will be responsible for satisfying their NEPA requirements for their permitting decision. Duke Energy will prepare a separate 404(b)(1) alternatives analysis as part of the CWA 404/401 individual permit application.

E.4.2 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) (19 USC §1536(c)), as amended, requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of such species. Under the ESA, the U.S. Fish and Wildlife Service (USFWS) is responsible for freshwater and terrestrial species, and the National Marine Fisheries Service (National Oceanic and Atmospheric Administration [NOAA] Fisheries) is responsible for marine and anadromous species (not applicable to the Project). In the notice of the Licensee's intent to file a Final License Application (FLA), filing of the PAD, commencement of pre-filing process, and scoping issued on April 22, 2022, the Commission designated Duke Energy as the Commission's non-federal representative for carrying out informal consultation pursuant to Section 7 of the ESA. Information from the USFWS and SCDNR and data collected during execution of the relicensing studies have been used by the Licensee to identify endangered or threatened species in the Project area. A discussion of the rare, threatened, and endangered (RTE) species relevant to the Project is contained in Section E.11.

E.4.3 Magnuson-Stevens Fishery Conservation and Management Act

The 1996 amendments to the Magnuson-Stevens Act authorized the National Marine Fisheries Service, in accordance with regional fisheries management councils, to delineate essential fish habitat for the protection of habitat of marine, estuarine, and anadromous finfish, mollusks, and crustaceans. Essential Fish Habitat includes "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The Project area is not located within designated essential fish habitat for any species.

E.4.4 Coastal Zone Management Act

Section 307(c)(3) of the Coastal Zone Management Act requires activities conducted or supported by a federal agency that affect the coastal zone be consistent with the enforceable policies of the federally-approved state coastal management plan to the maximum extent practicable. Policies associated with the Coastal Zone Management Act are not applicable to the Project, which is not located within South Carolina's designated Coastal Zone.

E.4.5 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966 (NHPA) (54 USC §300101 et seq.) requires federal agencies to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such actions. Historic properties include significant sites, buildings, structures, districts, and individual objects listed in or eligible for inclusion in the National Register of Historic Places (NRHP). If a property has not yet been nominated to the NRHP for determined eligible for inclusion, it is the responsibility of FERC to ascertain its eligibility.

The Commission's issuance of a new license for the continued operation of the Project is considered an undertaking subject to the requirements of Section 106 and its implementing regulations. FERC initiated consultation under Section 106 with federally recognized Indian Tribes by letter dated March 9, 2022. By notice dated April 22, 2022, FERC designated Duke Energy as its non-federal representative for purposes of conducting informal consultation pursuant to Section 106.

E.4.6 Wild and Scenic Rivers and Wilderness Act

The waterbodies associated with the Project are not located within or adjacent to any presently designated National Wild and Scenic River systems or state protected river segments. The Project does not occur in or occupy lands designated as wilderness area under the Wilderness Act.

E.5 Project Facilities and Operations

E.5.1 Maps of Project Facilities Within Project Boundary

The following figures in this DLA depict the Project facilities within the proposed Project Boundary:

- Exhibit G – Project Boundary Map (Volume III)
- Figure E.1-1 – Project Location Map with Project Boundary

E.5.2 Project Facilities

Licensed Project works consist of: (1) a 363-acre upper reservoir with a storage capacity of 35,513 acre-ft, of which 31,808 acre-ft is usable storage capacity between minimum elevation 2,150 ft msl and full pond elevation of 2,310 ft msl; (2) a rockfill impervious core dam with crest elevation at 2,315 ft msl about 2,600 ft long and 355 ft high across Bad Creek; (3) a rockfill impervious core dam with crest elevation at 2,315 ft msl about 900 ft long and 170 ft across West bad Creek; (4) a saddle dike with crest elevation at 2,313 ft msl about 900 ft long and 90 ft high across a natural depression on the eastern rim of the reservoir; (5) an ungated water intake structure in the upper reservoir; (6) a concrete line main shaft, power tunnel, and manifold, totaling 5,026 ft long and is 29.53 ft in diameter, connecting to 4 concrete, steel-lined penstocks about 386 ft long and varying from 13.78 to 8.43 ft in diameter; (7) an underground powerhouse containing four reversible pump-generating units, with a nameplate rating of 350,000 kilowatts each for a total generating capacity of 1,400 MW; (8) 4 concrete-lined draft tube tunnels about 316 ft long and 16.4 ft diameter, connecting by means of a manifold structure to two concrete-lined tailrace tunnels about 875 ft long and 24.61 ft diameter; (9) an I/O structure equipped with four 20-foot by 30-foot, steel lift gates located in the existing Lake Jocassee which serves as the lower reservoir; (10) transmission facilities consisting of (a) the generator leads, (b) the electrical bus housed in a vertical shaft about 528 ft high and 29.5 ft in diameter leading from the underground powerhouse to (c) four above ground 19/525-kilovolt (kV) step-up transformers, (d) a 100-kV transmission line extending about 9.25 miles from the Bad Creek switchyard to the Jocassee switchyard, (e) a 525-kV transmission line extending about 9.25 miles from the Bad Creek switchyard to the Jocassee switchyard; and (11) appurtenant facilities.

E.5.3 Project Waters

Bad Creek utilizes the Bad Creek Reservoir as the upper reservoir and Lake Jocassee, licensed as part of the KT Project, as the lower reservoir. The Project is operated in a “daily cycle” mode, commonly alternating between generating and pumping on a daily basis, with the upper reservoir typically maintained in the upper 50 to 60 ft at elevations of 2,310 and 2,250 ft msl. The upper reservoir is impounded by two large dams (main dam and west dam) and a saddle dike (east dike). The maximum reservoir drawdown is 160 ft with a usable storage capacity of 31,808 acre-ft.

At full pond (1,110 ft msl), the lower reservoir, Lake Jocassee, has a water surface area of approximately 7,980 acres and a storage capacity of approximately 1,206,798 acre-ft with 92.4 miles of shoreline. The usable storage (1,110 – 1,080 ft msl) is 225,447 acre-ft.

E.5.4 Turbine and Generator Specifications

Existing turbine and generator specifications for Bad Creek and Bad Creek II are included in Volume I (Exhibit A) of this DLA and are also provided in Table E.5-1 for reference.

Table E.5-1. Project Turbine and Generator Data

	Existing Turbine-Generators	***Bad Creek II Turbine-Generators***
Number of Units	4	4
Turbine Type	Francis pump-turbine	Francis pump-turbine
Design Head (net ft)	1,150	1,150
Rated Capacity (horsepower)	467,667	467,667
Minimum Hydraulic Capacity (cfs)	3,070 (per unit)	0 (per unit)
Maximum Hydraulic Capacity (cfs)	4,940 cfs (per unit)	4,940 cfs (per unit)
Operating Speed revolutions per minute (rpm)	300	+/- 300
Generator-Motor Type	Vertical	Vertical
Rated Capacity (kilowatts)	420,000 (per unit)	459,000 (per unit)*
Power Factor	0.9	0.9
Phase	3-phase	3-phase
Voltage (V)	19,000 V (per unit)	18,000 V (per unit)
Frequency (Hertz)	60 (per unit)	60 (per unit)
Synchronous Speed (rpm)	300	N/A
Variable speed (rpm)	N/A	300-10% / +7.9%

*Rated capacity increase for Bad Creek II results from variable speed capability, which enables higher efficiency and greater output at maximum power.

E.5.5 Dependable Capacity and Average Annual Energy Production

E.5.5.1 Dependable Generating Capacity

For a pumped storage facility, the "dependable generating capacity" may be defined as the total output in MW from the station with all units at maximum power while operating at the median upper reservoir storage limit. Using this definition, the dependable generating capacity of Bad Creek Units 1-4 is 410 MW each for a total of 1,640 MW. The dependable generating capacity of Bad Creek II Units 5-8 will be 440 MW each for a total of 1,760 MW. The combined dependable generating capacity for the Project will be 3,400 MW.

The Net Dependable Capacities for Bad Creek and Bad Creek II (Table E.5-2) are based upon the available energy storage within the upper 30 ft of the Bad Creek Reservoir which corresponds to an approximate gross head of 1,170 ft. The volume at this elevation is approximately 9,710 acre-ft. Based on the estimated hydraulic output of the pump-turbines at each facility, the capacities in generation mode can be achieved for a minimum duration for 3 hours while both facilities are in operation. The duration approximately doubles when either facility is not dispatched.

Table E.5-2. Net Dependable Capacities

Existing Facility		Bad Creek II	
Unit 1	410 MW	Unit 5	440 MW
Unit 2	410 MW	Unit 6	440 MW
Unit 3	410 MW	Unit 7	440 MW
Unit 4	410 MW	Unit 8	440 MW
Total	**1,640 MW**	**Total**	**1,760 MW**

E.5.5.2 Average Annual Energy Production

For a discussion of average annual energy production under existing Project operations as well as anticipated total production along with annual pumping power, please see Section B.4.2 of Volume 1.

E.5.6 Project Operations

The Project utilizes the Bad Creek Reservoir as the upper reservoir and Lake Jocassee as the lower reservoir. The Project currently operates on a “daily cycle” mode, commonly alternating between generating and pumping on a daily basis, with the reservoir typically maintained in the upper 50 to 60 ft at elevations of 2,310 and 2,250 ft msl (compared to a maximum drawdown of 160 ft). This operating mode permits the Licensee to maximize head, energy density, and plant/unit efficiency and utilize the Project like a massive battery to help balance the regional transmission system, including rapid consumption or generation of power due to variable solar energy production.

Duke Energy operates the Bad Creek Project in concert with operation of its downstream KT Project comprised of the Jocassee Pumped Storage Development and the Keowee Development. Operational requirements for the KT Project are set forth in the KT Project FERC license. KT Project license requirements affecting Bad Creek operations include the minimum and maximum reservoir elevations for Lake Jocassee and the KT LIP. Project operations are also affected by the 2014 Operating Agreement between the USACE, SEPA, and Duke Energy.

E.5.6.1 2014 Operating Agreement

The 2014 Operating Agreement ensures the percentages of remaining usable water storage in the Project and KT Project, combined, and the USACE's system (i.e., Hartwell, Richard B. Russell, and J. Strom Thurmond) remain in balance when low inflow conditions develop and as these conditions become more severe. Under the 2014 Operating Agreement, declining remaining usable water storage in the downstream USACE reservoir system triggers Duke Energy to release water from the Keowee Development so both systems remain in balance until the Duke Energy system (i.e., Lakes Jocassee, Lake Keowee, and Bad Creek Reservoir) reaches 12 percent remaining usable water storage. At that point, while downstream water flow releases from the Keowee Development associated with hydroelectric generation would cease (excluding releases that may be required by the FERC, for Oconee Nuclear Station operations, or situations covered by the KT Project Maintenance and Emergency Protocol [MEP]), approximately 650 acre-ft of water per week would continue flowing downstream due to leakage and seepage. Therefore, water continues flowing into Hartwell Lake even during the most severe droughts (Duke Energy 2014a).

The 2014 Operating Agreement and its effects are discussed further in Section E.8.1.3.2.

E.5.6.2 Low Inflow Protocol

The LIP was developed during KT Project relicensing to support management of the KT Project reservoirs (Jocassee and Keowee) and Bad Creek Reservoir during periods of low inflow (i.e., drought) while meeting the water resource needs of the public. The 2014 Operating Agreement and LIP are integrated with one another. The LIP is a requirement of the KT Project license and included in the KT Relicensing Agreement.

The LIP defines triggers for implementing specific actions depending on the severity of the drought. There are five different drought stages in the LIP and each is defined by available storage in Duke Energy reservoirs or the Drought Plan Level designated for the downstream USACE reservoirs, along with confirming triggers of the U.S. Drought Monitor designation and streamflows in the Upper Savannah River Basin. Stage minimum elevations are defined for each drought stage. When a subsequent stage of the LIP is reached, each Project reservoir must be within 0.25 ft of the Stage Minimum Elevation of the previous stage of the LIP before each Project reservoir can be lowered to the next Stage Minimum Elevation.

The LIP defines operational constraints reservoir elevations at Lake Jocassee and Lake Keowee at each LIP stage. Duke Energy maintains Lake Jocassee's level during normal inflow conditions within a range from a Normal Maximum Elevation of 1,110 ft msl to a Normal Minimum Elevation of 1,096 ft msl. During the most severe stage of the LIP, however, Lake Jocassee can be drawn down 30 ft to an elevation of 1,080 ft msl. The LIP does not include stage minimum reservoir elevations for Bad Creek Reservoir. While Bad Creek Reservoir elevations are not constrained by the LIP, Project pumping operations can be limited by the LIP when such operations would cause Lake Jocassee to fall below its LIP stage minimum elevation.

E.6 Proposed Action and Alternatives

E.6.1 No-Action Alternative

Under the no-action alternative, the Project would continue to operate as required by the current license (i.e., there would be no change to the existing environment). No new environmental protection, mitigation, and enhancement (PM&E) measures would be implemented. This alternative establishes baseline environmental conditions for comparison with other alternatives.

The existing license specified a number of PM&E measures applicable during initial Project construction that are no longer applicable to Project operation. The following PM&E measures required by the existing license are currently implemented by Duke Energy and would continue under this alternative:

- Aquatic Resources (Article 32): Article 32 required Duke Energy to develop and implement a mitigation plan addressing adverse impacts of Project operations on aquatic resources at Lake Jocassee and its tributaries. This requirement led to the development of the Bad Creek MOU between Duke Energy and SCDNR. The MOU seeks to protect fishery resources in Lake Jocassee and its tributaries as specified in Ten-Year Work Plans.

- Recreation Resources (Article 31): Consistent with Article 31 and Exhibit R (as amended), Duke Energy constructed and maintains approximately 43 miles of the Foothills Trail as well as two boat-in trail access points at Lake Jocassee.

In addition to existing license requirements, the Licensee also complies with the existing WQC issued August 9, 1976, implements the LIP as discussed in Sections E.5.6.2 and E.8.1.3.2, and implements the 2014 Operating Agreement as discussed in Sections E.5.6.1 and E.8.1.3.2.

E.6.2 Applicant's Proposal

The proposed action is to continue the operation and maintenance of the Project with additional PM&E measures discussed herein. Additionally, Duke Energy proposes to construct Bad Creek II to increase the Project's authorized installed capacity from 1,400 MW to 2,800 MW.

Many of the PM&E measures proposed by Duke Energy and discussed in this section are included in the BCRA (Appendix B).

E.6.2.1 Proposed Project Facilities

No changes are proposed to existing licensed Project facilities described in Section E.5.2. However, Duke Energy proposes to construct the Bad Creek II powerhouse with four variable-speed pump turbine units and associated structures to support operation of the Bad Creek II powerhouse. This includes a new upper reservoir I/O structure, new lower reservoir I/O structure, water conveyance tunnels, a new transformer yard, new switchyard, and a new 525-kV transmission line connecting to the Jocassee switchyard (Figure E.6-1 and Figure E.6-2).

Changes to minor and ancillary Project facilities will occur where necessary to facilitate construction and expanded Project operation. These changes include demolition of certain existing infrastructure to accommodate Bad Creek II facilities, as further described below.

- Existing stormwater system, which consists of numerous catch basins and storm drains, with stormwater ultimately conveyed to the south via five storm drains that discharge into a sedimentation basin. Bad Creek II design and construction will include new stormwater catch basins and storm drains for the new switchyard, transformer yard, and equipment building area.

- Wastewater treatment facilities. The existing Project includes a powerhouse sump wastewater treatment system which consists of a primary sedimentation basin, secondary sedimentation basin, oil skimming booms, and a Parshall flume near the planned location of the Bad Creek II lower I/O structure. Effluent from the secondary sedimentation basin flows by gravity through a Parshall flume for effluent flow measurement, and then discharges to Lake Jocassee through a permitted National Pollutant Discharge Elimination System (NPDES) outfall (SCG360018).[7] The existing system (as well as the existing sanitary sewer system, which consists of interior facilities connected to a sanitary sewer line that drains south and continues to a septic drain field) will be eliminated due to the construction of the proposed lower I/O structure. The Bad Creek and Bad Creek II powerhouse sump discharge streams will be combined into one modular package system, which will require permitting under the above-referenced NPDES permit.

[7] The existing sedimentation basins and subsequent discharge (outfall) of powerhouse sump wastewater is covered under the NPDES General Permit for Hydroelectric Generating Facilities (SCG360018). The General Permit has an oil and grease effluent limit of 10 milligrams per liter (mg/L) for the monthly average concentration and an effluent limit of 15 mg/L for the maximum daily concentration. In addition, the General Permit also has an effluent pH range of 6.0 to 8.0.

- A fire protection water storage reservoir located in the northern area of the construction and operations area.
- Drinking water well located in the northern area of the construction / operations area.
- Potentially existing buildings located near the operations area (motor pool and equipment storage buildings).

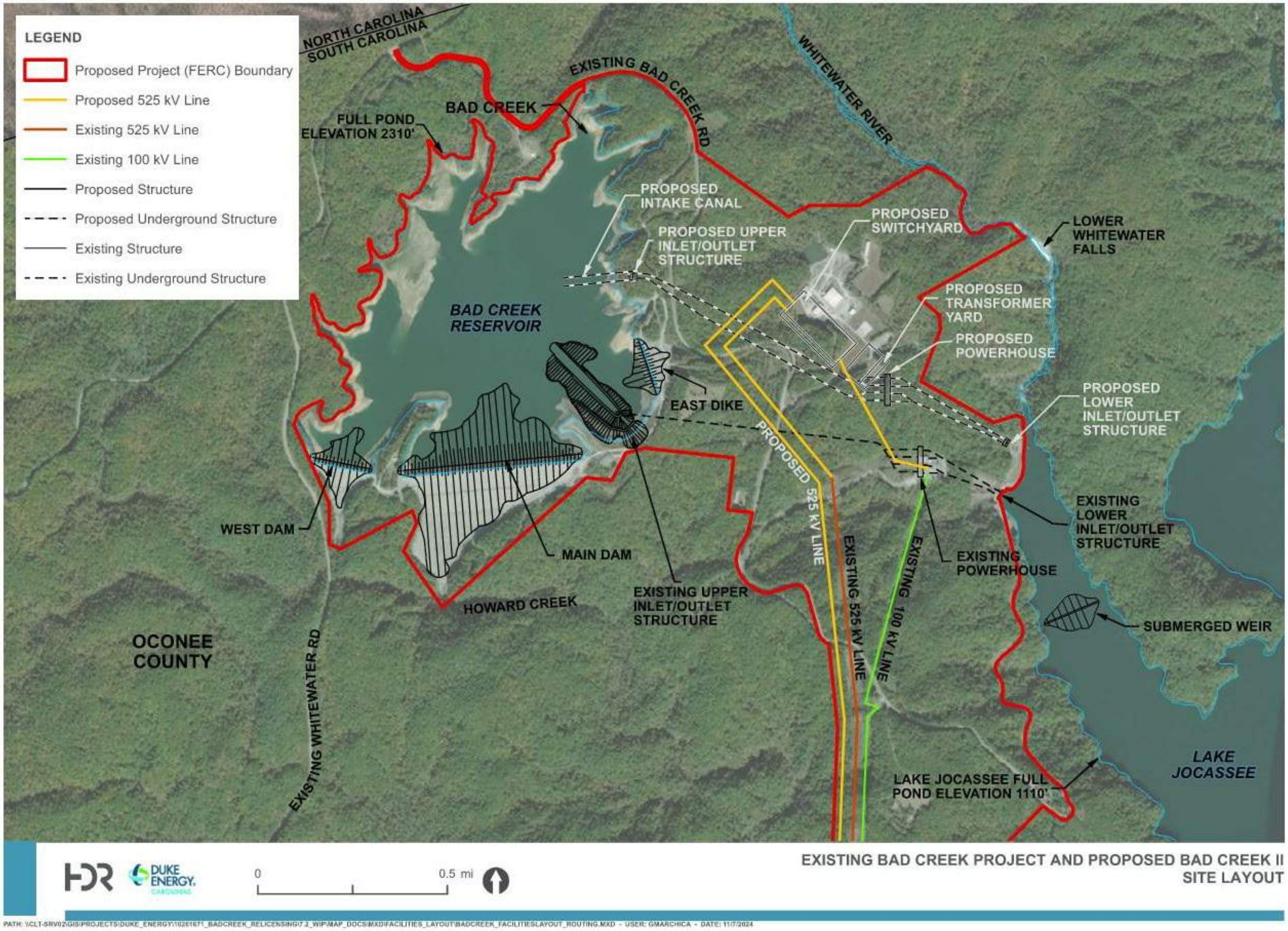


Figure E.6-1. Proposed Bad Creek II Site Layout

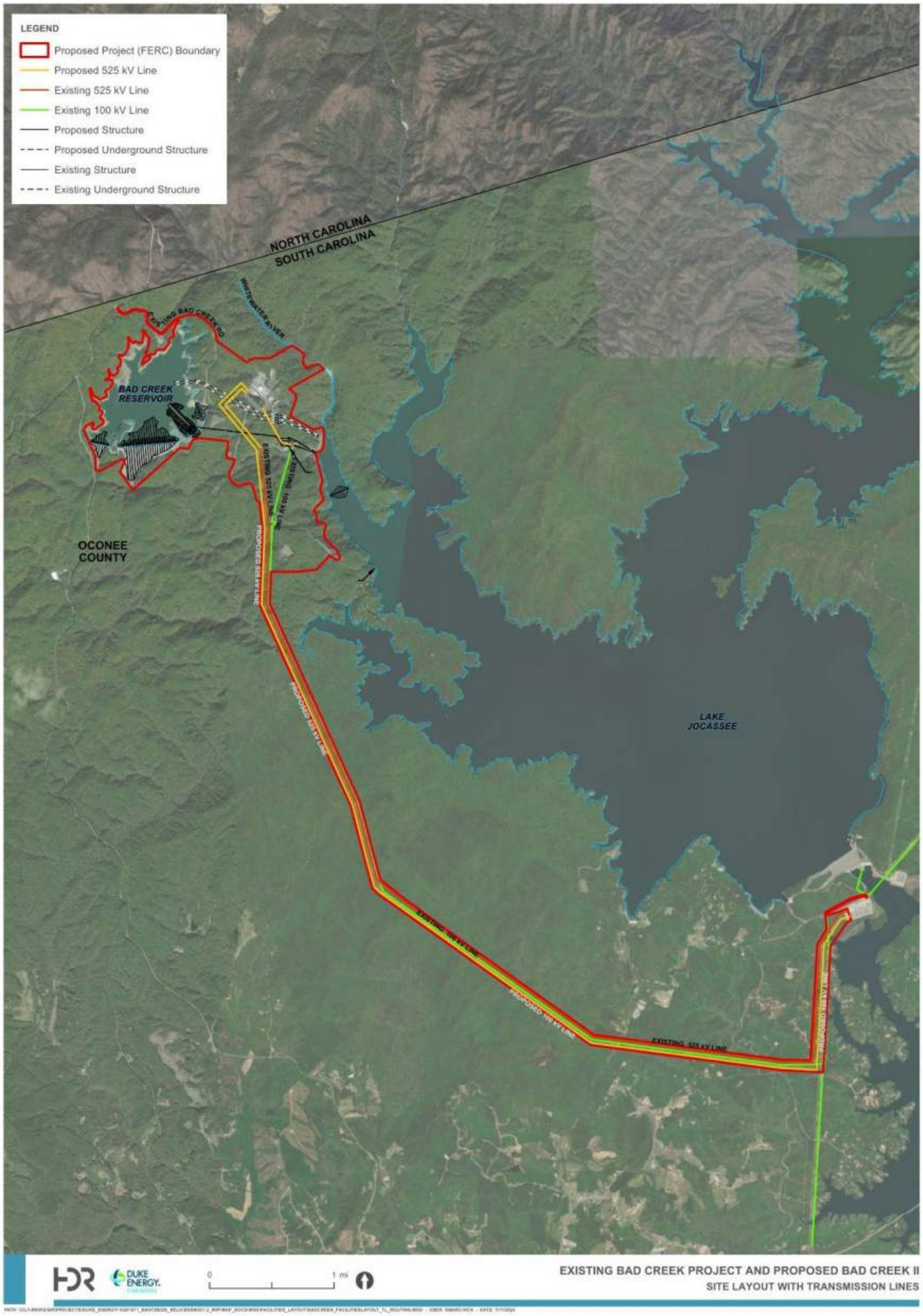


Figure E.6-2. Proposed Bad Creek II Site Layout with Expanded Transmission Line Corridor

E.6.2.2 Proposed Bad Creek II Construction

As currently planned, construction of Bad Creek II would occur over an approximately seven-year period as described below and summarized on Figure E.6-3. The Licensee expects construction activities would occur 24 hours per day, seven days per week during some periods of construction.

The existing Project (i.e., units 1 through 4) would continue operation during construction except during the final stages of construction of the upper reservoir I/O structure when Bad Creek Reservoir would be dewatered.

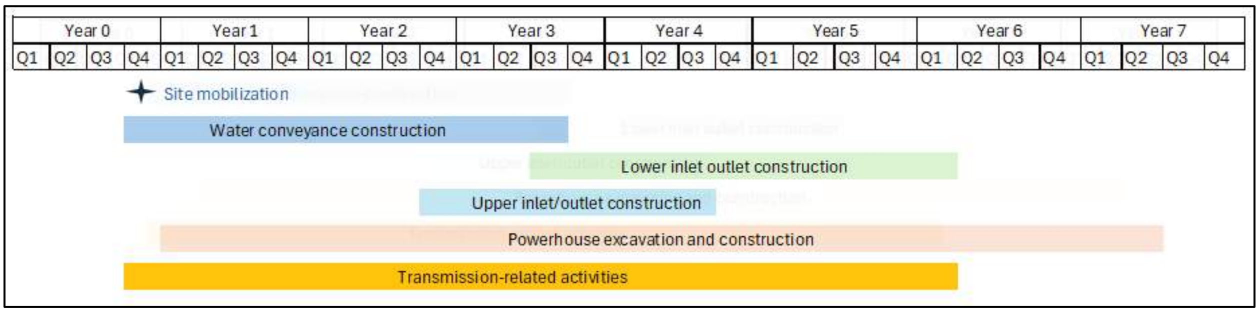


Figure E.6-3. Bad Creek II Construction Timeline

This license application is based on preliminary designs and plans for the expanded Project. The Licensee estimates the current level of design to be approximately 30% complete, and notes this is common for new development hydropower projects subject to FERC licensing. Design of Bad Creek II is ongoing and will continue, by or for the Licensee, through the post-filing phase of the relicensing process, including early contracts to the Original Equipment Manufacturer and the Engineering, Procurement and Construction (EPC) Contractor, who will provide final project design and construction. Detailed design and construction plans and specifications are expected to be prepared for and reviewed and approved by the FERC Division of Dam Safety and Inspections Atlanta Regional Office (D2SI-ARO), following new license issuance and prior to commencement of major phases of expanded Project construction. These documents will be detailed, comprehensive, and based on site-specific information, and analyses and designs will be performed in accordance with the FERC's Engineering Guidelines and commensurate with the Bad Creek Project's high hazard potential classification. Additional design documents that require FERC approval prior to starting construction include but are not limited to Quality Control Inspection Program, Erosion and Sediment Control Plans, Temporary Construction Emergency Action Plans, Temporary Construction Surveillance and Monitoring Plan, and Cofferdam Designs and Deep Excavations.

E.6.2.2.1 Site Mobilization, Grading, and Clearing

The initial stage of Bad Creek II construction would consist of site mobilization where the Licensee's contractors set up for construction activities. This stage would also include acquisition of necessary environmental permits (i.e., CWA Section 404/401 permit, Erosion and Sediment Control Permits, building permits, air permits, etc.).

Road access to and within the site will primarily be provided through the access roads used for Project construction and operation. Existing access roads at the Project are shown on Figure E.6-4 and Figure E.6-5 and described below:

- **State Route (SR) 130** is the sole public access road to the site. SR 130 originates at U.S. 123 south of Lake Keowee and runs generally north approximately 14 miles north to its intersection with U.S. 64 in North Carolina. The EPC Contractor's use of SR 130 will be coordinated directly with the North and South Carolina Departments of Transportation.
- **Bad Creek Road** originates at SR 130 just south of the North and South Carolina border. From this point, the road extends generally southeast for approximately 4 miles. It was constructed as part of the existing Bad Creek Project and is owned and maintained by the Licensee. Bad Creek Road is used by the public to access Fisher Knob Road, Musterground Road, and the Foothill Trails Trailhead.
- **Fisher Knob Road** originates at the southern end of Bad Creek Road and extends generally southeastern for approximately 2 miles to a ±30-parcel residential development. Public access to Fisher Knob Road will be maintained throughout construction of Bad Creek II as will be described in the Bad Creek Road Traffic Management Plan.[8]
- **Lower I/O Road** (also known as the "Last Mile") originates at the southern end of Bad Creek Road and runs generally north approximately 1 mile and steeply descends to the portal area adjacent to Lake Jocassee, past the existing lower reservoir I/O to the existing wastewater treatment area. The EPC Contractor may utilize this road for construction but must provide for continued access for Owner and Owner contractors who operate and maintain existing Bad Creek facilities.

[8] The purpose of the Bad Creek Road Traffic Management Plan is to effectively guide the implementation of measures to manage use of Bad Creek Road by non-construction users during Bad Creek II construction.

- **Lower Spoils Road** originates at Bad Creek Road and runs generally south approximately 1,000 ft to an original project spoils area. During construction this road may be used and widened, with the existing spoils area used for staging and laydown.
- **Microwave Tower Access Road** spurs off of Bad Creek Road and extends southwest approximately 1,000 ft to an existing microwave tower. This road will not be used for construction.
- **Dam Access Road** spurs off of Bad Creek Road and extends west and south approximately 0.5 mile to the crest of the existing East Dam. The road continues south and west to access the existing main dam and west dam. The EPC Contractor may use Dam Access Road for construction activities but will be prohibited from crossing the East Dike or Main Dam.
- **East Dam Toe Road** originates at Dam Access Road and extends south approximately 700 ft to the toe of the existing East Dam. This road may be used for construction activities.
- **Foothills Trailhead Access Road** spurs off of Bad Creek Road and extends northwest approximately 1,500 ft to the Foothills Trailhead. Foothills Trailhead Access Road is a public access road owned and maintained by the Licensee but will be closed to the public during construction. This road may be used for construction activities that do not interfere with Project operations.
- **Construction Yard Road** spurs off Foothill Trails Access Road and extends northwest approximately 800 ft to the original project construction yard that was converted to an operations and maintenance facility. This road may be used for construction activities that do not interfere with Project operations.
- **Musterground Road** spurs off of Foothills Trailhead Access Road and extends northeast approximately 3,500 ft to a bridge crossing of the Whitewater River. The road continues north from this point. Musterground Road will not be used for construction but will be closed to the public during construction. Access to Musterground Road will be maintained by the Licensee for SCDNR and FTC use.
- **Transformer Yard Road** spurs off of Bad Creek Road and extends northeast approximately 3,100 ft to the original project transformer yard and equipment building. This road may be used for construction activities that do not interfere with Project operations.

The Licensee expects new permanent access roads will be required for expanded Project construction and operation to include access to the new upper reservoir I/O facilities, the vertical shaft yard, switchyard, transformer yard/vertical access shaft equipment building, and main access tunnel portal and lower I/O operating deck.

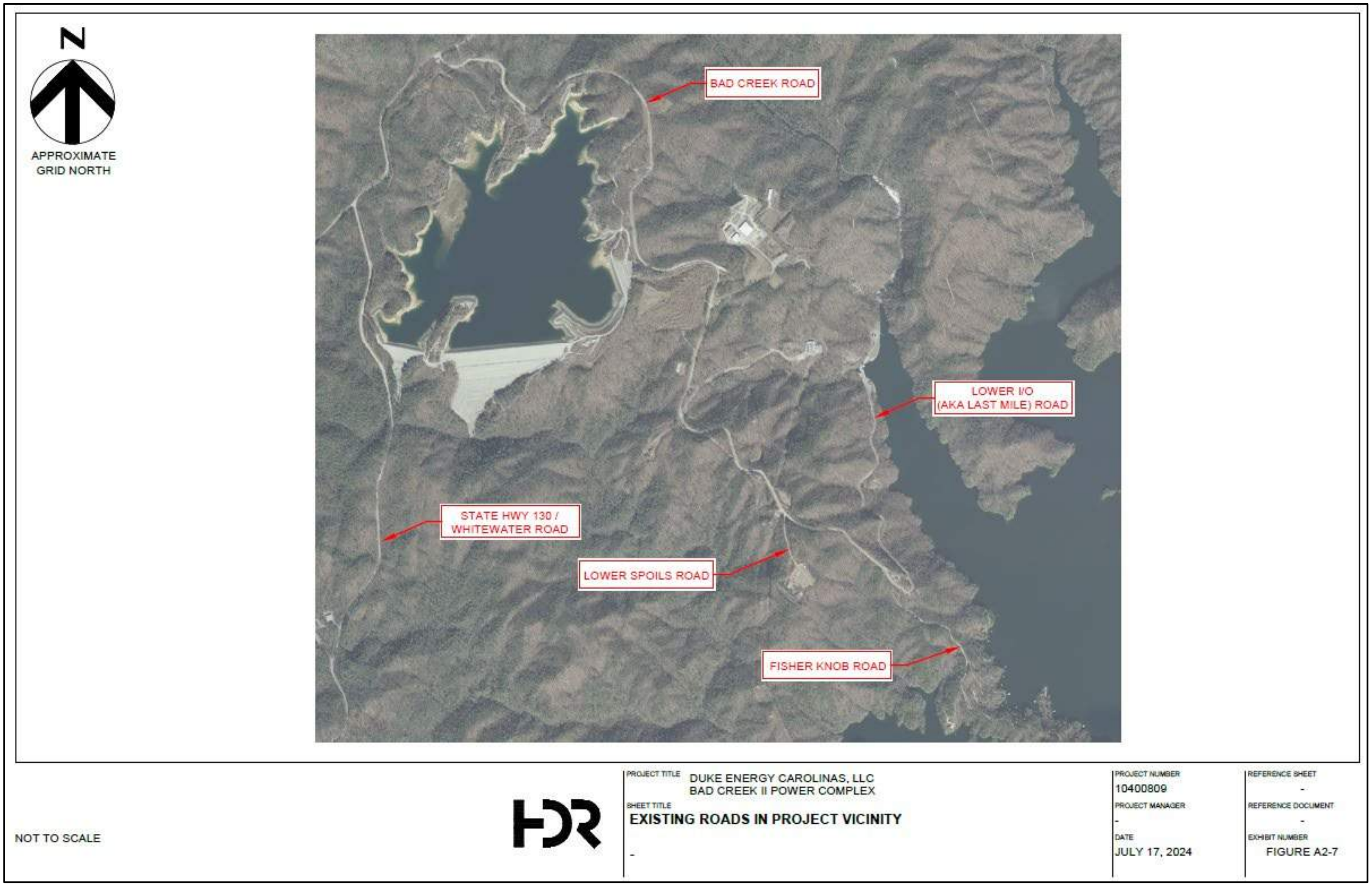


Figure E.6-4. Existing Roads at Bad Creek Project

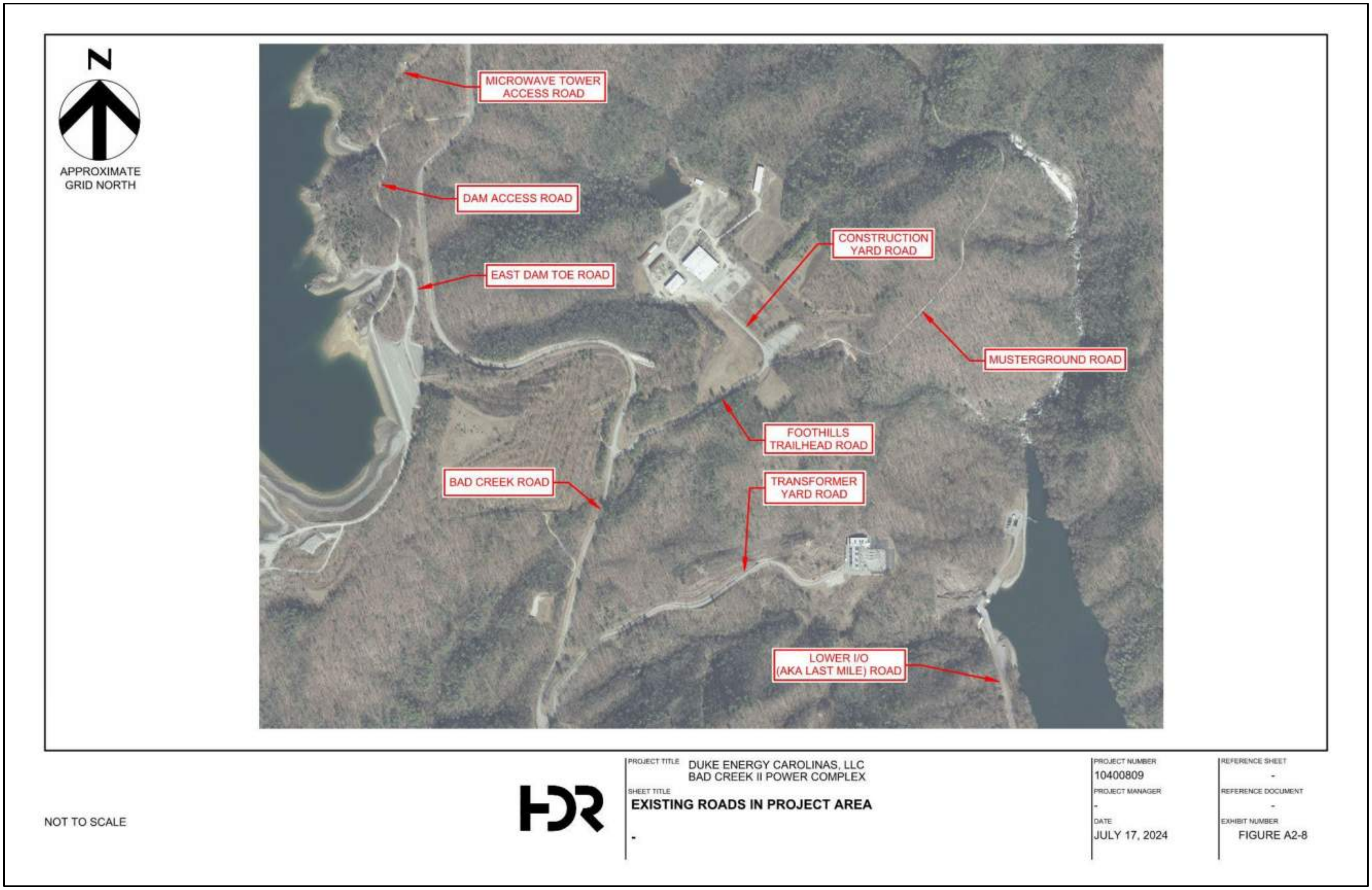


Figure E.6-5. Existing Roads at Bad Creek Project

Additional activities currently anticipated during the site mobilization, grading, and clearing phase include:

- Installation of Project signage.
- Grading, temporary utility installation, and setup of Project offices.
- Development of a concrete batch plant.
- Relocation of security fencing at the operations area in association with new transformer yard and switchyard.
- Closing the site to public access except for Fisher Knob property owners, guests, and service providers as will be described in the Bad Creek Road Traffic Management Plan.
- Installation of security fencing at the Bad Creek Foothills Trail Spur Trail and Musterground Road access points to prevent public access to the site.
- Reopening of Brewer Road for Musterground area access.
- Rerouting of Foothills Trail Access Road, Construction Yard Road, and Musterground Road.
- Relocation / demolition of the existing covered boat dock.
- Installation of a boating barrier to restrict recreational boating access in Whitewater River cove during Bad Creek II construction.

Following mobilization, site clearing and grading of primary construction areas will begin as follows:

- Demolition of the former wastewater treatment facility, grading and preparation of the portal access.
- Development and implementation of the Erosion and Sediment Control Plan including clearing and grubbing and installation of temporary erosion and sediment control best management practices (BMP), including new settling basins to store sediment produced by storm runoff during construction.
- Clearing and development of spoil disposal areas.
- Demolition of ancillary structures within the new transformer and switchyard footprint (garage, storage sheds, etc.).
- Grading and clearing of Bad Creek II transformer yard and switchyard.
- Grading and clearing for generator tie-lines between existing switchyard and Bad Creek II switchyard.

E.6.2.2.2 Lower Reservoir I/O Structure

Prior to construction of the lower reservoir I/O structure, the Licensee will first confirm the stability of the upland slope and implement stabilization measures if needed. See discussion on landslide activity in Section E.7.1.1.8.

Construction of the lower reservoir I/O structure as currently planned will be done in the dry to the extent practicable. Excavation of lower reservoir I/O structure footprint will initially begin on the upstream extent with work progressing towards Lake Jocassee. Existing overburden and rock between the lower reservoir I/O structure and Lake Jocassee will serve as a cofferdam during most of the construction period; breaching the coffer dam will be a final step in the construction process.

E.6.2.2.3 Upper Reservoir I/O Structure

As currently planned, upper reservoir I/O structure construction will also begin with upland construction activities with existing overburden and rock serving as a cofferdam between the reservoir and construction work area. Construction of the intake canal and in-water structures will be done during an approximately 3-month-long Bad Creek Reservoir drawdown; the existing Project would not operate during the drawdown.

E.6.2.2.4 Powerhouse and Water Conveyance System Construction

Construction of underground components of Bad Creek II is currently planned to begin with the excavation of the main access portal followed by construction of the remaining underground tunnels and powerhouse cavern.

Excavation of the powerhouse access tunnel, powerhouse cavern, and water conveyance systems will include both drilling and blasting operations with spoil material removed by dump truck. Excavations will begin in the first full year of Bad Creek II construction and be largely complete by year 5. Excavated material will be placed in spoil disposal areas in Lake Jocassee, Bad Creek Reservoir, and upland locations consistent with the requirements of the Section 404/401 permit and as discussed in Section E.6.2.2.6.

The EPC Contractor will be responsible for dewatering activities required for earthwork and related activities. Pumping, treatment, and discharge of water may require additional permits.

Excavation for tunnel adits will be minimized through the use of retaining walls and special excavation methods. Areas behind retaining walls will be backfilled, grassed, and reforested as soon as practical.

E.6.2.2.5 Transmission / Electrical System Construction

Construction of the new primary transmission line will begin concurrent with site mobilization. Initial activities will consist of improvements to existing non-Project transmission corridor access routes. While these existing routes were initially developed to support initial Project construction, portions now require maintenance or improvement activities to support current construction methods.

Construction of the new transformer yard and switchyard will begin concurrent with improvements to the transmission access routes.

As the access routes are improved, the Licensee will begin transmission corridor clearing and construction of new transmission towers. The new towers will generally parallel existing towers except where site topography, change in line orientation, or natural resources features dictate a different location. Conductor (i.e., transmission line) installation would begin as the towers are constructed. The existing line will be “swapped over” to new towers as shown on Exhibit G; this work will coincide with a Project outage associated with the final stages of construction of the upper reservoir I/O structure.

Some forested areas along the margins of the existing transmission line corridor will be cleared to maintain proper conductor clearances from the ground. Selective clearing will be utilized to the fullest extent feasible. When crossing valleys or low-lying areas between mountains, similar to the existing transmission line, long span towers will be used to alleviate the need to clear all vegetation from beneath the lines, with clearing in the low areas limited to that needed to string the conductors. Additionally, small areas will be cleared around each new tower site to facilitate construction and safe operation of the line. Wooded areas will be left intact on the expanded right-of-way where trees are determined to be safely below the conductor and pose no hazard to line operations. Where clearing is necessary, the right-of-way will be seeded immediately with cover crop in accordance with Duke Energy’s current transmission line construction specifications.

The steel towers will be erected by conventional methods where conditions permit. In areas inaccessible to cranes and heavy equipment, helicopters may be utilized.

E.6.2.2.6 Spoil Disposal

Excavation of the powerhouse, upper and lower I/O structures, water conveyance tunnels, underground powerhouse, and powerhouse access will generate approximately 4 million cubic yards of spoil material requiring disposal. This material will be disposed of within the proposed Project Boundary except for excavated rock that would be added to the existing submerged weir within Lake Jocassee. The Licensee is currently evaluating up to 21 locations for spoil (Figure E.6-6). These locations include both the inactive storage in Bad Creek Reservoir, upland locations within the Project Boundary, and at the existing submerged weir in Lake Jocassee. Spoil disposal at each of the locations would differ as described below:

- **Upland spoil disposal areas:** Spoil would be transported to the disposal locations via dump trucks. Spoil disposal sites would be engineered to have stable side slopes that would be stabilized at approximately 3:1 slopes with either non-woody vegetation, mulch, and/or stone. The spoil disposal areas would include access for construction of temporary and permanent stormwater measures utilizing low-density development approaches as well as avoidance and minimization practices in regard to natural resources. Temporary measures may include erosion and sediment control devices such as silt fencing, rock outlets, diversion ditches, water bars, and/or sediment basins to manage stormwater quantity. Consistent with the BCRA, French drains would be installed to minimize impacts to streams. Following the completion of spoil activities, spoil areas would be revegetated consistent with the Revegetation Plan. Over time, the appearance of the revegetated spoil disposal areas will become consistent with the surrounding vegetated landscape. The limits of disturbance (LOD) identified for each spoil disposal area evaluated herein include the footprint of the spoil disposal area as well as temporary and permanent stormwater control features, and access and work areas for construction, stabilization, and maintenance phases of work.

- **Bad Creek Reservoir spoil disposal:** Two potential spoil areas within Bad Creek Reservoir area being considered: H1 and H2. Both are located within the inactive storage pool so placing spoil within these areas will not decrease the volume of water available for hydroelectric generation. Spoil would be placed in these areas only during a station outage when the reservoir would be dewatered (i.e., in the dry). Material would be transported to the locations using earth moving equipment.
- **Lake Jocassee spoil disposal:** Spoil disposal area A adjoins the existing submerged weir in Lake Jocassee, which was constructed approximately 1,800 ft downstream of the lower I/O structure during initial Project construction with spoil material from the original excavation. Spoil material would be placed on the downstream face of the existing weir with the top elevation of 1,060 ft msl consistent with the existing submerged weir. Material would be placed using barges.

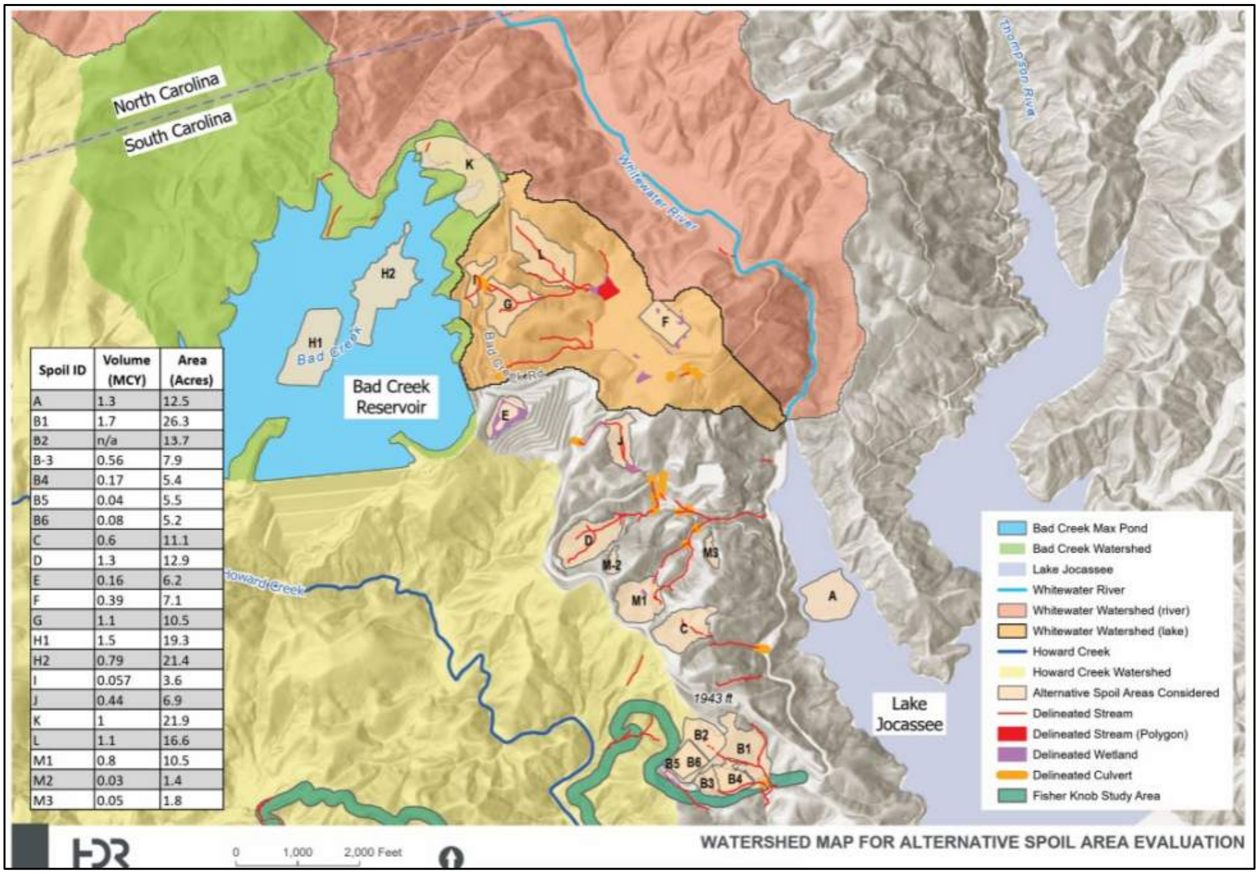


Figure E.6-6. Potential Spoil Disposal Areas

E.6.2.3 Proposed Project Operations

The Project would continue to utilize the Bad Creek Reservoir as the upper reservoir and Lake Jocassee as the lower reservoir. Operations of the existing and proposed Bad Creek II facilities would continue as described in Section E.5.6.

However, because of the increased hydraulic capacity with the addition of Bad Creek II, generation run times (at best efficiency) would decrease from approximately 23 hours to approximately 12 hours, but the energy density would increase by a factor of approximately two. This means that twice as many megawatt hours could be added to the grid during times of increased demand. Pump run times would also decrease but the rate of storage would double. Plus, the units could be used during pumping to capture more renewable energy with integration load following, since pump load can be varied, as well as help stabilize the power grid during pumping. This added capability in both modes of operation would allow the usage for generation and recovery via pumping of the entire upper reservoir usable volume on a daily basis.

E.6.2.3.1 Proposed Reservoir Operating Levels

Except when operating in some stages of the LIP, the MEP, or other temporary condition as may be approved by the FERC, the Licensee will maintain the Bad Creek Reservoir within a 160 ft operating range between a Normal Maximum Elevation of 2,310 ft msl (100 ft local datum) and a Normal Minimum Elevation of 2,150 ft msl (-60 ft local datum).

The Licensee is not proposing changes to the Normal Operating Ranges for Lake Jocassee or Lake Keowee as set forth in the existing KT Project license.

E.6.2.3.2 Proposed Operations during Adverse Conditions

The Licensee proposes to implement an MEP and the LIP as described below.

- **MEP:** The MEP identifies Licensee actions during both planned and unplanned maintenance and emergency situations at the Project. Under some emergency, equipment failure, power plant maintenance, and other situations, certain license conditions may be impractical or even impossible to meet and may need to be suspended or modified temporarily to avoid taking unnecessary risks. Examples of situations when the MEP might be used include hydro unit outages; dam safety emergencies; energy, voltage, or capacity emergencies; lake drawdowns required for maintenance; flood events; and support for local or regional emergencies.

  The MEP defines the most likely situations of this type, identifies the potentially impacted license conditions, and outlines the general approach the Licensee will take to mitigate the impacts to license conditions. Due to the potential variability of these situations, the MEP does not provide an exact step-by-step solution for all situations. It does, however, provide basic expectations for the Licensee’s approach to dealing with such situations. Specific details will vary and will be determined on a case-by-case basis as the MEP is implemented.

  In addition to specifying operational actions, the MEP also specifies when Duke Energy will notify entities of conditions under which reservoir elevations or downstream flow releases will differ from what may be specified in the FERC license (excluding operations under the LIP). The MEP lists the entities to be notified and/or consulted, along with procedures for doing so.

  The proposed MEP is included in Appendix F of the BCRA (the BCRA is included in Appendix B).

- **LIP:** The Licensee has been implementing the LIP as described in Section E.5.6.2 and proposes to continue doing so under the new license. The Licensee is also proposing administrative updates to the LIP. As specified in the BCRA and allowed in the LIP, the Licensee will update the LIP to reflect the Bad Creek Reservoir Usable Storage volume based on 2018 light detection and ranging (LiDAR) data as well as storage volume effects of Bad Creek II construction.

The proposed LIP is included in Appendix C of the BCRA.

In addition, the Licensee will continue to operate the Project consistent with the 2014 Operating Agreement as discussed in Section E.8.1.5.2.

E.6.2.4 Proposed Environmental Measures

The measures listed in Section E.6.2.4.1 are proposed for inclusion in a new license for this Project and are consistent with FERC's *2006 Policy Statement on Hydropower Licensing Settlements*. Other measures listed in Section E.6.2.4.2 are proposed as off-license measures under the BCRA.

E.6.2.4.1 Measures Proposed to be Included in a New License

Geology, Geomorphology, and Soils

- Erosion and Sediment Control Plan: Implement non-structural and structural BMPs during Bad Creek II construction.
- Implement WQMP to evaluate streams affected by upland spoil placement which could lead to increased turbidity and sedimentation.

Water Quantity

- Bad Creek Reservoir elevation: Maintain the reservoir between 2,310 ft msl and 2,150 ft msl.
- Continue implementing the LIP.
- Implement the MEP.

Water Quality

- Implement the WQMP during and after Bad Creek II construction in Lake Jocassee.

Aquatic Resources

- Install French drains when developing Bad Creek II construction spoil disposal areas to minimize impacts to streams.

- Fish entrainment measures: Modify lower reservoir I/O lighting and public safety devices to reduce light shining on Lake Jocassee, use the existing pumping start-up sequence, and coordinate with SCDNR regarding fish entrainment measures when Lake Jocassee's elevation falls below 1,099 ft msl.

- Conduct an Acoustic Doppler Current Profiler (ADCP) based flow study following Bad Creek II construction to identify unit sequencing to reduce entrainment.

Terrestrial Species Protection

- Implement the proposed Species Protection Plan (SPP) to protect bats, migratory birds, reptiles, amphibians, crayfish, and botanical species.
- Raptor protection: The Licensee will install eagle and raptor protection measures (i.e., pole retrofits, substation caps and covers, flight diverters) at several strategic eagle use and flyway areas.
- Integrated Vegetation Management Plan: Implement measures to protect sensitive native plant and wildlife species and habitats.
- Pollinator Enhancement: Plant milkweed and other native wildflowers at the Project and develop up to two Monarch Candidate Conservation Agreement monitoring locations.

Recreation and Visual Resources

- The Licensee is proposing to implement the Recreation Management Plan (RMP) included in Appendix E. The RMP, developed in consultation with external stakeholders including SCPRT, continues the Licensee's long-term commitment to the Foothills Trail and support of the FTC, provides for public recreational access during and following Bad Creek II construction, and supports regional land conservation. Activities included in the proposed RMP include:
    - Continue to maintain 43 miles of the Foothills Trail for the term of the license.
    - Obtain new easements for 43 miles of the Foothills Trail.
    - Privy Pilot Study: Install 2 primitive privies / outhouses along the Foothills Trail and study for 2 years.
    - Depending on the findings of the pilot privy study, install up to 8 additional privies along the Foothills Trail.
- In addition, the Licensee proposes to implement the following measures to support public recreation at the Project:

  - Bad Creek Visitors Overlook Improvements: New viewing telescopes, interpretative signage, picnic area.
  - Signage: enhance signage at the main ramp at Devil's Fork State Park and the Musterground Road entrance.
- During Bad Creek II construction, the Licensee will:
  - Restrict public access to the Whitewater River cove of Lake Jocassee.
  - Repair damage to Musterground Road and Foothills Trailhead Road intersection caused by construction activities prior to reopening it.
  - Provide FTC access to Musterground Road for trail maintenance during construction.
  - Provide Highway 281 Lot Security Monitoring.
  - Reopen Brewer Road to provide access to Musterground Wildlife Management Area during construction.
- Public Safety Plan: Following Bad Creek II construction, the Licensee will revise the Public Safety Plan as needed to install additional public safety measures in Whitewater River cove to educate boaters about the potential hazards of Bad Creek II operations.
- Visual Resources Management Plan: The Project is in an area renowned for its scenic attractiveness. The Licensee is, therefore, proposing to implement the Visual Resources Management Plan (VRMP) included in Appendix E. The VRMP includes measures to minimize the visual effects of both existing and proposed Project features including lighting.

Cultural Resources

- The Licensee is proposing to implement the proposed Historic Properties Management Plan (HPMP) included in Appendix E. The HPMP, developed in consultation with the South Carolina State Historic Preservation Officer (SHPO) and Native American Tribes, includes measures to protect archaeological resources as well as a Cultural Resources Interpretative Exhibit Plan. These measures include nominating Site 38OC249 for inclusion on the NRHP, monitoring the site annually, and developing an interpretative exhibit regarding the cultural history of the

Project area. The HPMP also includes actions the Licensee will implement if previously unknown historic properties are discovered in the APE during the new license term.

E.6.2.4.2 Measures Not Intended for Inclusion in a New License

Consistent with the BCRA, the KT Project license and other agreements, the Licensee will implement a number of measures to enhance resources in the Project area, but not necessarily within FERC's jurisdiction as they require the action of other parties or are not directly related to the operation of the Project. These measures, referred to as off-license measures, are summarized below and further described in the relevant sections of Exhibit E.

Water Quantity

- The Licensee will continue implementing the 2014 Operating Agreement.

Water Quality

- The Licensee will provide up to $1,000,000 in funding support to the Lake Keowee Source Water Protection Program to protect and enhance water quality in the Lake Keowee watershed which includes the Project.

Aquatic Resources

- The Licensee will provide $10,500,000 in funding support to SCDNR for fisheries enhancement and management with an additional $1,000,000 after Bad Creek II commercial operation.

Terrestrial Resources

- Oconee County Conservation Bank: Provide Oconee County up to $1,000,000 to support land conservation efforts in Oconee County.
- KT Habitat Enhancement Program: Provide the KT Habitat Enhancement Program up to $1,000,000 to support habitat enhancement in the Jocassee and Lake Keowee watersheds.
- Wildlife Enhancement Program: Provide $2,500,000, if Bad Creek II is constructed, to establish the Wildlife Enhancement Program for propagation/restocking/re-establishment efforts; habitat restoration and protection; research to address questions regarding species of interest such as species geographic distribution, population size and status, habitat suitability modeling; and genetics work.

Recreation

- The Licensee has donated the trail and traffic counters used in the 2023 RUN Study to the FTC for its use.
- Construct a storage building on Project lands for the FTC to support trail maintenance activities.
- Provide rights of first refusals to North Carolina and South Carolina for the Foothills Trail and spur trails.
- Consult with the FTC on spur trail expansion at the Foothills Trail.
- Develop a Pumped Storage Operations interpretative display for Devils Fork State Park.
- Develop courtesy docks at the Devils Fork State Park Villa Ramp with 2 slips (one with a lift for emergency responders) and simple courtesy dock at the remote ramp.
- Develop a Foothills Trail Interpretative Exhibit for display at the non-Project Bad Creek Visitors Center.
- Provide $1,500,000 to SCDNR to maintain roads within the Jocassee Gorges.
- Lease at no cost approximately 1,900 acres of land to SCDNR for the license term.
- Extend the Laurel Preserve Tract lease for the term of the new license.
- Sponsor an annual wildlife viewing and environmental education event at the Project.
- Develop a game carcass disposal area and game processing / cleaning station near Brewer Road in South Carolina.

E.6.3 Alternatives Eliminated from Further Consideration

For the reasons described in FERC's SD2, Federal Government Takeover, issuance of a non-power license, and Project decommissioning are not considered to be reasonable alternatives based on the relicensing proceeding to date and are not expected to be analyzed in FERC's NEPA document.

In developing this license application to include the proposed Project expansion (construction of Bad Creek II), Duke Energy reviewed alternative sites within its service territory for development of additional pumped storage hydropower. These sites included construction of new dams and reservoirs in the Whitewater River watershed (Limber Pole Creek and Coley Creek). Duke Energy eliminated these alternatives from further consideration because development would result in greater adverse environmental effects and would not be economically feasible.

The design of Bad Creek II is still preliminary. Through this stage of its development, Duke Energy has considered and rejected various alternative project features designs (e.g., shoreline powerhouse, underground powerhouse in different location, and underground powerhouse with a single tunnel), which were eliminated based on economical and operational considerations. Alternatives for project design, within the general scope and parameters of Bad Creek II as proposed in this DLA, will continue to be evaluated as the design of Bad Creek II is advanced and refined.

Based on these considerations, the alternatives eliminated from further consideration are not evaluated in this environmental report.

E.7 Geology, Geomorphology, and Soils

E.7.1 Affected Environment

E.7.1.1 Geologic Features

E.7.1.1.1 Physiography and Topography

The Project is located in the Blue Ridge physiographic province, a mountainous zone extending northeast-southwest from southern Pennsylvania to central Alabama, varying in width from less than 15 miles up to 70 miles. It is characterized by rugged terrain with valleys ranging from 1,000 ft msl in the south to greater than 1,500 ft msl in the north. Several mountain peaks have elevations greater than 6,000 ft msl with relief of up to 3,500 ft msl. The highest peak is Mt. Mitchell in North Carolina at 6,684 ft msl.

In North and South Carolina, massive and resistant gneissic and metasedimentary rocks underlie most of the Blue Ridge, with valleys trending along weaker-rock outcrops (e.g., schist or minor carbonate rocks) and fractures or fault/shear zones. Drainage is generally to the west; however, the slopes separating the Blue Ridge from the Piedmont physiographic province are typically steep and provide the initial run-off (headwaters) for some of the largest streams of the Piedmont province, which drain to the east and southeast. The underlying geologic structure in the region influences local topography. Streams are deeply incised, and the average relief is about 1,800 ft. A topographic map of the Project vicinity is presented on Figure E.7-1.

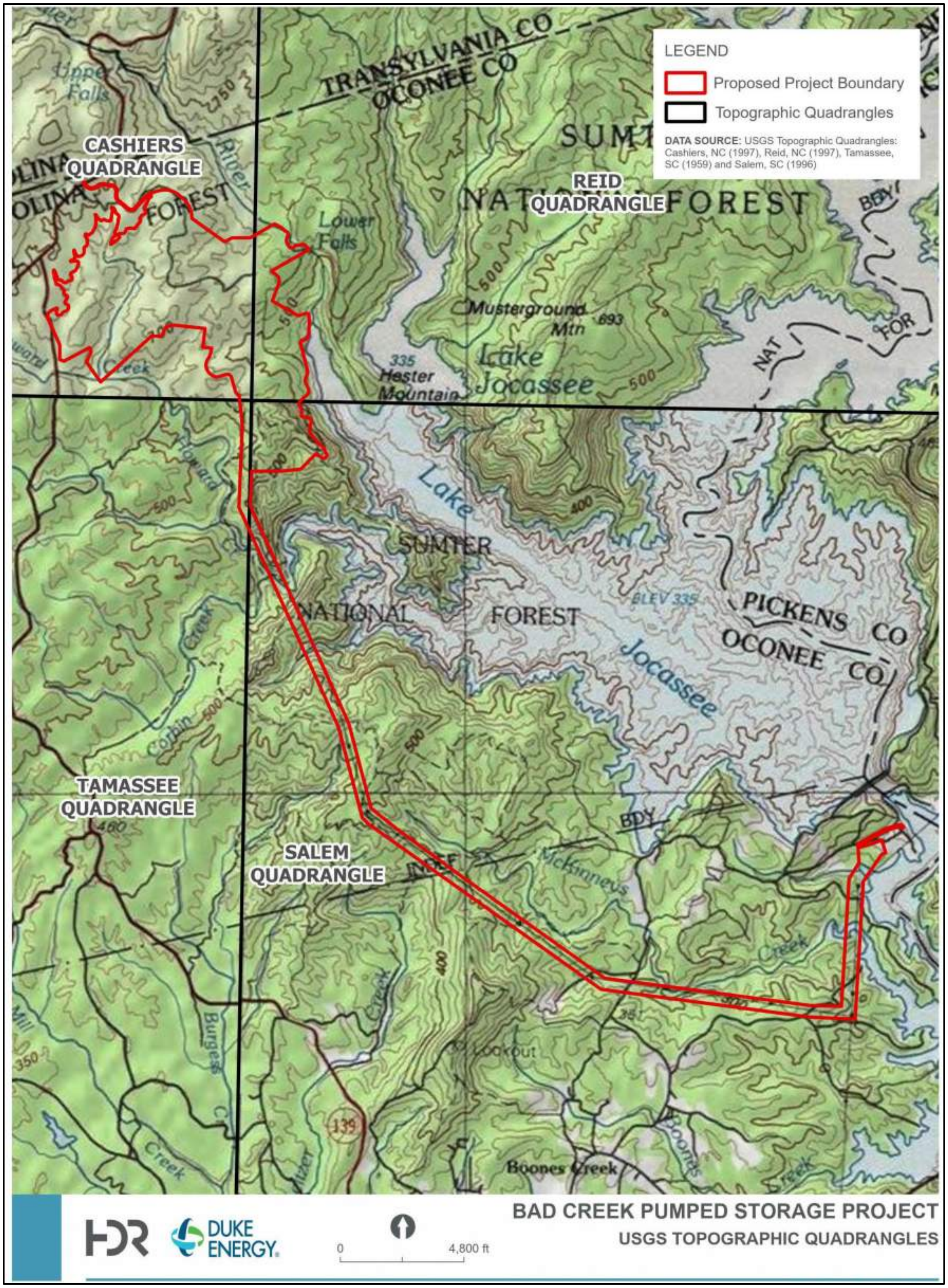


Figure E.7-1. Topographic Map of Bad Creek Pumped Storage Project

E.7.1.1.2 Regional Geology

The crystalline rocks of the southern Appalachians occur in northeast-trending parallel geologic terranes. The Bad Creek Project is situated within the Tugaloo terrane, which includes rocks of the eastern Blue Ridge province northwest of the Brevard zone (Hatcher et al. 2007; Hatcher 2002). The Blue Ridge province is a complex crystalline terrane consisting of Precambrian gneissic basement rocks structurally overlain by metasedimentary and metavolcanic rocks of Precambrian to lower Paleozoic age (Hatcher 1978a, 1978b). Numerous igneous bodies of mafic to felsic composition intrude into the basement core and into the overlying metasedimentary and metavolcanic sequences. The structure of the Blue Ridge province is controlled by major thrust faults, associated complex polyphase folding, and subsequent brittle faulting (Hatcher 1978a; Clendenin and Garihan 2007a, 2007b).

The southern Blue Ridge province is divided into three belts: 1) a western belt of imbricate thrust sheets involving upper Precambrian and lower Paleozoic rock and some basement rocks, 2) a central belt containing most of the basement rocks exposed in the Blue Ridge terrane along with higher grade upper Precambrian and possible lower Paleozoic metasedimentary rocks, and 3) an eastern belt of high-grade early Paleozoic metasedimentary and metavolcanic rocks (Hatcher 1978a, 1978b; Hatcher et al. 2007). The eastern belt of the southern Blue Ridge province comprises those portions of the Tugaloo terrane occurring northwest of the Brevard zone (Figure E.7-2).

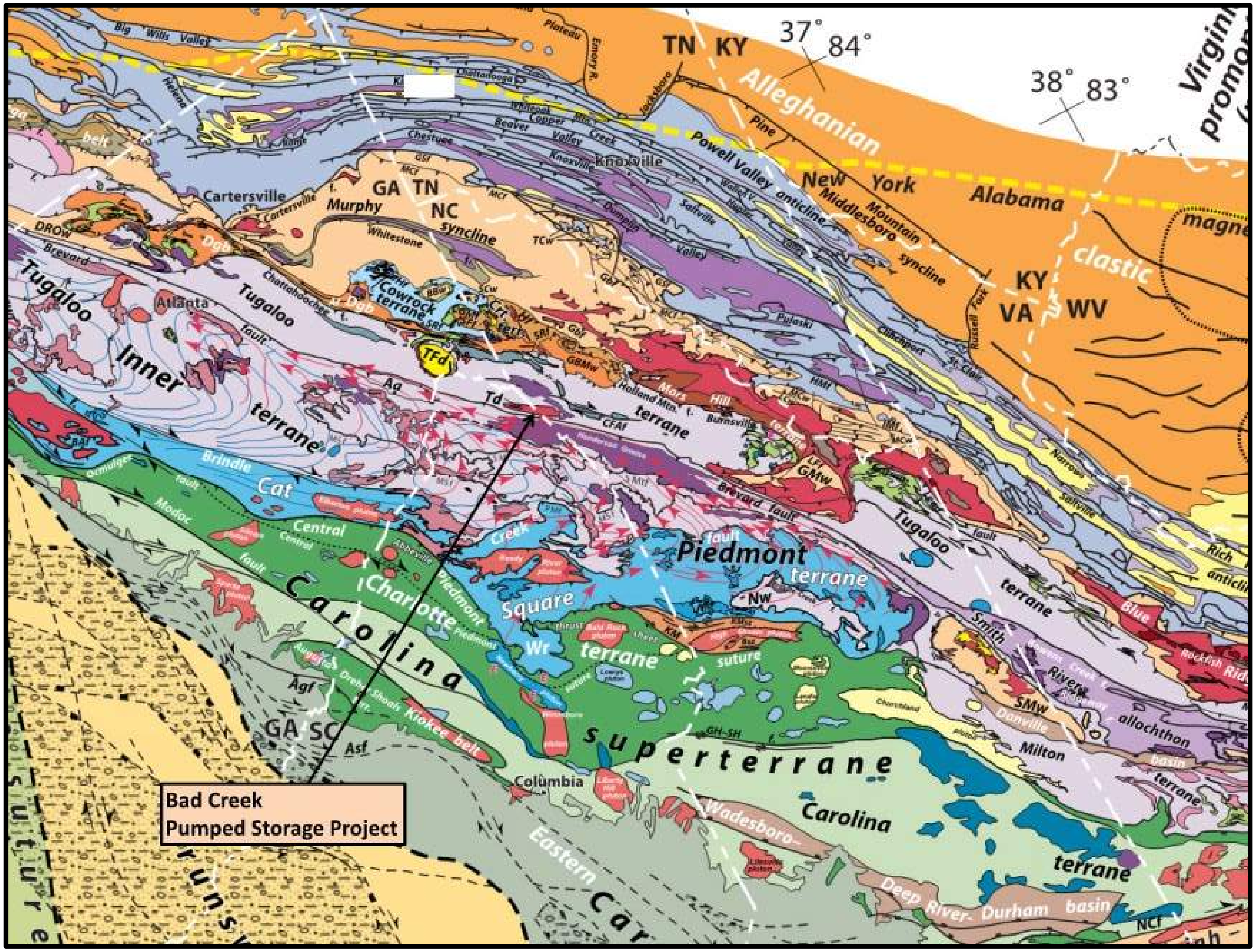
The principal rock unit of the western Tugaloo terrane (eastern Blue Ridge belt) is the Tallulah Falls Formation (TFF). The TFF consists of biotite gneiss (metagraywacke), pelitic schist, mafic volcanic rocks, and quartzite; in places the rocks of the TFF are migmatitic[9]. These rocks are intruded by Paleozoic granitoid rocks and overlie 1,150 to 1,200 million years ago (Ma) Precambrian Grenville basement rocks in the Toxaway Dome. The TFF consists of four members: 1) the quartzite-schist member, 2) the lower graywacke-schist-amphibolite member, 3) the garnet-aluminous schist member, and 4) the upper graywacke-schist member (Hatcher 1977). The lowest member contains quartzite with interlayered schist. The lower graywacke-schist-amphibolite member contains biotite gneiss, amphibolite, muscovite schist, and biotite schist. Layers of granitic gneiss and pegmatites also occur in this member. Overlying the lower member is the garnet-aluminous schist member. It consists of muscovite-garnet-kyanite schist with interlayered amphibolite, muscovite schist, biotite gneiss, granitic gneiss, and pegmatites. It is generally easily recognizable by abundant garnet and kyanite. The upper

[9] Migmatite – Rock consisting of alternating layers or lenses of granitic material in gneisses and schists; related to partial melting of the rock during deformation and metamorphism and then re-crystallization of the melt during the waning stages of metamorphism.

graywacke-schist member contains biotite gneiss, mica schist, garnet mica schist, and minor amounts of amphibolite, granitic gneiss, quartzite, calc-silicate rocks, and pegmatites.

The Toxaway Gneiss (TGn), part of the Precambrian basement of the eastern Blue Ridge province, is exposed in the core of the Toxaway Dome. It is typically a medium- to coarse-grained banded biotite-plagioclase-microcline-quartz gneiss with some massive and augen varieties, which do not appear to be significantly different in composition (Schaeffer 1987, 2016; Merschat et al. 2003). The TGn has an Rb/Sr whole-rock isochron age of 1,203+54 Ma (Fullagar et al. 1979). A derived zircon age for the TGn is 1,150 Ma (Carrigan et al. 2003 in Hatcher et al. 2007).

The TFF rocks are metamorphosed to the upper amphibolite facies (kyanite-sillimanite zone; Hatcher 1977; Butler 1991). Dominant metamorphic fabric and peak metamorphism in the eastern Blue Ridge province is circa 450 Ma, based on metamorphic ages of detrital monazite and zircon grains from TFF rocks (Miller et al. 1997; Moecher et al. 2011; Cattanach et al. 2012). The Grenvillian basement rocks of the Blue Ridge province, including the TGn, were subjected to granulite facies metamorphism approximately 1,000 Ma (Hatcher and Butler 1979).



Note: Td = Toxaway Gneiss

Figure E.7-2. Tectonic Map of the Southern and Central Appalachians and location of the Bad Creek Pumped Storage Project (Source: Hatcher et al. 2007)

E.7.1.1.3 Site Geology

The Bad Creek Project is located immediately northwest of the Brevard zone in the Tugaloo terrane within the Toxaway Dome (Figure E.7-3). The Toxaway Dome consists of a core of TGn and a sliver of TFF. It is an elongated feature having a steeply dipping to overturned northwest limb and a more moderately inclined southeast limb. At the ends, the structure plunges gently northeast and southwest, resulting in a structural dome defined by the upward arching of the dominant foliation in the TGn. Detailed mapping performed during the construction of the Bad Creek Project indicates the basement (TGn)/cover (TFF) contact is repeated several times due to isoclinal folding and transposition. Textural evidence (grain size reduction and truncated foliation and fold axis in the TGn at the contact) suggests the original basement/cover contact was a pre-metamorphic fault (before Taconic age [~450 Ma] and after Grenville age [~1,000 Ma] metamorphisms).

The majority of the site is underlain by TGn (Figure E.7-3). All of the tunnels, shafts, and the powerhouse cavern for the Bad Creek Project were excavated in the TGn (based on the geologic information available). The Main Dam and East Dike of the Bad Creek Project are founded on the TGn. The West Dam and a portion of the reservoir are underlain by a sequence of schistose rocks belonging to the TFF. The TFF rocks are predominantly the garnet-aluminous schist member; however, in some places, portions of the upper graywacke-schist member are present.

The TGn, part of the Precambrian basement of the eastern Blue Ridge province, is a medium- to coarse-grained gneiss of granitic to quartz monzonitic composition. It is composed of microcline, plagioclase, quartz, and biotite with minor amounts of epidote, garnet, allanite, muscovite, zircon, sphene, apatite, and opaques. The TGn can be divided into two major types: 1) a banded, medium- to coarse-grained granitic gneiss composed of alternating light-colored quartz-feldspar rich bands and dark biotite-quartz-feldspar bands; and 2) a coarse-grained augen granitic gneiss consisting of a poorly foliated feldspar-quartz-biotite gneiss with feldspar and locally hornblende augen up to 3 centimeters (cm) in length and a medium- to coarse-grained quartz-feldspar-biotite gneiss with a more distinct foliation and feldspar augen up to 1 cm. Layers of biotite-hornblende schist (sills or dikes, possibly feeders for the mafic volcanic rocks of the TFF) are present with thicknesses up to 20 ft. Their orientation is parallel to the dominant foliation/banding in the TGn. At least two generations of quartz-feldspar-mica pegmatites occur within the gneiss. They are distinguished by the fact the later generation is undeformed except by fracturing, whereas the earlier generation is folded. Most of the early pegmatites parallel the dominant foliation; the later generation cuts across foliation. Small cross-cutting quartz veins are also present.

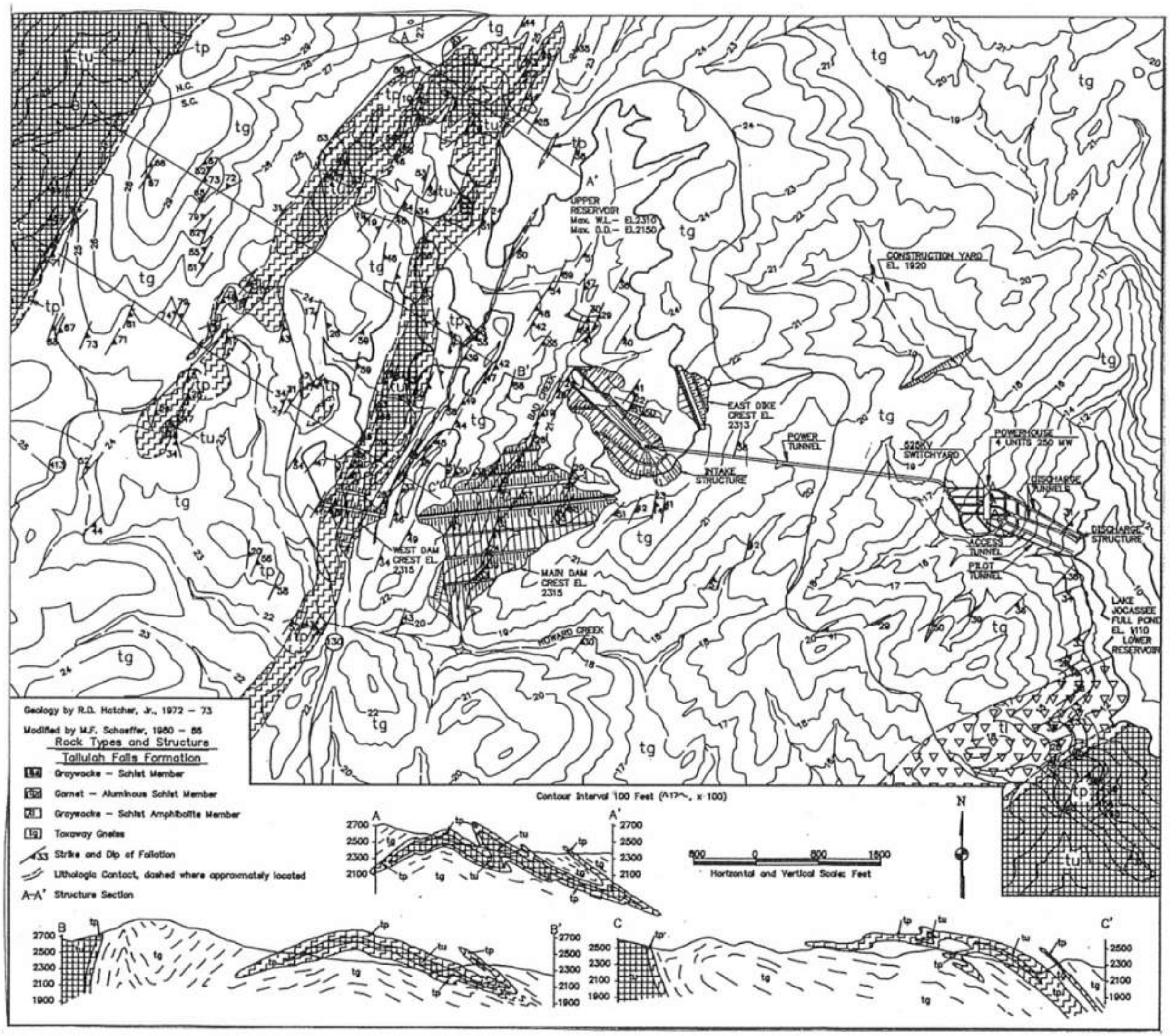


Figure E.7-3. Geologic Map of the Bad Creek Site and Vicinity (Schaeffer 1987; 2016)

The TFF consists of three members in the site vicinity (Hatcher 1977; Schaeffer 1987). The lower graywacke-schist-amphibolite unit consists of meta-graywacke (biotite gneiss), amphibolite, muscovite schist, biotite schist, pegmatites, and minor granitic gneiss. The garnet-aluminous schist member includes muscovite-garnet-kyanite schist with minor interlayered amphibolite, muscovite schist, and meta-graywacke. The upper graywacke-schist member consists of metagraywacke (biotite gneiss), muscovite schist, and muscovite biotite schist with minor amounts of interlayered amphibolite, granitic gneiss, and pegmatite. The units have undergone regional metamorphism to the kyanite zone of the amphibolite facies.

During the original design studies for the Bad Creek Project (pre-1985), the subsurface exploration program had the following primary objectives related to the underground excavations and structures: 1) examine the rock characteristics and geologic structure of the proposed powerhouse location, 2) determine the best powerhouse orientation and location with respect to the geologic structure and in-situ stresses, 3) provide the data and experience necessary to facilitate an efficient design of the underground portions of the Project, and 4) serve as a model for the instrumentation and monitoring to be incorporated into the permanent underground structures.

Early in the Bad Creek Project design, it was decided a pilot tunnel into the proposed powerhouse location would be the primary activity of the underground exploration program. Preliminary core drilling, laboratory testing of core samples, and deep borehole hydrofracturing stress measurements had been conducted before the design of the pilot tunnel program (Duke Power Company 1978; Schaeffer and Steffens 1979). Data from these tests showed generally good rock conditions, but with high horizontal in-situ stresses present. However, due to the magnitude of the project, the pilot tunnel program was considered a prudent investment. The pilot tunnel excavation and testing lasted from October 1976 through September 1977. The work was divided into three main components: 1) excavation monitoring, 2) rock testing including the measurement of the in-situ rock mass stress orientation and magnitude utilizing the overcoring methodology and 3) geologic mapping and investigations (Duke Power Company 1978; Schaeffer and Steffens 1979; Schaeffer et al. 1979).

The geologic program conducted during construction of the Bad Creek Project (from 1985 to 1991) provided additional geologic information for construction and design personnel to make necessary changes to design and construction techniques due to geologic conditions and to document the conditions encountered. The geologic studies included observation, measurement, sampling, photographs, mapping, and evaluation of the exposed rock and foundation surfaces. The geologic conditions encountered in the underground works were documented by geologic mapping of at least one rib of all tunnels, the walls of the two vertical shafts, and the walls, crown, and floor of the powerhouse cavern at a scale of 1 inch = 6.56 ft. The aboveground structures including dam foundations, intake excavation, and discharge excavation were mapped at a scale of 1 inch = 20 ft. The upper reservoir area was mapped at a scale of 1 inch = 200 ft after all excavation and borrow work was completed. The geologic work during construction, including additional studies beyond the geologic mapping (for documentation), are described and discussed in Duke Power Company (1991) and Schaeffer (2016).

The Supporting Design Report filed as Critical Energy/Electric Infrastructure Information with this license application contains original geology and subsurface investigation reports prepared to document subsurface engineering and stability prior to construction and Schaeffer (2016) *Engineering Geology of the Bad Creek Pumped Storage Project* is also provided. Additionally, recent efforts carried out for the Bad Creek II Updated Feasibility Study from 2022 to 2024 (HDR 2024a; HDR 2024b) provide additional geologic and geotechnical data. Recent geology and geotechnical findings are provided in the Supporting Design Report.

E.7.1.1.4 Lithology

Detailed geologic mapping of the Bad Creek Project underground excavations resulted in a detailed subdivision of rock types within the TGn. The following units were recognized and mapped during construction:

- Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of alternating layers of light-colored quartz-feldspar bands and darker biotite-quartz-feldspar bands, well-foliated;
- Banded Augen Granitic Gneiss, medium light gray to light gray, medium- to coarse-grained gneiss consisting of a foliated (banded) quartz-feldspar-biotite gneiss containing feldspar augen up to 1 cm long;
- Augen Granitic Gneiss, medium light gray, coarse-grained gneiss consisting of a coherent, massive, poorly foliated feldspar-quartz-biotite gneiss with feldspar and locally hornblende augen up to 3 cm long;
- Biotite Schist, medium dark gray to dark gray, coarse-grained biotite-hornblende schist;
- Biotite Gneiss, medium dark gray to dark gray, medium- to coarse-grained biotite-hornblende gneiss;
- Biotite Augen Gneiss, medium gray to medium dark gray, medium- to coarse-grained, foliated biotite-feldspar-quartz gneiss with feldspar augen up to 1 cm long, biotite content generally greater than 30 percent;
- Quartz-Feldspar Gneiss, very light gray to white, very coarse-grained, distinctly foliated quartz-feldspar gneiss with minor biotite (less than 10 percent);
- Very Coarse-Grained Granitic Gneiss, light gray, very coarse-grained, distinctly foliated quartz-feldspar-biotite gneiss, biotite content greater than 10 percent;
- Weathered Sheared Rock, moderate to moderately severe weathering, light gray to yellowish gray to greenish gray, original rock type granitic or augen granitic gneiss; and
- Hard Sheared Rock, medium light gray to light gray, medium- to coarse-grained rock, original rock type granitic or augen granitic gneiss.

E.7.1.1.5 Structural Geology

Foliation in the TGn and TFF rocks is defined by the parallel orientation of platy minerals and by compositional layering. The average orientation of foliation in the Bad Creek Reservoir area is N37E; 38SE and varies from N35-50E; 28-41SE in the underground works. Minor folds are present; some lie within foliation, whereas others fold the dominant foliation. The earliest set of folds is characterized by isolated “z-”, “s-”, and crescent-shaped fragments that are axial planar to the dominant foliation. The presence of these isolated fold fragments indicates transposition of an older foliation has occurred. The second set of folds is isoclinal to open with variable development of a secondary foliation. In areas where this folding is isoclinal, an axial planar foliation (defined by secondary biotite) is present. Later open folding was recognized in several tunnels of the Bad Creek Project.

Shear Zones

Shear zones with thicknesses up to 200 ft occur throughout the TGn and generally parallel the dominant foliation. Four major shear zones are present in the reservoir and dam areas (Shear Zones C through F) and two shear zones (A and B) were mapped in the underground tunnels (Figure E.7-4).

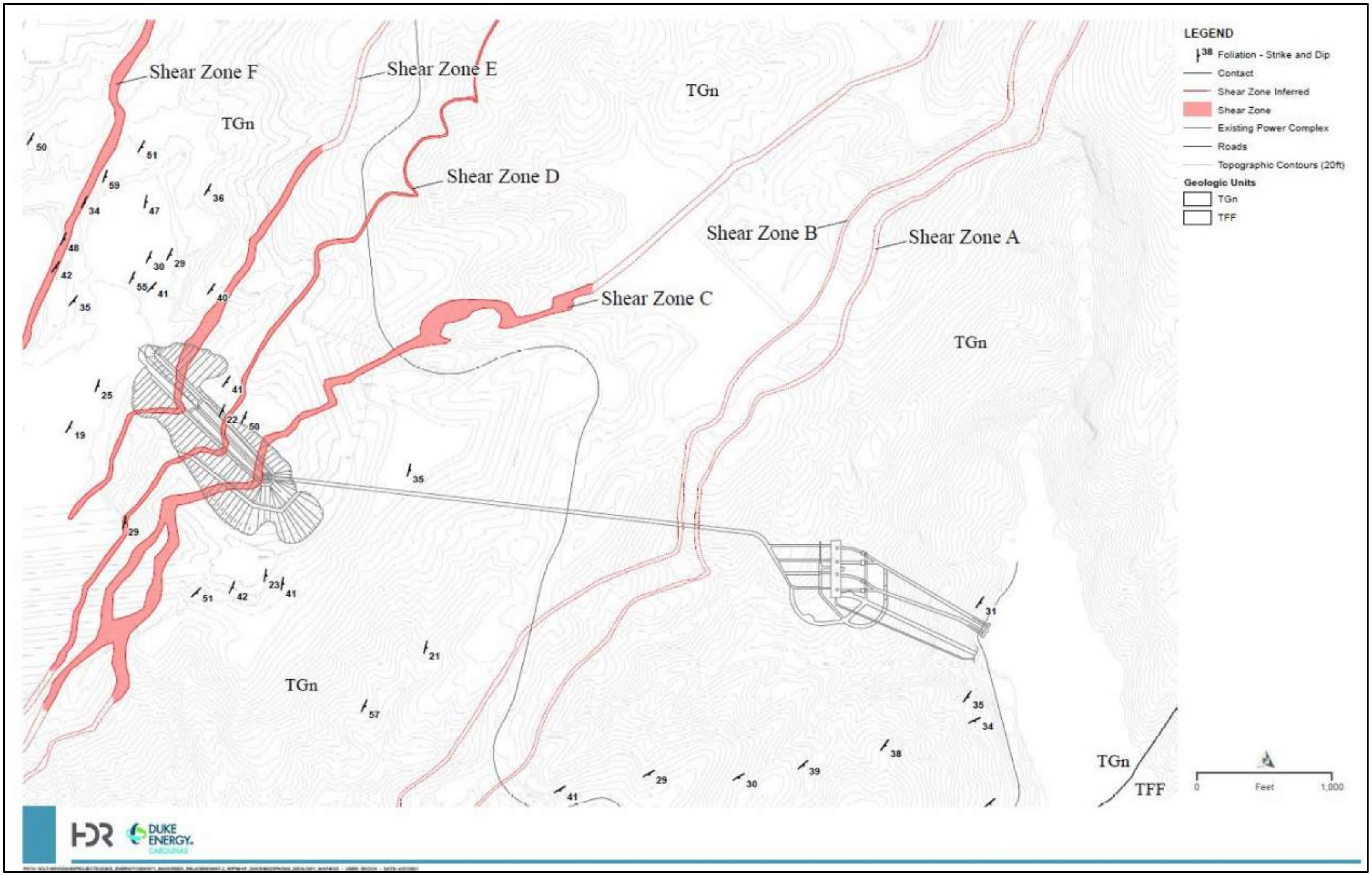


Figure E.7-4. Geologic Map showing Shear Zones Mapped in the Bad Creek Reservoir and in the Underground Excavations for the Bad Creek Project and their Surface Projections

The zones consist of hard sheared rock with layers of weathered sheared rock. A schematic cross-section of the existing Bad Creek subsurface shear zones is shown on Figure E.7-5. The shear zones are mineralized with chlorite, epidote, calcite, and quartz in various combinations. Originally white feldspars have been discolored to a pink or light orange-pink color within and adjacent to the shear zones. Along some of the shear planes, breccia is present with thicknesses of less than 1 inch to about 12 inches. The breccia consists of granitic gneiss, coarse quartz/feldspar (pegmatites), and vein quartz fragments in a matrix of fine-grained chlorite and epidote. Several of the shear zones have associated weathered zones up to 12 inches thick. Within the weathered zone there are up to two inches of gouge-breccia composed of granitic gneiss, coarse quartz/feldspar, and vein quartz fragments in a clay matrix. The hard-sheared rock exhibits tight, complex isoclinal folding with sheared-out limbs and a secondary axial planar foliation defined by biotite. This relationship indicates the major shearing is related to the second fold event, although some of the shear zones may have been reactivated from the first fold event. The brittle deformation along the shear zones is a later event overprinting the initial shear zone development.

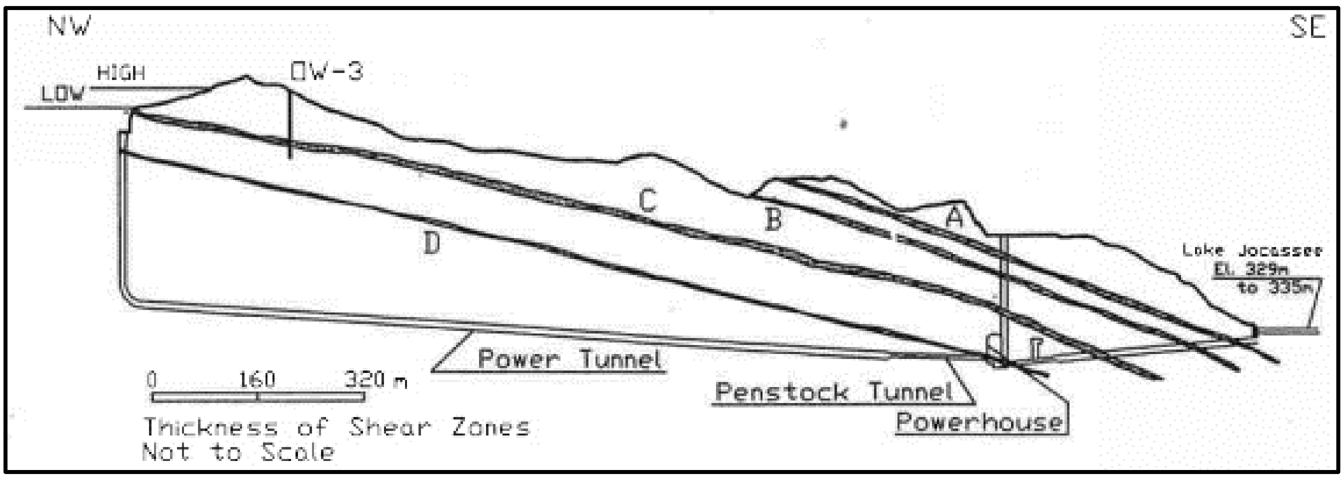


Figure E.7-5. Cross-section of Existing Bad Creek Underground from the Upper I/O to the Lower I/O Structure on Lake Jocassee showing location of Shear Zones A, B, C, and D (Talwani et al. 1999)

Joint Sets

There are three dominant joint sets in the Bad Creek Reservoir area: 1) N77E; 82 NW, 2) N42E; 74NW (strike joints), and 3) N47W; 88SW (dip joints). The predominant joint set varies between N70W and N70E with steep north and south dips in the underground works. Another set strikes N60E with moderate to steep northwest dips, and a weakly developed set oriented N45W with steep southwest dips is present. All joint sets have some degree of mineralization, but the northeast and particularly the east-west set (N77E in the reservoir area) contain a greater percentage of mineralized joints. The dominant mineral fillings are quartz, chlorite, epidote, biotite, and calcite in various combinations. Iron oxide and manganese staining is present along weathered joint surfaces. Spacing within the joint sets varies from less than 1 inch to greater than 50 ft.

In the underground portion of the Bad Creek Project, the dominant measured joint set is oriented N70E to N70W (east-west) with dips >50° north and south. Other sets are oriented N60E; 60NW, N65E; 30SE (foliation joints), and N45W; 70-90 SW or NE. The joints are tight at depth with similar mineral fillings as noted in the reservoir area. Near the ground surface some joints are open and weathering has resulted in blocky conditions at the main access tunnel portal and the first 200 ft into the tunnel is supported by steel sets and a concrete lining.

Fault Zones

South Carolina is traversed by several northeast trending fault systems that parallel the dominant strike of the Appalachian Mountains. These include the Brevard Fault Zone, the Pax Mountain Fault System, the King's Mountain Shear Zone, the Pageland Fault, and others. These faults are not believed to have been active for at least the last 300 million years.

Clendenin and Garihan (2007a) mapped two northwest-trending oblique-slip faults northeast and southeast of the existing underground works; however, mapping efforts for the Project did not identify these two faults and they were not field-verified. No northwest-trending faults were mapped in the existing Bad Creek Project underground works or in the area including the dam and dike foundations, the intake structure excavation, or the upper reservoir (Duke Power Company 1991; Schaeffer 1987, Shaeffer 2016).

E.7.1.1.6 Additional Geologic and Geotechnical Studies

As part of the proposed Bad Creek II feasibility studies performed by HDR Engineering, Inc. (HDR) in coordination with Duke Energy, a two-phase geotechnical field exploration program was carried out at the existing site. Phase 1 (feasibility phase) was conducted from February 2021 through June 2021, and Phase 2 (updated feasibility phase) was conducted from August 2022 through June 2024. The Bad Creek II geotechnical investigation was performed to support the feasibility studies for the Bad Creek II water conveyance tunnels and shafts, access tunnels and shafts, underground powerhouse, and appurtenant structures including the proposed lower and upper I/O works.

A total of twenty-four (24) borings were drilled at the Project site which included Standard Penetration Test sampling, HQ rock coring, downhole geophysical logging, borehole permeability testing, installation of monitoring wells in two of the borings, installation of vibrating wire piezometers in four of the borings, and installation of inclinometers in six of the borings. The borings were drilled to obtain geotechnical data including soil properties, depth to top of weathered rock, depth to top of competent rock, lithology, rock hardness, rock recovery, Rock Quality Designation, depth and thickness of shear zones, and rock permeability data. Downhole geophysical logging of the borings was performed to assess rock mass fractures, foliation/banding, and other rock mass discontinuities. Surface geophysical investigations including seismic refraction surveys to establish compressional wave velocities (Vp) and multi-channel assessment of surface waves (MASW) to establish shear wave velocities (Vs) of subsurface materials were utilized in the interpretation of subsurface materials (overburden, weathered rock, firm/sound rock).

The intake, underground structures (tunnels, powerhouse, vertical shafts), and intake/discharge structure of Bad Creek II will be excavated in the TGn based on the geotechnical investigation and the previously collected geologic data. The location of Bad Creek II is depicted on the geologic/shear zone map on Figure E.7-6. Compiled data from the underground geologic mapping was used in the projection of the shear zones into the vicinity of the proposed Bad Creek II water conveyance alignment. Figure E.7-6 also shows locations of bore holes drilled for the feasibility studies as well as the estimated location of previous and recent mass movement (discussed further in Section E.14.1.1.8).

Overall conclusions indicated there are no geological/seismological fatal flaws associated with construction and operation of Bad Creek II. After 30+ years, the underground excavations at Bad Creek have stabilized and the support measures installed during construction have and are serving their functions well, however, presence of geologic features must continue to be evaluated in consideration of construction and dewatering for Bad Creek II.

Detailed findings from the geotechnical and geological studies (HDR 2024a; HDR 2024b) performed for the Bad Creek II Feasibility Study are included in the Supporting Design Report.

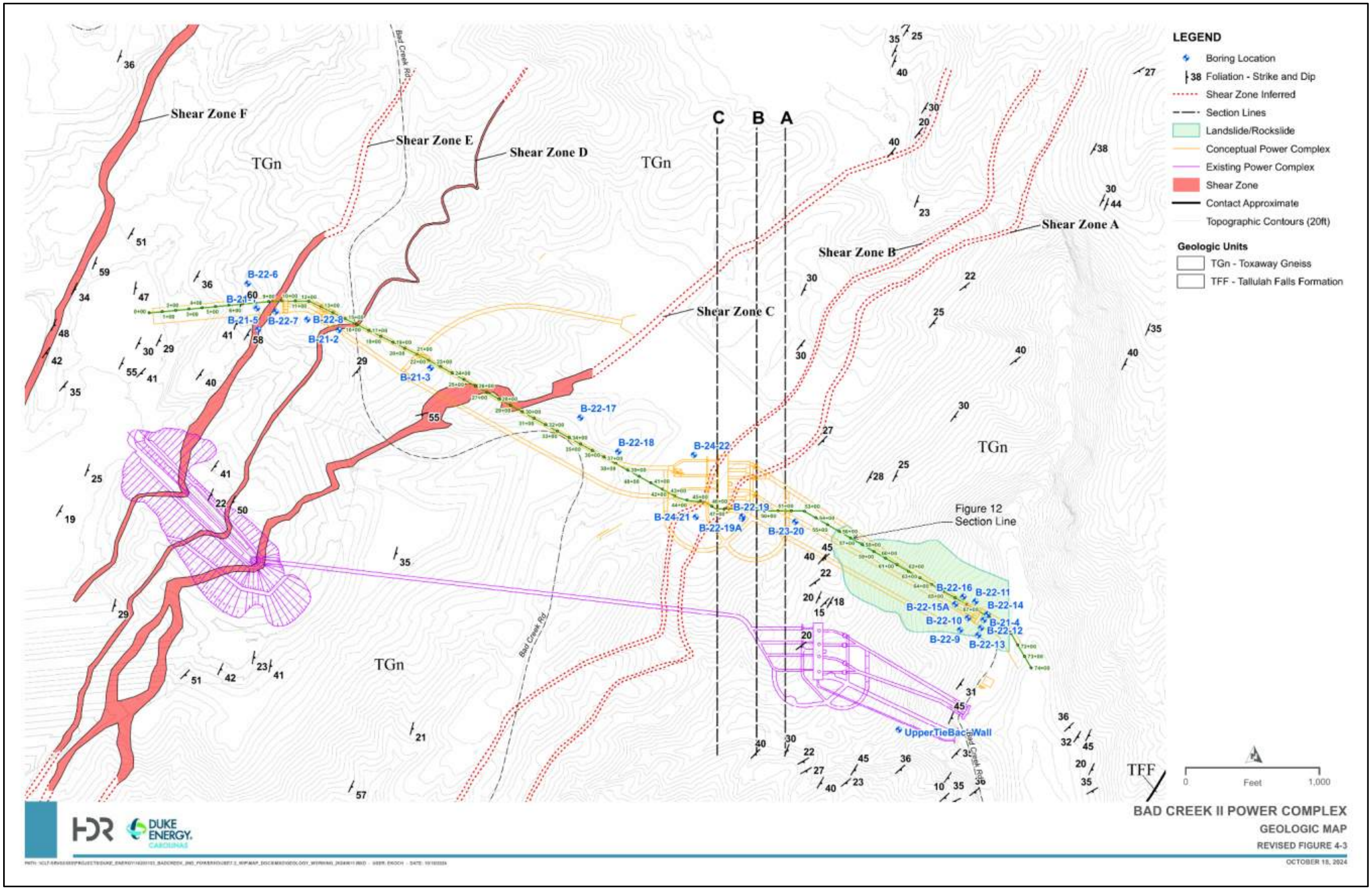


Figure E.7-6. Map showing Proposed Bad Creek II and existing Shear Zone and Boring Locations

E.7.1.1.7 Regional and Local Seismicity

Seismic Zones and Events

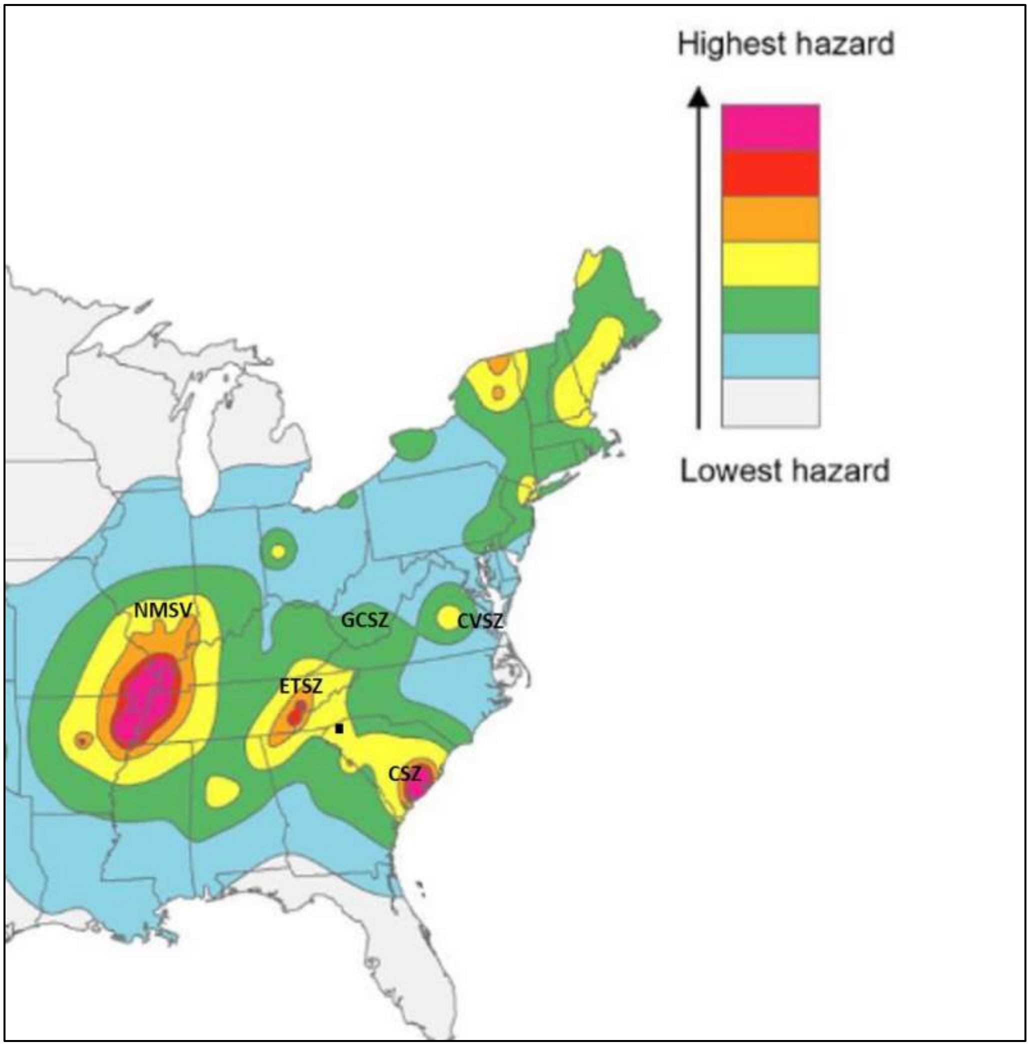
The East Tennessee Seismic Zone (ETSZ) is the closest seismic zone to the Bad Creek Project and is one of the most active seismic zones in eastern North America (Bollinger et al. 1991). It is located primarily in the Valley and Ridge province of Tennessee with a portion in the Valley and Ridge and Blue Ridge provinces of western North Carolina (Figure E.7-7). The zone is about 300 kilometers (km) long and 50 km wide. Earthquakes in the ETSZ occur at depths of to 5 to 25 km within Precambrian crystalline basement rocks beneath the thrust sheets of Paleozoic sedimentary rocks of the Valley and Ridge (Bollinger et al. 1976, 1991). The structures likely responsible for seismicity in the ETSZ are reactivated Precambrian to Cambrian normal faults formed during the rifting (extension) event that created the Iapetus Ocean. These faults are located beneath the later accreted Appalachian thrust sheets (similar to the Giles County Seismic Zone in Virginia; Wheeler 1995). Despite its relatively high rate of activity, the largest known earthquake in the ETSZ is M_w 4.7[10] (1973 Alcoa-Marysville earthquake; Bollinger et al. 1991).

The Central Virginia Earthquake of August 23, 2011 (M_w 5.7 - 5.8) was the largest earthquake in the central and eastern United States since the 1886 Charleston, South Carolina earthquake (estimated M_w 6.8 - 7.0). The earthquake occurred on a north or northeast-striking plane with reverse faulting within a previously recognized seismic zone, the Central Virginia Seismic Zone (CVSZ). The CVSZ is located in the Appalachian Piedmont Province between Richmond and Charlottesville, Virginia (see Figure E.7-7). The zone has an elliptical area, with a north-south dimension of 100 km and an east-west dimension of 120 km as defined by historical earthquake activity (Bollinger and Sibol 1985; Coruh et al. 1988). The depth of the earthquakes ranges from near surface to 12 km, placing them above the Appalachian detachment (Tuttle 2021)) in contrast to the ETSZ, where earthquakes occur below the detachment. The CVSZ has produced small and moderate earthquakes since at least the 18th century.

On August 9, 2020, a 5.1-M_w magnitude earthquake occurred with an epicenter about 2.5 miles southeast of Sparta, just south of the Virginia-North Carolina border (Figure E.7-8). Surface ruptures were attributed to a south southwest-dipping reverse fault (Little River fault) and were for ~2.5 km along the northwest trend (Hill 2020). The Little River Fault produced a maximum vertical displacement of 25.2 cm, with similar vertical displacements along much of the fault trace (Hill 2020). The hanging wall was to the south (northeast side up; reverse fault) as shown by the initial USGS focal mechanisms (USGS 2020a). There is no recorded historical seismicity in and around Sparta, but Little River Fault

[10] M_w = Moment Magnitude.

may be associated with the Giles County seismic zone, which is centered in Virginia about 100 km to the north (see Figure E.7-8). The depth of the main shock, 4.1 km (USGS 2020b), suggests it occurred above the master decollement (depths of 5 to 12 km) and is not related to the Giles County or East Tennessee Seismic Zones where the earthquakes typically occur below the decollement in the Paleozoic extended crust.



Note: GCSZ = Giles County Seismic Zone; ETSZ = East Tennessee Seismic Zone; CVSZ = Central Virginia Seismic Zone; CSZ = Charleston Seismic Zone; NMSZ = New Madrid Seismic Zone. Project location indicated by black square (source: USGS)

Figure E.7-7. Relative Seismic Hazard in the Southeastern U.S. with Identified Seismic Zones (modified from USGS 2018)

Seismic Hazards

The Peak Ground Acceleration with 2 percent probability of exceedance in 50 years, from the 2018 National Seismic Hazard Maps developed by the U.S. Geological Survey (USGS) is 0.26g for the site class boundary B/C. The 2018 Seismic Hazard Map incorporated the seismic data obtained from the Central Virginia Earthquake of August 23, 2011. This event would not influence the seismic hazard for the Project, which is predominantly governed by the seismicity of East Tennessee Seismic Zone.

Potential ground motions from a seismic event comparable to the Central Virginia or Sparta, North Carolina earthquake, but occurring in proximity to the Project site, would likely not have negative consequences for dam safety given the type of dams and observations on the seismic performance of other similar dams during past earthquakes. The Project dams have a design acceleration of 0.15g.

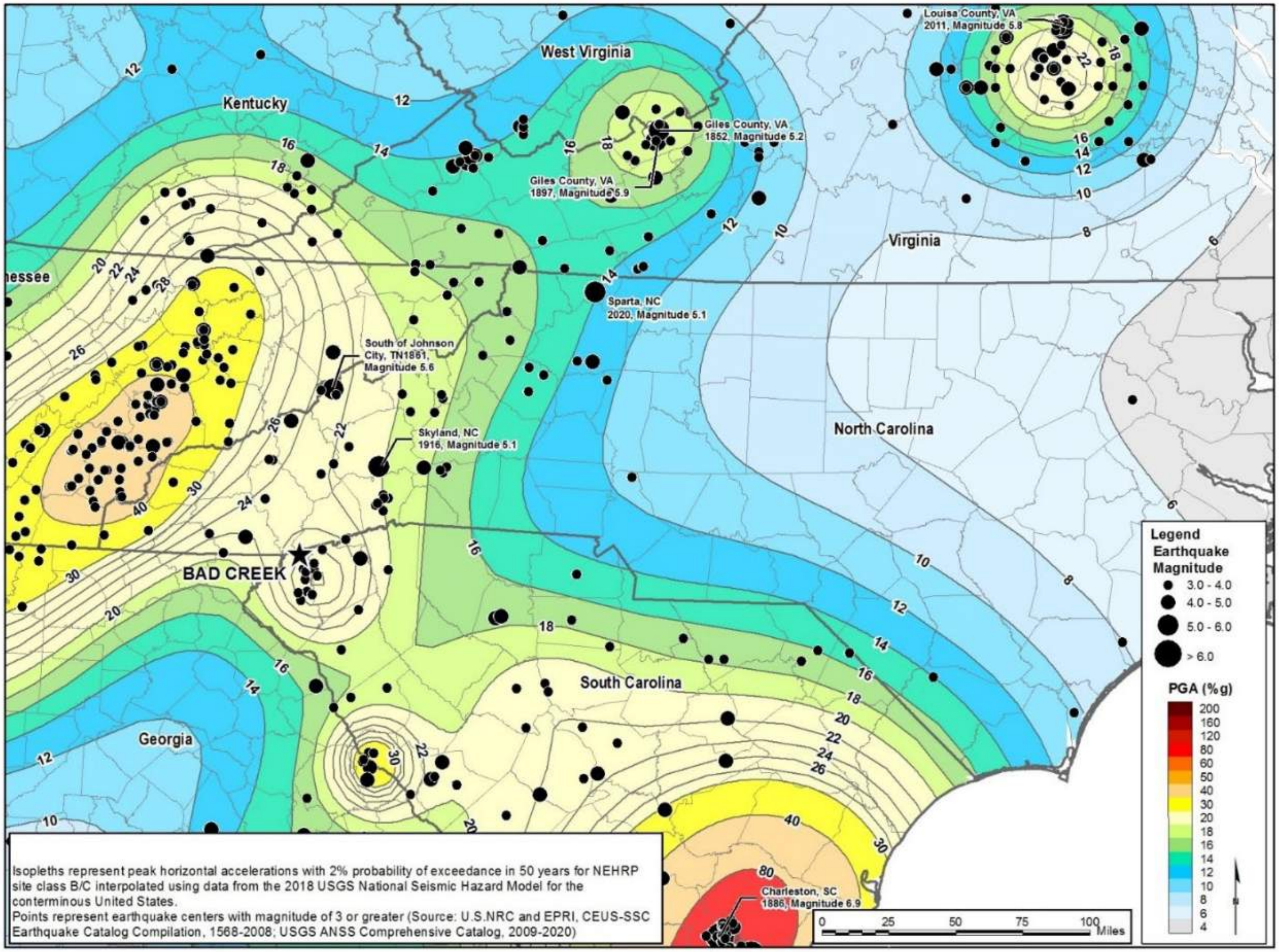


Figure E.7-8. Peak Ground Acceleration (PGA) and Historic Earthquake Centers near the Bad Creek Project

Previous Seismicity at the Site

Prior to filling Lake Keowee in 1968, no historical seismic activity was documented in the vicinity of the Bad Creek Project. Because seismic activity appeared to have increased after impoundment of the Lake Keowee (as evidenced by a swarm of seismic events associated with Lake Keowee in 1978 and other recorded events) the potential of reservoir-induced seismicity was studied by Duke Energy (Schaeffer 2000). Both Lake Keowee and then later Lake Jocassee reportedly appear to have been associated with reservoir-induced seismicity. Most of the events have been small, with the largest having a local Richter Magnitude of 3.8. Activity at Lake Jocassee has decreased significantly since first filling in 1976 while activity at Keowee has also decreased, although it appears to be cyclic in nature (Schaeffer 2000). During the study of the reservoir-induced seismicity, seismic activity was closely recorded by the stations of the seismic network operated by Duke Energy and that of the South Carolina Seismic Network. Prior to the filling of Lake Keowee in 1968, no historical seismic activity had been documented in the immediate vicinity. Both Lake Keowee and Lake Jocassee have been associated with induced earthquakes – most events have been small and activity has decreased significantly since first filling Lake Jocassee. A minor increase in seismicity was reportedly related to initial filling of the Bad Creek upper reservoir – from about 10 events per month (less than or equal to 1.0 second arrival at a station located northwest of the reservoir with magnitudes less than 0.0) to approximately 16 events per month (magnitudes <0.0). This increased occurred in January 1991, which coincided with the start of reservoir filing. Since the observed seismic activity has been minor and is generally attenuating, the close monitoring of the reservoir-induced seismicity has been suspended.

E.7.1.1.8 Geologic Hazards

Landslides

Work activities in the area of the west abutment of the Main Dam began in Spring 1986. Following the construction of a temporary construction road and initial stripping of slope, tension cracks indicative of slide movement were noted. Movement progressed over time and in July 1986, an exploration program was undertaken which included soil borings, installation of crack monitors, shear tubes, and inclinometers. The investigation determined the entire area was an old colluvial landslide bound by two drainage features. An area of wet and organic material at the toe of the slope was removed and replaced with random rock fill, which became a permanent feature, which was extended and enlarged until ultimately about 350,000 cubic yards of material had been placed. This area is currently monitored by three inclinometers which show some continued movement. The west abutment above the buttress continues to move as indicated by the inclinometers. Any landslide type of failure of the slope above the buttress would represent a maintenance concern with necessary remedial activity but would not impact Main Dam stability.

There was a previous landslide above the I/O structure; the slide material was removed during construction of the existing plant and a retaining wall was installed on the slope which stabilized part of the original landslide above the retaining wall and below the present control room/switchyard complex. There are four inclinometers on the retaining wall above the old landslide area to monitor potential slope movement at the I/O works. The discharge channel (lower) tieback wall was constructed on both sides of the I/O structure. The maximum height of the wall is approximately 50 ft. The wall consists of steel soldier piles seated on bedrock and anchored with steel tendons, timber lagging, and cast-in-place reinforced concrete facings. Rock bolts and shotcrete were installed along the slope downstream of the walls as needed to ensure the foundation remains stable.

On January 19, 2024, a slide occurred at the right (southern) end of the existing tieback wall. Appalachian Landslide Consultants were contracted by Duke Energy to study the area and document their findings (ALC 2024), including results of a desktop slope movement evaluation and limited field observations, and aerial imagery of the slide. The estimated location of the slide is shown on Figure E.7-6. Conclusions indicate that, based on field observations, limited review of borings and rock core, and discussion with onsite geologists, slope instability at the Project could be connected with weathered zones in the rock. These weathered zones may be conduits for water and may develop into slide planes. In some locations, the weathered zones are within fresh to very slightly weathered zones at depths up to around 57 ft below ground surface. The (ALC 2024) report is available upon request. Duke Energy is presently evaluating long-term remediation approaches, in consultation with the FERC Division of Dam Safety and Inspections.

The deformation of the upper tieback wall is monitored under existing the Dam Safety Surveillance and Monitoring Plan with inclinometers (five inclinometers were damaged due to the failure of the soil nail wall in January 2024).

Sinkholes

Bedrock in the Project vicinity is metamorphic gneiss, schist, or graywacke-schist. Solution prone carbonate rocks of sedimentary origin do not exist; therefore, sinkhole development is not considered a significant concern.

Liquefaction

Liquefaction occurs when loose, saturated, granular, and non-plastic soil is exposed to cyclic motion (e.g., earthquake) sufficient to increase soil pore water pressure and thus significantly reduce shear strength such that soil flows or settles significantly. Since the earth and rockfill embankments at the Project do not consist of or overlie loose sandy soils, liquefaction due to seismic shaking is not considered a significant concern.

E.7.1.1.9 Mineral Resources

South Carolina's leading mineral commodities include cement, crushed stone, construction sand and gravel, industrial sand and gravel, kaolin, and vermiculite. In Oconee County, resources include crushed stone-granite, marble, talc, and mica (Maybin et al. 1997) as well as gold and silver; however, there are no active mines or mining sites near the Project.

E.7.1.1.10 Existing Monitoring Program

Civil works and structures at the existing Project are surveyed and monitored under the *Duke Energy Carolinas, Hydro Fleet, Manual of inspection for Civil Works and Structures at Hydroelectric Station, Rev 7, September 24, 2019.* The Dam Safety Surveillance and Monitoring Plan provides details on inspection procedures, inspection frequency, and action values for specific measurements. A civil inspection is carried out annually and an inspection report is prepared by a registered professional engineer following each third-party inspection at the Project. An underwater inspection and a Part 12D Inspection are carried out every 5 years. The following structures are routinely inspected:

- Rockfill Dams (crest, slopes, toe, abutment, reservoir rim)
- Tunnels (wall and crown, concrete plug, rock drains)
- Powerhouse (structure, drainage system)
- Discharge and Retaining Walls (lower tieback wall and upper tieback wall including soil nail wall on the south side of the upper tieback wall)

The Instrumentation Monitoring Program provides guidance for routine monitoring of active instrumentation at the existing Project. Active instrumentation at the Project is listed below and additional monitoring includes crest profile surveys of the rockfill dams:

- Reservoir staff gage and pressure transducers
- Rain gage
- Standpipe piezometers, vibrating wire piezometers, pneumatic piezometers, and twin tube
- Hydraulic piezometers
- Parshall flumes, weirs, and leakage pipes
- Inclinometers, extensometers, and surface monuments
- Accelerographs

Reservoir Level Monitoring

The upper reservoir elevation is monitored by a staff gage and two pressure transducers located in the stream augmentation shaft between the Main Dam and West Dam. For over pumping protection, two cameras, with fixed views of the staff gage are accessible to staff (on site and remote) for confirmation of reservoir elevation. Continuous monitoring of the camera feed is implemented whenever the reservoir elevation exceeds 2,305 ft msl and units are in pump mode.

Rockfill Dams – Pore Water Pressure and Seepage Monitoring

Several types of piezometers (standpipe, vibrating wire, pneumatic, twin-tube hydraulic) are installed in the rockfill dams to monitor pore water pressures in the dams and their foundations. Multiple piezometers are installed in the main dam, west dam, an east dike. Parshall flumes and weirs are used to monitor seepage through the rockfill dams and there is at least one weir or flume associated with each dam.

Rockfill Dams – Deformation Monitoring

Surface (object) monuments were installed on the rockfill dams and are used to monitor the horizontal and vertical movements of the dams. Survey control and check monuments are located off the dams. Crest profile monitoring surveys are conducted to evaluate the available freeboard of the Main, West, and East dams. The survey consists of crest elevation measurements at points along the centerline of each dam. Inclinometers are used to monitor deformation in the Main Dam West Abutment.

Tunnels – Water Pressure Monitoring

Vibrating wire piezometers are used to monitor water pressures behind the tunnel linin and in the rock mass. Drain holes were drilled from the powerhouse bypass tunnel to relieve water pressure in the rock surrounding the penstock tunnels. The flow from the drain holes is collected and measured at the penstock bypass tunnel and tailrace bypass tunnel weirs.

Powerhouse

Drain pipes are used to measure flow from the perimeter drains behind the powerhouse wall and single-position borehole extensometers are used to monitor the deformation of the powerhouse cavern rock.

Upper Tie-Back Wall – Deformation Monitoring

Several inclinometers are used to monitor stability/deformation of the upper tieback wall (several were damaged due to the failure of the soil nail wall in January 2024, see Section E.7.1.1.8 for details on the landslide area).

Seismic Response Monitoring

Two strong-motion accelerographs, one on crest and one on the toe of the Main Dam, are used to record ground accelerations during a seismic event. The accelerographs have a recording trigger set at 0.01g.

Monitoring is carried out on a daily, weekly, monthly, or quarterly bases per the Dam Safety Surveillance and Monitoring Plan. It is expected that routine maintenance of structures and instrumentation will continue throughout the new license period.

E.7.1.1.11 Summary of Geologic Characteristics

Geologic characteristics of the bedrock, based on the geological and geotechnical studies performed during the design and construction of the existing Bad Creek Project underground structures as well studies performed for Bad Creek II are presented in Table E.7-1.

Table E.7-1. Summary of Geologic Characteristics

Geologic Characteristic	Relation to Project Area
High seismic risk/active faulting within the project area	The Project area is considered to have low to moderate seismic risk. No known Quaternary/active faults in the site vicinity.
Active landslides in project area	There is an old landslide at the intake/discharge of the Bad Creek Project on Lake Jocassee. The slide material was removed during construction of the existing plant and a retaining wall was installed on the slope that stabilized part of the original landslide above the retaining wall and below the present control room//switchyard complex. The landslide may possibly be in the crown of the tailrace tunnels as it approaches the I/O works and may be present around the main access tunnel portal. Appalachian Landslide Consultants (2024) report Desktop and Limited Field Slope Stability Study presents additional interpretation with respect to the location of this landslide and confirms the presence of landslide material in the vicinity of the main access tunnel portal.
Deep weathering profile	Total soil thickness and the depth of overburden (soil/saprolite) and weathered bedrock at the Upper Reservoir I/O works, low pressure headrace gates area, and vertical headrace shafts area varies from 10 ft to greater than 90 ft. At the Lower Reservoir I/O on Lake Jocassee, the overburden is primarily landslide deposits that are up to 100+ ft thick based on the

Geologic Characteristic	Relation to Project Area
	interpretation of the one borehole in the area and the seismic refraction and MASW lines. The landslide deposits are not deeply weathered.
Highly permeable rock	Most of the water encountered in the Bad Creek Project underground excavations, past the initial ~200 ft of the main access and tailrace tunnels from their portals on Lake Jocassee, were associated with specific geologic features - the foliation parallel shear zones and some of the high-angle fault zones. Sections A, B, and C are cut normal to the proposed Bad Creek II alignment and the location of the shear zones.
Soluble rock material	Not present in the TGn.
Low strength, vibration-sensitive, friable, highly abrasive, slaking, or unlithified rock material	Weathered rock associated with shear zones and biotite schist and biotite-hornblende schist will have lower shear strengths than the unweathered TGn.
Highly faulted, folded, or fractured rock material	Most of the faults/fractures in the TGn have secondary mineralization and are not highly fractured/faulted. The shear zones mapped in the reservoir and in the existing Bad Creek Project underground structures have weathered sheared rock and later brittle faulting associated with them.
Thinly laminated, structurally deformed, fine-grained rock masses	Phyllonitic material present along some of the foliation-parallel shear zones in the underground excavations and thin, foliation parallel biotite-hornblende schist layers.
Rock Mass In-Situ Stress Field	High in-situ stresses that can result in rock burst and stress-related issues in the larger underground opening including the powerhouse, voltage bus/excitation galleries, draft tube gate and access gallery tunnel, draft tube gate annexes, and draft tube gate vertical shafts and at intersections of tunnels and shafts.

E.7.1.2 Soils

While the type of underlying bedrock (parent material) typically dictates which soils are predominant in an area, climate, relief, the presence of organisms, and passage of time are also important soil formation factors. In the vicinity of the Project, the landscape influences soil formation through its effects on erosion, moisture, temperature and plant cover, and differences in slope and aspect. For example, soils with gentle slopes are stable and will develop mature profiles as a result of chemical weathering. On side slopes, soils may be thinner and can develop from materials from higher elevations.

Soils of the Project vicinity are considered upland soils, which are typically well drained sandy loam with some clay loam. In general, soils surrounding Lake Jocassee and Bad Creek are consistent because of the similar geologic conditions and topography in the reservoir area. Soils are typically sandy loam derived in place from metamorphic bedrock. Although the soils are typically sandy loam at the surface, these units often include a sandy clay, clay or clay loam subsoil. Several soil types include a significant percentage of gravelly or cobbly soil. They are typically underlain by saprolite or weathered rock at depths ranging from 10 to greater than 60 inches. In some locations, weathered or unweathered bedrock may be present below the surface soils at depths as shallow as 1 to 2 ft. Depths to weathered or unweathered crystalline bedrock are several tens of feet or more.

Soils in the Project Boundary are provided in Table E.7-2 (main facilities site area only) and Table E.7-3 (transmission line corridor only). An aerial view of the soils within the Project Boundary is included on Figure E.7-9 and soils within the Transmission Line corridor are shown on Figure E.7-10.

Table E.7-2. Soils in the Project Boundary (Excluding Transmission Line Corridor)

Map Unit	Soil Name/Description	Area (acres)	Percent of Area
AsF	Ashe sandy loam, 25 to 50 percent slopes	51.17	3.9
HaD	Halewood fine sandy loam, 10 to 15 percent slopes	4.57	0.4
HaE	Halewood fine sandy loam, 15 to 25 percent slopes	133.78	10.3
HaF	Halewood fine sandy loam, 25 to 45 percent slopes	725.67	55.9
HcC2	Hayesville and Cecil fine sandy loams, 6 to 10 percent slopes, eroded	8.23	0.6
HcD2	Hayesville and Cecil fine sandy loams, 10 to 15 percent slopes, eroded	10.18	0.8
HcE	Hayesville and Cecil fine sandy loams, 15 to 25 percent slopes	27.34	2.1
HcF	Hayesville and Cecil fine sandy loams, 25 to 45 percent slopes	11.72	0.9
Mv	Riverview-Chewacla complex, 0 to 2 percent slopes, frequently flooded	20.77	1.6

Note: Values do not sum to 100% due to 23.5% surface water.

Table E.7-3. Soils in the Project Boundary (Transmission Line Corridor)

Map Unit	Soil Name/Description	Area (acres)	Percent of Area
HaE	Halewood fine sandy loam, 15 to 25 percent slopes	16.80	3.7
HaF	Halewood fine sandy loam, 25 to 45 percent slopes	244.71	54.5
HcB	Hayesville and Cecil fine sandy loams, 2 to 6 percent slopes	1.06	0.2
HcD	Hayesville and Cecil fine sandy loams, 10 to 15 percent slopes	0.33	0.1
HcD2	Hayesville and Cecil fine sandy loams, 10 to 15 percent slopes, eroded	3.83	0.9
HcE	Hayesville and Cecil fine sandy loams, 15 to 25 percent slopes	11.55	2.6
HcE2	Hayesville and Cecil fine sandy loams, 15 to 25 percent slopes, eroded	8.02	1.8
HcF	Hayesville and Cecil fine sandy loams, 25 to 45 percent slopes	86.82	19.3
HcF2	Hayesville and Cecil fine sandy loams, 25 to 45 percent slopes, eroded	5.34	1.2
HhF	Hayesville, Cecil, and Halewood sandy loams, shallow, 25 to 60 percent slopes	42.94	9.6
HsE2	Hiwassee sandy loam, 15 to 25 percent slopes, eroded	0.50	0.1
MfE	Madison fine sandy loam, high, 15 to 25 percent slopes	1.47	0.3

Map Unit	Soil Name/Description	Area (acres)	Percent of Area
TcF	Talladega and Chandler loams, 25 to 60 percent slopes	15.97	3.6

Note: Values do not sum to 100% due to 22% surface water.

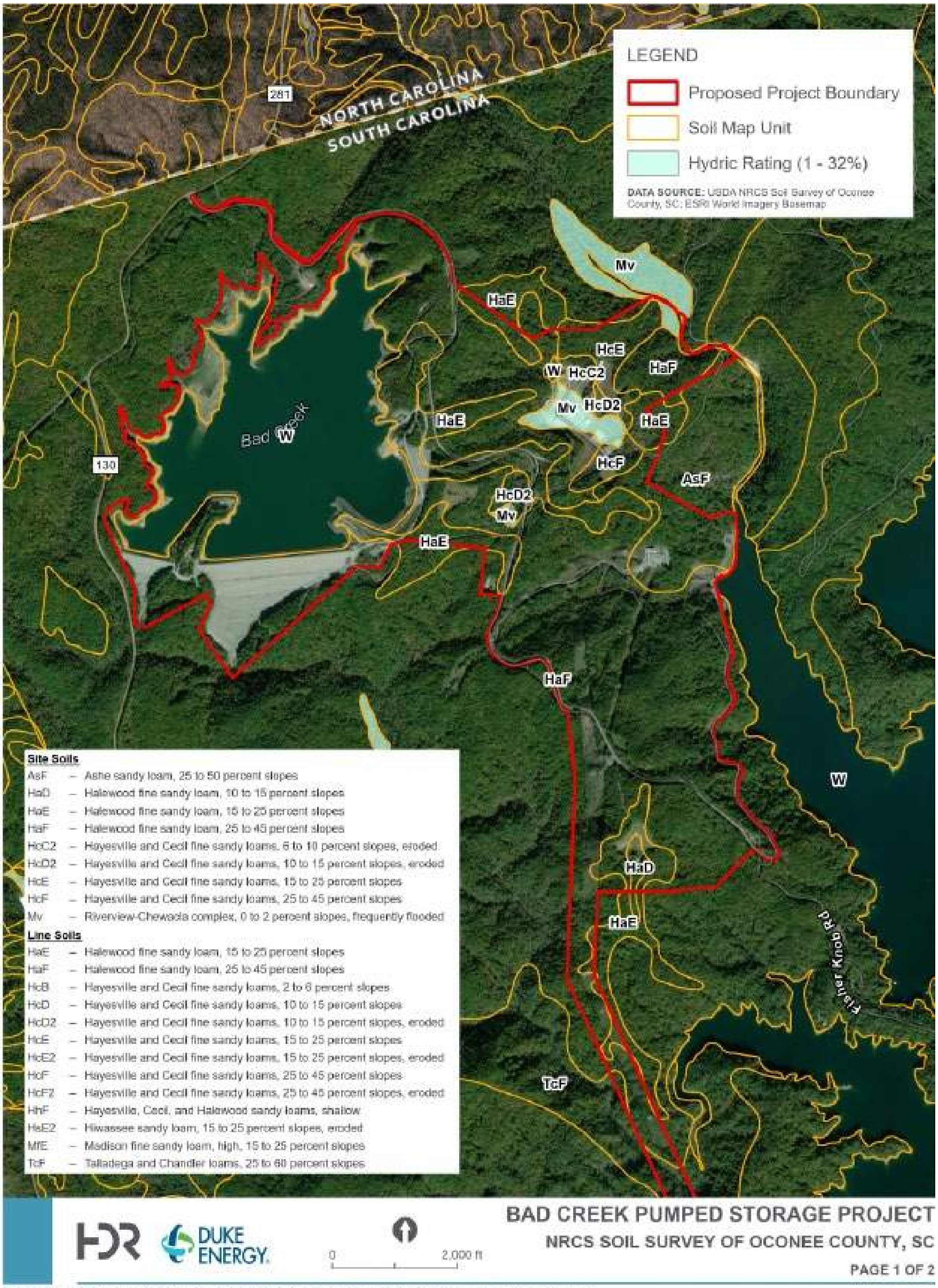


Figure E.7-9. Soils in the Project Boundary (Main Site)

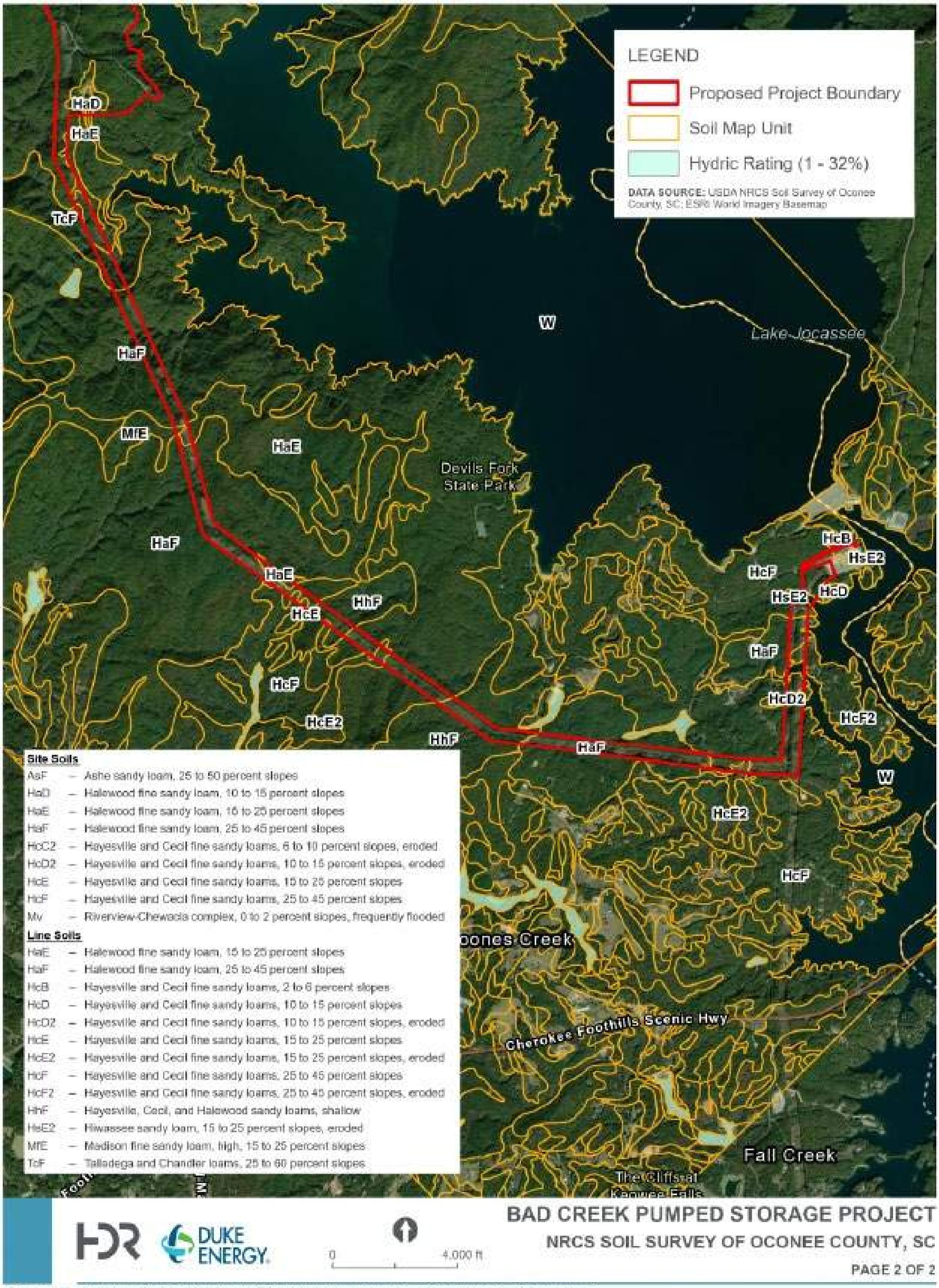


Figure E.7-10. Soils in the Project Boundary (Transmission Line Corridor)

E.7.1.3 Reservoir Shoreline and Stream Banks

E.7.1.3.1 Bad Creek Reservoir Shoreline

The Bad Creek Reservoir was designed to withstand extreme surface water fluctuation associated with daily and weekly pumping and generating cycles and is subject to inspection as part of Duke Energy's Owner's Dam Safety Program. The reservoir is not open to public use.

E.7.1.3.2 Lake Jocassee Shoreline

The Bad Creek Project Boundary does not include any portion of the Lake Jocassee shoreline except for the small (approximately 1,500 ft total length) engineered portion of shoreline associated with the existing outlet structure; however, because of the pump-back operation between Lake Jocassee and Bad Creek Reservoir and natural resources that have the potential to be affected by this relationship, the shoreline condition of Lake Jocassee is considered here.

To assess general characteristics of shoreline erosion on lakes Jocassee and Keowee, a Shoreline Erosion Study was carried out by Duke Energy (Baird 2013) to meet the requirements for the KT Project relicensing. The purpose of the erosion study was to determine the effects of KT Project operations, natural waves, and recreation-induced waves on erosion within the KT Project boundary and to quantify erosion along the shorelines of Lake Jocassee (and Lake Keowee), with the following specific objectives: (1) characterize the overall erosion along the shorelines of each reservoir; (2) identify project-induced erosion sites; (3) quantify the level of erosion occurring at those sites; and (4) collect adequate data on the project effect to evaluate the potential needs or opportunities for PM&E measures and monitoring in those sites.

The Baird (2013) study results indicated the primary sources of erosion include physical weathering (e.g., freeze-thaw), wave action from wind and recreational boating, concentrated runoff, operation of the reservoir (cyclic raising and lowering); and non-project development along the shoreline (i.e., new and former land development). Most erosion on the KT Project reservoirs was determined to be from wave action associated with wind and boat wakes, while water level fluctuations due to the project operations had minor effects on erosion.

To assess the relative magnitude of waves from wind versus recreational boating, wind data (from 1986 to 2009) and wave data were used to determine direction of prevailing winds, direction of impact on shorelines, and seasonal wind direction frequency/wind speed. A numerical model was used to estimate the percentage of erosion from boat wakes. A comparative evaluation of these indicated approximately 25 to 45 percent of the erosion noted was attributed to boat wakes in Lake Jocassee and the remainder was attributable to wind waves. To assess the effect existing project operations have on erosion, five representative sites were examined featuring eroding shorelines in soils and soft bedrock (see Baird 2013). Based on shoreline profile measurements through comparisons of sequences of orthophotos, Baird and Orbis 2013 indicated shoreline erosion is caused primarily by wind and boat waves and the extent of erosion at each site reflected the magnitude of waves from these sources and the relative resistances of the local substrate. KT Project operations did affect the elevations where wave-induced erosion occurs, but current KT Project operations do not appear to contribute appreciably to the overall rate of shoreline erosion. However, if the Normal Maximum Elevation (i.e., full pond; 1,110 ft msl) is raised, this could reduce erosion rates as the amount of time the reservoir would be drawn down would be reduced, thereby exposing less of the lower bank slopes, which would subsequently not be exposed to waves. In general, wind and wave-caused erosion is expected to continue in areas with erodible soils where bedrock has not been exposed but may occur at lower rates if pool elevations are raised (Baird 2013).

In previous shoreline studies (Orbis 2012) at Lake Jocassee, scarp height (thickness of soil visible above the water line), recession of banks, and percentage of shoreline protection around the reservoir were documented and are provided in Table E.7-4. Overall, on Lake Jocassee, 25 percent of the 92 miles of shoreline was classified as eroding in naturally occurring soils, 45 percent was previously eroded with exposed bedrock or protected shoreline (i.e., not eroding), and 30 percent was classified as not eroding and not showing signs of past erosion.

Table E.7-4. Scarp Characteristics for Lake Jocassee Shoreline and Erosion Classifications

Shoreline Erosion Classification	Scarp Characteristics	Lake Jocassee (% of shoreline)	Lake Keowee (% of shoreline)
Active low/mod/high	<1 ft to >3 ft scarp; unprotected with soil overburden	25	65
Passive low/mod/high	<1 ft to >3 ft scarp; bedrock or protected	45	2
Active none	No eroded scarp; unprotected with soil overburden	26	13
Passive none	No eroded scarp; bedrock or protected	4	20

Source: Based on Orbis, Inc. (2012, 2010a, b).

Note: None = no visual evidence of shoreline erosion; low = less than 1-foot vertical scarp; moderate = between 1 foot and 3 ft vertical scarp; high = above 3-ft vertical scarp; active = naturally occurring soils; passive = exposed bedrock or protected shoreline.

Overall, the study showed approximately 75 percent of the Lake Jocassee shoreline is either (a) bedrock or (b) shows no signs of erosion (Orbis 2012).

Additionally, Duke Energy is responsible for managing activities within the reservoir boundaries of lakes Jocassee and Keowee in a manner promoting safe public use and maintains environmental safeguards. Duke Energy implements the KT Shoreline Management Plan (SMP) for lakes Jocassee and Keowee (Duke Energy 2014b) classifying the respective shorelines and denotes where environmentally important habitat exists, where existing facilities and uses occur, and where future/existing construction activities may be considered. The SMP guides responsible reservoir use (i.e., private piers, slips, marina, shoreline stabilization efforts).

E.7.1.3.3 Whitewater River Stream Bank

A 0.4-mile-long portion of the Whitewater River's descending right bank adjoins the Project Boundary. The river in this reach is slightly meandering with boulder/cobble/gravel/sand substrate, shoals, some exposed bedrock, and well vegetated banks (heavily forested on both sides of the river). This portion of the river is immediately upstream of the steeper white-water/rapids reach of the river that empties into Whitewater Cove approximately half a mile downstream. Current project activities or future activities do not impact the Whitewater River or its shoreline.

E.7.2 Environmental Analysis

The proposed Bad Creek II may affect, and be affected by, existing subsurface features, surface features, and/or soil movement. Conditions that may impact the safety of Project structures during construction and with continued operation include underlying geology, slope movement (i.e., landslides), and seismic activity. Potential Project impacts are discussed below.

E.7.2.1 Project Impacts on Geology, Geomorphology, and Soils

In SD2, FERC identified the following environmental issues related to geology and soils resources to be addressed in its NEPA document:[11]

- Effects of project construction and spoil disposal on soil erosion and sedimentation.
- Effects of project operation on shoreline erosion along the lower reservoir.*
- Effects of project construction on slope instability in the project area.
- Effects of seismic activity in the project area on construction of Bad Creek II, and vice versa.

E.7.2.1.1 Effects of Project Construction and Spoil Disposal on Soil Erosion and Sedimentation

The construction of Bad Creek II has the potential to cause soil erosion, which could lead to sedimentation issues in waterways and wetlands. Activities that could contribute to soil erosion and

[11] Issues with and asterisk (*) will be analyzed for both cumulative and site-specific effects.

sedimentation include clearing and grubbing of construction areas and access roads, excavation of underground features, and placement of spoil in spoil disposal sites. The Licensee will prepare and implement an Erosion and Sediment Control (ESC) Plan consistent with its ESC Permit (also referred to as a Construction Stormwater Permit) issued by SCDES and discussed in Section E..3.2. Duke Energy also plans to implement a pre-construction and post-construction stream habitat monitoring program to evaluate streams with the potential to be impacted by erosion and sedimentation, as detailed in the WQMP provided in the Water Resources Study Report (Appendix D).

Excavation activities associated with the construction of Bad Creek II will generate approximately 4 million cubic yards of spoil material requiring disposal. Currently, the Licensee anticipates disposing of the spoil within Bad Creek Reservoir, in Lake Jocassee in association with expansion of the existing submerged weir, and/or in upland spoil disposal sites within the Project Boundary. Spoil disposal will require a CWA Section 404 permit (issued by the USACE) and associated Section 401 WQC issued by SCDES. Placing excavated rock fill material along the submerged weir will likely result in temporarily increased turbidity in a limited area of Whitewater River cove; Duke Energy plans to implement water quality monitoring in the Whitewater River cove for compliance with state turbidity standards in surface waters. See Section E.8.2 for detailed information about the Licensee's studies related to turbidity.

E.7.2.1.2 Effects of Project Operation on Shoreline Erosion along the Lower Reservoir

Existing Project

Wave energy from wind and boat wakes causes erosion at Lake Jocassee. Shoreline erosion at Lake Jocassee has been measured at approximately three inches per year with minimal effects on vegetation (Duke Energy 2014c). Continued operation at Bad Creek is unlikely to affect or increase shoreline erosion rates at Lake Jocassee.

Bad Creek II

A preliminary three-dimensional CFD model was built for the Bad Creek II Feasibility Study with the goal of identifying flow velocities and patterns under generation and pumping scenarios with various water level elevations in the Whitewater River cove near the I/O structure (upstream of the submerged weir) and to assess the potential for erosion along the opposite (east) shoreline due to increased generation flows from the combined powerhouses. Details on background, methods, and findings of this study are provided in the Bad Creek II Power Complex Feasibility Study Lower Reservoir CFD Flow Modeling Report (HDR 2022) and was also provided in the RSP as Appendix I, as described above in Section E.3.3.1.

The concentrated flow from the proposed I/O structure reduced the size of recirculation patterns and directed flow from the existing I/O structure towards the center of the Whitewater River cove. This effect reduced the existing Bad Creek region of high velocity along the east bank but created a new region of high velocity approximately 600 ft upstream (i.e., north). Peak velocities along the east bank were less than 3.5 ft per second (fps). Modeled pumping operations show distinct flow paths for each I/O structure. Along the east bank, water flows north and enters the proposed I/O structure. Flow along the west bank enters the existing I/O structure. Increased velocities and non-direct flow were shown in the approach to the proposed I/O structure. The simulated flow patterns may lead to uneven loading of the tunnels and ineffective flow areas. The maximum velocity near the submerged weir was 3.5 fps shown during the minimum reservoir pumping operations.

The peak velocities for the proposed Bad Creek II I/O configuration along the east bank do not exceed the modeled velocities shown in the existing Bad Creek configuration at Lake Jocassee elevation 1,110 ft msl. The proposed Bad Creek II I/O configuration predicted minor increases to peak velocities along the east bank when compared to the existing Bad Creek modeled velocities. The location of the peak velocities is spatially closer to the proposed Bad Creek II I/O structure and similar in magnitude to the physical model simulation results / existing conditions (Larsen and White 1986).

The results of this study indicate the additional generation flows resulting from Bad Creek II (in combination with the Bad Creek Station) do not appear to increase the potential for erosion along the east/opposite bank of the Whitewater River cove in Lake Jocassee, under consistent shoreline geology (i.e., predominantly bedrock). Duke Energy is not aware of any erosion along the east bank caused by flow from the existing operations, and modeled velocities are within the general current range under the proposed configuration.

E.7.2.1.3 Effects of Project Construction on Slope Instability in the Project Area

Active slope movement has been documented at the Project as well as evidence of previous mass wasting events (see Section E.8.1.1.8). There is an old landslide above the I/O of the Bad Creek Project as described in Schaeffer (2016). The slide material was removed during construction of the existing plant and a retaining wall was installed on the slope that stabilized part of the original landslide above the retaining wall and below the existing control room//switchyard complex.

Figure E.7-6 shows the extent of a recent landslide/rockslide near the proposed lower reservoir Bad Creek II I/O structure on Lake Jocassee. The landslide/rockslide could potentially affect excavation in this area to construct the works; it could be located in the crown of the tailrace tunnels as it approaches the I/O works and may be present around the main access tunnel portal. ALC (2024) was retained by Duke Energy to investigate recent slope movement and conclusions indicate that, based on field observations, limited review of borings and rock core, and discussion with onsite geologists, slope instability could be connected with weathered zones in the rock. These weathered zones may be conduits for water and may develop into slide planes. In some locations, the weathered zones are within fresh to very slightly weathered zones at depths up to around 57 ft below ground surface. The final (ALC 2024) report is available upon request. Duke Energy is presently evaluating long-term remediation approaches, in consultation with the FERC Division of Dam Safety and Inspections and will continue to monitor the location during construction. Additional borings and seismic refraction/MASW lines in the area of the lower reservoir I/O works to better define the limits (both horizontally and vertically) of the landslide deposits north of the proposed area of the excavation required for its construction.

E.7.2.1.4 Seismic Effects in the Project Area on or from Construction of the Complex

The shear zones mapped in the Bad Creek reservoir and in the existing Project underground structures have weathered sheared rock and later brittle faulting associated with them. Later brittle faults are present and are mineralized/healed with various combinations of greenschist facies minerals. Most of the water encountered in the underground excavations for the existing Project (past the initial ~200 ft of the main access and tailrace tunnels from their respective openings at Lake Jocassee) is associated with the existing shear zones parallel to the bedrock foliation. Similar conditions are anticipated in the Bad Creek II underground excavations. High in-situ stresses resulted in rock burst and stress-related issues in the larger underground openings in the existing underground excavations; this will likely occur in the underground excavations for Bad Creek II. Mitigation measures developed for existing underground excavations will be utilized in the excavation and construction of the proposed powerhouse and associated tunnels and shafts.

As indicated in Section E.7.1.1.7, the PGA at the site is 0.26g. The Main Dam, West Dam, and East Dike are expected to perform satisfactorily during an earthquake with comparable PGA. This conclusion is based on the embankment and foundation characteristics and satisfactory performance exhibited by similar type dams during past earthquakes. The embankment shells consist of high shear strength rockfill that is free draining; therefore, no excessive pore water pressure development is anticipated during earthquake loading, and the core and foundation soils are not considered susceptible to liquefaction. The publication by the Federal Emergency Management Agency, *Federal Guidelines for Dam Safety: Earthquake Analyses and Design of Dams, FEMA 65*, May 2005, indicates that well drained, compacted rockfill dams or dumped rockfill dams with impervious cores are resistant to earthquake forces provided they are constructed on rock or overburden foundations resistant to liquefaction. The existing Bad Creek Reservoir dams have undergone extensive stability analyses beginning in 1976 (initial design phase), and including combined earthquake and rapid drawdown load, with the most recent stability analysis conducted by HDR in 2017 for the Main Dam, as documented in the Supporting Design Report filed with the license application.

As mentioned in previous sections, the Project vicinity is considered to have low to moderate seismic risk and there are no known Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018) and potential ground motions from a seismic event comparable to the Central Virginia or Sparta, North Carolina Earthquake, but occurring in proximity to this Project site would not have negative consequences for dam safety given the type of dams and observations on the seismic performance of other similar dams during past earthquakes.

As noted in E.7.1.1.7, induced seismicity during original filling of reservoirs was recorded, however, that is not a concern during construction of Bad Creek II since no new reservoirs will be created.

With respect to the potential for seismic activity due to construction activities, specifications governing the underground excavation and blasting activities will be used to control particle velocities experienced in the vicinity of the work. Vibration from the blasting activities is limited by implementation of controlled blasting plans, as described in Section E.7.3.2. Monitoring devices to ensure established damage thresholds are not exceeded will be in place in the existing Bad Creek powerhouse and at other locations in effected area.

E.7.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.7.3.1 Existing Bad Creek Project

As described above, the Project vicinity is considered to have low to moderate seismic risk and there are no known Quaternary/active faults in the site vicinity (USGS 2014a, 2014b, 2018). The current Dam Safety Surveillance and Monitoring Plan and Instrumentation Monitoring Program will remain in place to monitor and assess risk associated with slope failure, increased pore water pressure, and seismicity, among others (Section E.7.1.1.10).

Based on the information provided above, continued operation of the Bad Creek Project is unlikely to affect or increase shoreline erosion rates at Lake Jocassee. No further PM&E measures are proposed at this time.

E.7.3.2 Bad Creek II

Mitigation measures developed for underground excavations will be utilized in the excavation and construction of the proposed powerhouse and associated tunnels and shafts. The EPC Contractor selected for Bad Creek II construction will prepare a Master Blasting Plan for review and approval by both Duke Energy and the FERC D2SI-ARO. The Master Blasting Plan will include procedures for the transportation, storage, handling, use, and security of explosives specific to the Project work area, including environmental protection measures (e.g., details of containment and contingency plans for quickly and effectively cleaning up any spilled explosive materials) and an Emergency Response Plan. The Master Blasting Plan will encompass blasting techniques to minimize over-break beyond the design lines of excavation, disturbance to or loosening of bedrock surrounding the excavation, and detrimental impacts of groundwater flow into excavations, as well as monitoring and mitigation for the potential for blast vibration impacts and damage to existing adjacent structures. Additional detail for design considerations and construction procedures relevant to deep underground blasting and excavation will be developed at a later design phase for Bad Creek II and submitted to FERC D2SI-ARO for approval.

The construction of Bad Creek II has the potential to cause soil erosion and sedimentation into waterways and wetlands and will require spoil disposal, therefore the Licensee will implement PM&E measures discussed below:

- **Erosion and Sediment Control (ESC) Plan:** Consistent with South Carolina state regulations, the Licensee will be required to obtain a stormwater construction permit and implement an approved ESC Plan. The ESC Plan will include both structural and non-structural BMPs. Non-structural BMPs include limiting the duration of ground exposure, phased seeding, and immediate permanent stabilization (including revegetation) following final grade establishment. Structural BMPs include sediment basins, installation of silt fences, use of compost socks on the low sides of silt fences draining to wetlands and waterways, and 50-foot undisturbed buffers between wetland and stream boundaries to silt fences.

- **Spoil Disposal:** As discussed in E.7.2.1.1, the Licensee will dispose of approximately 4 million cubic yards of spoil material during construction of Bad Creek II. PM&E measures associated with spoil activities are described as follows:

    - Use rock excavated from the underground powerhouse and power tunnels in Lake Jocassee to expand the submerged weir

- Install French drains in upland spoil disposal areas to minimize impacts to seeps and streams
- Comply with the requirements, including mitigation requirements, of the Section 404/401 permit issued by the USACE and SCDES

Duke Energy notes that the EPC Contractor selected for construction of Bad Creek II will be required to provide design for grade to provide access to facilities and to provide positive drainage of rainfall runoff away from the structures, with grade sloped away from above-ground building walls and equipment at a minimum pitch of two percent (2.0%). All surface runoff during and after construction will be controlled in accordance with the requirements of the ESC, stormwater prevention plan, NPDES permit and any existing plant permit requirements. Site yard areas disturbed during construction will be permanently stabilized by aggregate paving, asphalt paving or seeding and mulching per the ESC plan.

Duke Energy plans to continue the current Dam Safety Surveillance and Monitoring Plan and Instrumentation Monitoring Program throughout the new license. These measures will also inform construction activities associated with Bad Creek II. Monitoring and assessing risks associated with slope failure, increased pore water pressure, and seismicity at the existing Project also provides measures for risk assessment at the proposed Project since the existing dams and reservoirs are shared Project facilities.

E.8 Water Use and Quality

E.8.1 Affected Environment

E.8.1.1 Drainage Area

The Project, Project facilities, and the western portion of Lake Jocassee are situated in the Whitewater River watershed (HUC 030601010104), which has an area of approximately 80 mi^2. The Project transmission line corridor extends through a small portion of the Upper Little River-Lake Keowee watershed (HUC 030601010302) and terminates at the Jocassee station in the Cane Creek-Lake Keowee watershed (HUC 030601010201) (see Figure E.2-2). These watersheds are located within the northwestern portion of the Seneca sub-basin (HUC 03060101) (1,028 mi^2), which is part of the larger Savannah River Basin (10,577 mi^2).

Bad Creek Reservoir has a drainage area of approximately 1.5 mi^2 and receives drainage from two small streams, Bad Creek and West Bad Creek; these small streams were once tributaries of Howard Creek and are now partially to mostly submerged. Howard Creek flows from the northwest and through the southern border of the Project Boundary with a drainage area of approximately 4.3 mi^2 at its downstream confluence with Limber Pole Creek.

E.8.1.2 Bad Creek Reservoir Storage

Based on the Original License data (circa 1974), the reservoir consists of a 318-acre reservoir with a total storage capacity of 33,323 acre-ft, of which 30,229 acre-ft is usable storage. Usable storage is considered the volume of water between minimum reservoir 2,150 ft msl and full pond 2,310 ft msl. Updated reservoir curves and as-built data were developed in 1991 and 1992, and a comprehensive LiDAR survey was carried out in 2018 with the primary objectives of updating usable storage and total storage for the Bad Creek Reservoir (Theorem 2018). Based on the 2018 high-resolution LiDAR data, the usable storage volume is 31,808 acre-ft, an increase of 1,579 acre-ft compared to the original licensing volume. Table E.8-1 summarizes the historical Project reservoir surface areas and volumetric information. Duke Energy has consistently used the most recent LiDAR data for surface area (i.e., 363 acres) in its reporting.

Table E.8-1. Usable Storage Summary (Theorem 2018)

Data Description	Water Surface Area at 2,150 ft msl (acre)	Water Surface Area at 2,310 ft msl (acre)	Usable Storage: Cumulative Volume between 2,150 and 2,310 ft msl (acre-ft)
1974 Bad Creek Licensing Data	49.5	318	30,229

Data Description	Water Surface Area at 2,150 ft msl (acre)	Water Surface Area at 2,310 ft msl (acre)	Usable Storage: Cumulative Volume between 2,150 and 2,310 ft msl (acre-ft)
1991 Bad Creek Internal Data Memorandum	N/A	359	31,392
1991 Bad Creek Internal Volume Curve Data	69.5	359	31,338
1991 Bad Creek Internal Efficiency Data	N/A	359	30,932
1992 Bad Creek Licensing As-Built Data	N/A	367	31,400
2018 Bad Creek LiDAR Data	80.3	363	31,808

In 2020, HDR prepared upper reservoir area-volume curves for both the total and usable volumes as shown on Figure E.8-1 and Figure E.8-2.

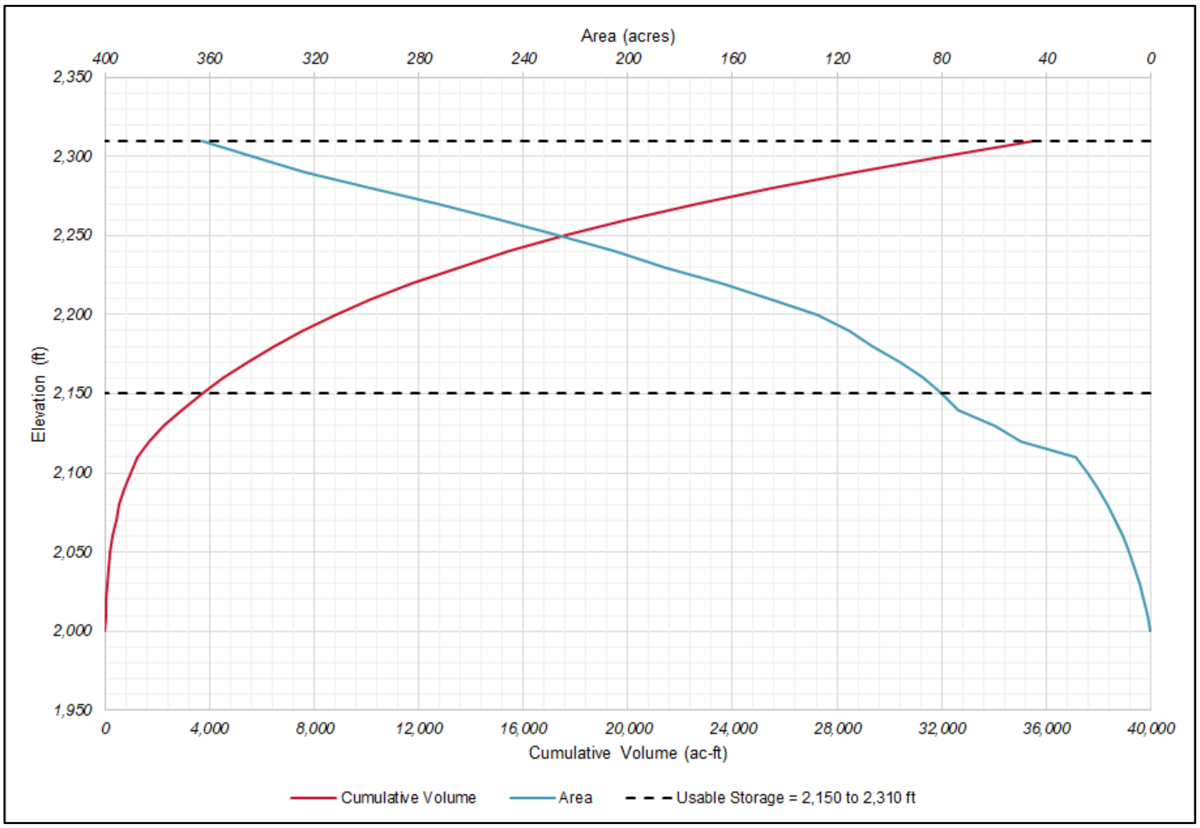


Figure E.8-1. Bad Creek Upper Reservoir, Total Area-Volume Curves

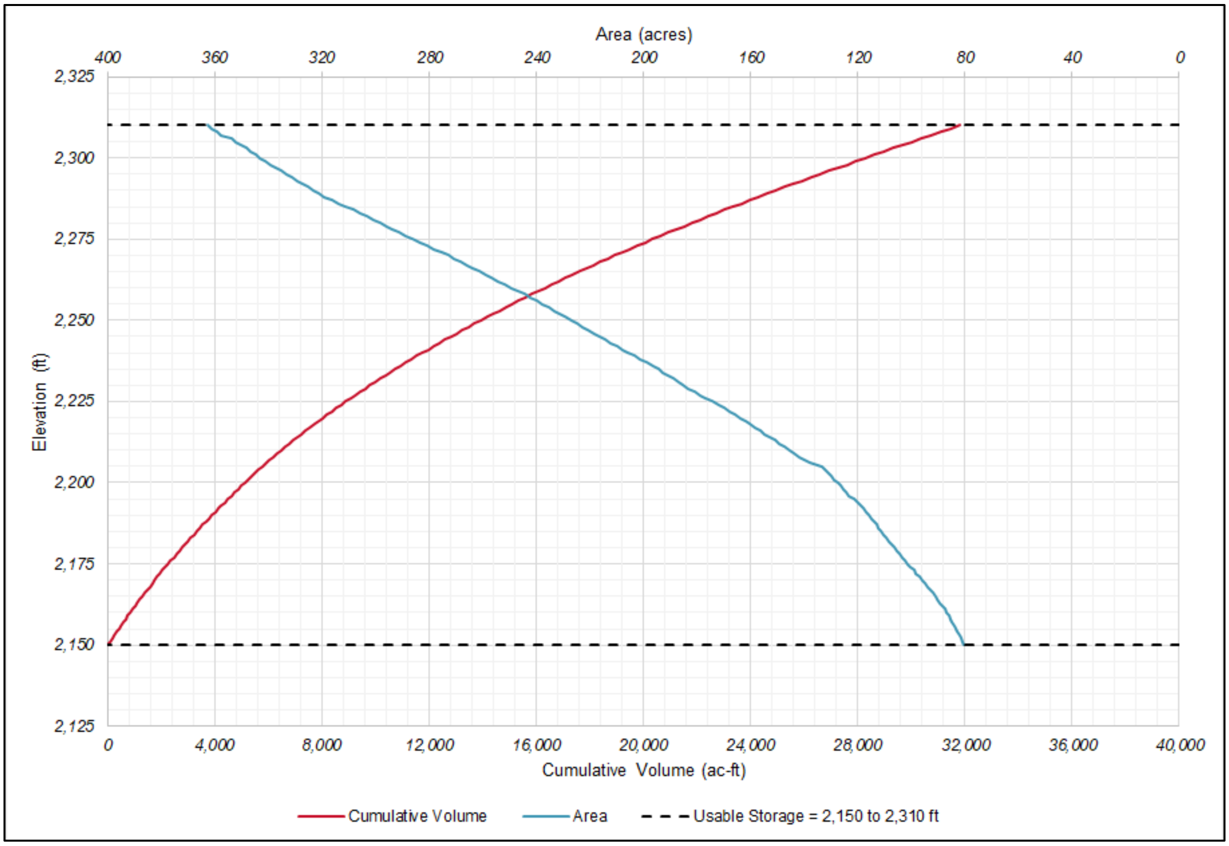


Figure E.8-2. Bad Creek Upper Reservoir, Usable Area-Volume Curves

E.8.1.3 Flows

The total contributing drainage area for the Bad Creek Reservoir is approximately 1.5 mi^2 and the average annual flow of Bad Creek and West Bad Creek, combined, is approximately 5 cfs. Annual evaporation from Bad Creek Reservoir is estimated to be 42 inches. Leakage through the Project embankments is approximately 5 cfs. Combined, water losses due to evaporation, leakage through embankments, and turbine leakage are considered insignificant when compared to the total volume of water cycled at the Project annually. The construction of Bad Creek II would not significantly affect leakage.

The Project exchanges water between Bad Creek Reservoir and Lake Jocassee and has no significant contributing inflows; therefore, neither monthly flow duration curves nor critical streamflow are applicable.

E.8.1.4 Streams and Other Open Waters

E.8.1.4.1 Expanded Project Boundary Excluding Transmission Line Corridor

Waters of the U.S. were surveyed within the proposed Project Boundary on June 8 to 10, 2021; September 19 and 20, 2021; October 18 and 19, 2023; May 21 to 23, 2024; July 23 to 25, 2024; July 31, 2024; August 1, 2024; and August 16, 2024. A request for Preliminary and Approved Jurisdictional Determination was provided to the USACE on September 9, 2024. A site visit was held with the USACE on December 3, 2024. Field surveys and subsequent USACE field verification of waters of the U.S. within the expanded Project Boundary found 51 jurisdictional streams including 37 intermittent and 14 perennial streams with approximately equal extent (a total of 13,846.3 linear ft [lf] of intermittent stream and 13,231.9 lf of perennial stream) (Table E.8-2; Figure E.8-3[12]). Five additional non-jurisdictional ephemeral conveyances totaling 911.0 lf were also noted within the expanded Project Boundary.

Table E.8-2. Summary of Jurisdictional and Non-Jurisdictional Conveyances within the Expanded Project Boundary, Excluding the Transmission Line Corridor

Feature ID	Flow	Average Width (ft)	Total Length (lf)
Jurisdictional Streams			
Stream 01	Intermittent	3	473.8
Stream 02	Intermittent	3	148.5

[12] Note Figures Figure E.8-3 and Figure E.8-4 include the formerly proposed Fisher Knob Access Road in the red boundary line shown, as that area was delineated in the above-referenced waters of the U.S. surveys, but is no longer proposed for inclusion in the Project or Project Boundary

Feature ID	Flow	Average Width (ft)	Total Length (lf)
Jurisdictional Streams			
Stream 03	Intermittent	3	1,691.3
Stream 04	Intermittent	3	641.0
Stream 05	Intermittent	3	424.1
Stream 06	Intermittent	3	60.8
Stream 07	Intermittent	4	1,550.8
Stream 08	Intermittent	3	153.7
Stream 09	Intermittent	3	393.1
Stream 10	Intermittent	3	307.7
Stream 11	Intermittent	5	244.0
Stream 12	Intermittent	8	143.8
Stream 13	Intermittent	3	98.8
Stream 14	Intermittent	2	291.3
Stream 15	Intermittent	4	1,282.7
Stream 16	Perennial	4	243.3
Stream 17	Intermittent	3	830.8
Stream 18	Intermittent	3	197.6
Stream 19	Intermittent	3	251.5
Stream 20	Perennial	3	2,407.8
	Perennial	4	326.0
Stream 21	Perennial	5	2,158.3
	Perennial	5	986.1
Stream 22	Intermittent	13	122.3
Stream 23	Intermittent	12	149.6
Stream 24	Perennial	6	141.5
Stream 25	Perennial	5	148.7
Stream 26	Intermittent	3	106.3
Stream 27	Perennial	7	327.6
Stream 28	Intermittent	7	427.6
Stream 30	Perennial	8	839.8
Stream 31	Intermittent	5	182.4
	Intermittent	7	53.4
Stream 32	Intermittent	4	1,493.1
Stream 34	Intermittent	3	69.5
Stream 35	Intermittent	6	186.0
Stream 36	Perennial	6	273.6
Stream 37	Perennial	6	825.9
Stream 37A	Perennial	6	957.1

Feature ID	Flow	Average Width (ft)	Total Length (lf)
Jurisdictional Streams			
Stream 42	Intermittent	3	354.7
Stream 43	Perennial	4	598.8
Stream 44	Intermittent	5	143.5
Stream 45	Perennial	5	728.5
Stream 46	Intermittent	12	133.7
Stream 47	Perennial	12	471.7
	Perennial	12	1,165.2
Stream 48	Intermittent	8	38.7
Stream 49	Intermittent	6	87.2
Stream 50	Intermittent	6	310.5
Stream 51	Perennial	5	632.0
Stream 52	Intermittent	8	142.1
Stream 65	Intermittent	4	101.0
Stream 70	Intermittent	4	12.7
Stream 76	Intermittent	3	125.6
Stream 107	Intermittent	12	421.1
		Total Length (lf)	**27,078.2**
Non-Jurisdictional Conveyances			
Non-JD1	Ephemeral	N/A	285.8
Non-JD2	Ephemeral	N/A	329.2
Non-JD3	Ephemeral	N/A	76.7
Non-JD4	Ephemeral	N/A	114.5
Non-JD5	Ephemeral	N/A	104.8
		Total Length (lf)	**911.0**

JD=Jurisdictional

In addition to Bad Creek Reservoir (see Section E.8.1.2), there are also several open water bodies and/or large streams within the proposed Project Boundary totaling 1.7 acres of ponds and 0.34 acre of large streams/creeks (Table E.8-3; Figure E.8-3).

Table E.8-3. Summary of Open Water and Large Streams within the Expanded Project Boundary, Excluding the Transmission Line Corridor

Feature ID	Total Area (acres)
Open Waters (excluding Lake Jocassee and Bad Creek Reservoir)	
WOTUS 1	1.62
WOTUS 4	0.08
Total Area (acres)	**1.7**

Feature ID	Total Area (acres)
Large Streams	
Stream 11A	0.17
Stream 21	0.17
Total Area (acres)	**0.34**

WOTUS=Waters of the U.S.

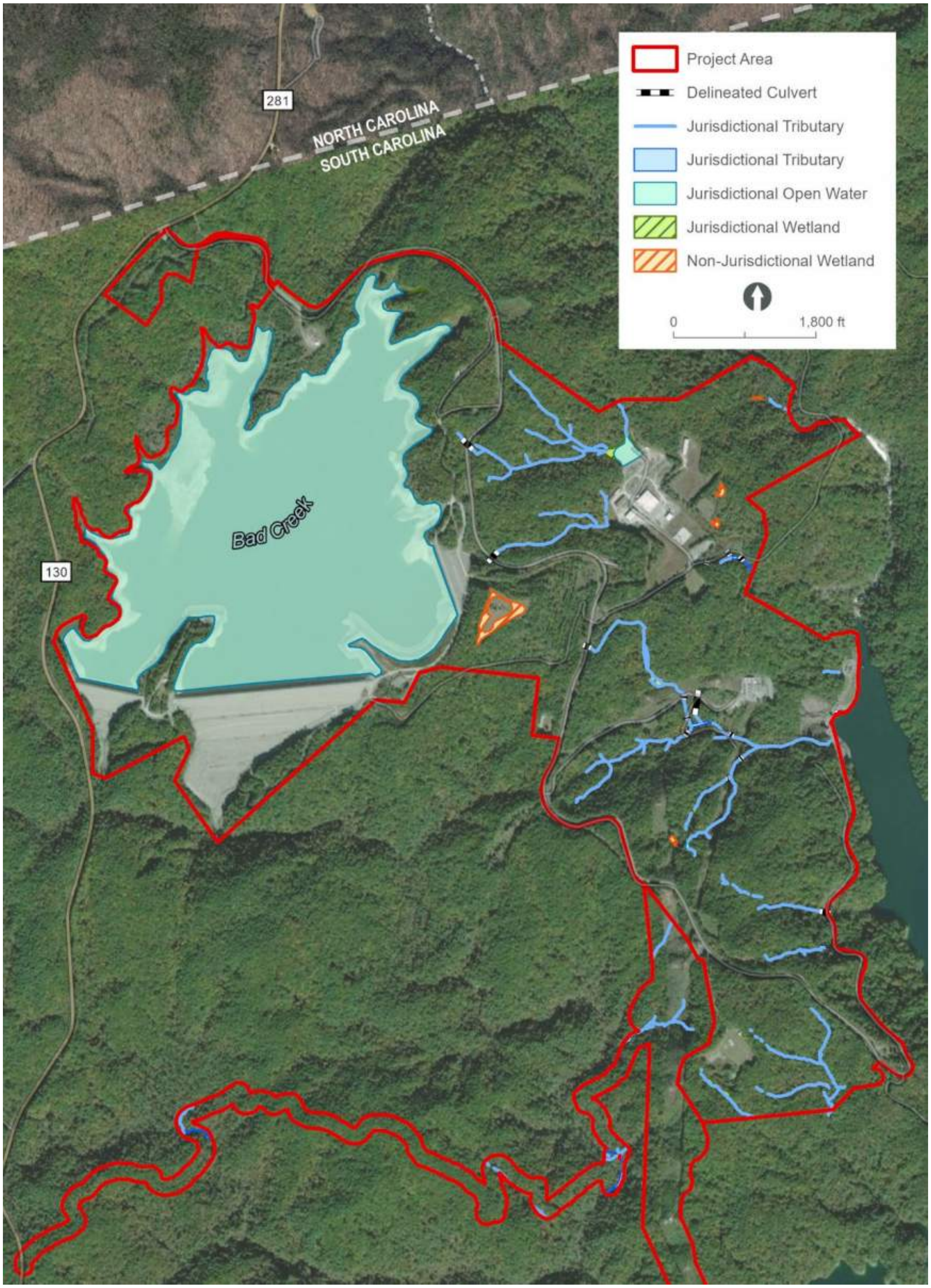


Figure E.8-3. Waters of the U.S. within the Expanded Project Boundary (Excluding the Transmission Line Corridor)

E.8.1.4.2 Transmission Line Corridor

Forty streams comprising 26 intermittent streams and 14 perennial streams totaling 17,762.1 lf were identified within the survey area for the transmission line corridor (Table E.8-4; Figure E.8-4 through Figure E.8-7). Five additional non-jurisdictional ephemeral streams totaling 911.0 lf were also noted within the Project Boundary.

Table E.8-4. Summary of Jurisdictional Streams and Non-Jurisdictional Conveyances within the Transmission Line Corridor

Feature ID	Flow	Average Width (ft)	Total Length (lf)
Jurisdictional Streams			
Stream 38	Intermittent	1	548.8
Stream 39	Perennial	5	1,092.8
Stream 40	Intermittent	5	208.1
Stream 41	Perennial	2	308.7
Stream 67	Intermittent	2	761.2
Stream 68	Perennial	5	1,091.4
Stream 69	Perennial	2	814.9
Stream 71	Perennial	4	879.4
Stream 72	Intermittent	2	364.3
Stream 73	Perennial	2	588.4
Stream 74	Intermittent	1	1,244.2
Stream 75	Intermittent	1	236.0
Stream 77	Intermittent	1	232.2
Stream 78	Intermittent	1	92.7
Stream 79	Intermittent	2	266.2
Stream 80	Intermittent	5	352.3
Stream 81	Intermittent	4	549.7
Stream 82	Perennial	4	338.2
Stream 83	Intermittent	3	325.7
Stream 84	Intermittent	2	306.6
Stream 85	Perennial	8	541.8
Stream 86	Intermittent	5	89.1
Stream 87	Intermittent	5	207.0
Stream 88	Intermittent	4	246.0
Stream 89	Intermittent	3	212.5
Stream 90	Intermittent	3	206.3
Stream 92	Intermittent	3	142.6
Stream 93	Intermittent	1	195.1

Feature ID	Flow	Average Width (ft)	Total Length (lf)
Stream 95	Intermittent	5	242.4
Stream 96	Perennial	5	474.4
Stream 97	Intermittent	4	672.4
Stream 98	Intermittent	2	460.6
Stream 99	Perennial	5	507.6
Stream 100	Perennial	3	415.3
Stream 101	Perennial	5	847.4
Stream 102	Intermittent	2	140.0
	Intermittent	14	448.8
Stream 103	Perennial	4	684.1
Stream 104	Intermittent	4	85.0
Stream 105	Intermittent	1	293.8
Stream 106	Perennial	4	48.1
		Total Length (lf)	**17,762.1**
Non-Jurisdictional Conveyances			
Non-JD6	Ephemeral	N/A	66.5
Non-JD7	Ephemeral	N/A	53.6
Non-JD8	Ephemeral	N/A	24.7
		Total Length (lf)	**144.8**

There are several large open water bodies and streams that fall within the transmission line corridor, including However Creek, McKinneys Creek, and Lake Keowee. The total open water area amounts to 13.89 acres. The majority of open water area consists of Lake Keowee (9.97 acres) with a few large streams (Table E.8-5; Figure E.8-4 through Figure E.8-7).

Table E.8-5. Summary of Open Water and Large Streams within the Transmission Line Corridor

Feature ID	Total Area (acres)
Open Water	
Lake Keowee	9.97
Large Streams	
Stream 64 (Howard Creek)	1.61
Stream 66	1.13
Stream 91	0.52
Stream 94 (McKinneys Creek)	0.66
Total Area (acres)	**3.92**

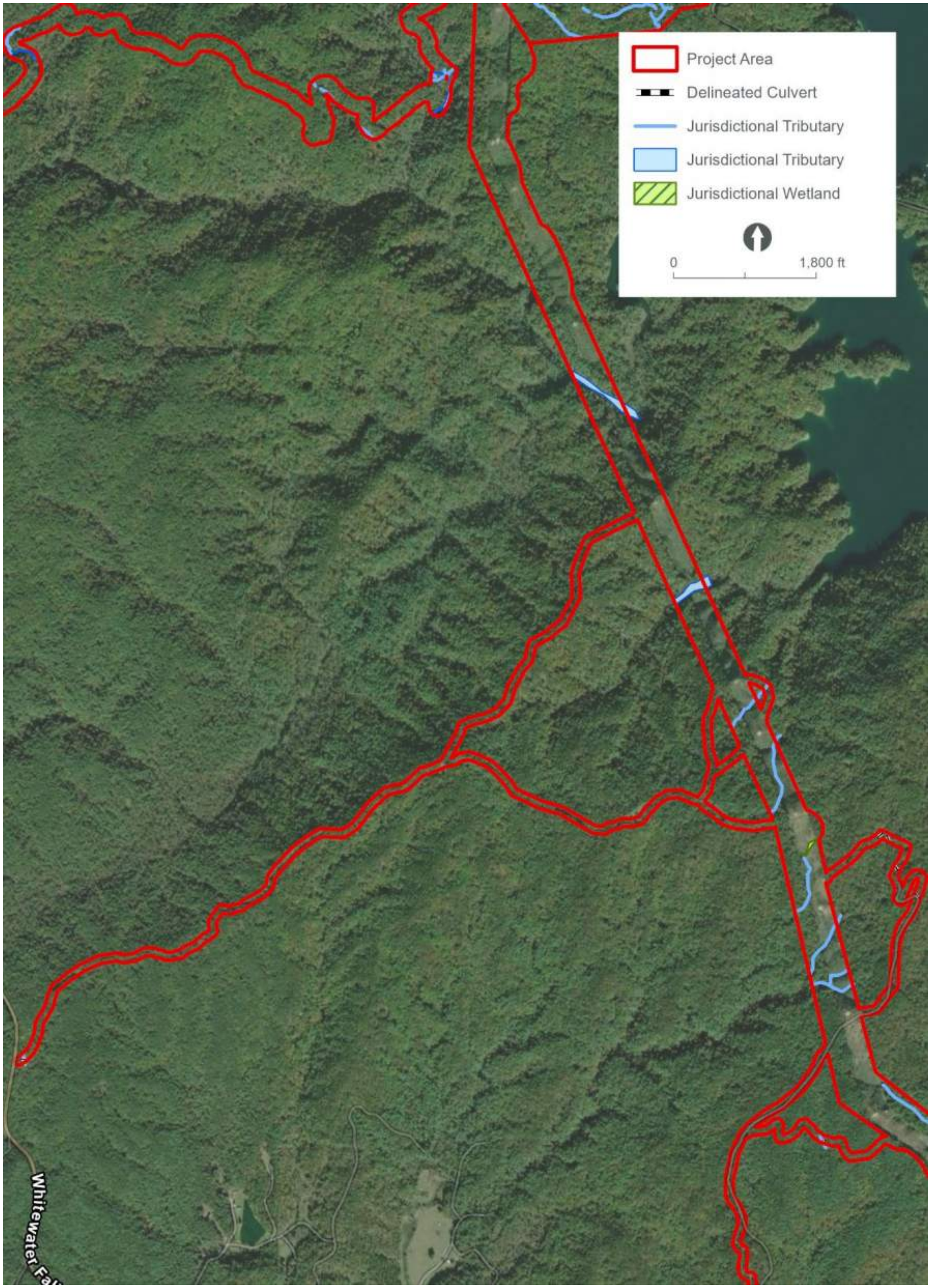


Figure E.8-4. Waters of the U.S. observed within the Transmission Line Corridor

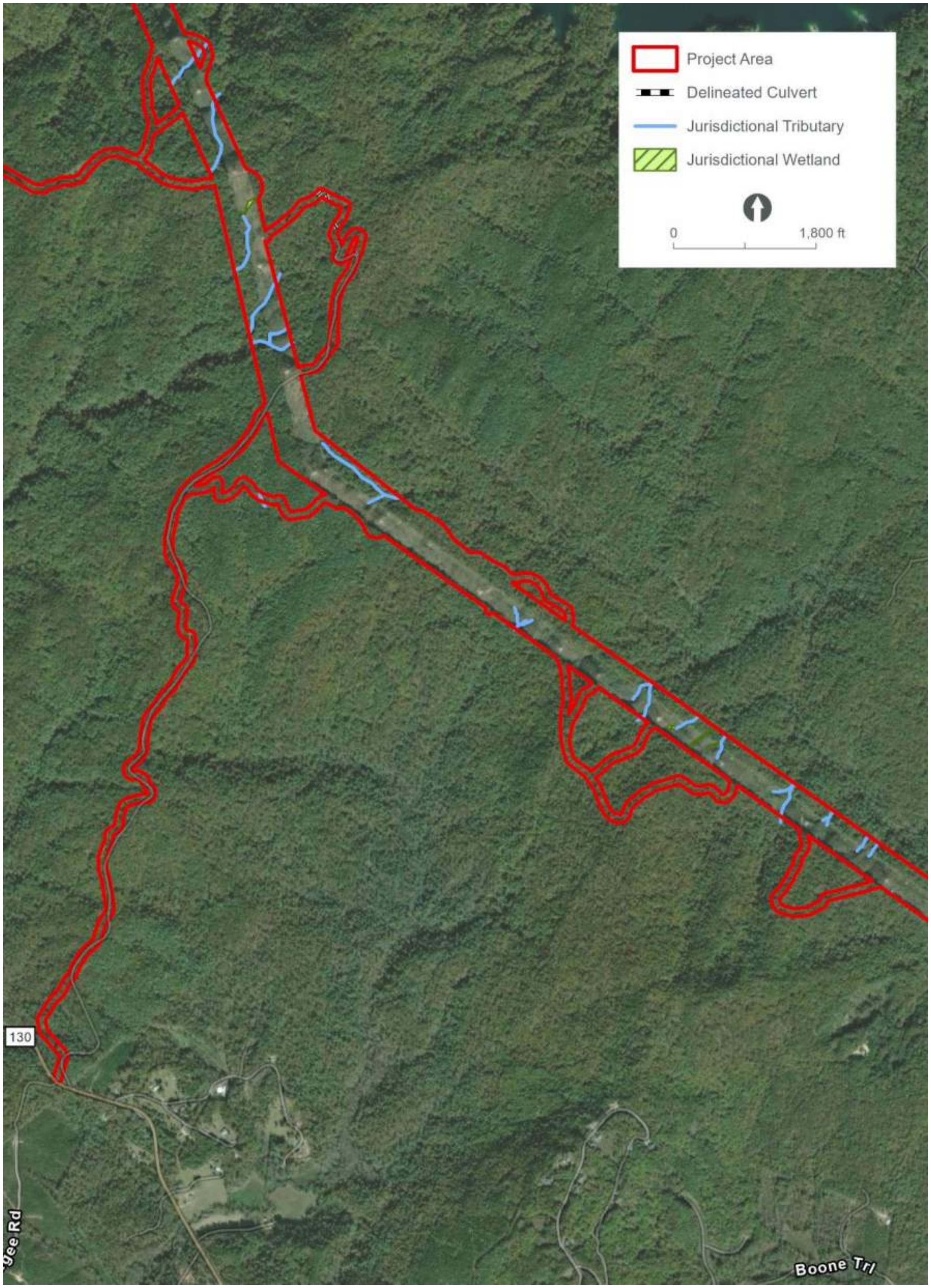


Figure E.8-5. Waters of the U.S. observed within the Transmission Line Corridor

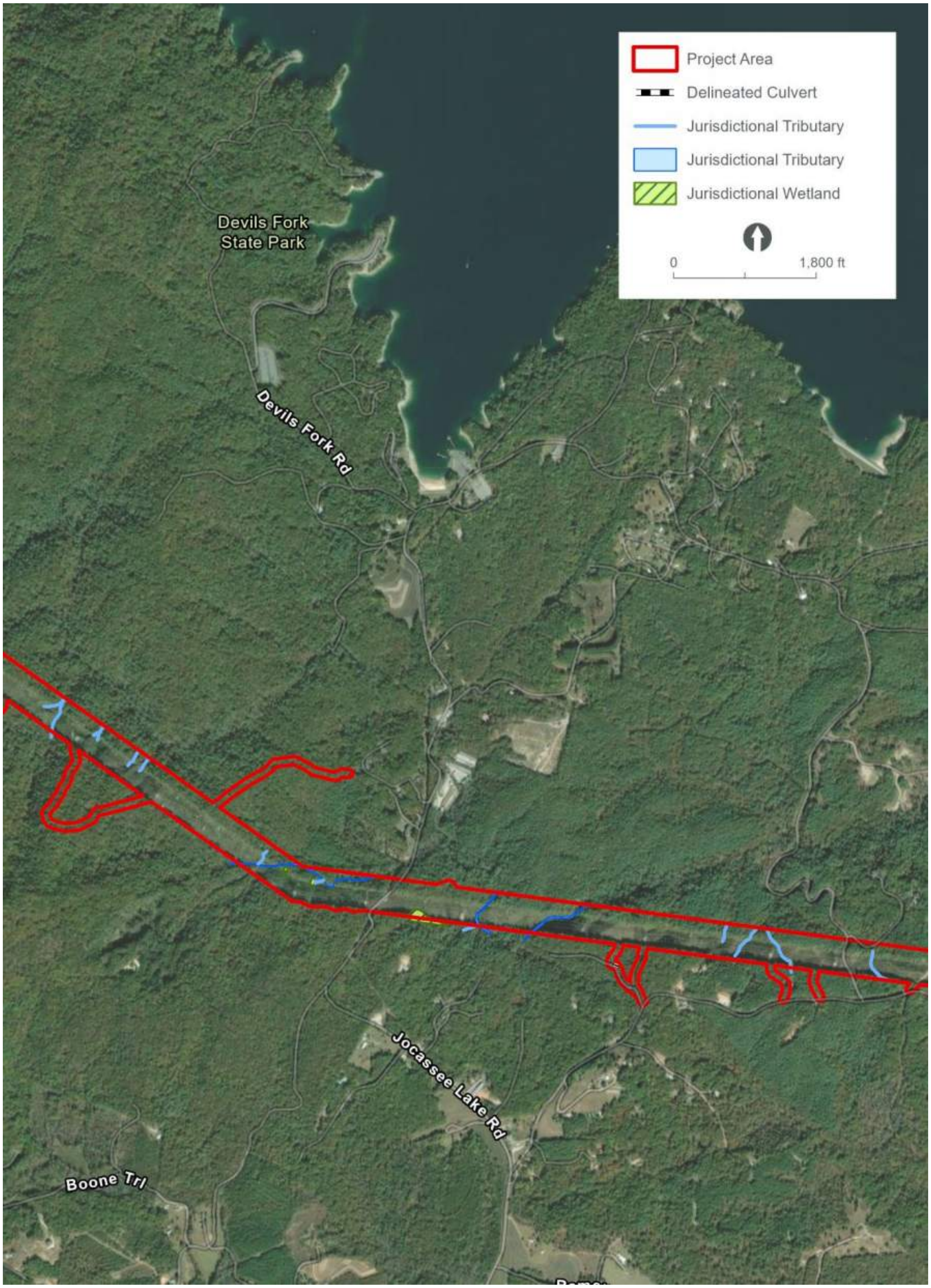


Figure E.8-6. Waters of the U.S. observed within the Transmission Line Corridor

Figure E.8-7. Waters of the U.S. observed within the Transmission Line Corridor

E.8.1.5 Water Uses

E.8.1.5.1 Existing and Proposed Uses of Project Waters

Existing waters of the Bad Creek Reservoir are used only for Project operations. There are no other existing or proposed uses for Project waters.

E.8.1.5.2 Existing Instream Flow Uses

Downstream of the Bad Creek and KT Projects, the USACE operates three large reservoirs (Hartwell Lake, Richard B. Russel Lake, and J. Strom Thurmond Lake). These reservoirs provide flood control, fish and wildlife habitat, water supply, recreation, water quality, and power generation. There are also several other downstream facilities (see Section E.2.3).

On October 1, 1968, Duke Energy entered into an agreement with the USACE and SEPA (1968 Operating Agreement) regarding water releases from the KT Project with the sole purpose to ensure the upstream projects were operated such that the downstream facilities received sufficient flows to meet their power-generating requirements. The 1968 Operating Agreement did not recognize the Bad Creek Project (which was not yet licensed) or the USACE's Richard B. Russell Project.

In conjunction with KT Project relicensing, Duke Energy, USACE, and SEPA replaced the 1968 Operating Agreement with an updated 2014 Operating Agreement executed on October 17, 2014. The 2014 Operating Agreement required the percentages of remaining usable water storage in the Duke Energy and USACE systems remain in balance when low inflow conditions develop and as drought conditions become more severe.

Under the 2014 Operating Agreement, declining remaining usable water storage in the downstream USACE reservoir system triggers Duke Energy to release water from the Keowee Development so both systems remain in balance until the Duke Energy system (i.e., lakes Jocassee, Lake Keowee, and Bad Creek Reservoir) reaches 12 percent remaining usable water storage. At that point, while downstream water flow releases from the Keowee Development associated with hydroelectric generation would cease (excluding releases that may be required by the FERC, for Oconee Nuclear Station operations or situations covered by the MEP), approximately 650 acre-ft of water per week would continue flowing downstream due to leakage and seepage. Therefore, water continues flowing into Hartwell Lake even during the most severe droughts. Further, at the point of ceasing hydroelectric generation releases, without sufficient inflow, the remaining usable water storage combined in the three Duke Energy reservoirs would continue to decline below 12 percent due to reservoir water withdrawals, surface evaporation, leakage, and seepage. Thus, as the USACE system continues to decline below 12 percent remaining usable water storage, the Duke Energy system remaining usable water storage would also continue to decline. The 2014 Operating Agreement also included operational effects of access to additional water storage in Lake Keowee not previously available due to the operational limitations of Oconee Nuclear Station. The USACE completed an Environmental Assessment of the potential effects of the updated operating agreement and issued a Finding of No Significant Impact prior to executing the 2014 Operating Agreement (USACE 2014).

Implementation of the LIP, described in Section E.5.6.2, is integrated with the requirements of the 2014 Operating Agreement.

As part of the relicensing process for the KT Project, Duke Energy conducted a detailed Water Supply Study (HDR 2014). The assessment compiled information about water withdrawals and returns within the Savannah River Basin (greater than or equal to 100,000 gallons per day). Table E.8-6 provides an aggregate summary by watershed of projected net withdrawals in future years. Net withdrawal is defined as the difference between the amount of water withdrawn within a particular reservoir's watershed and the amount of water returned within a particular reservoir's watershed. It is possible to have a negative net withdrawal of water within a particular watershed if the amount of water returned is greater than withdrawn. Results indicate overall net water withdrawal for the entire basin is expected to increase over time (see Table E.8-6).

Table E.8-6. Existing and Projected Annual Average Net Withdrawal Rates by Watershed in the Savannah River Basin

Reservoir	Base[1]	2016	2026	2036	2046	2056	2066
Bad Creek	0	0	0	0	0	0	0
Jocassee	5	5	5	5	5	5	5
Keowee	64	74	88	112	126	139	155
Hartwell	24	38	45	59	64	69	74
Russell	-4	-4	4	3	2	10	9
Thurmond	18	19	30	33	35	49	53
Subtotal	**107**	**132**	**173**	**211**	**232**	**272**	**296**
Woodlawn	-2	-3	-4	-7	0	-4	-8
Stevens Creek	12	12	13	13	24	24	25
North Augusta	25	37	55	63	73	85	99
Augusta Canal Diversion	0	0	0	0	0	0	0
Augusta Canal Diversion Return	84	84	85	85	84	83	82
Augusta	-19	-20	-12	-14	-17	-19	-23
Girard	33	79	77	74	71	67	64
Millhaven	3	4	4	4	13	14	14
Clyo	7	7	7	16	25	24	24
Below Clyo	-8	-10	2	7	10	22	20
Total	**243**	**325**	**399**	**452**	**516**	**569**	**592**

Source: HDR 2014

1. Base year rates were based on the most recent available years for which withdrawals and returns were recorded. The most recent year for a given water user ranged between 2007 and 2010.

E.8.1.6 Water Quality

E.8.1.6.1 Approved Water Quality Standards

Bad Creek Reservoir is used only for Project operations; it is not designated for any other uses and therefore has no applicable state or federal water quality standards.

Lake Jocassee is included in the highest water quality classification (i.e., excellent rating) as designated by SCDES and preservation of existing conditions is recommended, with most tributaries within the watershed fully supporting their designated use. Lake Jocassee is one of only a few reservoirs in South Carolina that possesses the necessary aquatic habitat (water temperature and DO) to support both a warmwater and a coldwater (salmonid [trout]) fishery year-round. The South Carolina state-mandated DO average daily water quality standard is a minimum of 5.0 milligrams per liter (mg/L) for non-trout waters and not less than 6.0 mg/L for trout waters. Because TPGT waters (i.e., Lake Jocassee) are considered a type of trout water, they are subject to the same water quality standards as natural trout waters, therefore, the DO minimum for Lake Jocassee is 6.0 mg/L or above. As stated above, SCDES has consistently identified Lake Jocassee (as well as downstream Lake Keowee) among the cleanest South Carolina reservoirs based on data from 1980-1981, 1985-1986, and 1989-1990 studies (USACE 2014). Recent data collected for the relicensing continue to indicate Lake Jocassee (main lake and downstream of the weir) fully supports aquatic life and recreational designated uses.

A summary of water quality standards for South Carolina applicable to Project waters is included in Table E.8-7.

Table E.8-7. South Carolina Numeric State Water Quality Standards Applicable to Project Waters

Parameter	South Carolina Water Quality Standard
Temperature (applies to heated effluents only)	Not to exceed 2.8°C (5°F) above natural temperatures up to 32.2°C (90°F). Trout Waters: Not to vary from levels existing under natural conditions, unless determined some other temperature shall protect the classified uses.
Dissolved Oxygen	Daily average not less than 5.0 mg/L. Instantaneous low of 4.0 mg/L. Trout Waters: Not less than 6.0 mg/L.
pH	Between 6.0 and 8.5. Trout Waters: between 6.0 and 8.0.
Turbidity	FW Except for lakes: Not to exceed 50 NTUs provided existing uses are maintained. FW Lakes Only: Not to exceed 25 NTUs provided existing uses are maintained. Trout Waters: Not to exceed 10 NTUs or 10% above natural conditions, provided existing uses are maintained.
Phosphorus	Blue Ridge - Shall not exceed 0.02 mg/L. Piedmont - Shall not exceed 0.06 mg/L.
Nitrogen	Blue Ridge - Shall not exceed 0.35 mg/L.

Parameter	South Carolina Water Quality Standard
	Piedmont - Shall not exceed 1.5 mg/L.
Chlorophyll *a*	Blue Ridge - Shall not exceed 10 micrograms/L. Piedmont - Shall not exceed 40 micrograms/L.

Source: SCDES (2023); NTU=nephelometric turbidity units

E.8.1.6.2 Impaired Waters

A review of the SCDES Watershed Atlas for identified three stations in Lake Jocassee near the expanded Project Boundary with listed impairments (Table E.8-8) (SCDES 2025). Two of the impairments were for nitrogen and one for mercury. No other waters were identified with impaired uses.

Table E.8-8. Impaired Waters

Station	Location Description	Impairment	Impaired Use	Distance to Project Boundary (miles)
SV-336	Lake Jocassee at confluence of Thompson and Whitewater rivers	Nitrogen	Aquatic Life	0.7
SV-313	Lake Jocassee at end of Sec Rd 25	Mercury	Fish Consumption	1.2
CL-019	Lake Jocassee forebay, equidistant from dam and shorelines	Nitrogen	Aquatic Life	0.5

E.8.1.6.3 Historical Water Quality Data from the Project Study Area

Bad Creek Reservoir

Water quality has not historically been monitored in Bad Creek Reservoir due to significant daily exchanges from pumping and generation, and because it is not subject to state classification designation or the associated standards.

Lake Jocassee

Duke Energy has monitored water quality conditions in Lake Jocassee in some capacity since its formation (1974). Duke Energy water quality sampling generally consisted of monthly, quarterly, or annual in situ temperature, DO, conductivity and pH at several locations in the lake. Nutrients, chlorophyll *a*, and primary anions and cations as well as various metals have been sampled at least semi-annually over the years. The chemical composition of the water in Lake Jocassee reflects the chemical composition and weathering sequence of the surrounding parent rock material. Not only does the ionic composition mimic the consistency of the solutes from the chemical weathering of the parent rock material, but the very low concentrations also reflect the extremely slow rates of chemical weathering of the underlying rock formations. The ionic strength, i.e. low conductivity, was found to be similar to other systems draining the Blue Ridge escarpment (USGS 1982). A table of mean chemical composition of Lake Jocassee is included in Table E.8-9. Other key water quality parameters (i.e., DO and temperature) are discussed in the following section.

Table E.8-9. Mean Chemical Composition of Lake Jocassee (USACE 2014)

Parameter	Concentration (mg/L)
Sodium	1.39
Calcium	1.2
Potassium	0.67
Magnesium	0.41
Bicarbonate	5.06
Chloride	1.16
Sulfate	1.92
Total Dissolved Solids	10.4
Total Suspended Solids	0.84
Inorganic Solids	0.60
Conductivity (units)	17

Submerged Weir Construction

During construction of Bad Creek, monitoring of Lake Jocassee took place over three periods to determine the impact of construction and operation on Lake Jocassee water quality: pre-construction (baseline), construction (construction impacts), and operational (Project impacts). The pre-construction data indicated that Lake Jocassee is a somewhat acidic, oligotrophic reservoir with very low dissolved solids and nutrients. Because of the lake's geomorphological characteristics, there is little mixing between the upper and lower levels of the water column; therefore, thermal stratification may persist for up to four years without turn-over (Duke Power Company 1995a). Because stratification patterns in the reservoir can affect the water quality regime, Duke Energy conducted physical and analytical modeling and based on those results, constructed an energy dissipating weir 1,800 ft downstream of the Project discharge. The crest of the weir, built out of nearly half a million cubic yards of rock excavated during Project construction, extends to within approximately 40 ft of full pond elevation of Lake Jocassee and was installed both to help minimize the effects of Bad Creek operations on the natural stratification of Lake Jocassee and to dissipate the energy of the discharging water.

The construction and operational phases of monitoring indicated water quality impacts were temporary and spatially confined to the Whitewater River cove upstream of the submerged weir. As construction activities ceased, impact parameters (i.e., turbidity and phosphorous) quickly returned to pre-Project levels (Duke Power Company 1995a). Temperature and DO data during operational monitoring results (over the first three years of Bad Creek operation) indicated no changes in temperature or DO profiles in Lake Jocassee due to the operations at Bad Creek with the exception of increased thermal and chemical mixing upstream of the submerged weir (which was predicted during the initial [pre-construction] modeling effort). Overall, operational monitoring indicated the weir successfully restricts Bad Creek impacts to an isolated area of the Whitewater River cove upstream of the submerged rock weir and stratification is preserved at all locations downstream of the weir.

Water Quality Monitoring

As a condition of the Original License for the Bad Creek Project, Duke Energy entered into a MOU with the SCDNR for the long-term management and maintenance of high-quality fishery resources in Lake Keowee, Lake Jocassee, and their tributary streams. The MOU and first 10-Year Work Plan were approved pursuant to Article 32(b)(1) of the Original License issued for the for the Bad Creek Project on May 1, 1997 (FERC 2017). Through this MOU, SCDNR and Duke Energy personnel have worked cooperatively, and included third parties as necessary, to design and implement data collection and other activities to develop and enhance management strategies for fish in these areas. Activities included in the 10-Year Work Plans have been focused on fisheries surveys and inventories, water quality and aquatic habitat evaluations, fish stocking, recreation, and shoreline impacts.

Duke Energy's trout habitat monitoring program addresses two different license articles for the Bad Creek Project. License Article 32(b)(2) covers Lake Jocassee pelagic trout habitat and License Article 34 covers Lake Jocassee water quality. Both articles required Duke Energy to conduct a water quality and trout habitat monitoring program for a 5-year period (i.e., 1995 – 1999).[13] The first 5-year summary report (Foris n.d.), which also included historic data from 1973, concluded operations at the Bad Creek Project had minimal impact on pelagic trout habitat in Lake Jocassee, because the weir likely restricted vertical mixing in the main body of the reservoir. More recent data (from 10-Year Work Plan results as well as studies conducted for the KT Project relicensing) confirm Bad Creek operations have minimal to no impact on trout habitat in Lake Jocassee.[14] More detail on trout habitat is provided in Section E.9 (Fish and Aquatic Resources).

Generally, DO concentrations in Lake Jocassee are a function of the degree of the previous winter mixing – colder winter temperatures result in deeper mixing within the reservoir, which results in higher DO concentrations the following year (USACE 2014). A comparison of temperature and DO

[13] The pelagic trout habitat monitoring program in Lake Jocassee began in 1973 to coincide with operations at the Jocassee Pumped Storage Station.

[14] Under the existing monitoring program, if trout habitat is projected to be less than 10 m thick by September, Duke Energy will measure temperature and DO in June and August to monitor thickness, as well as consult with SCDNR regarding potential modifications to hydropower operations; however, this situation has yet to arise based on monitoring. This condition has never been triggered during the Original License term.

distribution between full pond and drawdown conditions indicated low water years exhibited deeper, stronger thermoclines. Multiple droughts over the reservoir's history have resulted in maximum drawdowns up to 29 ft (USACE 2014); however, the overall thermal structure of the reservoir maintained average DO concentrations throughout the water column and were not impacted by the drawdown events (i.e., reduced water elevation), indicating even under extreme drought conditions, DO remains above threshold levels (i.e., 6.0 mg/L).

Although Lake Jocassee water quality meets (and exceeds) state standards, SCDES's Water Quality Certification (CWA Section 401) for the KT Project requires Duke Energy to monitor DO, therefore, this parameter (as well as temperature) is routinely monitored in the Keowee Hydro Station and Jocassee Pumped Storage Station tailwaters. In 2008, Duke Energy installed water quality monitors (temperature, DO, conductivity, and water level) in the tailraces of both Jocassee and Keowee hydroelectric stations. These monitors were equipped with Hach LDO® oxygen sensors and were serviced at regular intervals. Recent data collected with the temperature and DO monitors revealed a similar yearly cycle of meteorologically controlled temperatures. The only differences between the Jocassee Pumped Storage Station and the Keowee Hydro Station tailrace temperature data resulted from different withdrawal depths (i.e., Lake Jocassee releases cooler water from deeper in the lake than the surface water withdrawal at the Keowee Hydro Station). Though it should be noted that Lake Keowee is also subject to impacts of operation of the Oconee Nuclear Station.

DO concentrations in the tailraces reflect the oxygen concentrations at the withdrawal depths with Lake Jocassee exhibiting less variability than Keowee water releases. The more consistent DO values in the Jocassee tailrace were the result of high exchange rates of similar water in the tailrace during the Jocassee generating and pumping cycle. Whereas the Keowee Hydro Station released water at infrequent intervals, greater temperature and DO variability was observed due to the differences between the released water and the water remaining in the tailrace for longer periods. The DO concentrations in the water released from both Jocassee Pumped Storage Station and Keowee Hydro Station were all well above and continue to remain above state water quality standards.

An example of typical DO and temperature in the forebay and tailrace of Lake Jocassee is included below. A study by Reservoir Environmental Management, Inc. (REMI) (2013) was carried out for the KT Project relicensing effort. Temperature and DO data were collected in the forebay and tailwaters of Jocassee in 2012 and were compared against historic water quality. Study results show tailwaters for 2012 consistently meet state water quality standards and the monthly historical temperature and DO profile data that have been collected in the forebay of Lake Jocassee since the reservoir was impounded in 1974 suggests state DO standards at the Jocassee tailwaters have likely been continually met since initial impoundment of the reservoir (REMI 2013). Example DO and temperature conditions measured at Lake Jocassee during this study (i.e., 2012) are shown in Table E.8-10.

Table E.8-10. Hourly and Daily Temperature and DO from 2012 Study (REMI 2013)

Location	**Jocassee Tailwater**					**Jocassee Forebay**						
Hourly Average												
Parameter	**Dissolved Oxygen (mg/L)**		**Temperature (°C)**			**Dissolved Oxygen (mg/L)**		**Temperature (°C)**				
Month	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Mean*	*Min*	*Mean*	*Mean*	*Min*	*Mean*
Jan	8.83	9.06	9.33	11.0	12.0	14.3	--	--	--	--	--	--
Feb	9.11	9.69	10.05	10.5	11.3	13.7	9.17	9.62	9.95	10.5	11.0	13.3
March	9.09	9.82	10.23	11.0	14.0	18.9	9.21	9.64	9.97	11.9	14.0	17.1
April	8.86	9.46	9.97	14.3	17.2	22.2	8.92	9.34	9.62	14.1	16.7	18.5
May	8.31	8.95	9.63	17.0	20.5	24.3	8.5	8.94	9.27	18.5	20.7	23.8
June	7.73	8.37	8.89	21.4	23.7	27.3	6.56	8.32	8.95	20.2	22.0	24.2
July	7.17	7.75	8.30	24.7	26.5	29.2	5.82	7.70	8.23	24.0	26.6	28.9
Aug	6.80	7.37	8.44	26.6	27.5	29.7	6.61	7.47	7.91	26.4	27.3	29.4
Sept	6.55	7.41	7.72	24.5	26.3	28.5	6.91	7.45	7.85	24.4	26.1	28.2
Oct	7.29	7.74	8.35	19.3	22.6	25.7	7.17	7.73	8.35	19.3	22.4	25.5
Daily Average												
Parameter	**Dissolved Oxygen (mg/L)**			**Temperature (°C)**			**Dissolved Oxygen (mg/L)**			**Temperature (°C)**		
Month	*Min*	*Mean*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Min*	*Mean*	*Mean*	*Min*	*Mean*
Jan	8.92	9.06	9.22	11.1	12.0	13.7	--	--	--	--	--	--
Feb	9.15	9.69	9.92	10.6	11.3	12.7	9.46	9.63	9.82	10.6	11.0	11.7
March	9.57	9.82	10.03	11.3	14.0	16.9	9.52	9.63	9.78	13.0	14.0	15.5
April	9.08	8.63	9.79	15.4	17.2	19.6	9.18	9.35	9.50	15.0	16.6	17.3
May	8.61	8.95	9.39	18.1	20.1	22.9	8.68	8.94	9.12	19.5	20.8	22.7
June	8.04	8.37	8.67	22.1	23.7	25.4	7.35	8.31	8.77	20.7	22.8	25.6
July	7.43	7.75	8.09	25.4	26.5	27.9	7.15	7.70	8.03	25.4	26.6	27.9
Aug	7.21	7.37	7.64	26.9	27.5	29.1	7.06	7.47	7.65	26.9	27.3	28.0
Sept	7.23	7.41	7.58	25.0	26.9	29.1	7.25	7.45	7.60	24.6	26.1	27.2
Oct	7.45	7.75	8.24	19.5	22.6	24.8	7.45	7.73	8.24	19.5	22.4	24.4

Levels of pH in the waters of Lake Jocassee coincide with a gain or loss of oxygen, giving strong evidence for biological processes dominating the oxygen and carbon dioxide concentrations throughout the water column. Levels also depend on level of mixing in the reservoir and are more pronounced during summer (stratification) than winter (mixing) (Duke Energy 2011). Total phosphorus, nitrate-nitrogen, and chlorophyll *a* measurements have also been collected by Duke Energy since the time of impoundment. Phosphorus levels have generally been below the South Carolina state water standards for waters of the Blue Ridge (0.02 mg/L) and are far below standards for Piedmont reservoirs (0.06 mg/L) (Duke Energy 2011), while chlorophyll *a* concentrations average 2 to 3 micrograms/liter, which is well below the 10 microgram/liter reference standard for the Blue Ridge and Piedmont (40 microgram/liter) reservoirs.

Turbidity in Lake Jocassee is considered low and is consistently below the state standard for trout waters of 10 NTU (Duke Energy 2014c). Turbidity in Lake Jocassee was high in the newly impounded reservoir but soon decreased (1979-1980) as shown on Figure E.8-8. With the construction and initial operation of the Bad Creek Project, turbidity increased again in the late 1980s and gradually decreased back to pre-construction levels after construction activity ceased (Duke Energy 2011).

In the Environmental Assessment report developed in 2014 for the KT Project relicensing, FERC specifically did not recommend water quality monitoring for the following reasons: (1) existing water quality in the reservoirs and tailwaters (i.e., Lake Jocassee and Lake Keowee) is meeting or exceeding levels consistent with state water quality standards, and is consistent with levels supporting designated uses, and no issues have been raised concerning pH and total dissolved gas; (2) water quality modeling results indicate under the proposed [KT] Project operation, suitable DO levels and water temperatures would exist for the propagation of aquatic life in the Keowee Development water releases; (3) there are no proposed changes in KT Project operation that would alter water quality from existing conditions in the Jocassee Development tailwaters; and (4) the fishery at the KT Project is considered high quality.

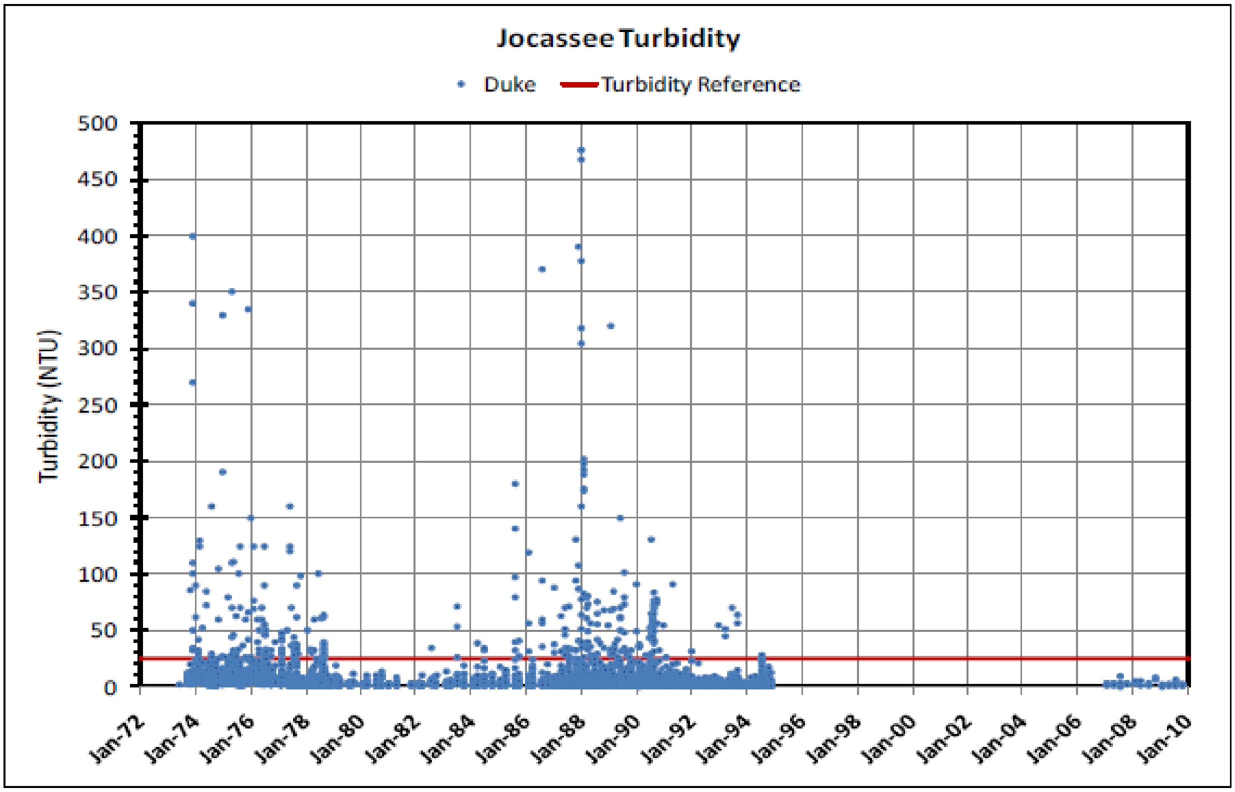


Figure E.8-8. Lake Jocassee Turbidity (Source: Duke Energy 2011)

E.8.2 Environmental Analysis

E.8.2.1 Studies in Support of the Current Relicensing

In support of the current relicensing, Duke Energy conducted a Water Resources Study in 2023 and 2024. This study consisted of five tasks including: 1) Summary of Existing Water Quality Data and Standards; 2) Water Quality Monitoring in Whitewater River Arm; 3) Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse; 4) Water Exchange Rates and Lake Jocassee Reservoir Levels; and 5) Future Water Quality Monitoring Plan Development. A summary of the methods and results of the Water Resources Study is provided in this section, and details are provided in Appendix D. The specific objectives of the Water Resources Study are included below:

- To evaluate water resources and water quality impacts of current Project operations using existing data.
- To evaluate water resources and water quality impacts potentially resulting from the construction and operation of Bad Creek II.
- To address stakeholder concerns regarding water resources in the Project Boundary with clear nexus to the Project and Bad Creek II.

E.8.2.1.1 Summary of Existing Water Quality Data and Standards (Task 1)

Task 1 Methods

The study area for the desktop review of existing water quality data included Lake Jocassee and Howard Creek. Water quality datasets for the 12 existing Duke Energy water quality monitoring stations (Table E.8-11) in Lake Jocassee were provided by Duke Energy's Environmental Science Group in July 2022 and included values for DO, temperature, pH, conductivity, turbidity, and nutrients. To satisfy the objective of summarizing existing water quality conditions and comparing them to conditions that existed prior to Project construction, Lake Jocassee water quality data were pooled and separated into two time periods: pre operations (prior to 1991) and post operations (1991 to 2020). For the Whitewater River cove (also referred to as Whitewater River arm) analysis, a third time period covering the years during Project construction (1985-1991) was evaluated in addition to pre and post-construction. Additionally, turbidity values (vertical profiles) were assessed at the three Whitewater River cove locations.

Historic water quality data from Howard Creek were summarized from Abernathy et al. (1994), which are considered representative under existing (i.e., operational) conditions, with the goal of identifying and assessing changes observed in water quality between pre-construction and post-construction data.

Table E.8-11. Water Quality Monitoring Station Periods of Record in Lake Jocassee

Monitoring Station	Start Year	End Year	Minimum Reading Elevation (ft)
558.7	1987	2015	763
558.0	1975	2020	757
559.0	1987	2015	793
560.0*	1975	2015	826
562.0	1980	2015	965
565.4	1987	1994	918
551.0	1975	2011	1083
564.0*	1976	2015	865
564.1*	1987	2017	960
557.0	1975	2015	820
554.8	1986	2015	945
556.0	1975	2015	918

*Whitewater River arm

Task 1 Results

Water Temperature

Since temperatures at depth determine patterns of stratification (i.e., warmer water in the upper water column, cooler water at depth), depth-averaged temperatures were assessed during this desktop review as well as surface water temperatures. Over the entire reservoir at all depths, Lake Jocassee winter temperatures range between 0 and 17°C, with an average of 10°C. Thermal stratification is not prevalent in the winter months (December – February) and at some stations, February temperatures vary by less than one degree between surface and bottom waters. Spring temperatures range from 5 to 25°C with an average of 11°C. Stratification begins to form in the upper third of the water column as temperatures continue to warm towards late spring. Summer temperatures range from 7 to 30°C with an average of 15°C. Stratification continues to develop through summer and extends further down into the water column. Fall temperatures range from 7 to 28°C with an average of 15°C. Stratification peaks in early fall and begins to wane as temperatures cool. All data tables showing temperatures and patterns of stratification for each monitoring station are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

Bad Creek operational impacts to temperature are limited to monitoring Station 564.1 in the Whitewater River cove, which is between the I/O structure and submerged weir. Monthly average temperatures within the water column at this location are nearly uniform after 1991 (post Bad Creek operation). Vertical mixing from Bad Creek operations and to a lesser degree, inflow from the Whitewater River, eliminates stratification at this monitoring station. The pre-construction depth-averaged temperature at Station 564.1 is 13.9°C, and the post-construction average temperature at (through 2017) is 17.2°C, a difference (increase) of 3.3°C.

Monitoring Station 564.0 is located downstream of the submerged weir and, in contrast to Station 564.1 upstream of the weir, stratification is prevalent at this location after 1991. There is very little difference in temperature profiles between pre and post Bad Creek operations at Station 564.0. This is primarily due to the presence of the submerged weir, which limits mixing downstream of the weir structure (i.e., mixing is confined to the portion of the Whitewater River cove upstream of the submerged weir).

Tables of monthly averaged temperature profiles for pre and post Bad Creek operational conditions at each of the 12 monitoring locations are provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. Additionally, tables of data showing depth-averaged temperatures for pre-construction, construction, and post-construction in the Whitewater River arm indicating changing stratification trends are also included with the final report.

Surface water temperature minimum, average, and maximum values for all stations over the entire dataset are included in Table E.8-12. Discrete water quality data assessed in Lake Jocassee consistently met South Carolina water quality standards for trout waters for temperature. There is no numeric threshold for temperature, however, for trout waters, narrative criteria indicate water temperatures should not vary from levels existing under natural conditions (unless determined some other temperature shall protect the classified uses), which is supported by study findings.

A comparison of pre vs. post operations for surface water at each station is provided in Table E.8-13, and average surface water data are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. There is no clear trend in warming from pre to post operations in surface waters and temperature differences are mostly within one degree. It is important to note that surface waters are affected by ambient air temperature; therefore, any elevated temperatures under present-day conditions may be impacted by climate warming over the last three decades. It is noteworthy that surface waters at Station 564.1 near the station do not indicate the warmer temperatures noted at depth between pre and post operation periods (i.e., -0.8°C change at the surface but +3.3°C change at depth, indicative of the I/O structure at depth) (Table E.8-12).

Table E.8-12. Water Temperature in Surface Waters of Lake Jocassee

Lake Jocassee Surface Temperature (degrees Celsius)			
Station	Minimum	Average	Maximum
558.7	8.20	18.59	29.02
558.0	7.10	18.44	28.22
559.0	8.10	18.81	28.90
560.0	7.10	18.87	28.47
562.0	8.10	19.23	29.20
565.4	8.50	18.84	28.50
551.0	0.20	13.48	27.24
564.0	7.40	19.15	28.61
564.1	8.50	18.99	28.40
557.0	7.10	18.81	29.23
554.8	7.70	19.24	29.15
556.0	7.30	19.04	29.12

Table E.8-13. Average and Standard Deviation of Surface Water Temperatures, Pre vs. Post Operations

Monitoring Station	**Lake Jocassee Surface Temperature (degrees Celsius)**				**Difference of Averages**
	Pre Operations		Post Operations		
	Average	Standard Deviation	Average	Standard Deviation	
558.7	18.3	6.1	18.6	6.1	0.3
558.0	18.1	6.4	18.6	6.1	0.5

Monitoring Station	Lake Jocassee Surface Temperature (degrees Celsius)				Difference of Averages
	Pre Operations		Post Operations		
	Average	Standard Deviation	Average	Standard Deviation	
559.0	18.4	6.3	18.9	6.1	0.5
560.0	18.5	6.4	19.1	6.1	0.6
562.0	18.6	6.5	19.4	6.3	0.8
565.4	18.9	6.6	18.8	6.2	-0.1
551.0	13.3	6.0	14.7	7.2	1.4
564.0	19.0	6.6	19.2	6.0	0.2
564.1	19.7	6.2	18.9	5.8	-0.8
557.0	18.2	6.4	19.1	6.2	0.9
554.8	19.3	6.5	19.2	6.4	-0.1
556.0	18.7	6.5	19.2	6.3	0.5

Dissolved Oxygen

Lake Jocassee is very deep in some places, and it is not unusual for DO to be depleted at depth. Since near-surface waters are used by most forms of aquatic life, DO concentrations measured at the water surface or in near-surface waters are used to assess the health of a waterbody (instead of DO at depth). Because depth-averaged values are not considered when determining the health of the waterbody (i.e., SCDES standards only apply to water at the surface), these data are provided for context, however, average surface water values are also provided below for each season and as minimum, maximum, and average for each station in Table E.8-14. All data (depth and surface) are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

The position of the thermocline varies from location to location and between seasons, as is typical for large, deep reservoirs, therefore, an overall trend of DO values are provided herein. Lake Jocassee winter DO concentrations (throughout the water column) are between 0 and 14 mg/L, with an average of 7 mg/L. In deeper portions of Lake Jocassee, winter DO stratification is characterized by a rapid decline in DO in the lower half of the water column, with the upper half generally at constant values. The average winter surface (i.e., measurement depth 0.3 m) DO over the entire dataset is 9.4 mg/L. Winter stratification is less prevalent in shallower portions of the lake.

Spring DO concentrations range from 0 to 13 mg/L with an average of 8 mg/L. DO concentrations remain consistent throughout the spring months and some stratification is present in the deepest sections of the lake. Average spring surface DO (0.3 m) is 9.7 mg/L.

Summer DO concentrations range from 0 to 13 mg/L with an average of 7 mg/L. Stratification becomes more pronounced throughout the lake with the transition from spring into summer. This stratification is generally limited to the lower half of the lake in both deep and shallow areas. Average summer surface DO is 8.2 mg/L. Fall DO concentrations range from 0 to 11 mg/L with an average of 6 mg/L. The most notable stratification pattern is seen in the fall where the bottom of the lake can reach anoxic levels. DO concentrations remain constant in the top third of the water column, however, significant stratification is observed in the lower water column. Average fall surface DO is 8.1 mg/L.

Tables of monthly averaged DO profiles for pre and post Bad Creek operational conditions at each of the 12 monitoring locations are provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. Additionally, tables of data showing depth-averaged DO values for pre-construction, construction, and post-construction in the Whitewater River arm to show changing stratification trends over time are included in the final report in Appendix D.

Similar to trends in temperature data, Bad Creek operational impacts to DO are limited to monitoring Station 564.1 between the I/O structure and submerged weir. Monthly average DO concentrations within the water column at this location are nearly uniform after 1991 (post Bad Creek operation). Vertical mixing from Bad Creek operations does not allow for stratification at this monitoring location regardless of season.

DO stratification does occur at monitoring Station 564.0 (downstream of the weir), and there is very little difference in DO profiles between pre and post Bad Creek operation indicating the submerged weir is functioning as intended.

In general, DO concentrations in Lake Jocassee are a function of the extent of the previous winter mixing – colder winter temperatures result in deeper mixing within the reservoir, which results in higher DO concentrations the following year. Multiple droughts over the reservoir's history have resulted in maximum drawdowns up to 29 ft (USACE 2014); however, the overall thermal structure of the reservoir helped to maintain DO concentrations throughout the water column and were not impacted by the drawdown events (i.e., reduced water elevation), indicating even under extreme drought conditions, DO remains above state threshold levels throughout Lake Jocassee (USACE 2014).

The state standard for DO in trout waters is not less than 6.0 mg/L (instantaneous minimum). Before 1991 there were two instances of surface DO less than 6.0 mg/L: 4.6 mg/L at monitoring Station 558.0 in 1973 and 5.4 mg/L at monitoring Station 556.0 in 1976, which correspond to the first few years after the reservoir was filled in 1973. There were no instances of surface DO values less than 6.0 mg/L after 1991. Average surface water data are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

Over the entire dataset, there were 4,241 surface measurements assessed; a total of five measurements were below the state standard, which accounts for 0.12 percent of the dataset. Therefore, surface water DO concentrations in Lake Jocassee fully support the designated use classification (i.e., less than 10 percent criterion excursions).

Table E.8-14. Dissolved Oxygen in Surface Waters of Lake Jocassee

Lake Jocassee Surface DO (mg/L)			
Station	Minimum	Average	Maximum
558.7	6.8	8.7	11.2
558.0	4.6	8.7	11.2
559.0	6.9	8.7	11.1
560.0	6.1	8.7	11.8
562.0	6.9	8.8	11.3
565.4	7.4	8.8	11.2
551.0	7.2	9.9	14.4
564.0	6.6	8.8	12.2
564.1	6.6	8.6	11.1
557.0	6.7	8.9	11.6
554.8	6.7	8.9	11.2
556.0	5.4	9.0	11.6

Dissolved Oxygen Saturation

Lake Jocassee winter DO saturation ranges from 100 percent at the surface to 0 percent at the bottom of the water column. The average winter surface (measured at 0.3 m) DO saturation is 87.2 percent. DO saturation remains constant in the upper top half of the lake and decreases from about 80 percent saturation to near anoxic levels at the reservoir bottom.

The average lake-wide spring surface DO saturation is 98.6 percent. Spring has the highest average DO saturation; spring DO saturation decreases relatively uniformly with depth, with the deepest sections of the lake generally dropping from 100 percent at the surface to 50 percent saturation at the lake bottom.

The average lake-wide summer surface DO saturation is 101.3 percent. Similar to spring values, DO saturation decreases uniformly with depth, but more sharply, generally decreasing from 100 percent at the surface to 35 percent at the lake bottom.

The average lake-wide fall surface DO saturation is 91.5 percent. As expected, fall continues the trend of decreased saturation in the lower portions of the water column, becoming anoxic near the lake bottom.

Dissolved oxygen saturation depth profile tables at each of the 12 monitoring stations are provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D (DO saturation sampling began in 1998, i.e., post Bad Creek operations). Additionally, depth-averaged DO percentages for pre-construction, construction, and post-construction in the Whitewater River arm are also included in the final report. While no data exist prior to operations, stratification between the stations in Whitewater River cove is apparent.

Dissolved oxygen percentage in surface samples are shown in Table E.8-15. There is no state standard for DO saturation, however, since Lake Jocassee supports a diverse, healthy fish community, it is assumed percentage of DO saturation is suitable for aquatic resources.

Table E.8-15. Dissolved Oxygen Saturation in Surface Waters of Lake Jocassee

DO Saturation (%)			
Station	Minimum	Average	Maximum
558.7	65.80	93.98	108.50
558.0	68.20	93.63	106.00
559.0	62.70	94.30	109.80
560.0	53.30	93.75	107.70
562.0	66.50	96.59	112.70
565.4	--	--	--
551.0	85.80	95.51	100.80
564.0	58.30	93.84	107.20
564.1	63.00	92.27	108.20
557.0	67.80	95.99	109.60
554.8	74.80	97.26	111.90
556.0	74.00	97.04	110.80

Note: (--) indicates no DO saturation data were collected at Station 565.4.

pH

Typical Lake Jocassee pH values range between 5 and 10 (averaged throughout the water column) with an average of 6.2, which is considered neutral and indicative of a system with low production (i.e., little potential for algal growth). There is very little difference in pH between seasons and while there is some variation in the water column, there is very little to no pH stratification. Similar to temperature and DO trends, pH concentrations at monitoring station 564.1 are well mixed as a result of Bad Creek operations. Just downstream of the submerged weir at monitoring Station 564.0, there is some pH variation in the water column post 1991 as the submerged weir limits vertical mixing at this location. pH profiles at this monitoring location are similar pre and post Bad Creek operations. Tables of monthly averaged pH depth profiles for pre and post Bad Creek operational conditions at each of the 12 monitoring locations are provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

Surface pH values for all stations are included in Table E.8-16, and average surface water data are included in the in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. Instantaneous pH surface readings were compared against the pH state standard for trout waters (6.0-8.0 Standard Units). Over the entire dataset, there were 4,253 samples assessed; a total of 2 samples were above the state standard (i.e., less than 1 percent of the dataset) and 255 samples were below the state standard (i.e., 6 percent of the dataset). Therefore, surface water pH levels in Lake Jocassee fully support the designated use classification (i.e., within 10 percent criterion excursions).

Table E.8-16. pH in Surface Waters of Lake Jocassee

pH (Standard Units)			
Station	Minimum	Average	Maximum
558.7	5.50	6.67	7.60
558.0	5.20	6.56	8.00
559.0	5.30	6.67	7.71
560.0	5.60	6.69	7.80
562.0	5.60	6.76	7.90
565.4	5.60	6.50	8.10
551.0	5.50	6.53	7.90
564.0	5.60	6.78	7.90
564.1	5.60	6.73	7.90
557.0	5.50	6.73	7.80
554.8	5.60	6.84	8.10
556.0	5.63	6.80	7.90

Phosphorus

Lake Jocassee phosphorus concentrations at depth range from 0.002 to 0.68 mg/L with an average of 0.01 mg/L. Tables of monthly averaged depth profiles for pre and post Bad Creek operational conditions at each of the 12 monitoring locations are provided in in the *Summary of Existing Water Quality Standards Final Report*, Appendix D. As with other water quality parameters, mixing due to Bad Creek operations creates relatively constant profiles of phosphorus in the water column at monitoring station 564.1.

Table E.8-17 below shows a summary of phosphorus for the surface waters of Lake Jocassee over the entire dataset and surface water data tables are included in the Water Resources Study, Appendix D. The state standard for total phosphorous in lakes and reservoirs in the Blue Ridge region of South Carolina shall not exceed 0.02 mg/L.

Over the entire dataset, there were 2,228 surface samples assessed; a total of 228 samples were above the state standard, which accounts for 9.8 percent of the dataset. Therefore, surface water phosphorus concentrations in Lake Jocassee fully support the designated use classification (i.e., less than 10 percent criterion excursions).

Table E.8-17. Phosphorus in Surface Waters of Lake Jocassee

Surface Phosphorus (mg/L)			
Station	Minimum	Average	Maximum
558.7	0.002	0.007	0.100
558.0	0.002	0.011	0.650
559.0	0.002	0.008	0.056
560.0	0.002	0.009	0.081
562.0	0.002	0.009	0.037
565.4	0.002	0.012	0.082
551.0	0.005	0.015	0.100
564.0	0.002	0.009	0.057
564.1	0.002	0.011	0.165
557.0	0.002	0.010	0.087
554.8	0.002	0.010	0.057
556.0	0.002	0.009	0.061

Nitrogen

The dataset for total nitrogen is limited in Lake Jocassee relative to other water quality parameters. Of the nearly 2,000 measurements recorded for NO_2 and NO_3, there are only 545 readings where Total Kjeldahl Nitrogen was measured, therefore, the dataset for total nitrogen includes 545 datapoints. Tables of monthly averaged total nitrogen depth profiles for pre and post Bad Creek operational conditions at each of the 12 monitoring locations are provided in the *Summary of Existing Water Quality Standards Final Report*, Appendix D.

Table E.8-18 below shows a summary of total nitrogen for the surface waters of Lake Jocassee over the entire dataset, and surface water data tables are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. The state standard for total nitrogen for lakes and reservoirs in the Blue Ridge region of South Carolina shall not exceed 0.35 mg/L. Over the entire dataset, there were 545 surface samples assessed; a total of 33 samples were above the state standard, which accounts for 6.1 percent of the dataset[15]. Therefore, surface water total nitrogen concentrations in

15 Note that of the 33 total nitrogen excursions, only one excursion was caused by elevated inorganic nitrogen; the remaining excursions were due to elevated organic nitrogen (i.e., TKN), which is naturally occurring.

Lake Jocassee fully support the designated use classification (i.e., less than 10 percent criterion excursions).

Table E.8-18. Total Nitrogen in Surface Waters of Lake Jocassee

Surface Total Nitrogen (mg/L)			
Station	Minimum	Average	Maximum
558.7	0.11	0.23	0.56
558.0	0.11	0.23	0.59
559.0	0.14	0.26	0.78
560.0	0.11	0.23	0.55
562.0	0.13	0.24	0.56
565.4	0.13	0.21	0.47
551.0	0.12	0.16	0.20
564.0	0.11	0.22	0.51
564.1	0.18	0.22	0.34
557.0	0.11	0.21	0.54
554.8	0.12	0.21	0.48
556.0	0.11	0.22	0.53

Chlorophyll a

Typically, increased chlorophyll *a* is a result of external nutrient inputs from surface runoff from agricultural areas with fertilizers, septic systems, sewage treatment plants, and urban runoff. However, the Lake Jocassee watershed is largely undisturbed (i.e., forested), therefore, does not have these input sources. Rather, chlorophyll *a* concentrations in Lake Jocassee stem from internal loading of phosphorus from inside the lake. As stratification develops during the summer months, cooler oxygenated water settles to the bottom of the reservoir. The oxygen is consumed over the summer and fall months due to the decomposition of organic matter and uptake from fish. When this happens, it triggers the release of phosphorous from the organic matter and sediments at the bottom of the reservoir. Because Lake Jocassee is oligotrophic (i.e., high dissolved oxygen, lower amounts of organic matter, and low levels of phosphorus), phosphorus input from internal loading does not significantly increase the total phosphorus levels (or chlorophyll *a* concentrations) in Lake Jocassee. Tables of monthly averaged chlorophyll a depth profiles for pre and post Bad Creek operational conditions at each of the 12 monitoring locations are provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

Table E.8-19 below shows a summary of chlorophyll *a* for the surface waters of Lake Jocassee over the entire dataset and surface water data tables are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. The state standard for chlorophyll *a* for lakes and reservoirs in the Blue Ridge region of South Carolina Shall not exceed 10 µg/L. Over the entire dataset, there were

1,753 surface samples assessed; all samples were below the state standard, which accounts for 100 percent of the dataset. Therefore, surface water chlorophyll *a* concentrations in Lake Jocassee fully support the designated use classification (i.e., less than 10 percent criterion excursions).

Table E.8-19. Chlorophyll *a* in Surface Waters of Lake Jocassee

Surface Chlorophyll a (µg/L)			
Station	Minimum	Average	Maximum
558.7	0.46	2.06	5.67
558.0	0.50	2.05	5.44
559.0	0.49	1.92	4.46
560.0	0.28	2.07	5.61
562.0	0.63	2.76	7.53
565.4	0.55	2.38	6.64
551.0	0.25	1.01	1.86
564.0	0.53	2.13	6.54
564.1	0.65	2.06	4.63
557.0	0.36	2.00	5.17
554.8	0.65	2.86	6.61
556.0	0.04	2.46	7.46

Conductivity

Conductivity is a measure of the ability of water to pass an electrical current; because dissolved salts and other inorganic chemicals conduct electrical current, conductivity increases as salinity increases, therefore it is an indirect measure of the saltiness of the water. Conductivity is also directly related to rainfall runoff events as tributary inflows to Lake Jocassee carry these dissolved salts and inorganic chemicals from the watershed into the reservoir. Since rainfall is consistent through the year in the region, conductivity values in Lake Jocassee do not vary seasonally but do increase during periods of higher rainfall runoff. For example, during drier periods, conductivity in Lake Jocassee is very low ranging from 2.0 to 5.0 microsiemens (µS) / cm. During wetter periods, conductivity ranges from 85.5 to 275 µS/cm. The overall annual average conductivity in the reservoir was approximately 18.1 µS/cm.

Similar to the other water quality parameters, conductivity values at monitoring station 564.1 on the upstream side of the submerged weir are well mixed due to Bad Creek operations. Downstream of the submerged weir at monitoring station 564.0, there is some variability in conductivity throughout the water column but the conductivity profiles at this location are similar pre and post Bad Creek operations indicating limited vertical mixing due to the submerged weir.

Tables of monthly averaged conductivity[16] profiles for pre and post Bad Creek operational conditions at each of the 12 monitoring locations are provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

Table E.8-20 below shows a summary of conductivity for the surface waters of Lake Jocassee over the entire dataset and surface water data tables are included in *Summary of Existing Water Quality Standards Final Report* in Appendix D. While there is no state standard for specific conductivity, concentrations less than 500 µS/cm are generally considered to be suitable for aquatic species in southern Appalachian waters. The maximum surface conductivity measured was 34 µS/cm and the minimum was 2.0 µS/cm; since Lake Jocassee supports a diverse, healthy fish community, it is assumed this range of conductivity is suitable for aquatic resources.

Table E.8-20. Conductivity in Surface Waters of Lake Jocassee

	Conductivity (µS/cm)		
Station	**Minimum**	**Average**	**Maximum**
558.7	9.10	18.33	24.00
558.0	4.70	18.16	32.00
559.0	9.00	18.23	24.00
560.0	8.00	17.58	34.00
562.0	9.10	18.29	34.00
565.4	12.00	18.05	24.00
551.0	2.00	10.65	34.00
564.0	8.00	17.90	34.00
564.1	9.00	18.41	26.00
557.0	9.00	17.80	34.00
554.8	8.50	17.85	24.00
556.0	8.50	17.38	24.00

Turbidity

During original Project construction, waters of the Whitewater River cove were directly impacted by construction activities. Historical turbidity data in the Whitewater River cove at three monitoring stations were evaluated to determine if original construction activities resulted in a noticeable increase in turbidity values and if so, estimate how far downstream impacts extended and for how long turbidity

[16] Erroneously high conductivity readings at or near the lakebed were removed from the dataset as the conductivity measuring device likely impacted the lakebed, stirring up sediment leading to false readings.

was elevated; this was done by comparing turbidity values from (1) pre-construction (<1985), construction (1985-1991)[17], and post-construction (1992-2015) (see Table E.8-21).

In general, turbidity data were collected once per month, however, there are notable gaps in datasets (several months or years at a time) depending on the station. Measurements were taken at varying depths along the vertical profile (i.e., varied between collection events). Data gaps and vertical depth measurement locations are shown on the turbidity data plots provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. Note that turbidity does not show spatial trends or patterns of stratification such as temperature and DO; turbidity measurements represent a snapshot in time and are typically driven by external factors, therefore, data points do not need to be contiguous in space or time for confidence in interpretation. Where it was obvious that a dataset had a falsely elevated bottom reading (due to resuspension of bed sediment) or an erroneously high measurement in the water column when compared with data above and below it, values were removed from the dataset. Of 6,682 data points, 28 data values were removed, representing less than 1.0 percent of the dataset.

Table E.8-21. Monitoring Stations and Years of Data

Station	Pre-Construction	During Construction	Post-Construction
564.1	N/A	Jan 1988 – Dec 1991	Jan 1992 – Jan 2015
564.0	Aug 1976 – Oct 1985	Feb 1986 – Dec 1991	Jan 1992 – Jan 2015
560.0	Sept 1973 – Oct 1985	Feb 1986 – Dec 1991	Jan 1992 – Jan 2015

Turbidity results are summarized by monitoring station in the sections below. To evaluate turbidity impacts at depth, this parameter was evaluated throughout the water column. Three sets of turbidity figures are provided in the *Summary of Existing Water Quality Standards Final Report* in Appendix D, for each of the three monitoring stations and include:

- Turbidity values vs. lake elevation and year for pre-construction, construction, and post-construction periods (three separate figures);
- Turbidity values vs. lake elevation and year for the full dataset; and
- Depth-averaged turbidity values compared to the 10 NTU state standard.

[17] Duke Energy will expand the existing submerged weir with newly excavated rockfill during construction of Bad Creek II in part to help mitigate the impacts of a second I/O structure in Whitewater River cove. Assessing pre-construction turbidity data and estimating impacts to turbidity during original construction may help inform water quality conditions during proposed construction of the Bad Creek II.

Station 564.1

Station 564.1 is located just downstream of the Project I/O structure and immediately upstream of the submerged weir. This station receives direct inflow from the Whitewater River and is approximately 45 m (148 ft) deep. Details of data from Station 564.1 are provided in Table E.8-22. Turbidity was not measured at Station 564.1 until January 1988, therefore, there is no pre-construction dataset. During the construction period, when elevated turbidity values were observed, they were elevated consistently in the water column on the same days (i.e., rather than randomly in the water column or across many different days); this likely indicates episodic events contributing increased sediment to the area (e.g., construction activities). In general, turbidity values were elevated lower in the water column vs. near the surface on all days where elevated turbidity values were observed. The depth-averaged turbidity reading at this station during the construction period was 18.5 NTU with a standard deviation (stdev) of 51 NTU, indicating significant variance in the dataset. The dataset from Station 564.1 contains the highest turbidity values from any period or monitoring station. There were three notable instances where turbidity was elevated for several readings in a row:

- January – September 1988 (average 65 NTU); the first two readings at this station (January and February 1988) had the highest values at 476 NTU (Jan) and 202 NTU (February). Consistently elevated readings over a nine-month period are likely the results of construction activities. These values continued to decrease each month from March through September.
- July – December 1990 – Nine consecutive readings with an average of 26 NTU over the nine readings.
- April – August 1989 (average 25 NTU).

Additionally, there was one measurement on February 21, 1990, with elevated turbidity; however, because elevated turbidity values were not noted in the measurements before or after this day, this was likely due to a rain event or very short-lived construction event.

Under post-construction conditions, turbidity values at all depths averaged 0.8 NTU (stdev 2.0). The maximum turbidity level measured during this time was 28 NTU.

- There were seven measurements that exceeded the state standard of 10 NTU over the post-construction dataset. Six of those seven measurements occurred on the same day - August 17, 1994. This event was correlated with Tropical Storm Beryl, which made landfall in the southeastern U.S. on August 16th. The state of South Carolina suffered more damage than any other state.

Overall, turbidity was consistently lower when compared to values from the construction period (Table E.8-22).

Table E.8-22. Monitoring Station 564.1 Data Collection Details

Period	Maximum Depth (m)	Average NTU	Stdev NTU	Maximum NTU	Count
Pre-Construction	N/A	N/A	N/A	N/A	N/A
During Construction	45	18.5	51.0	476	480
Post-Construction	44	0.8	2.0	28	890

Station 564.0

Pre-construction values were measured on average once per month, however, there are several periods without recorded data; the depth-averaged turbidity at Station 564.0 over the dataset was 6.6 NTU (stdev 10) and the maximum was 71 NTU (July 26, 1983). Details of data from Station 564.0 are provided in Table E.8-23. Note that Project construction had not yet begun, therefore, these episodes of higher turbidity in the water column were likely due to rainfall events resulting in high inflows from Whitewater River. Elevated values were episodic and specific to the day the measurement was taken (i.e., high NTU values did not carry over to the following measurement).

Higher turbidity values were associated with the same six days, listed below (all maximum values were recorded near the bottom of the lake[18]). Note that Project construction did not begin until 1985.

- 8/10/1976: max 50 NTU
- 3/15/1977: max 48 NTU
- 5/16/1978: max 60 NTU
- 9/12/1978: max 38 NTU
- 7/26/1983: max 71 NTU
- 8/27/1985: max 40 NTU

During the construction period, the average turbidity was lower than during the pre-construction period with an average of 2.9 NTU (stdev 5.2) and a maximum measurement of 57 NTU. All higher NTU readings (within the water column) were associated with the same days and it is noteworthy that all elevated NTU values were at the bottom depth. The elevated turbidity values noted for Station 564.1 (extended periods of time in 1988 and 1990) were not observed at Station 564.0, indicating that elevated turbidity did not extend into the downstream section of Whitewater River cove.

[18] Continued decomposition of organic material early in the life of Lake Jocassee also likely contributed to elevated turbidity values.

Post-construction values at Station 564.0 were lower than pre-construction and construction periods (Table E.8-23) with an average of 0.7 NTU (stdev 1.0) and a maximum reading of 14.0 NTU on February 20, 2012. (Note that this elevated turbidity value was from a surface measurement and decreased to < 1.0 NTU just below the surface measurement).

Table E.8-23. Monitoring Station 564.0 Data Collection Details

Period	Maximum Depth (m)	Average NTU	Stdev NTU	Maximum NTU	Count
Pre-Construction	40	6.6	10	71	382
During Construction	74	2.9	5.2	57	545
Post-Construction	74	0.5	1.2	14	1,351

Station 560.0

During the pre-construction period, the depth-averaged turbidity was 3.0 NTU (stdev 2.9) and the maximum turbidity value was 19 NTU. Note that half of the elevated turbidity values (i.e., those exceeding 10 NTU) were from a single day on September 12, 1978 (average 13.25 NTU) and includes the maximum reading. During the construction period, there was only one value that exceeded 10 NTU (bottom reading) on February 17, 1988, and during the post-construction period, the average NTU was 0.7 (stdev 1.0) with a maximum NTU of 11.6, which was also a bottom reading. Details for monitoring Station 560.0 are included in Table E.8-24.

Table E.8-24. Monitoring Station 560.0 Data Collection Details

Period	Maximum Depth (m)	Average NTU	Stdev NTU	Maximum NTU	Count
Pre-Construction	60	3.0	2.9	19	593
During Construction	82	1.5	1.0	13	462
Post-Construction	78	0.7	1.0	11.6	621

Surface Turbidity

In addition to values at depth, surface turbidity values were assessed and are provided in Table E.8-25 and surface water data tables are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

In freshwater lakes in South Carolina, turbidity is not to exceed 25 NTU provided existing uses are maintained; however, for trout waters, the threshold is not to exceed 10 NTU or 10 percent above natural conditions, provided existing uses are maintained. Over the entire dataset, there were 550 surface samples assessed; a total of 9 samples were above the state standard (i.e., 10 NTU), which accounts for 0.02 percent of the dataset (this also includes data collected during construction).

Therefore, surface water turbidity levels in Lake Jocassee (at the monitoring stations assessed) fully support the designated use classification (i.e., less than 10 percent criterion excursions).

Table E.8-25. Turbidity in Surface Waters of Lake Jocassee

Turbidity (NTU)			
Station	Minimum	Average	Maximum
560.0	0.00	1.90	17.00
564.0	0.00	1.96	47.00
564.1	0.00	1.61	19.00

Howard Creek

Howard Creek is a high-gradient, third-order, headwater mountain stream. It flows from about 3,200 ft msl to 2,000 ft msl at its confluence with Limber Pole Creek and Lake Jocassee. It is typically less than 30 ft wide and 1.65 ft deep, consists mostly of pools and riffles with steep sections of chutes and waterfalls, and has an average gradient of 8.6 percent (Miller et al. 1997).

The *Summary of Existing Water Quality Standards Final Report* in Appendix D provides a summary of: (1) results from January – December 1993, which represent water quality data for Howard Creek under existing (i.e., operational) conditions and (2) changes observed in water quality between pre-construction and post-construction data, as presented by Abernathy et al. (1994). While baseflow water quality in Howard Creek and major tributaries was monitored from near Howard Creek's confluence with Lake Jocassee to its headwaters upstream of the Project, the data summary only considers water quality downstream of the Project as upstream waters are not considered impacted by the Project.

Table E.8-26 provides water quality parameters for post-construction (i.e., existing conditions) as well as pre-construction (1980-1981) as a comparison, indicating that total suspended solids (TSS), turbidity, temperature, DO, pH, 5-day biochemical oxygen demand (BOD_5) and fecal coliform under operational conditions are generally similar and fall well within the range of variation observed during pre-construction conditions. Station H/1 is the furthest downstream, Station H/7 is just downstream of the Project, and Station H/9 is the control station (Abernathy et al. 1994). Comparisons between pre-construction and post-construction water quality data for each monitoring station are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D.

Table E.8-26. Comparison of Water Quality Data Pre-Construction vs. Post-Construction in Howard Creek

		H/1		H/7		H/9	
Parameter		1980-1981	1993	1980-1981	1993	1980-1981	1993
TSS	MAX	14.0	9.5	40.0	16.7	17.0	9.6

		H/1		**H/7**		**H/9**	
Parameter		1980-1981	1993	1980-1981	1993	1980-1981	1993
	MIN	0.05	0.7	0.6	1.4	0.05	1.2
	MEAN	4.9	5.3	8.5	6.1	3.9	4.5
TUR	MAX	19.0	5.8	34.0	5.6	18.0	4.3
	MIN	0.6	1.5	0.67	1.35	0.53	1.2
	MEAN	4.26	3.48	5.1	2.9	3.9	2.5
DO	MAX	15.2	12.8	15.0	11.8	13.7	12.8
	MIN	8.2	8.3	8.6	8.6	7.6	8.4
	MEAN	10.8	10.6	10.9	9.9	10.2	10.5
pH	MAX	7.3	6.4	7.2	6.5	7.4	6.4
	MIN	6.0	5.8	5.8	5.9	5.4	5.8
	MEAN	6.36	6.08	6.2	6.18	6.07	5.98
TA	MAX	16.4	21.4	15.4	32.4	10.7	10.7
	MIN	2.6	13.0	1.4	18.5	0.3	6.0
	MEAN	8.8	17.2	7.2	25.2	5.7	8.3
TH	MAX	24.2	10.0	36.9	17.0	38.2	5.5
	MIN	5.9	3.0	5.3	8.5	5.1	1.0
	MEAN	10.7	6.2	10.8	12.6	10.2	3.0
SC	MAX	35.0	27.0	19.0	44.5	19.0	13.0
	MIN	7.5	13.3	7.5	24.0	5.0	8.2
	MEAN	17.8	20.1	13.2	34.8	12.1	10.5
BOD_5	MAX	2.5	1.1	3.3	0.9	3.8	1.3
	MIN	0.2	0.3	0.2	0.0	0.2	0.2
	MEAN	0.8	0.8	0.8	0.6	0.8	0.7
FC	MAX	52.0	19.0	52.0	10.0	28.0	13.0
	MIN	1.0	<2.0	1.0	<2.0	1.0	<2.0
	MEAN	11.0	9.0	9.0	6.0	8.0	6.0

TSS=total suspended solids; BOD_5=biochemical oxygen demand; FC=fecal coliform
Notes:
H/1 = Between Corbin Creek and Lake Jocassee.
H/7 = Just downstream from Bad Creek.
H/9 = Just upstream of Highway 130.

Overall, Howard Creek, while showing typical annual variations, has remained a high-quality mountain stream with no major changes in the upper portion of the watershed upstream of the Project. Abernathy et al. (1994) notes that even with the major construction of the Project, most baseflow water quality conditions were relatively unchanged during and after construction and post-construction water quality conditions are generally similar to pre-construction, indicating little or no impact for the parameters studied. Notable changes in water quality that were observed between pre and post-construction conditions included pH, total alkalinity, total hardness, and specific conductance.

Specific conclusions of the Abernathy et al. (1994) study include the following:

- Howard Creek's baseflow water quality in the post-construction period is similar to that of pre-construction. Differences are within the range of normal seasonal/annual variations with the following exceptions:
    - During 1991 pH readings were elevated above pre-construction and post-construction, by 1992 the values had returned to near normal, and in 1993 values dropped near or below pre-construction, most likely due to lack of rainfall.
    - Total alkalinity values were elevated above pre-construction levels at Station H/7 during 1991 and 1992 and remained elevated through 1993.
    - Total hardness values were elevated above pre-construction levels at Station H/7 during 1991 and remained slightly elevated through 1992 and 1993. The control Station H/9, however, experienced a drop in mean total hardness during 1993 as compared to the pre-construction mean.
    - Specific conductance values were elevated above pre-construction levels at Station H/7 during 1991 and 1992 and-although decreasing-remained elevated through 1993.
- The elevated values of total alkalinity, total hardness, and specific conductance, and to some extent pH, following construction were likely due to seepage waters through the main and west dams coming into contact with grout materials. It is expected that these parameters (with the exception of pH) will continue to decline and stabilize over time.

Task 1 Conclusions

Overall, the effect of Bad Creek operations on Lake Jocassee water quality is negligible except for the effects seen at the monitoring station upstream of the submerged weir in Whitewater River cove. Tables of water quality data at the three stations in the Whitewater River cove over the three construction periods are included in the *Summary of Existing Water Quality Standards Final Report* in Appendix D. Trends in stratification patterns upstream and downstream of the weir and turbidity data are also included in the final report.

Upstream of the submerged weir, data from monitoring Station 564.1 indicate mixing (from Bad Creek operations), which eliminates all stratification. Temperature and DO values have a uniform profile within the water column at Station 564.1. Immediately downstream of the submerged weir at location 564.0, post Bad Creek operation condition datasets show stratification and trends that follow trends at monitoring locations in other portions of the lake; therefore, based on this desktop review, results indicate that the submerged weir confines mixing to the upstream portion of the Whitewater River cove upstream of the submerged weir and effects of operations are not noted downstream of the weir.

Temperature Conclusions - Prior to 1991 (pre operations), temperatures averaged throughout the water column in Lake Jocassee averaged between 11.7 and 15.3°C with a standard deviation around 5°C. After 1991, average temperatures in Lake Jocassee averaged between 12.1 and 17.2°C with a standard deviation around 5°C as shown in Table E.8-27. There is little difference between the pre and post operation temperature of Lake Jocassee. The variance in temperature is also reasonably consistent at each station between pre and post operations. Outside of Station 564.1, there are no discernable patterns that would suggest Lake Jocassee temperatures are affected by Bad Creek operations or outside the range of natural conditions and there is no pattern of warming or cooling between time periods (variation between time periods on average is less than one degree); therefore, Project operations have not impacted water temperatures in Lake Jocassee. The notable exception is the average temperature change from pre to post operations at monitoring Station 564.1; this station shows an increase of approximately 3.3°C (Table E.8-27).

Table E.8-27. Average and Standard Deviation of Depth-Averaged Temperatures, Pre vs. Post Operations

Monitoring Station	Temperature (°C)				Difference
	Pre Operations		Post Operations		
	Average	Standard Deviation	Average	Standard Deviation	
558.7	12.5	4.9	12.1	4.8	-0.4
558.0	12.9	5.2	13.5	5.4	0.6
559.0	12.5	5.0	12.1	4.9	-0.4
560.0	11.7	4.6	12.3	4.9	0.6
562.0	15.3	5.6	16.0	5.3	0.7
565.4	14.1	5.4	13.1	4.7	-1.0
551.0	13.5	5.8	14.8	7.3	1.3
564.0	12.1	4.7	12.7	4.9	0.6
564.1	13.9	5.6	17.2	5.5	3.3
557.0	11.7	4.5	12.2	4.8	0.5
554.8	14.6	5.5	14.2	5.3	-0.4
556.0	12.8	4.9	13.4	5.2	0.6

Dissolved Oxygen Conclusions - There is little difference between the pre and post operation conditions of Lake Jocassee. The variance in DO at each station is also reasonably consistent between pre and post operations. As discussed previously, outside of Station 564.1, there are no discernable patterns that would suggest Lake Jocassee DO values are affected by Bad Creek operations or outside the range of natural conditions and there is no pattern of increasing or decreasing DO between time periods (variation between time periods on average is less than 0.5 mg/L); therefore, Project operations have not impacted water temperatures in Lake Jocassee. The notable exception is the average change from pre to post operations at monitoring Station 564.1, which is immediately downstream of the Project I/O structure; this station shows an increase of approximately 1.1 mg/L and the standard deviation dropped from 3.2 to 0.8, indicating there is little variation in DO at that station due to mixing (Table E.8-28).

Table E.8-28. Average and Standard Deviation of Surface Dissolved Oxygen, Pre vs. Post Operations

Monitoring Station	Dissolved Oxygen (mg/L)				Difference
	Pre Operations		Post Operations		
	Average	Standard Deviation	Average	Standard Deviation	
558.7	6.9	2.4	6.9	1.9	0
558.0	6.5	2.8	7.0	1.8	0.5
559.0	6.5	2.7	6.5	2.2	0
560.0	6.7	2.5	6.4	2.3	-0.3
562.0	7.8	2.7	7.9	2.0	0.1
565.4	7.3	2.9	7.1	2.5	-0.2
551.0	9.9	1.3	9.6	1.6	-0.3
564.0	6.4	3.0	6.2	2.6	-0.2
564.1	7.4	3.2	8.5	0.8	1.1
557.0	6.8	2.9	6.8	2.3	0
554.8	7.7	3.1	7.4	2.8	-0.3
556.0	7.4	2.9	7.3	2.6	-0.1

Turbidity Conclusions - Where data are available, NTU values are higher during pre-construction periods than during construction and post-construction periods. This is true for depth-averaged turbidity (Table E.8-24) as well as surface water turbidity (Table E.8-29). Pre-construction data show episodic elevated turbidity values likely associated with high surface water inflows during storm events from surface runoff. Additionally, turbidity would have been naturally elevated during that time as organic material decomposed in the years following initial reservoir filling. Over the three stations monitored, the highest values of turbidity are associated with monitoring Station 564.1 immediately downstream of the Project (closest to the Whitewater River mouth) during Project construction; however, these elevated turbidity values are not noted at monitoring Station 564.0, indicating that elevated turbidity does not extend into the downstream section of Whitewater River cove (Table E.8-30).

Additionally, data indicate that elevated turbidity values typically returned to baseline for the following measurement, indicating rapid recovery from elevated values back to normal values (i.e., within one month conservatively, based on sampling frequency). There were several periods of prolonged elevated turbidity values noted at Station 564.1 during the construction period, therefore, these data are assumed to be associated with construction activities.

Table E.8-29. Depth-Averaged Turbidity Values (NTU) Over Construction Periods

Period	Station 564.1	Station 564.0	Station 560.0
Pre-Construction	N/A	6.6	3.0
During Construction	18.5	2.9	1.5
Post-Construction	0.8	0.5	0.7

Table E.8-30. Average and Standard Deviation of Surface Turbidity, Pre-Operations vs. Operations

Monitoring Station	Turbidity (NTU)			
	Pre-Operations		Operations	
	Average	Standard Deviation	Average	Standard Deviation
560.0	2.5	2.7	1.0	1.6
564.0	2.6	4.4	1.0	1.6
564.1	2.8	3.1	1.0	0.9

E.8.2.1.2 Water Quality Monitoring in Whitewater River Arm (Task 2)

Task 2 Methods

Three historic water quality monitoring stations in the Whitewater River arm of Lake Jocassee were assessed as part of Water Resources Study (Stations 564.1, 564.0, 560.0). Continuous water quality data (temperature and DO) were collected at all three stations from June 1 – October 11, 2023 and May 21 – October 8, 2024 with in-Situ VuLink® dataloggers positioned at five staggered elevations as detailed in Table E.8-31. The depths and elevations of the dataloggers are dependent on Lake Jocassee elevations, which are shown for the 2023 and 2024 study seasons in Figure E.8-9.

Table E.8-31. Datalogger Depth and Elevation*

Logger	Approximate Water Depth (ft)	Approximate Elevation (ft msl)	Notes
1	3	1,107	Near surface
2	30	1,080	Normal maximum Lake Jocassee drawdown elevation
3	50	1,060	Approximate crest of the submerged weir
4	70	1,040	Approximately 20 ft below the crest of the submerged weir
5	100	1,010	Approximate location of the thermocline

*Depths and elevations are dependent on Lake Jocassee elevations.

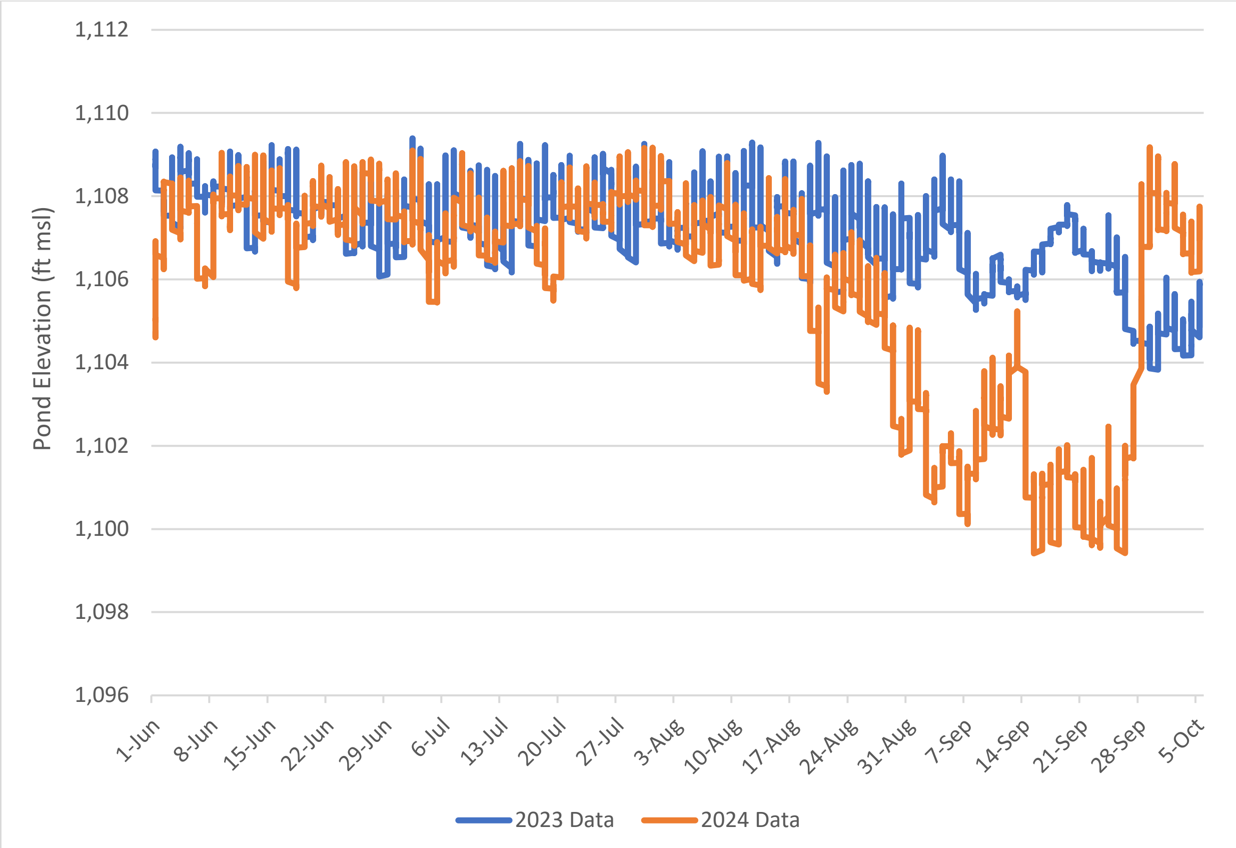


Figure E.8-9. Lake Jocassee Pond Elevations - 2023 and 2024 Study Periods

Water temperature and DO data were also collected during the discrete bi-weekly sampling events; vertical profiles were collected from the water surface to the lake bottom (in approximately 6-foot [2-meter] increments) at all three monitoring locations. The field dates for all water quality data collections during the 2023 and 2024 study seasons are provided in Table E.8-32. Detailed methods and instrumentation descriptions are included in the *Whitewater River Cove Water Quality Field Study Final Report* in Appendix D.

Table E.8-32. Field Dates for Water Quality Measurement and Data Collection

Study Period	Date	Details
2023	May 22	Deploy instrumentation
	May 31	Data download and vertical profile
	June 14	Data download and vertical profile
	June 27	Data download and vertical profile
	July 13, 14*	Data download and vertical profile
	July 24	Data download and vertical profile
	August 11*	Data download and vertical profile
	August 21	Data download and vertical profile

Study Period	Date	Details
	September 7	Data download and vertical profile
	September 23*	Data download and vertical profile
	October 11	Data download; Remove instrumentation
2024	May 21	Deploy instrumentation
	June 11	Data download and vertical profile
	June 17	Data download and vertical profile
	July 1	Data download and vertical profile
	July 16	Data download and vertical profile
	July 30	Data download and vertical profile
	August 14	Data download and vertical profile
	August 26	Data download and vertical profile
	September 9	Data download and vertical profile
	September 25	Data download and vertical profile
	October 7	Data download and vertical profile; Remove instrumentation

*ADCP flow measurements were conducted for computational fluid dynamics (CFD) model verification during this event in support of the Water Resources Study Task 3.

Task 2 Results

Duke Energy collected continuous water temperature data and periodic DO concentration data (bi-weekly) from locations near three historic monitoring stations to determine current-day representative (i.e., baseline) water quality information. Data collected in 2023 represented conditions under three-unit operations and data collected in 2024 represented conditions under fully upgraded four-unit operations at the Project. The results from 2023 and 2024 are summarized below, and detailed results are provided in the *Whitewater River Cove Water Quality Field Study Final Report* in Appendix D.

Study Season 1 (Summer 2023)

Station 564.1 (Upstream of Weir)

Station 564.1 is immediately downstream of the Project I/O structure and upstream of the submerged weir. From June to early September, epilimnetic water temperatures increased, peaking at 27.7°C in late July, while hypolimnetic water temperatures peaked in early September at 25.4°C. DO concentrations remained above 7.0 mg/L at all datalogger depths throughout the entire monitoring period. While there was some minor evidence of thermal stratification between 20 and 40 ft in the earliest part of summer, there was no indication of a stable thermocline, indicating vertical mixing occurred throughout the monitoring period. Vertical mixing is associated with the operation of the Project, which facilitates the direct exchange of water between Bad Creek Reservoir and Lake Jocassee. Vertical mixing at this location is further supported by historical water quality monitoring

(Task 1 of the Water Resources Study – Section E.8.2.1.1) and CFD modeling conducted for Task 3 of the Water Resources Study (Section E.8.2.1.3).

Continuous temperature data generally indicated a gradual increase in water temperature throughout the summer months, which stabilized in September before experiencing a gradual decline into mid-October. The near surface datalogger recorded greater temperature variability, reflecting diurnal atmospheric temperature fluctuations. This observed variability aligns with the anticipated effects of solar heating and nighttime cooling on surface waters. In contrast, dataloggers positioned at depths between 30 ft and 100 ft recorded relatively stable temperatures, indicative of vertical mixing (due to Project operations) and minimal diurnal temperature variability. This stability displayed effective thermal stratification where deeper waters remain less susceptible to short-term atmospheric temperature changes.

Station 564.0 (Immediately Downstream of Weir)

Station 564.0 is located on the downstream side of the submerged weir, upstream of the confluence of the Whitewater River arm and the Thompson River arm of Lake Jocassee. The recorded surface water temperature exhibited a seasonal trend, characterized by a steady increase throughout the summer months, with a peak temperature of 27.8°C in early September, followed by a gradual decline towards the end of the month. Thermal stratification shows a well-defined thermocline observed at a depth of approximately 100 ft, separating the epilimnion from the hypolimnion. DO concentrations exhibited a consistent decline over the monitoring period from June through September. Surface DO concentrations ranged from 7.3 to 8.8 mg/L, while concentrations at a depth of approximately 200 ft ranged from 0.0 to 2.3 mg/L.

Temperature and DO profiles at Station 564.0 indicate that the presence of the submerged weir minimizes vertical mixing on the downstream side of the weir, as evidenced by the presence of a stable thermocline. This stratification limits the mixing of oxygenated surface waters at depths greater than 100 ft.

Continuous water temperature monitoring data show distinct thermal dynamics at varying depths. Surface water temperatures (at the 3-ft-depth datalogger) reached a maximum of approximately 28.4°C in late July, while temperatures at greater depths (≥ 30 ft) displayed a delayed peak in early September and continued to decline until the end of data collection on October 11, 2023. As anticipated, the surface water temperatures showed diurnal fluctuations, reflecting the influence of direct solar heating and atmospheric interactions. In contrast, depths at 30, 50, and 70 ft exhibited more stable profiles, with reduced diurnal variability, which are buffered from rapid surface driven temperature changes.

Daily water temperature fluctuations at a depth of 100 ft were larger than fluctuations at depths above 100 ft, likely due to flow circulation patterns immediately downstream of the submerged weir (also shown in the CFD modeling results near this location) and thermal density gradients associated with the thermocline, which were most pronounced at this depth. The submerged weir significantly reduces vertical mixing on the downstream side of the weir which is why thermal and DO stratification is more pronounced compared to Station 564.1 on the upstream side of the weir.

Station 560.0 (Downstream of Weir)

Thermal and DO profiles at Station 560.0 exhibited stratification patterns similar to those observed at Station 564.0. Throughout the monitoring period, surface water temperatures increased, reaching a peak of 28.1°C, while DO concentrations ranged from 7.8 to 8.9 mg/L. A thermocline was observed at approximately 100 ft, separating the warmer epilimnion from the cooler hypolimnion.

At Station 560.0, which has a depth of approximately 260 ft, temperatures below the thermocline were approximately 11°C, with DO concentrations ranging from 0.9 to 2.2 mg/L. The deeper and wider channel at this location exhibits less vertical mixing (confirmed by the CFD modeling results) resulting in pronounced thermal and DO stratification.

Surface water temperatures reached a maximum of approximately 28.7°C in late August, while temperatures at greater depths (≥ 30 ft) peaked in early September before gradually declining through the end of the study period. Similar to observations at Station 564.0, surface temperatures exhibited diurnal fluctuations.

At 100 ft, water temperature fluctuations were also observed, but the magnitude of the fluctuations were reduced compared to those observed at Station 564.0. This can be attributed to the decreasing influence of flows in the Whitewater River arm as the channel deepens and broadens resulting in a more stable thermal environment.

Pond elevations in Lake Jocassee remained within the upper 4 ft of the reservoir's 30-ft operating band from early June through early September. However, during the latter part of the study period, drought conditions resulted in decreased pond elevations (as low as 1,103.3 ft msl, or 6.7 ft below full pond) in early October. Despite this decrease, there was no observable impact on water temperature or DO trends in the recorded data.

Study Season 2 (Summer 2024)

Station 564.1 (Upstream of Weir)

In the early summer months (June – mid-July) of 2024, similar to the previous year, there was some evidence of thermal stratification between 20 and 40 ft. Epilimnetic temperatures peaked at approximately 28.5°C in mid-July, while deeper hypolimnetic waters reached a maximum temperature around 21.0°C. By August, thermal stratification was less evident in the upper water column (likely due to mixing/Project operations) and relatively isothermal conditions persisted through the end of the study period in early October. DO concentrations remained consistently above 6.0 mg/L across all depths, indicating well-oxygenated conditions during the study period.

Continuous temperature monitoring data showed a gradual increase in water temperatures throughout the summer, plateauing in early September before experiencing a gradual decline into mid-October. The surface datalogger (3 ft) recorded greater temperature variability, likely driven by diurnal fluctuations in atmospheric temperatures, corresponding to solar heating during the day and cooling at night. In contrast, temperature loggers positioned at depths of 30 to 100 ft recorded relatively similar thermal conditions, indicative of effective vertical mixing and minimal influence from diurnal atmosphere variability.

Station 564.0 (Immediately Downstream of Weir)

The recorded surface water temperature at Station 564.0 exhibited a seasonal progression of stratification, characterized by a thermal increase throughout the summer months with a peak temperature of 28.2°C in mid-July followed by a gradual decline throughout the end of the monitoring period. The thermal stratification at this station was more pronounced compared to Station 564.1, with a distinct thermocline observed at approximately 100 ft, separating the epilimnion and hypolimnion. DO concentrations exhibited a decline over the monitoring period, with epilimnetic concentrations ranging from 7.5 to 8.9 mg/L, while concentrations in the hypolimnion ranged from 0.7 to 7.0 mg/L. This stratification, made evident by the thermocline, indicates the presence of hypoxic conditions at depths greater than 150 ft, where vertical mixing does not occur.

The submerged weir is a significant factor in preventing vertical mixing downstream, allowing for natural thermocline development in Lake Jocassee. The stable thermocline at Station 564.0 was also confirmed through CFD modeling and previous water quality monitoring.

Continuous temperature data also shows distinct thermal characteristics at the various datalogger depths. The surface water temperatures recorded at the 3-ft-deep logger reached a maximum of approximately 28.2°C in early August, while depths ≥ 30 ft displayed a peak in late August, and declined until the end of the monitoring period. As observed in 2023, surface temperatures exhibited diurnal fluctuations, while depths at 30, 50, and 70 ft showed thermally stable profiles.

Continuous temperature data at 100 ft observed higher variability than at other depths, which can be attributed to the complex flow circulation patterns influenced by the submerged weir. CFD modeling supports the conclusion that the presence of the submerged weir minimizes mixing downstream of the weir allowing natural thermal stratification to develop.

Station 560.0 (Downstream of Weir)

The temperature and DO profiles at Station 560.0 displayed similar stratification patterns to those observed at Station 564.0. Surface water temperatures peaked near the end of August at 28.3°C while DO concentrations in the epilimnion ranged from 6.3 to 8.9 mg/L. Also similar to Station 564.0, a defined thermocline was present at approximately 100 ft.

Temperatures recorded in the hypolimnion ranged from 11.0 to 17.6°C, while DO concentrations ranged from 3.9 to 6.3 mg/L. The greater depth and wider channel at this station likely contributed to the observed stratification by promoting a stable thermal gradient inhibiting thermal mixing.

Continuous water temperature monitoring further illustrated the seasonal thermal dynamics observed at this station. Surface water temperatures peaked at approximately 28.7°C in early August, while temperatures at greater depths than 30 ft peaked in 25.8°C in early September, followed by a gradual decline toward the end of the monitoring period. Diurnal fluctuations in surface water temperatures were observed, as expected, reflecting diel cycles of solar heating and radiative cooling. Similar to Station 564.0, water temperature fluctuations at the 100-ft depth were also evident, likely influenced by complex circulation patterns and thermal density gradients downstream of the weir as discussed above. This effect, supported by CFD modeling, highlights the significant role of the weir, as it dissipates effects of Project operations.

Hurricane Helene

On September 23, 2024, the National Oceanic and Atmospheric Administration classified a developing storm system near the Cayman Islands as a tropical storm, projected to impact northwestern Florida. By September 26, the tropical storm intensified into a Category 4 Hurricane with sustained wind speeds reaching 140 miles per hour making landfall with a 15-ft storm surge near Tallahassee, Florida.

Over the next 24 hours, Hurricane Helene headed northwest affecting Georgia, South Carolina, North Carolina, Tennessee, and Virginia, with a storm radius extending over 300 miles (NOAA 2024).[19]

During this event, the Jocassee Gorges watershed experienced up to 18 inches of precipitation over a three-day period. Rainfall at the Project totaled 15.89 inches (Alan Stuart, personal communication). This extreme precipitation event is considered a 1,000-year flood, a hydrological occurrent with a 0.1 percent annual probability (NOAA 2024).

Continuous temperature monitoring at Station 564.1 showed a sudden decline in water temperatures (except for surface temperatures) and temperatures reached approximately 21°C at the three deepest dataloggers. This pattern indicates a substantial influx of cooler water from the Whitewater River into Lake Jocassee consistent with the timing of the hurricane event. Temperatures recovered (i.e., became mixed) after the initial decline, with the lower datalogger (100-ft) taking longest to recover to pre-hurricane temperatures. Duke Energy drew the lake down to 1,099 ft msl on September 26 in preparation for the predicted storm.

The combined effects of storm-driven wind stress, colder inflows, and decreasing air temperatures promoted vertical mixing, facilitating the descent of cooler, denser epilimnetic water. This, in turn, caused an upwelling of hypolimnetic water, leading to a temporary downward shift in the thermocline, which was observed at the deepest dataloggers for both stations downstream of the weir.

The rainfall from Hurricane Helene and impacts from this event on water temperatures and mixing in Whitewater River arm, while significant, were temporary and not typical.

Task 2 Conclusions

Duke Energy collected continuous water temperature data and periodic DO concentration data (bi-weekly) from locations near three historic monitoring stations to determine current-day representative (i.e., baseline) water quality information. Data collected in 2023 represented conditions under three-unit operations and data collected in 2024 represented conditions under fully upgraded four-unit operations at the Project. There is no noticeable difference in the water quality datasets due to increased pumping or generation. Results from both years indicate water upstream of the submerged weir is, as expected, well-mixed and does not stratify, or is weakly stratified for a short period of time in early summer in the upper water column. Data from monitoring locations downstream of the weir reveal stratification under all pumping and generation scenarios, indicating the weir is functioning as

[19] https://www.noaa.gov/

it was designed and helps to dissipate energy from the I/O structure. This preservation of stratification downstream of the weir is also supported by historical water quality monitoring and by CFD model results under current Project conditions as well as Bad Creek II conditions, which will have near double the flows generated from the combined powerhouses.

Due to the relatively small surface area, high degree of mixing, and short residence time of water in the Bad Creek Reservoir, warming impacts due to solar radiation in the upper reservoir are limited, therefore, conditions in the Whitewater River arm are reflective of conditions in the upper reservoir.

Duke Energy has developed a WQMP focused on effects of construction and operation of Bad Creek II on water quality in the Whitewater River arm (provided in Appendix D).

E.8.2.1.3 Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse (Task 3)

Task 3 Methods

Models developed for determining the effect of a second powerhouse include a 2-D hydraulic flow model and a 3-D CFD model. The 2-D model was developed first to evaluate the hydraulics of the Whitewater River cove with the goal of determining the CFD model boundary. Results from the 2-D model were used as input into the CFD model to determine the downstream modeling boundary; the significantly reduced computational run time of the 2-D model was able to achieve this step in a single model run as opposed to a lengthy iterative process. Sixteen scenarios (Table E.8-33) were evaluated using the CFD model to evaluate effects of Project operations on vertical mixing in the Whitewater River arm and downstream of the submerged weir to determine how far downstream Project effects extend. Scenarios modeled the existing and expanded submerged weir configuration in both generating and pumping mode; and at full pond (elevation 1,110 ft msl) and maximum drawdown (elevation 1,080 ft msl). Results under full pond and maximum drawdown provide potential upper and lower limits of hydraulic effects of Bad Creek II operations. The CFD model domain covers approximately 922 acres and generally encompasses the area upstream of the Devil’s Fork arm and Whitewater River arm confluence. Scenarios were compared relatively to assess how pumping and generating affect the hydraulics downstream of the submerged weir and also to assess how the geometry of the submerged weir affects the flow patterns and vertical mixing downstream of the weir.

Table E.8-33. CFD Model Scenarios

Station	Operating Mode	Submerged Weir Geometry	Scenario	Flow (cfs)	Jocassee Reservoir Elevation (ft msl)
Bad Creek Only	**Generating**	Existing	1	16,000	1,110
			2	16,000	1,080
	Pumping		7	13,780	1,110
			8	13,780	1,080
	Upgraded Generation	Existing	13	19,440	1,110
			14	19,440	1,080
	Upgraded Pumping		15	15,000	1,110
			16	15,000	1,080
Bad Creek & Bad Creek II	**Generating**	Existing	3	39,200	1,110
			4	39,200	1,080
	Pumping		9	32,720	1,110
			10	32,720	1,080
	Generating	Expanded	5	39,200	1,110
			6	39,200	1,080
	Pumping		11	32,720	1,110
			12	32,720	1,080

More details on model description, limitations, and modeling approach are included in in the *Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse Final Report* in Appendix D. To provided verification of and confidence in modeled results, flows were measured in the Whitewater River cove along five transects with an acoustic Doppler current profiler as described below; results from the verification studies agreed well with modeled results and a verification report developed was developed as an addendum to the Task 3 report.

Additionally, in late 2023 (after submittal of the final study report) Duke Energy provided updated hydraulic capacities, provided by the preferred Original Equipment Manufacturer, for proposed variable speed pump-turbines for Bad Creek II. Based on this information, additional CFD modeling was conducted using the updated proposed hydraulic capacities. A summary is included below and an addendum report is included as a second addendum to the *Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse Final Report* in Appendix D.

Task 3 Results

CFD Model Results

Existing Project Configuration

To establish a baseline for comparison, the existing Bad Creek configuration and operations were modeled under full pond and maximum drawdown. Scenarios included the maximum generating flow of 16,000 cfs, the maximum pumping flow of 13,780 cfs, and the existing submerged weir geometry.

Simulation times for the existing generation and pumping scenarios are 22.9 and 26.5 hours, respectively.

The four upgraded powerhouse scenarios (Scenarios 13-16 in Table E.8-33) figures are presented in the *Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse Final Report* in Appendix D. Results from these scenarios are consistent with the other 12 scenarios.

Generation

Full Pond

Existing hydraulic conditions at the full pond elevation are characterized by low flow velocities throughout the model domain. Flow velocities peak across the top of the submerged weir at approximately 0.6 fps.

Dense areas of streamlines downstream of the submerged weir indicate an area of potential mixing that extends approximately 850 ft downstream of the submerged weir.

More information on water quality and mixing at existing monitoring stations in the Whitewater River cove is provided in the *Summary of Existing Water Quality and Standards Report* (provided in the Water Resources Study, Appendix D). Results from the desktop water quality study indicate that flow is well mixed (i.e., lacks stratification) upstream of the weir at water quality monitoring location 564.1 but stratification is present throughout the year at monitoring location 564.0 just downstream of the weir. Results of the CFD modeling align with these field data observations.

While flow appears to be mixing downstream of the submerged weir, velocities are very low (less than 0.25 fps) in the reservoir between the weir and monitoring location 564.0. Because the weir dissipates energy from Bad Creek I/O structure, the slow-moving uniform flow regime downstream of the weir creates conditions suitable for vertical stratification, similar to what occurs at other monitoring stations in the main body of Lake Jocassee. This effect (i.e., mixing on the upstream of the weir and vertical stratification on the downstream side) is present across the range of simulations evaluated.

Maximum Drawdown

At maximum drawdown, the effect of the submerged weir is more pronounced. Surface velocity contours show an area of slightly elevated velocity in the immediate vicinity of the submerged weir. This area of slightly elevated velocity extends approximately 200 ft from the weir crest and peaks at 1.1 fps. Model results indicate the area of higher velocity is present through the majority of the water column across the top of the weir, but as flow expands into the downstream section of the Whitewater River Cove, this effect has dissipated. At lower reservoir elevations (i.e., pond levels), water velocities are accelerated across the top of the weir as flows are forced to the surface. This results in an area of slightly higher surface velocities, and a slightly shorter potential mixing length downstream of the weir.

As with the full pond scenario, the weir limits downstream mixing and because of the very low velocities downstream of the weir, stratification trends at monitoring station 564.0 mimic the rest of Lake Jocassee.

Pumping

Full Pond

Existing pumping conditions at full pond are similar to existing generation conditions at full pond. Low velocities are seen throughout the model domain, and peak across the top of the submerged weir at approximately 0.5 fps. There is little to no vertical mixing downstream of the submerged weir under pumping operations. As flow is pumped to Bad Creek Reservoir, it is gradually pulled from the upper surface layer of Lake Jocassee over the submerged weir resulting in a very uniform, laminar flow regime downstream of the weir. Flow patterns at monitoring location 564.0 extending upstream to the weir are uniform and have velocities less than 0.2 fps indicating seasonal stratification would be maintained throughout the reservoir downstream of the weir.

Maximum Drawdown

Similar to generating at maximum drawdown, pumping at maximum drawdown increases the effect of the submerged weir. An area of higher velocity extends approximately 1,200 ft upstream of the submerged weir peaking at 1.9 fps. Model results indicate minimal vertical mixing effects are observed downstream of the submerged weir. Velocity streamlines in the Whitewater River cove are uniform and slow moving, indicating stratification would be present downstream of the weir. As flow is pulled across the top of the weir it is accelerated near the surface into the upstream section of the Whitewater River cove.

Proposed Project, Existing Weir

Generation

Full Pond

The proposed generation flow is more than double the existing flow (39,200 cfs vs 16,000 cfs). This significant increase in flow results in a localized increase in velocity at the surface and through the water column. Conditions at the full pond elevation are characterized by low flow velocities throughout the model domain. Flow velocities peak across the top of the submerged weir at approximately 1.4 fps. The area of elevated velocity (1-2 fps) extends approximately 1,000 ft downstream of the weir crest.

The model results show dense areas of streamlines downstream of the submerged weir that indicate an area of potential mixing extends approximately 850 ft downstream of the submerged weir, which is a similar mixing length as existing generation at full pond. While flow appears to be mixing downstream of the submerged weir, velocities are very low, less than 0.25 fps, between the weir and monitoring location 564.0. These slow, uniform flow patterns are very similar to existing conditions and facilitate conditions for stratification within the water column at water quality monitoring station 564.0 just downstream of the weir.

Maximum Drawdown

At maximum drawdown, the effect of the submerged weir is more pronounced. Contours of surface velocity show an area of slightly elevated velocity in the immediate vicinity of the weir. This area of slightly elevated velocity extends downstream approximately 2,100 ft from the weir crest and peaks at 3.7 fps. Model results indicate the area of higher velocity is present through the majority of the water column across the top of the weir, but as flow expands into the downstream section of the Whitewater River cove, flow is concentrated on the right descending bank, and only in this section are velocities elevated throughout the water column. At lower pond levels, water velocities are accelerated across the top of the weir and flows are forced to the surface. This results in an area of slightly higher surface velocities, and a slightly shorter potential mixing length downstream of the weir.

As with the full pond scenario, because of the very low velocities downstream of the weir at water quality monitoring location 564.0, it can be reasonably expected that flow conditions would promote stratification.

Pumping

Full Pond

The proposed pumping flow is more than double the existing flow (32,720 cfs vs 13,780 cfs). This significant increase in flow results in a localized increase in velocity at the surface and through the water column. Conditions at the full pond elevation are characterized by low flow velocities throughout the model domain. Flow velocities peak across the top of the submerged weir at approximately 1.1 fps. The area of elevated velocity (1-2 fps) extends approximately 160 ft upstream of the weir crest.

There is little to no vertical mixing downstream of the submerged weir under pumping operations. As flow is pumped to Bad Creek Reservoir, it is gradually pulled from Lake Jocassee across the top of the submerged weir resulting in a very uniform, laminar flow regime downstream of the weir. Flow patterns at monitoring location 564.0 extending upstream to the weir are uniform and have velocities less than 0.2 fps indicating stratification would be present throughout the reservoir downstream of the weir.

Maximum Drawdown

Similar to generating at maximum drawdown, pumping at maximum drawdown increases the effect of the submerged weir. An area of higher velocity extends approximately 1,200 ft upstream of the submerged weir peaking at 1.9 fps. Velocity streamlines in the Whitewater River cove are uniform and slow moving, indicating stratification would be present downstream of the weir. As flow is pulled across the top of the weir it is accelerated into the upstream section of the Whitewater River cove.

Proposed Project, Expanded Weir

Generation

Full Pond

The proposed expanded submerged weir has a slightly stronger effect of accelerating flow across the top of the weir and downstream into the lower Whitewater River cove. Similar to the existing weir configuration, full-pond hydraulic conditions in the Whitewater River cove under proposed flow with the expanded weir geometry are characterized by relatively low velocities. Flow velocities peak across the top of the submerged weir at approximately 1.3 fps. Model results indicate an area of elevated velocity is present in the water column 800 ft downstream of the submerged weir, however it is confined to the top portion of the water column, indicating the proposed weir is functioning as intended. The area of slightly elevated velocity (1.0-2.0 fps) extends about 1,800 ft downstream of the submerged weir.

Dense areas of streamlines downstream of the submerged weir indicate an area of potential mixing that extends approximately 1,050 ft downstream of the submerged weir. While flow appears to be mixing downstream of the submerged weir, velocities are very low, less than 0.25 fps, in the reservoir between the weir and monitoring location 564.0. These slow, uniform flow patterns allow for stratification to be established within the water column at water quality monitoring location 564.0.

Maximum Drawdown

The scenario with the proposed generating flow and expanded weir at maximum drawdown presents the greatest effect to water velocities and flow patterns in Whitewater River cove. With the lowered pond level, expanded weir geometry (in the downstream direction) and higher flowrate, the effect of the expanded weir is the most pronounced. Contours of surface velocity show an area of elevated velocity in the immediate vicinity of the weir. This area of slightly elevated velocity extends approximately 2,500 ft from the weir crest and peaks at 4.5 fps. For context, 4.5 fps is approximately 3.0 miles per hour or roughly the average adult walking speed.

Model results indicate the area of higher velocity is present through the majority of the water column across the top of the weir, but as flow expands into the downstream section of the Whitewater River cove, flow is concentrated on the right descending bank and near the surface. Velocities in the Whitewater River cove are between 2.0-3.0 fps approximately 1,500 ft downstream of the submerged weir but are concentrated at the surface indicating little downstream mixing potential.

At lower pond levels, water velocities are accelerated across the top of the weir and flows are forced to the surface. This results in an area of slightly higher surface velocities, and a significantly reduced potential mixing length downstream of the weir.

As with the full pond scenario, because of the low velocities within the water column downstream of the weir at water quality monitoring location 564.0, it can be reasonably expected that flow conditions would not inhibit thermal stratification.

Pumping

Full Pond

The expanded weir has a slightly stronger effect of accelerating flow across the top of the weir and upstream into the upper Whitewater River cove. Full pond pumping hydraulic conditions in the Whitewater River cove under the proposed flow with the expanded weir geometry are still characterized by relatively low velocities. Flow velocities peak across the top of the submerged weir at approximately 1.1 fps. Model results indicate little to no elevated velocities downstream of the submerged weir. The area of slightly elevated velocity (1-2 fps) extends 200 ft upstream of the submerged weir.

There is little to no vertical mixing downstream of the submerged weir under pumping operations. As flow is pumped to Bad Creek Reservoir, it is gradually pulled from Lake Jocassee across the top of the submerged weir resulting in a very uniform, laminar flow regime downstream of the weir. Flow patterns at monitoring location 564.0 extending upstream to the weir are uniform and have velocities less than 0.2 fps indicating stratification would be present throughout the reservoir downstream of the weir.

Maximum Drawdown

Similar to generating at maximum drawdown, pumping at maximum drawdown increases the effect of the submerged weir. An area of higher velocity extends approximately 1,800 ft upstream of the submerged weir peaking at 3.3 fps. Model results indicate minimal vertical mixing effects are observed downstream of the submerged weir. Velocity streamlines in the Whitewater River cove are uniform and slow moving, indicating stratification would be present downstream of the weir. As flow is pulled across the top of the weir it is accelerated into the upstream section of the Whitewater River cove.

Effect of Submerged Weir Geometry

The expanded weir geometry results in a small increase in flow acceleration as water flows over the crest of the weir (when compared to the existing weir geometry). Comparison of model results shows similar magnitudes of velocity increases, but the area of elevated surface velocity are slightly larger with the expanded weir geometry. Comparison of streamlines downstream of the weir indicate the flow patterns are very similar, and it can be reasonably expected to result in similar stratification patterns at water quality monitoring location 564.0.

Comparison of the pumping scenarios leads to the same conclusion. Flow is accelerated over the expanded weir and the increased velocity has a slightly larger footprint compared to the existing weir. However, expanding the weir geometry results in flow patterns and magnitudes that are similar to the flow patterns and magnitudes of the existing submerged weir geometry, which limits downstream vertical mixing.

CFD Model Verification Addendum (November 2023)

Verification flow data were collected along four transects in the Whitewater River cove using an Acoustic Doppler Current Profiler (ADCP) and results are provided in an addendum to the *Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse Final Report* in Appendix D.

Approximate locations of flow transects include Transect 1 (upstream of the weir near water quality monitoring Station 564.1), Transect 2 (across the top of the submerged weir), Transect 3 (downstream of the submerged weir near Station 564.0), and Transect 4 at the confluence of the Whitewater River arm and Thompson Creek arm. Velocity profiles were measured during three separate field visits on June 12 & 13, August 10 & 11, and September 20 & 21, 2023. Due to varying water depths along the transects, two different ADCPs were used; a deep-water ADCP and a shallow-water ADCP.

Velocities measured along Transect 1, which is the furthest upstream transect near water quality monitoring station 564.1, were collected with the Project in pumping mode to evaluate velocity magnitudes and flow patterns in the area most affected by pumping operations (i.e., near the Project's I/O structure). Velocities are generally moving in the upstream direction towards the Project I/O structure. The overall measured velocity magnitude is < 0.5 fps from top to bottom indicating flows in this area are generally slow moving, but well mixed throughout the water column, which also matches the CFD model results. Both historic and current water quality profiles at this location also indicate the water column in this area is well-mixed due to Project operations.

Velocities were measured across the top of the submerged weir (Transect 2) with the Project in generation mode. The maximum depth along Transect 2 is 53 ft; it is the shallowest of the ADCP transects which range from 53 to 234 ft deep. Due to the smaller cross-sectional area for discharged water to pass through, the area across the top of the weir is also well mixed and exhibits higher velocities compared to the other transects. Maximum measured velocities across the top of the weir with the Project in generation mode were close to 1.0 fps while the majority of Transect 2 had velocities < 0.5 fps. The CFD model results for Transect 2 were similar to the measured data and also exhibited areas with higher velocities up to approximately 0.7 fps.

Transects 1 and 2 exhibited complete datasets with no obvious invalid cell measurements or erroneous data, as many of the challenges and limitations associated with ADCP data collection (described in the addendum) were not a factor at these two transects.

The two downstream transects (Transects 3 and 4) are deeper and the velocities are slower at these two locations compared to Transects 1 and 2. There are numerous invalid ensembles and velocity spikes for both of these transects, and artificially high velocities. A review of the ADCP bottom tracking data shows continuous black lines along the bottom of each transect indicating that there were no issues with bottom tracking. Air entrainment (typically due to turbulence) was also not an issue at Transects 3 and 4 and no specific user quality criteria were used in the measurements. This means the invalid ensembles were likely the result of decorrelation of the acoustic pulse and/or low backscatter due to lack of moving particles in the water column (particularly at deeper depths).

Transect 3 is located between the submerged weir and water quality monitoring location 564.0. This location has slightly elevated velocities near the surface which is carry-over from the higher velocities across the top of the submerged weir. Most of the velocities at this location are generally < 0.5 fps which is consistent with the CFD model results. There are several areas with missing or erroneous data at depth (areas are depicted on Figure 5-3 in the addendum).

Lake Jocassee has very low turbidity and limited growth of algae and other organisms. These two factors increase the likelihood of low backscatter, especially at depth. Additionally, because trees and other debris were not cleared before Lake Jocassee was filled, there are likely many areas where trees are still standing, which can cause decorrelation of the acoustic pulse.

Transect 4 is located just upstream of the confluence of the Whitewater River arm and Thompson River arm. It is the deepest of the four transects (maximum 234 ft) and velocities are very low (<0.50 fps) from the surface to the bottom. There are numerous areas along Transect 4 with either blank cells and/or erroneous high velocities at depth. The combination of low back scatter and submerged debris interrupting the acoustic pulse are feasible explanations for these areas of invalid data; most of the invalid data points are below depths of 100 ft, where there is little turbidity or organic growth present to reflect the acoustic energy back to the ADCP.

While Transects 3 and 4 exhibit some blank cells and erroneous data, this is to be expected when measuring velocities in deep, clear water with very low velocities (i.e., < 0.3 fps). Knowing that data collection would be a challenge at these two locations, extra time was taken in the field to collect a higher density of data ensembles, including hovering in place over areas where data gaps occurred in an attempt to minimize those gaps. Most of the data ensembles at these two locations are complete and a comparison of measured velocities is consistent with the CFD model.

CFD Model Updated Pumping Rates Addendum (September 2024)

Additional CFD model runs carried out to incorporate updated hydraulic capacities associated with Bad Creek II that were not available during original CFD modeling. Updated generating capacity resulted in similar flows as originally estimated (i.e., less than 2 percent difference), so the study focuses on the effects of updated pumping capacities on Whitewater River cove flows and results are provided in an addendum to the *Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse Final Report* in Appendix D.

Existing Pumping Velocity Profiles

Under existing pumping conditions at the full pond elevation, depth-averaged velocities[20] approaching the I/O structure (i.e., approach velocities) are 1.8 fps approximately 100 ft from the I/O structure with a maximum velocity of 2.1 fps. Maximum velocities in the water column near the face of the I/O structure vary based on tunnel position and the hydrostatic pressure acting on tunnel flows and range from 5.5 fps to 6.2 fps.[21]

[20] It is noteworthy that bathymetry of the lake bottom impacts flows as they approach the tunnel openings.
[21] Trashracks on the I/O structure are not considered, therefore velocities at the face of the tunnels would be higher than shown here.

Under existing pumping conditions at the intermediate pond elevation, depth-averaged approach velocities are 2.2 fps approximately 100 ft from the I/O structure with a maximum velocity of 2.5 fps. Maximum velocities near the face of the I/O structure range from 7.2 fps to 7.7 fps.

Under existing pumping conditions at the minimum pond elevation, depth-averaged approach velocities are 4.6 fps approximately 100 ft from the I/O structure with a maximum velocity of 5.2 fps. Maximum velocities near the face of the I/O structure range from 7.9 fps to 8.4 fps.

Under existing pumping conditions, the maximum velocity inside the I/O tunnel chambers near the structure face is approximately 13.3 fps and approximately 23 fps in the tailrace tunnel based on the 31-ft-diameter tunnel and given flowrates.

The width of the Whitewater River cove at the existing I/O structure is approximately 1,110 ft and the extent of velocity effects extend approximately 230 ft from the I/O structure into the Whitewater River cove at the minimum pond elevation.

Updated Proposed Pumping Velocity Profiles

The updated increased pumping capacity at Bad Creek II results in higher velocities in the Whitewater River cove in the vicinity of the proposed I/O structure when compared to existing velocities at the Bad Creek I/O structure.

Under updated pumping conditions at the full pond elevation, depth-averaged approach velocities for the proposed I/O structure are 1.7 fps approximately 100 ft from the I/O structure with a maximum velocity of 2.0 fps. Maximum velocities in the water column near the face of the I/O structure vary based on tunnel position and hydrostatic pressure and range from 9.6 fps to 10.1 fps.

Under updated pumping conditions at the intermediate pond elevation, depth-averaged approach velocities are 2.5 fps approximately 100 ft from the I/O structure with a maximum velocity of 3.1 fps. Maximum velocities near the face of the I/O structure range from 9.2 fps to 9.7 fps.

Under updated pumping conditions at the minimum pond elevation, depth-averaged approach velocities are 4.5 fps approximately 100 ft from the I/O structure with a maximum velocity of 8.3 fps. Maximum velocities near the face of the I/O structure range from 7.4 fps to 10.9 fps.

Under updated pumping conditions, the maximum velocity inside the I/O tunnel chambers near the structure face is approximately 16 fps and approximately 28 fps in the tailrace tunnel based on the 31-ft diameter-tunnel and given flowrate.

The width of the Whitewater River cove at the proposed I/O structure is approximately 675 ft and the extent of velocity effects extend approximately 400 ft from the I/O structure into the Whitewater River cove at the minimum pond elevation.

Surface Velocities

Areas of recirculation occur near the west and east banks under both full pond and minimum pond scenarios, and velocities increase as reservoir levels decrease and with increased proximity to the proposed I/O structure, as indicated by velocity vectors. Recirculation patterns in the vicinity of the proposed I/O structure under the minimum pond scenario are also present. These patterns are caused by flow splitting at the tunnel abutments and the restricted flow area near the I/O structure, resulting in increased velocities.

As the pond level decreases, the volume of water decreases and increases the strength of recirculation in the recirculation area. This effect results in concentrated flow through the center of the proposed I/O structure approach channel and center tunnels and is more pronounced as the pond level decreases.

Accelerated flows across the weir in the direction of the I/O structure are more pronounced at minimum pond. As water is pulled upstream through the Whitewater River cove during pumping, flows are spread evenly across the submerged weir before converging into a main center channel in the cove, with localized eddies of slower moving water (i.e., recirculation) on both sides of the main flow path.

Under existing pumping conditions and full pond levels, surface velocities do not exceed 2.0 fps in the Whitewater River cove and are on average below 1.0 fps. At minimum pond, existing maximum surface velocities across the weir could reach 3.0 fps and up to 5.0 fps directly in front of the existing I/O structure.

Under full pond conditions for proposed updated pumping operations, velocities are very similar to existing conditions with maximum velocities of 1.5 fps near the existing and proposed I/O structures. Under proposed updated pumping at the minimum pond level, surface velocities could reach 10.0 fps near the proposed I/O structure; however, these higher velocities are localized and constrained within the small area adjacent to the I/O structure in a recessed alcove. As part of Bad Creek II construction, expansion of the submerged weir (in the downstream direction) is being considered; maximum velocities over the proposed expanded weir are 3.5 fps, which are consistent with maximum velocities over the existing submerged weir.

As indicated above, surface velocities under minimum pond could reach 10.0 fps, which could have implications for non-motorized boats moving northward through Whitewater River cove, however, the high flows are constrained to the area immediately adjacent to the I/O structure within the recessed area of the shoreline where the proposed I/O will be constructed. Additionally, at minimum pond the area upstream of the proposed I/O is largely dewatered and therefore would not support boating activities regardless of Bad Creek II operations. It should be noted that Lake Jocassee has never been at the licensed maximum drawdown since its creation; maximum drawdown scenarios in this evaluation provide the most conservative hypothetical condition.

Task 3 Conclusions

Each CFD model scenario was run at full pond and maximum drawdown. These two elevations were selected to bookend the potential operating conditions of the existing and proposed powerhouse configurations. Over the last 45 years, Lake Jocassee elevation has been above the minimum pond level 100 percent of the time.

The CFD model domain was appropriately sized to evaluate the hydraulic effects of Bad Creek and Bad Creek II. Results indicate hydraulic effects in Lake Jocassee due to operations are limited to the model domain (i.e., the area upstream of the Devil's Fork arm and Whitewater River arm confluence) and water conditions to maintain natural stratification downstream of the weir exist under all modeled scenarios.

In generation mode, the energy of the water discharged from Bad Creek is dissipated as it is forced across the top of the existing submerged weir. Similar vertical mixing patterns result from the existing and proposed expanded weir geometries under existing and proposed generation flows. Model results indicate Bad Creek II powerhouse operations will not alter existing stratification patterns observed at Station 564.0 (downstream of weir) or further downstream into Lake Jocassee.

In pumping mode, hydraulic effects due to Bad Creek II operations are limited to the Whitewater River cove upstream of the submerged weir and in the upper water column across the top of the weir. No modeled configuration of pumping operations creates mixing downstream of the submerged weir. Water quality profile data (current and historic) also support CFD model results, indicating stratification is preserved downstream of the submerged weir.

CFD Model Verification Addendum (November 2023)

ADCP velocity measurements at the four transects located in the Whitewater River arm of Lake Jocassee generally corroborate the CFD model results at these locations. Velocity magnitudes and directions and overall flow patterns are consistent with CFD model results which show a mixed water column on the upstream side of the submerged weir (Transect 1), an area of slightly higher velocities across the top of the submerged weir (Transect 2) and deeper, slower moving water (i.e., < 0.50 fps) towards the Whitewater River arm / Thompson River arm confluence.

There are several assumptions and limitations associated with ADCP data collection (described in Section 4.1 of the addendum) that can make velocity data resolution challenging, especially in deep, clear, slow-moving water such as the Whitewater River arm of Lake Jocassee. In particular, the lack of moving particles in the lower portions of the water column, coupled with very slow-moving water (i.e., <0.30 fps) in many areas resulted in data gaps and erroneous velocity spikes. Even with these challenges, a robust velocity dataset was collected at each of the four transect locations and results are consistent with the CFD model results in both pumping and generation mode.

Overall, velocities predicted with the CFD model compare well with measured velocities across each transect. Modeled velocities are generally within 0.1-0.3 fps of valid measured velocities and accurately represent actual flow dynamics. This study is considered appropriate and sufficient to provide confidence in the CFD model results used to carry out Task 3 of the Water Resources Study.

CFD Model Updated Pumping Rates Addendum (September 2024)

As expected, velocities in the Whitewater River cove under all operational scenarios increase with decreased reservoir elevations. Lake Jocassee has never been at the licensed maximum drawdown since its creation, and it is worth noting Bad Creek II would likely not operate at maximum hydraulic capacities in the unlikely event of a drawdown (licensed minimum pond level). Therefore, maximum drawdown scenarios with maximum pumping evaluated in this study provide the most conservative results.

Surface velocities in the Whitewater River cove under minimum pond elevations could reach 10.0 fps, which may have implications for non-motorized boats moving through the Whitewater River cove near the Project. To support the relicensing effort, Duke Energy carried out a Recreational Use Evaluation with the goal of characterizing the existing recreational use of Whitewater River cove to inform Duke Energy on the level of boating use disruption that could occur in the cove during Bad Creek II construction.[22] The final evaluation developed in consultation with relicensing stakeholders,

[22] Whitewater River cove will be closed to recreation during Bad Creek II construction (approximately 7 years) for public safety.

Whitewater River Cove Existing Recreational Use Characterization Final Report, is included in the Recreational Resources Study, Appendix D.

Results of this study, which was carried out from Memorial Day through Labor Day in 2023, showed the majority of boats in Whitewater River cove were motorboats (83 percent), followed by personal watercraft (e.g., jet ski) (10 percent), kayaks (7 percent), and canoes (less than 1 percent); therefore, a minor percentage (<10 percent) of boaters using the Whitewater River cove do so in a non-motorized boat. It is likely from a recreational boater safety perspective that boats would be able to navigate this area of the Whitewater River cove by keeping to the east side of the Whitewater River cove along the shore opposite the proposed lower reservoir I/O structure since the new I/O structure would be situated approximately 200 ft back from the existing shoreline in a recessed alcove. It is important to note that at low reservoir elevations, the northern portion of the Whitewater River cove would be dewatered and therefore be inaccessible as the reservoir bottom elevation in this area is higher than 1,080 ft msl. As a result, boating in this area of Whitewater River cove would largely be precluded by low lake levels, regardless of Bad Creek II operations.

E.8.2.1.4 Water Exchange Rates and Lake Jocassee Reservoir Levels (Task 4)

Task 4 Methods

Operation of the proposed Bad Creek II, which will add pumping and generating capacity to the Project, has the potential to impact water surface elevation rate of change in Lake Jocassee compared to typical conditions (but will not change the allowable fluctuation in Lake Jocassee under the KT Project License and associated agreements). Duke Energy used the existing Computer Hydro-Electric Operations and Planning Software™ (CHEOPS) model to evaluate the difference in water exchange rate, frequency, and magnitude between Bad Creek Reservoir and Lake Jocassee due to the addition of a second powerhouse. Additionally, potential impacts to Lake Keowee as a result of operating an additional powerhouse at the Project were considered.

The Savannah River (SR) CHEOPS Model was originally developed during 2011-2013 to support relicensing of the KT Project based on input and physical characteristics included in the Savannah River ResSim model (Duke Energy 2014). It was custom-configured for the Upper Savannah River system based on the specific system constraints such as flow requirements, target reservoir elevations, powerhouse equipment constraints, and reservoir storage balancing between the Duke Energy hydroelectric reservoirs (Bad Creek Reservoir, Lake Jocassee, and Lake Keowee) and downstream USACE hydroelectric reservoirs (Lake Hartwell, Richard B. Russell Lake, and J. Strom Thurmond Lake).

In support of the ongoing Bad Creek relicensing, the SR CHEOPS Model has been updated to reflect both mechanical and operational changes that have occurred since initial model development (i.e., since the KT Project relicensing) and changes anticipated to occur during the term of the new Bad Creek license. These changes include:

- An updated reservoir storage curve for the Upper Reservoir.
- Upgraded units at the Project.
- Requirements of the current KT Project FERC license.
- Updated pumping and generation dispatch tables for both Bad Creek and Jocassee Pumped Storage Station. These tables were revised to reflect anticipated changes in operation at both facilities as additional renewable generation is incorporated into Duke Energy's generation portfolio.

Verification of the SR CHEOPS Model was performed using historical operations data provided by Duke Energy and the USACE. The modeled flow releases from the hydroelectric facilities were compared to historical data to show whether the model provides a reasonable representation of hydroelectric operations throughout the year (e.g., timing, magnitude, and duration of operations).

Verification results show the model compares favorably to historical data, reasonably characterizes study area operations, and is appropriate for use in evaluating the effects of alternative operating scenarios. As with any model, accuracy is highly dependent on input data; consequently, model results should be viewed in a relative, rather than absolute, context. The CHEOPS model is a tool that can be successfully used to evaluate the relative sensitivity and response of the Project to changing operational constraints.

Task 4 Results

Effects of Bad Creek II

Model results for the Baseline and Bad Creek II scenarios were compared to identify potential differences in the effects of Bad Creek II as contrasted with existing license conditions. This comparison is focused primarily on reservoir elevation effects.

As demonstrated by the modeling results, the effects of Bad Creek II are constrained by Duke Energy's continued compliance with the existing KT Project FERC license including the LIP and the 2014 Operating Agreement. These requirements would not be modified with the relicensing of the Project or the construction and operation of Bad Creek II, so little to no effects to the downstream USACE hydroelectric projects were identified in the model results.

The relative size differences between the Bad Creek Reservoir, Lake Jocassee, and Lake Keowee directly affect how generation and pumping volumes affect reservoir levels within the three reservoirs. As a general guide and ignoring all other inflows, withdrawals, downstream flow releases, and evaporation, a change of 1.0 ft of reservoir storage at the Bad Creek Reservoir results in 0.05 ft (0.6 inches) of change in Lake Jocassee's water level. If the same volume of water was then moved upstream or downstream at Jocassee, Lake Keowee's level would change by 0.02 ft (0.25 inches).

The following sections summarize key comparisons of modeling results for the Baseline and Bad Creek II scenarios. See *Water Exchange Rates and Lake Jocassee Reservoir Levels Final Report* in Appendix D for the Performance Measures sheets and additional information regarding the modeled outcomes for the Project and KT Project.

Project and KT Project Reservoir Levels

Model results in Table E.8-34 through Table E.8-37 and Figure E.8-10 demonstrate an additional 8.4 ft to 21.4 ft, depending on hydrology, of storage at the Bad Creek Reservoir would be accessed under the Bad Creek II scenario as compared to the Baseline scenario.

Depending on hydrological conditions, effects on minimum reservoir levels at Lake Jocassee and Lake Keowee are less pronounced. As demonstrated by the reservoir elevation curves for Lake Jocassee and Lake Keowee (Figure E.8-11 and Figure E.8-12), reservoir elevations under both scenarios are comparable. This is further demonstrated by the Performance Measures sheets provided in *Water Exchange Rates and Lake Jocassee Reservoir Levels Final Report* in Appendix D. There are few differences in reservoir level-related measures when comparing the Baseline and Bad Creek II scenarios under all three hydrology conditions.

Both the Project and the KT Project reservoirs' normal minimum and normal maximum reservoir level limits in the existing Project license and the KT Project license would remain unchanged. As discussed above, reservoir elevations at Lake Keowee under the three hydrology conditions remain above the minimum reservoir operating levels for municipal water intakes and Oconee Nuclear Station, so no new effects to existing water intakes are anticipated.

Table E.8-34. Normal Hydrology Minimum Simulated Reservoir Elevations Compared to the Baseline Scenario (ft msl)

Scenario	Bad Creek	Jocassee	Keowee
Baseline (Existing License)	2,246.1	1,084.1	791.6
Bad Creek II	2,224.7	1,084.5	791.6
Difference from Baseline	**-21.4**	**0.4**	**0.0**

Table E.8-35. ccLow Sensitivity Minimum Simulated Reservoir Elevations Compared to the Baseline Scenario (ft msl)

Scenario	Bad Creek	Jocassee	Keowee
Baseline (Existing License)	2,246.1	1,083.8	791.6
Bad Creek II	2,224.7	1,084.2	791.7
Difference from Baseline	**-21.4**	**0.4**	**0.1**

ccLow = Low Impact of Climate Change Sensitivity
The ccLow scenarios were simulated with a 3.0°Farenheit (°F) temperature increase, which was modeled as a 10 percent increase in natural surface evaporation.

Table E.8-36. ccHigh Sensitivity Minimum Simulated Reservoir Elevations Compared to the Baseline Scenario (ft msl)

Scenario	Bad Creek	Jocassee	Keowee
Baseline (Existing License)	2,160.0	1,083.0	792.0
Bad Creek II	2,151.6	1,080.0	791.4
Difference from Baseline	**-8.4**	**-3.0**	**-0.6**

ccHigh = High Impact of Climate Change Sensitivity
The ccHigh scenarios were simulated with the addition of a 6.0°F temperature rise and a 10 percent decrease in incremental inflows to each reservoir. The 6.0°F increase in temperature was modeled as a 20 percent increase in natural surface evaporation.

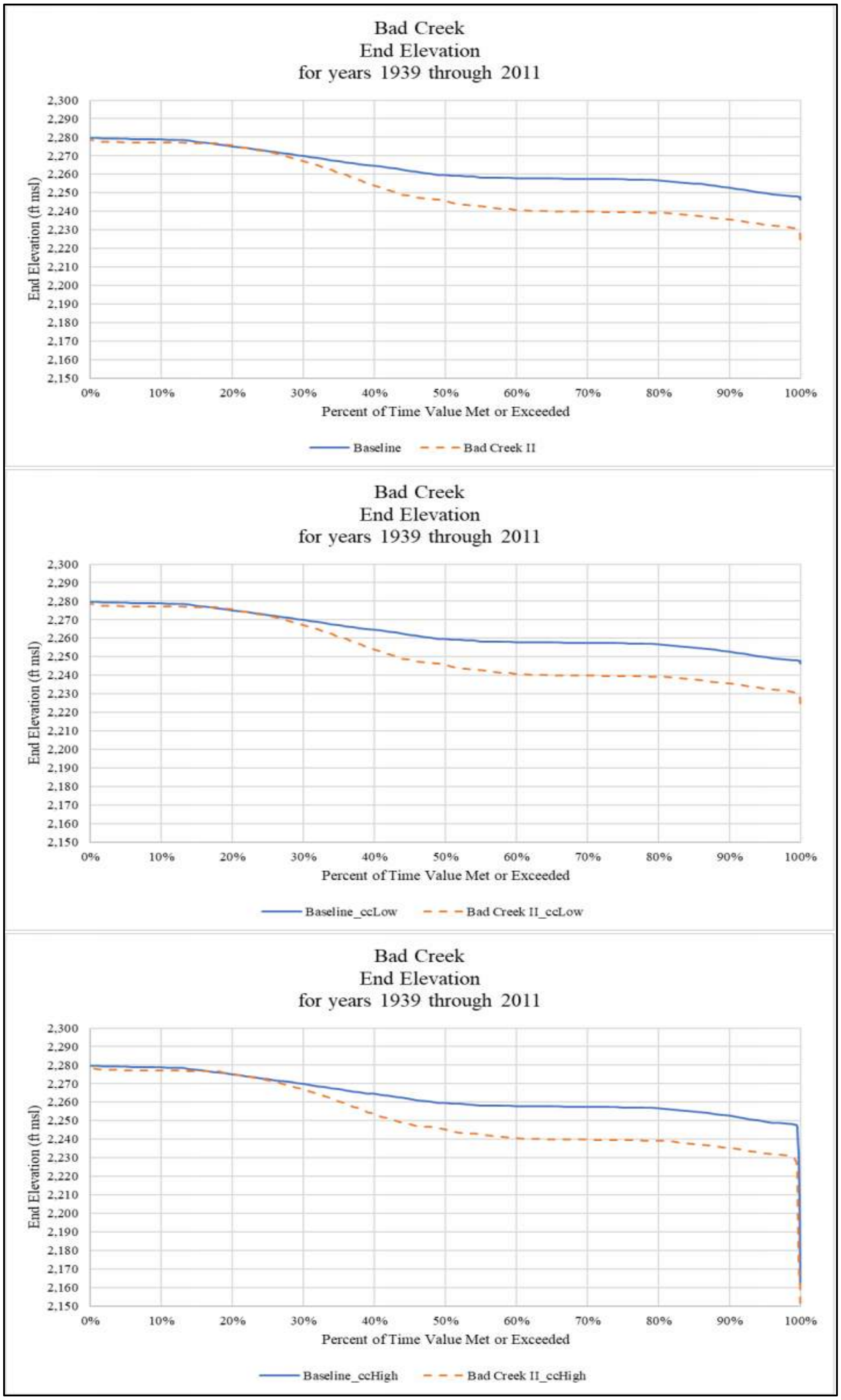


Figure E.8-10. Bad Creek Simulated Reservoir Elevation Duration Curves (1939-2011)

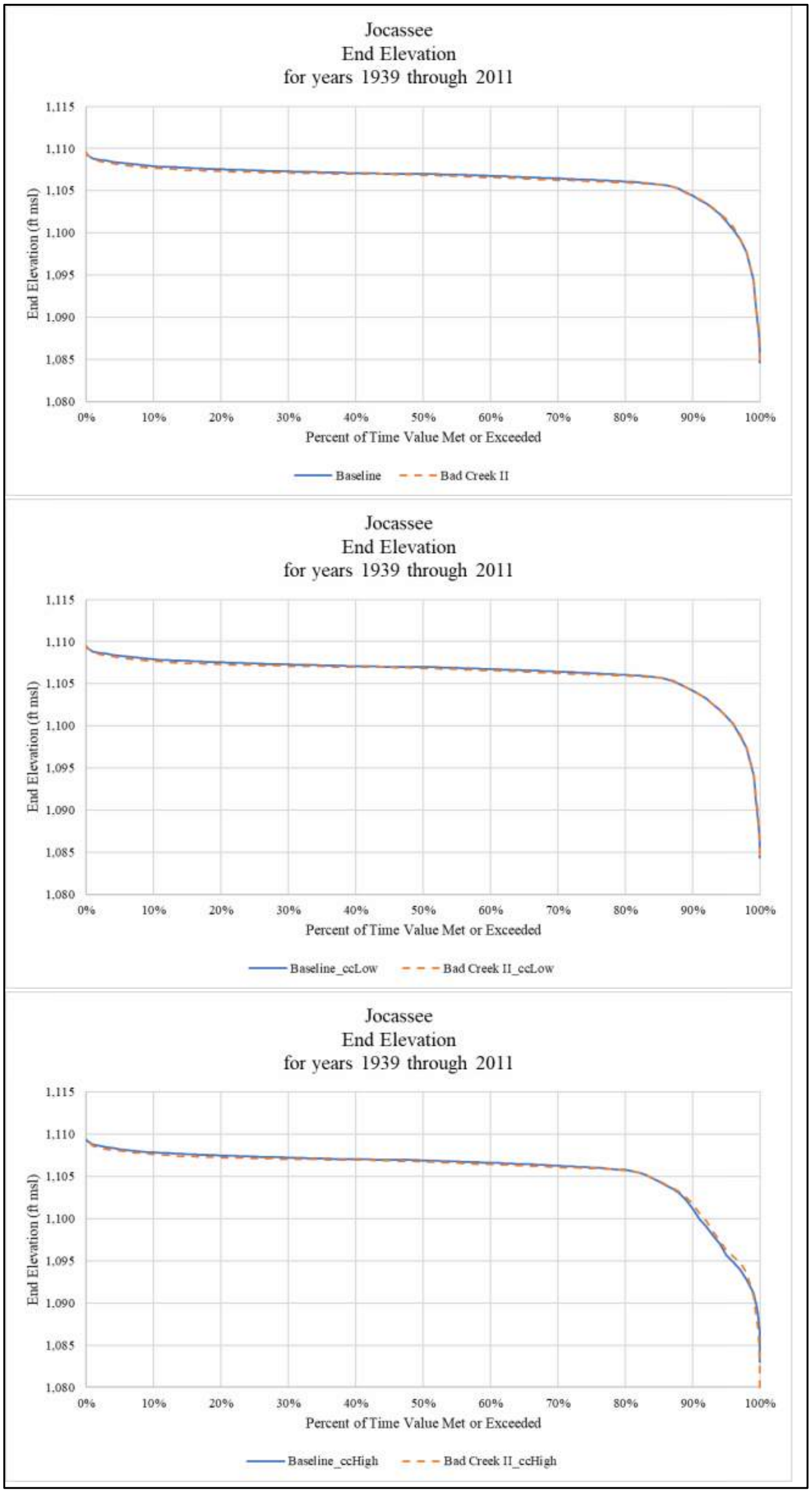


Figure E.8-11. Jocassee Simulated Reservoir Elevation Duration Curves for 1939-2011

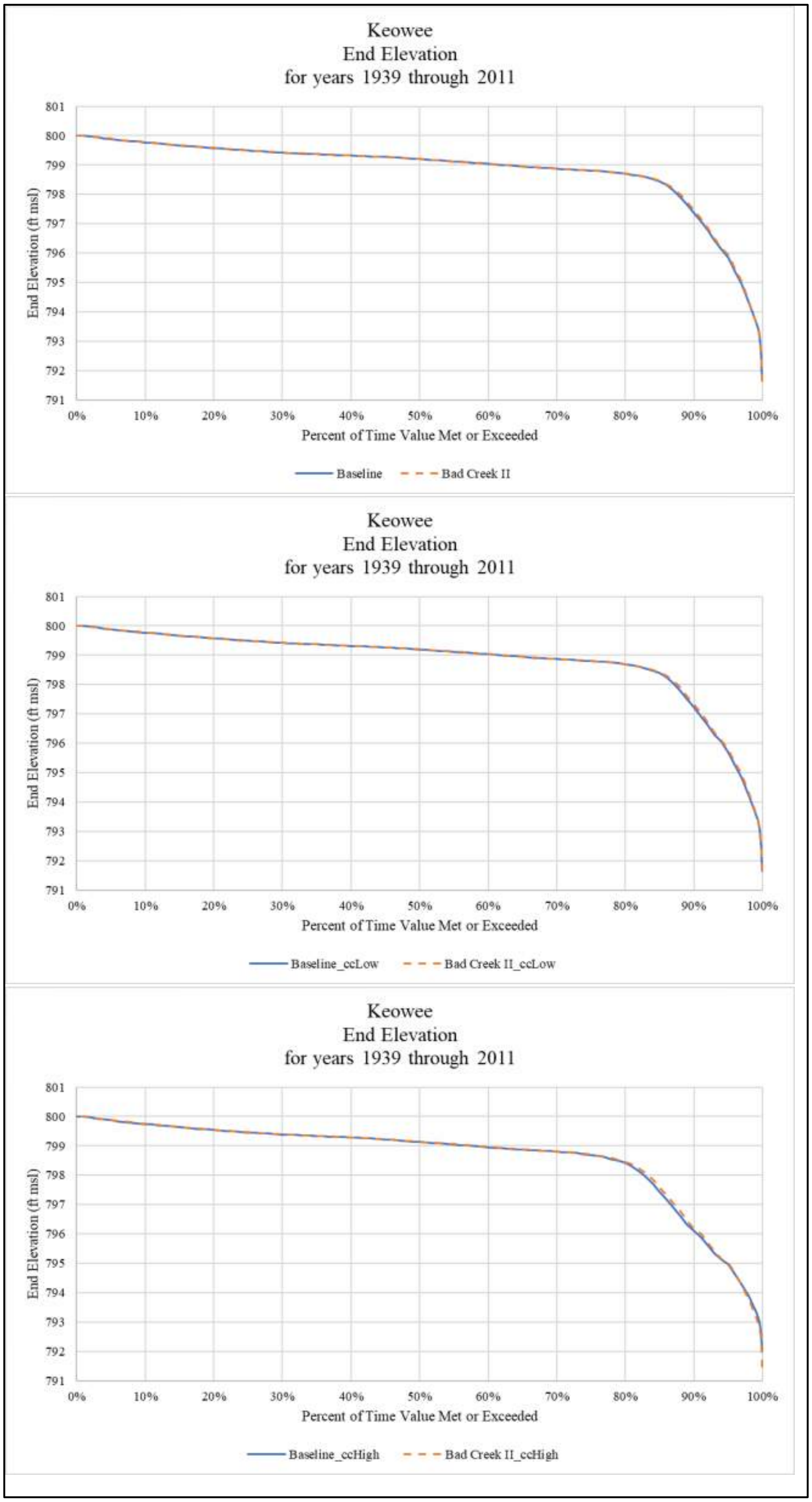


Figure E.8-12. Keowee Simulated Reservoir Elevation Duration Curves for 1939-2011

Lake Level Fluctuations and Shoreline Erosion

Fluctuation Rates

Model results in Table E.8-37 demonstrate the maximum reservoir fluctuation over a 24-hour window during the period of record (POR) for both the Baseline and Bad Creek II scenarios. Typically, about 60 percent of the time, the Bad Creek II scenario results in an approximately 15-foot increase in 24-hour fluctuation at Bad Creek as compared with the Baseline scenario. In contrast, at Jocassee, about 97 percent of the time, the Bad Creek II scenario results in an approximately 0.4- to 0.2-ft decrease in 24-hour fluctuation as compared to the Baseline scenario. The decreased range in 24-hour fluctuations in Lake Jocassee is due to increased generation and pumping volumes associated with Bad Creek II. Both Bad Creek and Bad Creek II operations are synched with Jocassee Pumped Storage Station operations in the model such that both Bad Creek and Bad Creek II typically generate and pump when Jocassee generates and pumps. However, a larger volume of water moves between Bad Creek Reservoir and Lake Jocassee in the Bad Creek II scenario, offsetting more of the lake level fluctuation effects at Lake Jocassee caused by Jocassee Pumped Storage Station operations. The model indicates little to no difference in 24-hour fluctuations at Lake Keowee between the Bad Creek II scenario and the Baseline scenario.

The reduction in Jocassee reservoir elevation fluctuations for the Bad Creek II scenario is demonstrated by the Performance Measures related to fish spawning success. Under all three hydrology conditions, reservoir elevations are within a tighter fluctuation band compared to the Baseline scenario. At Lake Keowee, there are no significant differences in the spawning fluctuation bands.

Table E.8-37. Normal Hydrology Maximum Simulated Reservoir Fluctuation Over 24-hours Compared to the Baseline Scenario (ft)

Scenario	Bad Creek	Jocassee	Keowee
Baseline (Existing License)	33.1	4.3	2.3
Bad Creek II	52.6	4.5	2.3
Difference from Baseline	**19.2**	**0.2**	**0.0**

Whitewater River Cove Shoreline Erosion

As part of the Bad Creek II Feasibility Study a three-dimensional Computational Fluid Dynamic model was developed for lower reservoir modeling to complement the Upper and Lower Reservoir Operational Impact Studies. This effort was carried out in support of evaluating a second lower reservoir I/O structure and the potential associated erosion impacts to the Whitewater River cove of Lake Jocassee. The final report *Bad Creek II Feasibility Study Lower Reservoir CFD Flow Modeling*

Report (HDR 2022) was filed with the Bad Creek Revised Study Plan as Appendix I in December 2022.

The results of the modeling indicate additional generation flows resulting from Bad Creek II would not increase erosion potential along the east bank (i.e., opposite bank) of the Whitewater River cove in Lake Jocassee across from the I/O structure assuming the geology is consistent along the eastern bank (i.e., bedrock). The modeled velocities were approximately equivalent to the physical model study velocities, which are representative of existing conditions.

Flows from the existing configuration and operations have not resulted in erosion along the east bank and velocities are within the general range compared to the proposed configuration.

Lake Jocassee Shoreline Erosion

To assess general characteristics of shoreline erosion along Lake Jocassee (and Lake Keowee), Duke Energy conducted a Shoreline Erosion Study (Baird 2013) during the KT Project relicensing. The purpose of the erosion study was to determine the main drivers of shoreline erosion and to quantify erosion along the shorelines. The Baird (2013) study results showed sources of erosion include physical weathering (e.g., freeze-thaw), wave action from wind and recreational boating, concentrated runoff, non-Project development along the shoreline (i.e., land development), and operation of the reservoir (cyclic raising and lowering lake levels). Results indicated the majority of shoreline erosion was caused by wave action associated with wind and boat wakes, and while water level fluctuations due to operations affected the elevations at which wave-induced erosion occurs, water level fluctuations themselves do not appear to contribute appreciably to the overall rate of shoreline erosion. Results indicated approximately 25 to 45 percent of the erosion noted was attributed to boat wakes in Lake Jocassee and the remainder was attributable to wind waves (Baird 2013). In general, wind and wave-caused erosion is expected to continue in areas with erodible soils where bedrock has not been exposed but may occur at higher or lower rates if pool elevations are modified (Baird 2013). Because the operating band for Lake Jocassee and Lake Keowee will not change with Bad Creek II operations, and CHEOPS modeling demonstrates the Lake Jocassee elevations will be generally consistent between the Baseline and Bad Creek II scenarios, the addition of Bad Creek II is not anticipated to affect erosion rates along the shorelines of Lake Jocassee.

Additionally, shoreline studies at Lake Jocassee including scarp height (thickness of soil visible above the water line), recession of banks, and percentage of shoreline protection around the reservoir, have been carried out (Orbis 2012). Overall, the study results showed approximately 75 percent of the Lake Jocassee shoreline is either (a) bedrock or (b) shows no signs of erosion (past or present) (Orbis 2012).

Duke Energy is responsible for managing activities within the reservoir boundaries of lakes Jocassee and Keowee in a manner promoting safe public use and maintaining environmental safeguards. Duke Energy implements the KT Shoreline Management Plan classifying KT Project shorelines and denoting where environmentally important habitat exists, where existing facilities and uses occur, and where future/existing shoreline activities may be considered.

Aquatic Resources

Potential effects to aquatic resources in Lake Jocassee related to changes in water level fluctuation and exchange of water between the upper and lower reservoirs are evaluated in the *Aquatic Resources Study Report* described in Section E.9.2.1.2.

LIP Stages

The percent of days in some stage of the LIP increased under all three hydrology conditions (Normal, ccLow and ccHigh) when comparing Bad Creek II with the Baseline scenario. The various LIP stages are triggered by the ratio of storage in the Duke Energy reservoirs compared to the storage in the USACE reservoirs. The addition of Bad Creek II results in increased (simulated) flow releases from Keowee, which in turn creates reservoir storage imbalances between the Duke Energy and USACE reservoirs. This effect is slightly more pronounced under the ccHigh hydrologic conditions. While these incremental changes in reservoir storage balance are small between the Duke Energy and USACE reservoirs (i.e., typically less than 1.5 percent), they are oftentimes enough to trigger the next LIP stage. As a result, the Bad Creek II scenario results in a shift of days from “normal” (i.e., non-drought stage) to LIP Stage 0 (the first drought stage), as shown on Figure E.8-13. Likewise, there are a few occurrences where there is a similar shift in days from one LIP Stage to the next. In reality, these shifts may not occur, or the frequency of occurrence may be less, due to real-time operations which would likely limit excess flow releases from Keowee during drought conditions. As a result, the number of days in any LIP stage may be less than what is depicted on Figure E.8-13.

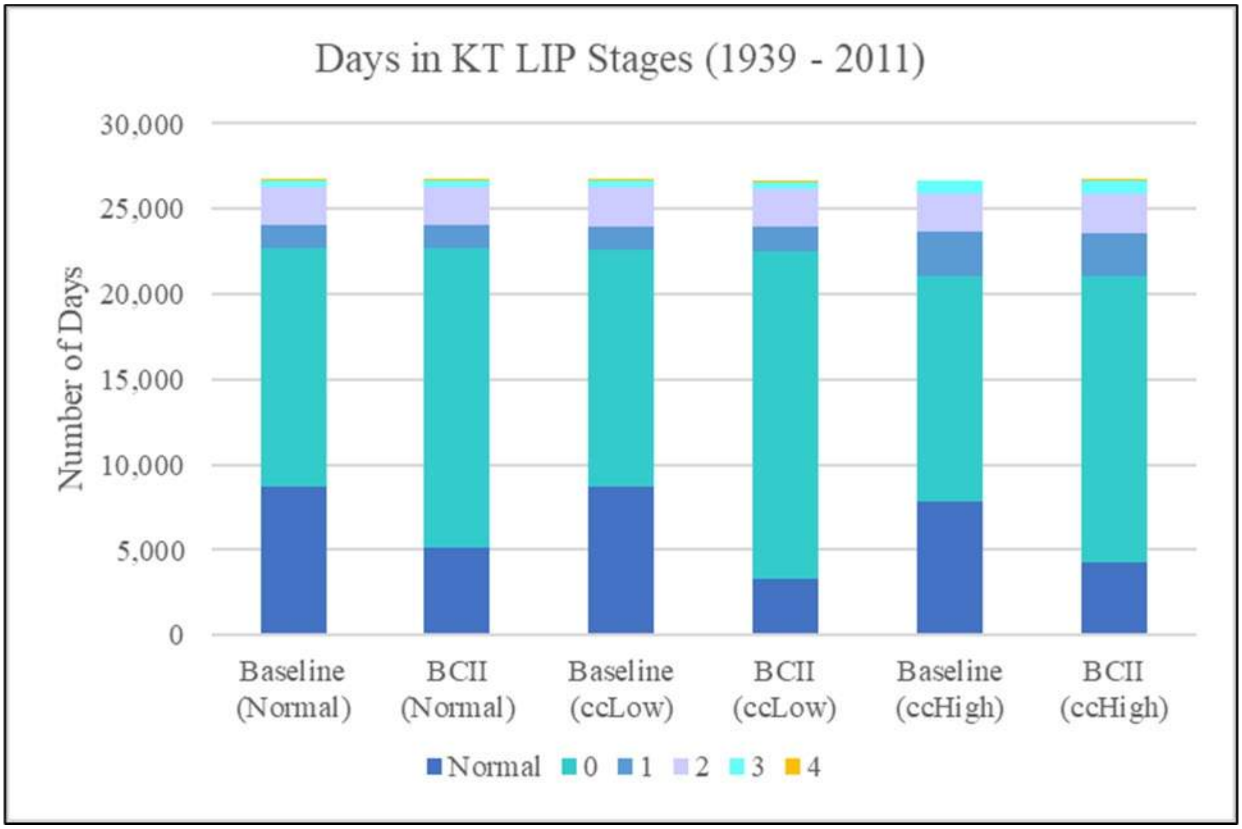


Figure E.8-13. Days in LIP Stages (1939-2011)

Effects on USACE Reservoirs

The Water Resources Study Plan identified the geographic extent of the CHEOPS task as Lake Jocassee and Lake Keowee. However, FERC identified the geographic scope of the cumulative effects analysis for water resources as the Savannah River to its mouth. To support this evaluation, CHEOPS results for the three downstream USACE reservoirs were reviewed to identify differences in the timing and magnitude of flow releases from Keowee into Lake Hartwell, the most upstream USACE reservoir.

As discussed above, both the Baseline and Bad Creek II scenarios include continued compliance with the existing KT FERC license including implementation of the LIP and the 2014 Operating Agreement. These requirements limit the potential effects of Project operations and Bad Creek II proposed operations on the USACE reservoirs. As shown in Table E.8-38, average annual downstream flow releases from the Keowee Development under both scenarios are identical under Normal and ccLow hydrology; using the ccHigh hydrology, differences are less than one percent. Consequently, the average annual releases from the J. Strom Thurmond Development are identical for both scenarios using Normal and ccLow hydrology and differ by only 0.1 percent under ccHigh hydrology.

Table E.8-38. Average Annual Flow Releases from the Keowee and J. Strom Thurmond Developments for the Baseline and Bad Creek II Scenarios (1939-2011)

Hydrology	Keowee Average Annual Release (cfs)			J. Strom Thurmond Average Annual Release (cfs)		
	Baseline	Bad Creek II	Change (%)	Baseline	Bad Creek II	Change (%)
Normal	944	94	0	7,719	7,719	0
ccLow	939	939	0	7,680	7,680	0
cc High	829	837	0.9	6,825	6,833	0.1

The timing of downstream releases is also tightly aligned as demonstrated by an evaluation of the total cumulative volume of water released downstream of the Keowee Development and J. Strom Thurmond for the POR (see Figure 6-5 in the *Water Exchange Rates and Lake Jocassee Reservoir Levels Final Report* in Appendix D). Given these findings, few if any effects on the USACE reservoirs are anticipated.

Task 4 Conclusions

Reviewing the results of the Baseline and Bad Creek II scenarios leads to the following observations:

- Additional reservoir storage at the Bad Creek Reservoir would be accessed with Bad Creek II operations as compared to operations under the Baseline Scenario.
- Lake Jocassee reservoir level fluctuations over a 24-hour period would generally be smaller than would occur under the Baseline Scenario. The 24-hour fluctuations would be two ft or less approximately 90 percent of the time under the Bad Creek II scenario, but only 75 percent of the time under the Baseline Scenario.
- The effects of the proposed Bad Creek II on lake level fluctuations at Lake Keowee would be comparable to the effects of Bad Creek. There is no significant long-term difference between reservoir elevations including reservoir level range or reservoir level fluctuation frequencies.
- Proposed Bad Creek II operations have no modeled effect on municipal water intakes on Lake Keowee or the intake for Oconee Nuclear Station.
- LIP Stage 0 would be triggered more frequently with Bad Creek II, but the differences in LIP stage frequencies generally diminish in the more advanced stages of the LIP.
- Proposed Bad Creek II operations have little to no modeled effects on the downstream USACE reservoirs or flow releases into the Savannah River.

E.8.2.1.5 Water Quality Monitoring Plan Development (Task 5)

Potential impacts to water resources are anticipated associated with the construction and operation of Bad Creek II. Development of the Bad Creek II WQMP is a collaborative effort between Duke Energy, the State regulatory agency (i.e., SCDES), and other relicensing stakeholders and documents methods for monitoring site conditions to maintain Project compliance with SCDES ESC requirements in upland watersheds and turbidity water quality standards in the Whitewater River arm of Lake Jocassee. The WQMP is applicable for waters covered under a CWA USACE Section 404 permit/SCDES Section 401 WQC and identifies and documents frequency and location of water quality sampling/monitoring for in-water work (Lake Jocassee) as well as locations for qualitative monitoring of upland waters that would be applicable under a SCDES NPDES Construction Stormwater Permit.[23] The WQMP describes two different monitoring strategies to assess Project waters depending on location (i.e., Lake Jocassee vs. upland areas).

Lake Jocassee: Water quality monitoring in the Whitewater River cove of Lake Jocassee will follow established Duke Energy procedures and standard methodology for water surface measurements. Duke Energy proposes to monitor the following water quality parameters during the construction and post-construction phases:

- Turbidity
- DO
- Temperature
- pH

Data will be compared to state water quality criteria. During the construction phase, all four parameters will be measured, but only turbidity data will be used to inform construction activities, since increased suspended loading is the proposed impact. Duke Energy seeks a temporary variance from SCDES during construction of Bad Creek II to meet the turbidity compliance criteria standard for South Carolina freshwater lakes (25 NTU) instead of TPGT waters (10 NTU) under S.C. Reg.61-69 given that sensitive populations will be able to avoid areas of higher turbidity and move into other areas of Lake Jocassee (i.e., abundant availability and accessibility to turbidity refugia exists) and potentially increased turbidity levels will be temporary (i.e., fish that leave Whitewater River cove are expected to return following the impact). A more conservative turbidity threshold of 25 NTU for compliance reporting, which would still be protective of natural resources, would allow Duke Energy to construct the new facility while maintaining compliance with state regulations, which is a critical focus of Duke Energy for any project. Surface water quality at the proposed compliance point at the downstream end of Whitewater River cove will be measured daily throughout construction. If daily readings exceed the turbidity compliance threshold (i.e., excursion) for more than 10 percent (but less than 25 percent) of readings over a rolling 30-day period, Duke Energy will investigate to determine if excursions are the

23 Note that quantitative water quality monitoring in upland areas is not required or proposed under the WQMP during the construction phase for the purposes of land disturbance.

direct result of construction activities or if they are tied to rain events. If elevated turbidity is determined to be the result of a rainfall event (i.e., overland flow and runoff), data characterizing the rain event (timing and amount of precipitation) will be documented using the nearest weather station along with corresponding turbidity data. If turbidity excursions are not clearly linked to a rainfall event (i.e., attributable to construction-related activities), Duke Energy will consult with SCDES if daily readings exceed the turbidity compliance threshold of more than 10 percent but less than 25 percent of readings over a rolling 30-day period. For additional details, see the *Water Quality Monitoring Plan* in Appendix D.

Upland areas: During construction, temporary BMPs (e.g., sediment basins, silt fences, waddles, etc.) proposed under the SCDES Construction General Permit will be installed, regularly inspected, and maintained to control runoff from affected areas into surface waters. Water quality monitoring is not required or proposed as part of the SCDES Construction General NPDES permit; however, Duke Energy proposes to conduct stream habitat quality assessment surveys in perennial streams associated with drainage from spoil areas before and after Bad Creek II construction. Stream habitat surveys will implement the USEPA Rapid Bioassessment Protocol (RBP), North Carolina Stream Assessment Method (NCSAM), South Carolina Stream Quality Tool, and macroinvertebrate sampling. For perennial streams associated with drainage from spoil areas, the point of compliance will be in an accessible downstream reach where the cumulative effect of the construction can be observed. This location will be used to document stream conditions and function where water has flowed from the construction area, through a BMP, and into waters of the U.S. Assessments will be carried out prior to construction and at 1-, 3-, and 5-years following construction to ensure streams provide fully functioning and supportive habitat and replicate original (pre-construction) stream conditions.

The WQMP was developed in coordination with the Water Resources Committee as a task under the Water Resources Study to address water quality monitoring and associated impacts to water quality during construction of Bad Creek II. The WQMP will also be used to support the application for the 401 WQC, and the final plan is included in Appendix D. A separate Standard Operating Procedures document will be developed in parallel with the construction permitting process and will provide technical and logistical details associated with the WQMP.

E.8.2.2 Project Impacts on Water Resources

In SD2, FERC identified the following environmental issues related to water resources to be addressed in its NEPA document:[24]

- Effects of construction-related erosion, sedimentation, and spoils disposal on water quality, aquatic habitat, and aquatic biota in Lake Jocassee and streams in the project vicinity.
- Effects of Project operation on water levels in Lake Jocassee.*****
- Effects of Project operation on water quality in Lake Jocassee, including water temperature, dissolved oxygen (DO) concentrations, and vertical mixing of DO.*****

E.8.2.2.1 Effects of Construction-Related Erosion, Sedimentation, and Spoils Disposal on Water Quality in Lake Jocassee and Streams in the Project Vicinity

Temporarily elevated turbidity levels are anticipated in the Whitewater River cove of Lake Jocassee during construction activities associated with the I/O structure and expansion of the existing submerged weir. Additionally, temporarily elevated turbidity levels in Lake Jocassee due to surface runoff have the potential to occur during high precipitation events impacting construction areas. Therefore, the primary (temporary) impact to surface water quality in Lake Jocassee is increased turbidity caused by potential sediment loading from construction activities (e.g., proposed lower reservoir I/O and cofferdam, bank excavation, expansion of the submerged weir), as well as overland runoff due to temporary land disturbance.

Construction of Bad Creek II would cause unavoidable impacts to streams and waterbodies in the expanded Project Boundary. Impacts as defined under CWA Section 404 are quantifiable and would occur from facility development (e.g., transformer yard), overburden (i.e., soil and rock) placement, and expansion of the transmission line corridor (Table E.8-39; Figure E.8-14 through Figure E.8-18). Indirect impacts could also occur such as increased sediment runoff due to traffic on access roads during construction. Impacts as a result of “Facility Development” is summarized in Table E.8-39 and consist of streams and open waterbodies that occur within the footprint of the preliminary LOD for the crescent yard expansion, the lower reservoir I/O area, the switchyard and associated grading, the contractor staging area, and the transformer yard and associated grading. These impacts are assumed to be permanent in nature.

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[24] FERC stated that issues with an asterisk (*) will be analyzed for both cumulative and site-specific effects.

As currently proposed, a new 525-kV transmission line would be constructed between the Bad Creek II switchyard and Jocassee Tie and a short section of the existing 525-kV line will also be rerouted. The ROW for the new 525-kV line will adjoin the existing ROW and use existing ROW access routes for construction, however installation of new or enlarged culverts at access route stream crossings may be necessary and are estimated in Table E.8-39.

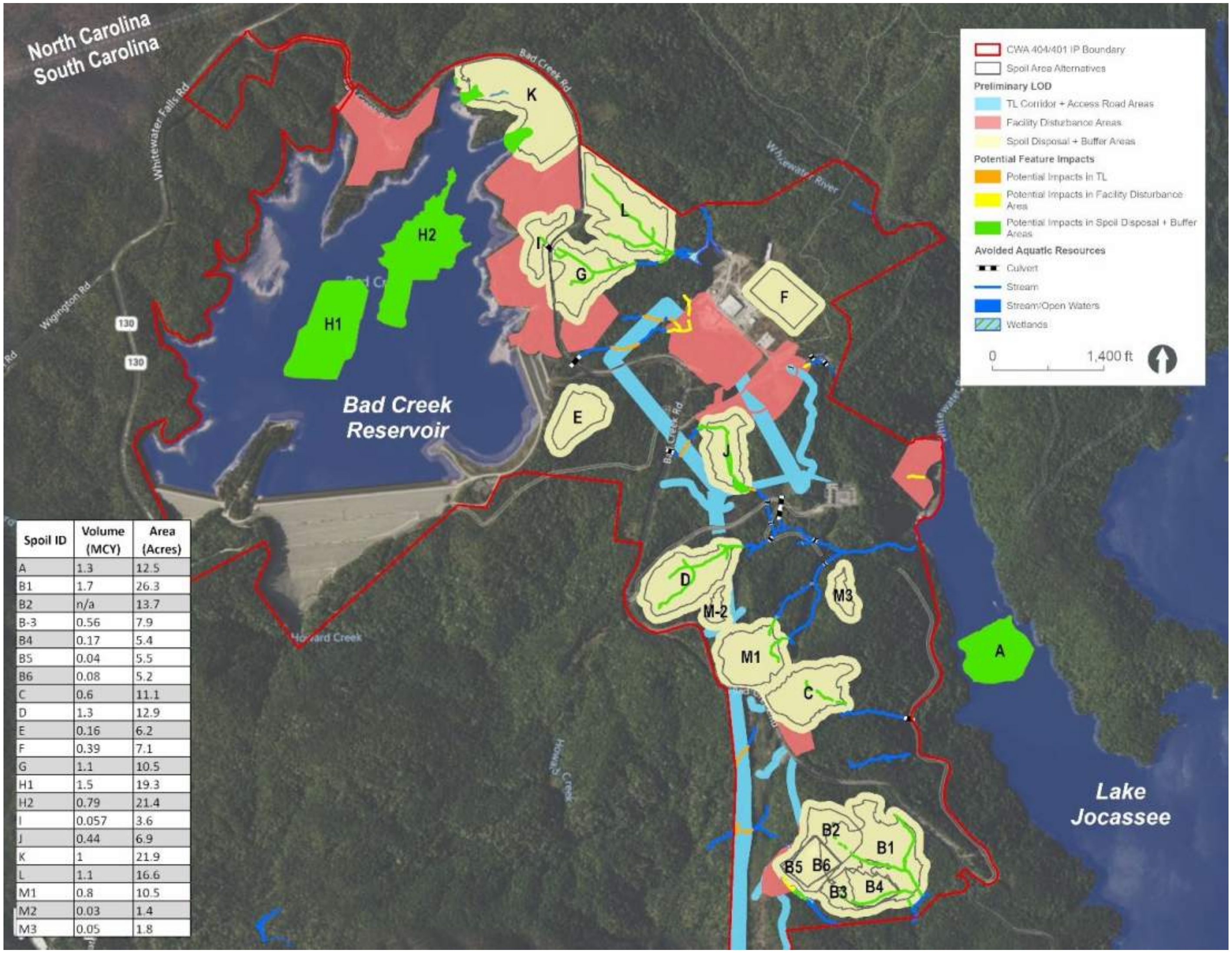
Overburden (i.e., soil and rock) material from the construction activities are proposed to be deposited in several spoil locations throughout the site. A total of 21 spoil locations have been identified for potential on-site spoil deposition, however only siting for spoil locations alternatives is ongoing by Duke Energy. Due to the amount of material to be managed for construction, existing topography, and prevalence of headwater streams and seeps located throughout the site, it is unlikely there would be a practicable alternative identified that will result in zero impacts to streams and downstream waters. Placement of excavated rock removed from the underground excavations to the downstream slope of the existing submerged weir in Lake Jocassee, as was done for the construction of the existing Project, would significantly reduce the amount of material to be placed at upland disposal sites, thereby reducing impacts to existing streams and wetlands. Upland disposal resulting in impacts to streams or wetlands, as well as placement of rock spoils at the submerged weir, will require an individual permit from the USACE as well as water quality certification from SCDES under the authorities of Sections 404 and 401 of the CWA, as described in Section E.4.1. Impacts due to spoil placement were estimated for individual spoil pile footprints (permanent impact) and a 100-foot buffer area required for the work area (temporary impact). Preliminary estimated impacts to waters due to Bad Creek II construction are included in Table E.8-39; Duke Energy plans to refine spoil area configurations and revise associated impacts for the FLA.

Table E.8-39. Preliminary Estimated Impacts to Streams and Open Waterbodies due to the Construction of Bad Creek II

Activity	Streams (linear ft)		Open Water (acres)	
	Permanent Impact	Temporary Impact	Permanent Impact	Temporary Impact
Facility Development	1,303	--	--	--
Transmission Line Corridor Expansion				
Transmission Line Corridor	--	--	--	--
Transmission Line Access Routes	281	--	--	--
Spoil Areas				
A	--	--	12.5	--
B1	3,007	414	--	--
B2			--	--
B3			--	--

Activity	Streams (linear ft)		Open Water (acres)	
	Permanent Impact	Temporary Impact	Permanent Impact	Temporary Impact
B4			--	--
B6[1]	--		--	--
C	529	--	--	--
D	2,134	121	--	--
E	--	--	--	--
F	--	--	--	--
G	1,744	--	--	--
H1	--	--	19.3	--
H2		--	21.4	--
I	99	--	--	--
J	1,763	434	--	--
K	--	--	1.39	1.12
L	2,231	500	--	--
M1	403	215	0.08	--
M2	--	--	--	--
M3	--	--	--	--

[1] B5/B6 generally overlay one another. Additionally, due to the complexity of Spoil Areas B1-B6 overlap, only the direct footprint of Spoil Area B6 was assessed separately for permanent stream and open water impacts.



Spoil ID	Volume (MCY)	Area (Acres)
A	1.3	12.5
B1	1.7	26.3
B2	n/a	13.7
B-3	0.56	7.9
B4	0.17	5.4
B5	0.04	5.5
B6	0.08	5.2
C	0.6	11.1
D	1.3	12.9
E	0.16	6.2
F	0.39	7.1
G	1.1	10.5
H1	1.5	19.3
H2	0.79	21.4
I	0.057	3.6
J	0.44	6.9
K	1	21.9
L	1.1	16.6
M1	0.8	10.5
M2	0.03	1.4
M3	0.05	1.8

Figure E.8-14. Preliminary Potential Impacts to Waters of the U.S. within the Expanded Project Boundary (Excluding the Transmission Line Corridor)

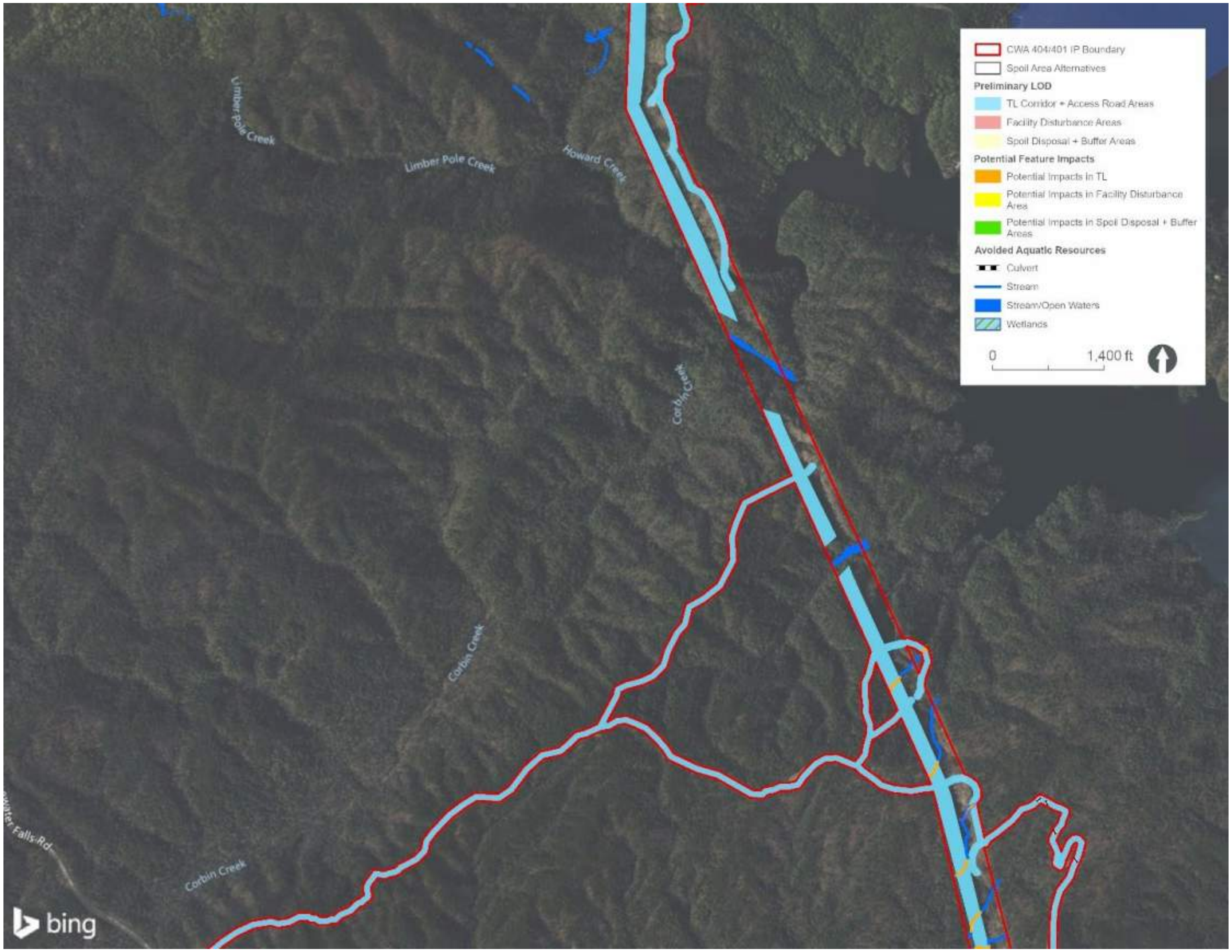


Figure E.8-15. Preliminary Potential Impacts to Waters of the U.S. within the Transmission Line Corridor

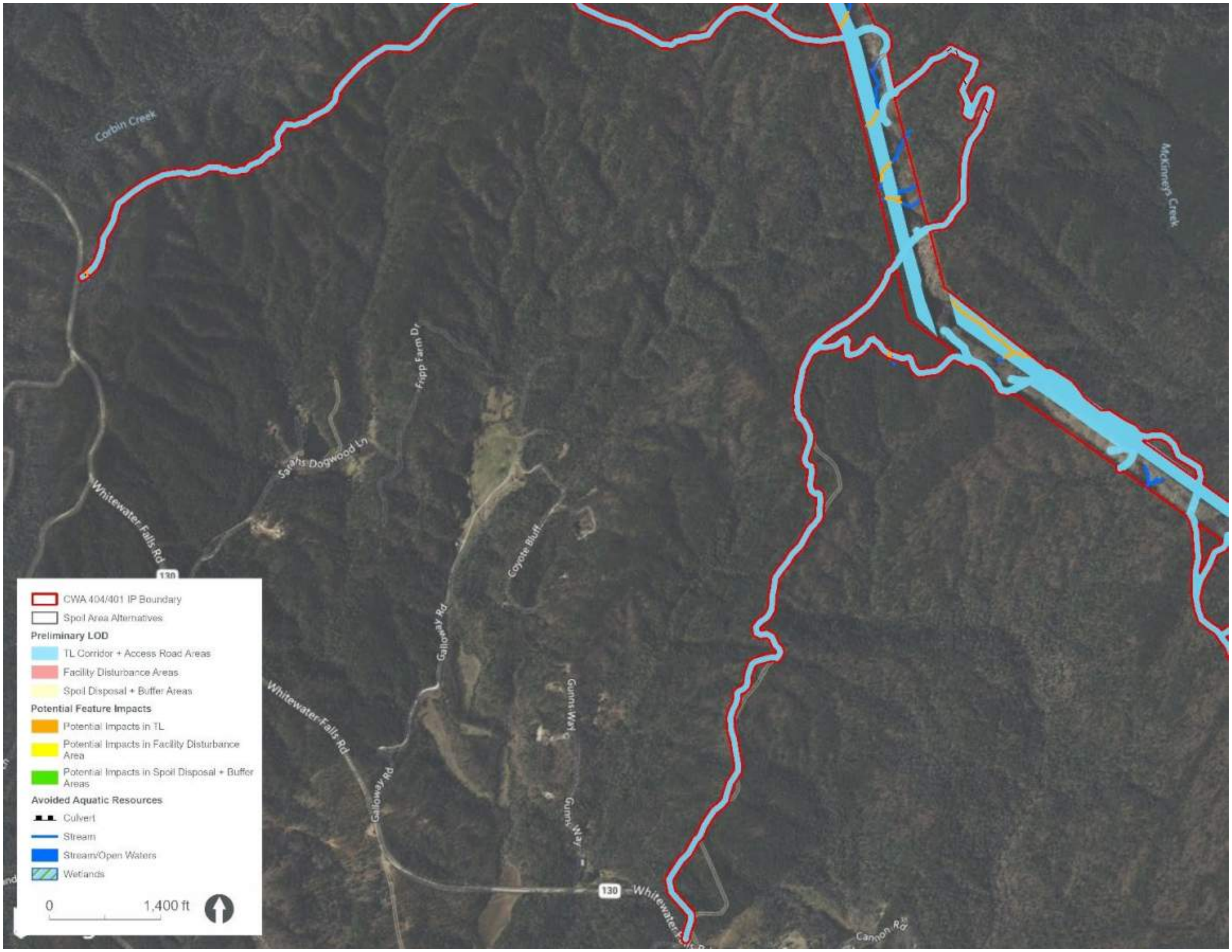


Figure E.8-16. Preliminary Potential Impacts to Waters of the U.S. within the Transmission Line Corridor

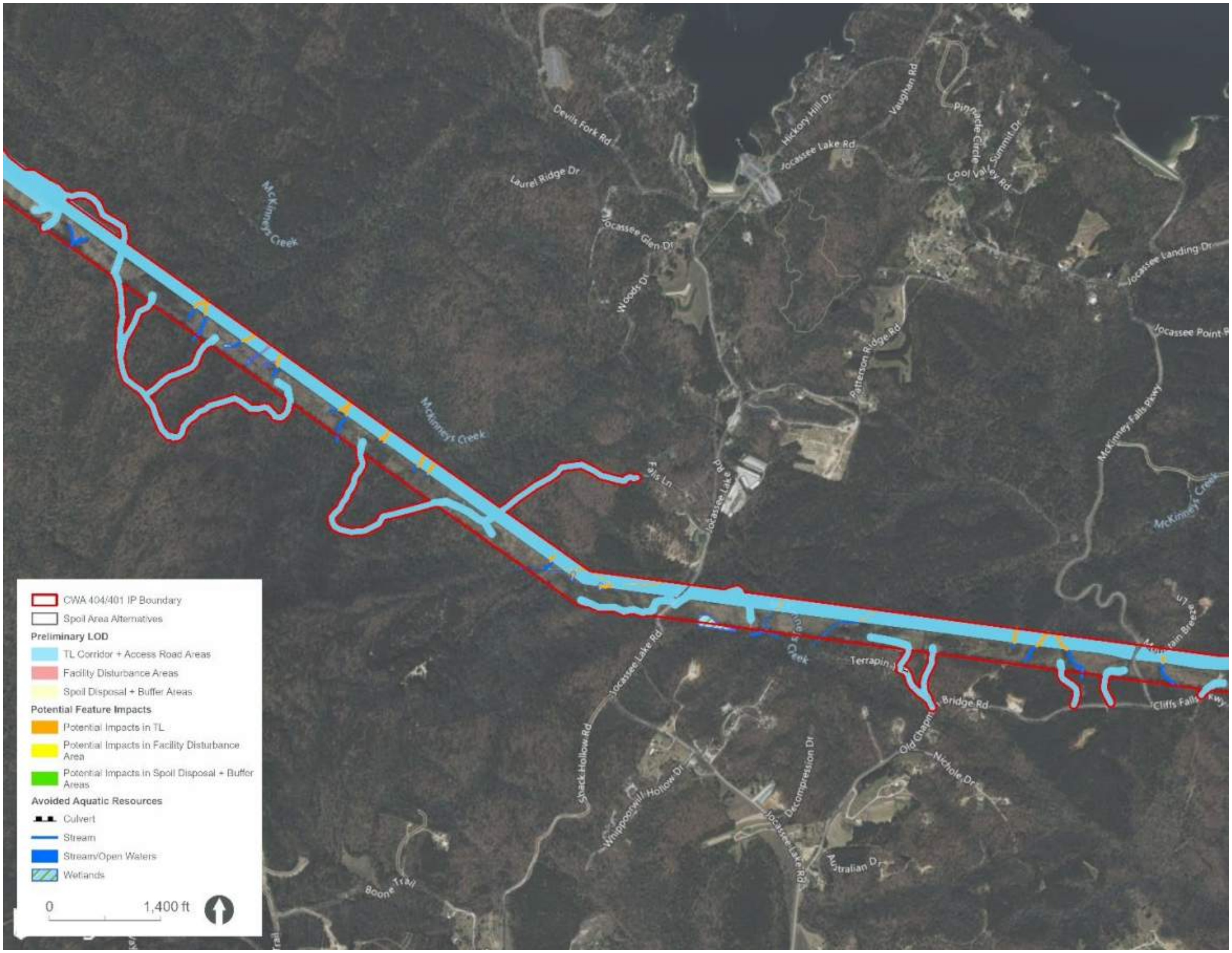


Figure E.8-17. Preliminary Potential Impacts to Waters of the U.S. within the Transmission Line Corridor

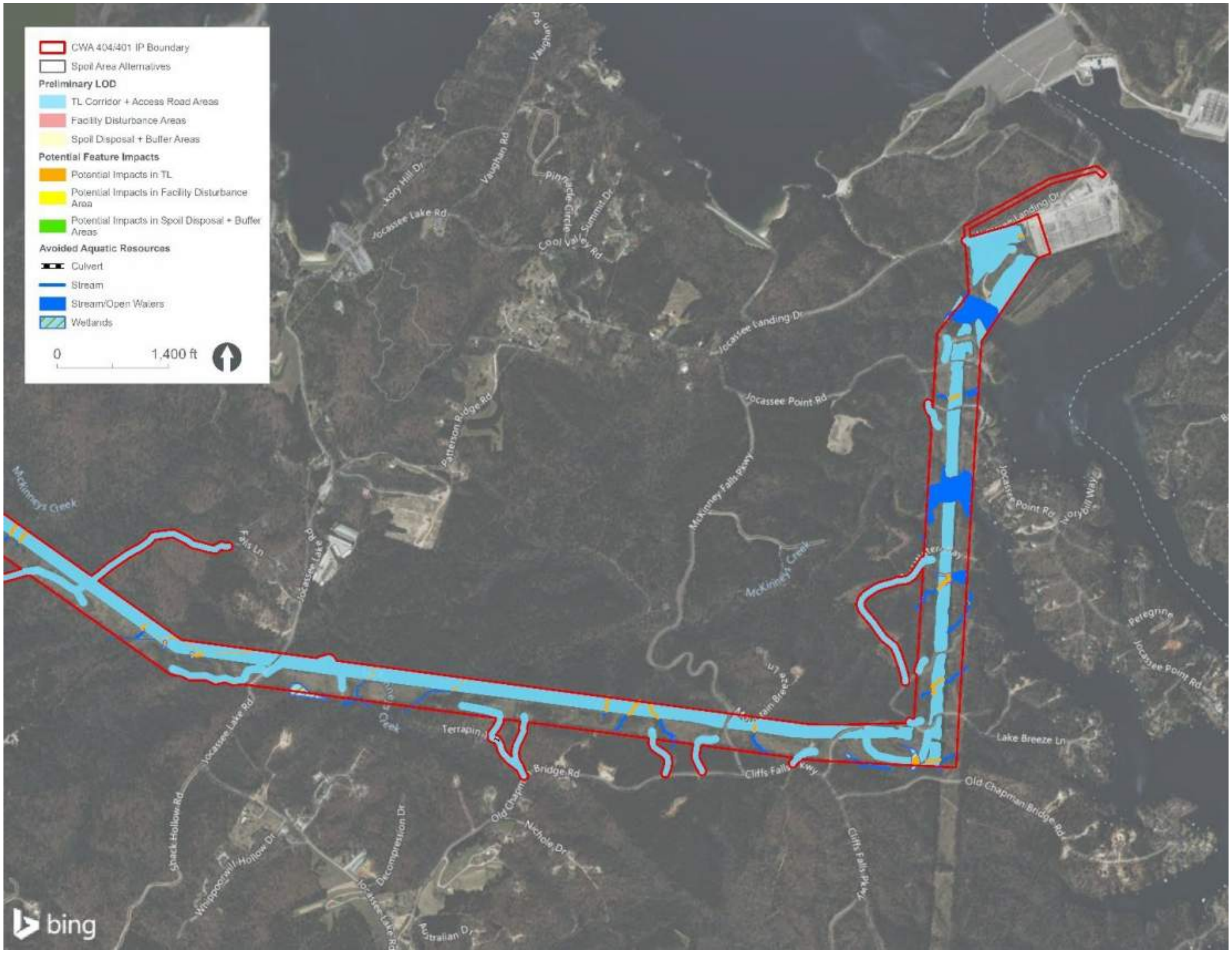


Figure E.8-18. Preliminary Potential Impacts to Waters of the U.S. within the Transmission Line Corridor

Excess sediment deposition and accumulation in upland areas have the potential to alter water quality and bottom substrate that provides important habitat to aquatic species; BMPs would be put in place during construction and a comprehensive ESC Plan would be implemented during all phases of construction to reduce impacts to the extent possible. The WQMP includes monitoring locations and methods to conduct stream habitat quality assessment surveys in perennial streams associated with drainage from spoil areas. Operations of Bad Creek II are not likely to affect existing streams or tributaries.

Long-term impacts to the water quality of Lake Jocassee are not expected as a result of the operation of the proposed Bad Creek II. The primary (temporary) impact to surface water quality (Lake Jocassee) during construction would be increased suspended sediment loads due to overland runoff and stream bank activities associated with the construction activities. These activities could lead to elevated turbidity levels, decreased DO levels, and degradation of aquatic habitat in Lake Jocassee; however, effects would only occur in a localized area and would likely affect only the Whitewater River arm of Lake Jocassee. Temporary impacts during construction activities would also occur in the Whitewater River cove due to construction of the new lower reservoir I/O structure and expansion of the submerged weir by placement of rock materials excavated during tunneling activities. Similar to the impacts of the construction of the existing Project, temporarily elevated turbidity would be anticipated in the Whitewater River arm of Lake Jocassee. Previous studies during original weir construction indicated while turbidity did increase during the construction phase, turbidity levels returned quickly to normal following construction activities.

Turbidity will be monitored regularly in Lake Jocassee during the expansion of the weir and Bad Creek II construction and will continue to be monitored for one year after commencement of Bad Creek II operations, as described in the WQMP. Lake Jocassee is considered trout waters, therefore, the state standard water surface criteria is not to exceed 10 NTU. Because there is abundant availability and accessibility to turbidity refugia and potentially increased turbidity levels will be temporary, Duke Energy is seeking from SCDES a temporary water quality turbidity variance of 25 NTU, which is the criteria for freshwater lakes in South Carolina, at the Whitewater River cove compliance point downstream of Bad Creek II for the duration of construction activities.

Construction of Bad Creek II will result in short-term (non-permanent) changes to onsite water use and disposal. The EPC Contractor may install temporary pumping and conveyance systems that utilize the upper and/or lower reservoirs as water sources (Duke Energy notes that withdrawals of 3,000,000 gallons per month would require separate and additional permitting) or may refurbish groundwater wells previously utilized during the original Bad Creek Project construction. The EPC Contractor will also be responsible for development of temporary sanitary facilities and systems.

E.8.2.2.2 Effects of Project Operation on Water Levels in Lake Jocassee

Existing Project

The effects of Project operation on Lake Jocassee water levels are minimal due to the relative difference in size between Bad Creek Reservoir and Lake Jocassee. If the entire Bad Creek Reservoir active storage volume of 31,808 acre-ft (i.e., the volume of water of the reservoir's 160-ft operating range) was released, Lake Jocassee's elevation would increase by approximately 4 ft if Jocassee Pumped Storage Station were not operating. However, this minor effect is further dampened by Duke Energy's current practice of generally operating the Project and Jocassee Pumped Storage Station in tandem; the Project and Jocassee Pumped Storage station typically generate at the same time and typically pump at the same time.

Operational data at the Project and Lake Jocassee for 15 years (2006 through 2020) indicate an average daily change of approximately 10 ft in Bad Creek Reservoir levels with a maximum daily change of 60 ft. Assuming no operation of Jocassee Pumped Storage Station, the volume of water associated with the average daily change equates to a change of 0.5 ft of elevation at Lake Jocassee. The largest single day change in Bad Creek Reservoir elevation would result in a change of 2.4 ft of elevation at Lake Jocassee.

Bad Creek II

Operation of the proposed Bad Creek II, which will add pumping and generating capacity to the Project, has the potential to effect water surface elevations of Lake Jocassee. Duke Energy used the CHEOPS model to evaluate the difference in water exchange rate, frequency, and magnitude between Bad Creek Reservoir and Lake Jocassee due to the addition of a second powerhouse. Additionally, potential impacts to Lake Keowee as a result of operating Bad Creek II were evaluated.

Model results for the Baseline and Bad Creek II scenarios were compared to identify potential differences in the effects of Bad Creek II as contrasted with existing license conditions. This comparison is focused primarily on reservoir elevation effects.

Model results showed approximately 60 percent of the time, the Bad Creek II scenario results in an approximately 15-foot increase in 24-hour fluctuation of the Bad Creek Reservoir as compared with the Baseline scenario. In contrast, at Jocassee, about 97 percent of the time, the Bad Creek II scenario results in an approximately 0.4- to 0.2-ft decrease in 24-hour reservoir elevation fluctuations as compared to the Baseline scenario. The decreased range in 24-hour reservoir elevation fluctuations in Lake Jocassee is due to increased generation and pumping volumes associated with Bad Creek II operations. Both Bad Creek and Bad Creek II operations are synched with Jocassee Pumped Storage

Station operations in Duke Energy's dispatch curves and subsequently the model such that both Bad Creek and Bad Creek II typically generate and pump when Jocassee generates and pumps. However, a larger volume of water moves between Bad Creek Reservoir and Lake Jocassee in the Bad Creek II scenario, offsetting more of the lake level fluctuation effects at Lake Jocassee caused by Jocassee Pumped Storage Station operations. The model indicates little to no difference in 24-hour fluctuations at Lake Keowee or downstream reservoirs between the Bad Creek II scenario and the Baseline scenario.

Based on the modeling results, impacts to water levels in Lake Jocassee from the operation of Bad Creek II are expected to be minimal.

E.8.2.2.3 Effects of Project Operation on Water Quality in Lake Jocassee

Existing Project

Water quality data presented in Section E.8.2.1.1 indicates that overall, the effect of Bad Creek operations on Lake Jocassee water quality is negligible except for the effects seen at the monitoring station upstream of the submerged weir in Whitewater River cove. Upstream of the submerged weir, data from monitoring Station 564.1 indicate mixing (from Bad Creek operations), which prevents stratification in the water column. Temperature and DO values have a uniform profile within the water column at Station 564.1. Immediately downstream of the submerged weir at location 564.0, post Bad Creek operation condition datasets show stratification and trends that follow trends at monitoring locations in other portions of the lake; therefore, based on the desktop review of existing water quality data, results indicate that the submerged weir confines mixing to the upstream portion of the Whitewater River cove upstream of the submerged weir and effects of operations are not noted downstream of the weir.

Duke Energy collected continuous water temperature data and periodic DO concentration data (bi-weekly) from locations near three historic monitoring stations in Whitewater River arm of Lake Jocassee to determine current-day representative (i.e., baseline) water quality information. Data collected in 2023 represented conditions under three-unit operations and data collected in 2024 represented conditions under fully upgraded four-unit operations at the Project. There is no noticeable difference in the water quality datasets due to increased pumping or generation. Results from both years indicate water upstream of the submerged weir is, as expected, well-mixed and does not stratify, or may be weakly stratified for a short period of time in early summer in the upper water column. Data from monitoring locations downstream of the weir reveal stratification under all pumping and generation scenarios, indicating the weir is functioning as it was designed and helps to dissipate energy from the lower reservoir I/O structure. This preservation of stratification downstream of the weir is also supported by historical water quality monitoring and by CFD model results under current Project conditions as well as Bad Creek II conditions, which will have near double the flows generated from the combined powerhouses.

Due to the relatively small surface area, high degree of mixing, and short residence time of water in the Bad Creek Reservoir, warming impacts due to solar radiation in the upper reservoir are limited, therefore, conditions in the Whitewater River arm are reflective of conditions in the upper reservoir.

Based on historical and recently collected water quality data, impacts to water quality in Lake Jocassee from the operation of the existing project are confined to the uppermost reach of Whitewater River cove.

Bad Creek II

Operation Impacts to Lake Jocassee

Operation of Bad Creek II has the potential to impact waters of Lake Jocassee. It was concluded in early modeling studies (prior to operation of the existing Project) the only substantial impact to Lake Jocassee related to Bad Creek Project operations was vertical mixing of the reservoir. This impact is reduced downstream through the presence of the submerged weir. Similar to the I/O structure for the Bad Creek Project, the I/O structure for Bad Creek II would be upstream of the submerged rock weir; therefore, vertical mixing is expected to be limited to this isolated area of Whitewater River cove. Based on extensive CFD modeling of the Whitewater River cove to support the evaluation of an additional powerhouse within the Whitewater River arm of Lake Jocassee upstream of the weir (see Section E.7.2.1.2), results indicated velocities produced by full generation from both powerhouses (i.e., existing and proposed) are similar to maximum velocities experienced in the Whitewater River cove since operations began in 1991. Vertical mixing upstream and downstream of the weir was similar from existing to proposed conditions, therefore, no additional impacts to water quality in Lake Jocassee are anticipated due to operations of Bad Creek II.

Site and Road Impacts

Traffic on access roads used during construction through continued Project operation can also increase sediment runoff, therefore, BMPs (e.g., vegetation or matting) will be installed near haul roads and access roads. Additionally, spill prevention, control, and safety management plans will be in place to prevent vehicle fluids from entering the watersheds if spilled.

E.8.3 Protection, Mitigation, and Enhancement Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.8.3.1 Existing Bad Creek Project

There are no known potential adverse effects to existing uses of Project waters or water quality in the upper or lower reservoirs due to the continued operation of the Project, therefore, no additional PM&E measures are proposed at this time. The Licensee anticipates implementing the new Water Quality Certificate that will be issued by SCDES.

E.8.3.2 Bad Creek II

Upland placement of spoil materials will result in potential impacts to surface waters. Therefore, an individual permit from the USACE will be required as well as a water quality certification from SCDES under the authorities of Sections 404 and 401 of the CWA, as described in Section E.4.1. Note that the upland disposal areas (e.g., spoil areas) will also be located within the overall Project LODs and the construction phase activities and temporary land disturbance impacts will be covered under the SCDES NPDES Construction General permit (e.g. erosion and sediment control permit). The LOD will be planned with perimeter and internal BMPs such that the overland stormwater flow / water quantity will be managed. Water quality monitoring is not required or proposed as part of the SCDES Construction General NPDES permit.

During construction, temporary BMPs (e.g., sediment basins, silt fences, waddles, etc.) proposed under the SCDES Construction General Permit will be installed, regularly inspected, and maintained to control runoff from affected areas into surface waters. Spill Prevention, Control, and Containment Plans and a Hazardous Materials Containment and Fuel Storage Plan will be developed for the expanded Project construction, as well as for Bad Creek II operation. The construction plan will include measures for stormwater that has the potential to contain petroleum-based or other controlled substances to be provided with containment and measures to prevent release into natural receiving waters. Spill containment will also be provided for all oil filled transformers, other oil filled equipment, oil storage areas, and chemical storage/unloading areas. Containment will consist of curbing, concrete sumps or walled pits with grating installed for equipment access. The bottom of the containment shall slope to a sump, and containments shall be appropriately coated to protect the concrete surface. All containments will have a minimum of 6 inches of freeboard above the required level of the contained liquids.

While no long-term degradation of water quality is expected to result from construction of Bad Creek II, construction activities could result in temporary impacts related to erosion and sedimentation, therefore, Duke Energy proposes to implement the WQMP, which includes conducting stream habitat quality assessment surveys in perennial streams associated with drainage from spoil areas and routine turbidity monitoring in Lake Jocassee (see Appendix D).

- *Upland streams*: Stream assessments would consist of evaluating downstream reaches where the cumulative effect of construction activities can be observed. These locations would be used to document stream conditions and function where water has flowed from the construction area, through a BMP, and into waters of the U.S. Pre-construction stream conditions can be compared with post-construction conditions to document construction-related impacts and also determine when areas have recovered to pre-construction conditions to help plan for site restoration/stabilization.
- *Lake Jocassee*: A monitoring station is proposed in Whitewater River cove downstream of the submerged weir where daily measurements of DO, temperature, pH, and turbidity will be recorded during construction and for one year following commencement of Bad Creek II operations. Turbidity will be used for compliance reporting since elevated suspended sediment is the proposed impact. Proposed methods and reporting criteria for monitoring are included in the WQMP. Duke Energy's proposed monitoring strategy addresses potential challenges in meeting SCDES water quality standards during construction by reviewing turbidity data routinely during construction immediately downstream of the Project so that any turbidity-related issues can be identified quickly and mitigative management controls applied if necessary. Water quality monitoring will continue for one year following Bad Creek II operations.
- *Bad Creek Reservoir*: Routinely monitoring water quality in Whitewater River cove during and shortly after Bad Creek II construction will provide the additional benefit of water quality information in Bad Creek Reservoir since water is exchanged directly between the upper reservoir and the Whitewater River cove.

As an off-license measure under the BCRA, the Licensee will also make a funding contribution of $500,000 to the Lake Keowee Source Water Protection Program for initiatives to protect and enhance water quality in the KT Project watershed (which includes the area draining to Bad Creek Reservoir) within two years following new license issuance, and an additional $500,000 within one year following the start of commercial operation of Bad Creek II.

E.9 Fish and Aquatic Resources

E.9.1 Affected Environment

E.9.1.1 Aquatic Habitat

Aquatic habitat within the expanded Project Boundary includes Bad Creek Reservoir, Lake Jocassee, streams, and wetlands. Streams present in upland areas within the expanded Project Boundary are described in Section E.8.1.4 and wetlands are described in Section E.10.

E.9.1.1.1 Bad Creek Reservoir

Bad Creek Reservoir is approximately 363 acres in extent. Bad Creek Reservoir is used only for Project operations; it is not designated for any other uses and therefore has no applicable state or federal water quality standards (see Sections E.8.1.5 and E.8.1.6). Due to the water level fluctuations, no public access (including fishing) is permitted for Bad Creek Reservoir. Since there are no regulatory designations, water sampling is not performed and no aquatic habitat or aquatic biota information is available for Bad Creek Reservoir.

E.9.1.1.2 Lake Jocassee

Littoral Habitat

The littoral fish habitat in Lake Jocassee resembles many undeveloped mountain lakes in the Carolinas, comprising rocky outcrops (77 percent of the littoral zone), sand (8 percent), emergent vegetation or stream confluences (7 percent), residentially developed piers and riprap (4 percent), clay (3 percent), and cobble (1 percent) (Duke Energy 2014c). Much of the littoral zone exhibits steep slopes, with areas of significant woody debris (large stumps). Standing timber in deeper areas of Lake Jocassee (at depths greater than 100 ft) may provide trout habitat during the summer and fall months if not excluded by water quality characteristics related to seasonal stratification (Barwick et al. 2004). Limited aquatic vegetation growth is likely due to a steep littoral zone, insufficient substrate, and frequent water level fluctuations preventing plant establishment.

Duke Energy used the CHEOPS operations model to simulate hourly water levels in Lake Jocassee under four alternative scenarios compared to baseline conditions as related to KT Project operations, using hydrology from the years 1939 to 2011 (Duke Energy 2014c). Twelve metrics were defined to assess the effects on spawning conditions for black bass, sunfish, blueback herring, and threadfin shad. Under the most severe hydrologic conditions modeled, hourly model outputs indicate KT Project operations support reservoir target levels for at least 20 consecutive days, at least 99 percent of the time, and 100 percent of the time for 15 or fewer consecutive days for the black bass spawning period.

Given that littoral spawning species hatch and disperse from nests within 5 days of hatching, the 20-consecutive-day period of uninterrupted spawning should enhance an already healthy fish community for shallow water species. The stable reservoir conditions may also benefit pelagic species such as threadfin shad or blueback herring by expanding habitat.

Fish species spawning in the littoral zone are primarily sunfish and black bass, which are highly adaptable spawners and maintain robust populations in Lake Jocassee (Duke Energy 2014c; see Section E.9.1.2.2). Life history characteristics fostering successful reproduction for these species include spawning over a range of water depths, the relatively short duration required for eggs to hatch and for larvae to become mobile, and high fecundity (see Section E.9.1.4.1).

Pelagic Habitat

Lake Jocassee is classified as an oligotrophic waterbody exhibiting low productivity, low nutrient concentrations, and high clarity. Generally, DO concentrations remain relatively high due to the low productivity (slow consumption of oxygen due to limited biological activity and benthic decomposition rates) (Dobson and Frid 2009). It is a dimictic lake experiencing seasonal thermal stratification (summer) and mixing (winter), however as stated in Section E.8.1.6.3, the lake's geomorphological characteristics can sometimes result in minor mixing between the upper and lower levels of the water column, allowing for thermal stratification to persist for up to four years without turn-over (Duke Power Company 1995a). Seasonal stratification can lead to a "temperature-oxygen squeeze" for some coldwater species, limiting the habitat available due to hypoxic hypolimnetic waters and a warm epilimnion (Coutant 1985).

E.9.1.1.3 Essential Fish Habitat

The NOAA Inland Essential Fish Habitat Mapper was reviewed for Lake Jocassee and Bad Creek Reservoir. Neither waterbody contains Essential Fish Habitat requiring consultation with NOAA.

E.9.1.2 Environmental Studies and Agreements under the Work Plan

Duke Energy filed a revised Exhibit S within one year of the original FERC license issuance to address fish and wildlife PM&E measures. Environmental studies under the revised Exhibit S required by the FERC license included an assessment of Project effects on fish entrainment and associated mortality; coldwater fish (trout) habitat in Lake Jocassee; and a detailed mitigation plan with proposed fish and wildlife PM&E measures to be implemented by Duke Energy to mitigate impacts associated with Bad Creek Project operations on Lake Jocassee and nearby stream fisheries. Duke Energy and the

SCDNR developed the MOU in 1996 to establish a framework to help maintain the high-quality fisheries of lakes Jocassee and Keowee (SCDNR and Duke Energy 1996).

The Bad Creek Fishery Resources MOU resulted in three, successive 10-Year Work Plans (i.e., 1996 – 2005; 2006 – 2016[25]; and 2017 – 2027). The activities and agreements in the 10-Year Work Plans include:

1) Agreement on minimizing fish entrainment via the Project;
2) Electrofishing of littoral fish populations;
3) Water quality monitoring for trout habitat;
4) Hydroacoustic monitoring of small pelagic fish;
5) Cost sharing for trout stocking; and
6) Cost sharing for fisheries research and enhancements.

While most of the activities and agreements under the scope of work include both lakes Jocassee and Keowee, only descriptions relative to Lake Jocassee are included herein.

Current 10-Year Work Plan (2017-2027)

The current 10-Year Work Plan (2017-2027; SCDNR and Duke Energy 2016) continues many of the management activities implemented in prior work plans. Duke Energy and SCDNR continue to cooperatively monitor the fishery in lakes Jocassee and Keowee while annually reviewing the results of the monitoring studies. Many of the studies and activities conducted at Lake Jocassee under the MOU are relevant to assessing potential environmental impacts associated with existing and continued operation of the Project. The current 10-Year Work Plan is composed of the same main components as the six listed above, with the exception of water quality monitoring for trout habitat (no. 3 above), which was completed under the 2006-2015 work plan (see Section E.9.1.2.4). However, trout habitat monitoring in Lake Jocassee was adopted as a requirement of the KT Relicensing Agreement and will continue through that project's current license period (expires August 31, 2046).

E.9.1.2.1 Bad Creek Pumped Storage Station Entrainment Study

Duke Energy completed a fish entrainment study at Bad Creek during the first three years of Project operations (1991-1993) (Barwick et al. 1994). The entrainment study plan was developed in cooperation with the SCDNR and the USFWS. The study goals were to: (1) estimate the number and

[25] Several activities conducted under the first two 10-year work plans were identified as PM&E measures under the KT Project (FERC No. 2503) and are now included in the KT Project Relicensing Agreement and the new license issued by FERC in 2016. As a result, the original 2006 – 2015 Work Plan was extended by one year to cover 2016.

mortality of fish entrained from Lake Jocassee during the pumping mode of operation and (2) evaluate the impact of entrainment on fishery resources in Lake Jocassee.

Project Operations during Entrainment Sampling

The existing Project uses excess electricity to pump water from Lake Jocassee into Bad Creek Reservoir for later use in generation to meet system demands (Barwick et al. 1994). During pumping, water can be withdrawn from Lake Jocassee through four bays in the upper reservoir I/O structure at a depth of 50-80 ft (when the reservoir is at full pond). Pumping with Units 1 or 2 withdraws water through Bays 1 and 2 and pumping with Units 3 or 4 withdraws water through Bays 3 and 4. Pumped storage operations can result in weekly water level fluctuations of 98-131 ft in Bad Creek Reservoir. The total annual hours of pumping during the 3-year entrainment study (for all units combined) were 2,789 hours (1991), 4,385 hours (1992), and 7,070 hours (1993).

Entrainment Sampling Methods

To estimate entrainment during pumping at the Project, fixed hydroacoustic techniques and full-recovery netting were used from January 1991 through December 1993 (Barwick et al. 1994). Hydroacoustic monitoring was conducted to estimate the density of fish, or entrainment rate, through the facility. Full-recovery netting was performed to assess the accuracy of hydroacoustic estimates and species composition of fish entrained.

For hydroacoustic monitoring, one transducer was mounted above each bay at 8.0 m below full pond elevation of Lake Jocassee (Barwick et al. 1994). For details on hydroacoustic system models, transducers, and installed depths and locations, see Barwick et al. (1994). All hydroacoustic entrainment data were expressed as mean number of fish entrained per hour per month per bay.

Full-recovery samples were at least 2.5 hours in duration; sample specimens were identified to lowest practical taxonomic level, enumerated, and measured for total length. Early in the study, because daytime entrainment was low and netting during the day provided little meaningful data beyond that collected at night, daytime netting was discontinued (in March 1992).

Mortality was assumed to be 100 percent for all fish entrained during pumping operations. A summary of multiple empirical entrainment studies summarized by the Electric Power Research Institute demonstrates that some survival occurs through hydroelectric power facilitates (EPRI 1997), and therefore an assumption of 100 percent mortality is an overvaluation.

Regression analyses were used to determine the relationship between numbers of fish caught in the nets (except when large numbers of turbine-struck fish were caught or one of the nets failed) and numbers of fish estimated via hydroacoustics to have been entrained (Barwick et al. 1994). No attempt was made to estimate entrainment at the Project during the generation mode (versus pumping) of operation because, as stated above, it was assumed that fish would experience 100 percent mortality if entrained during pumping.

Entrainment Study Results

Total annual entrainment in 1991 was estimated at 51,146 fish or 18.3 fish per hour based on 2,789 hours of pumping operations at Bad Creek (Table E.9-1) (Barwick et al. 1994). In 1992, an estimated 22,183 fish or 5.1 fish per hour were entrained during 4,385 hours of pumping operations. Entrainment was generally highest during spring and early summer in 1991, and greatest in summer and early fall in 1992. Five species comprised greater than 90 percent of fish entrained during the study: threadfin shad (*Dorosoma petenense*), blueback herring (*Alosa aestivalis*), bluegill (*Lepomis macrochirus*), white bullhead (*Ameiurus catus*), and redbreast sunfish (*Lepomis auritus*). All other taxa represented two percent or less of the total estimated entrainment. Generally, most of the fish entrained were small or intermediate in length with few fish longer than 300 millimeters.

Table E.9-1. 1991-1993 Bad Creek Project Entrainment Study Results

Year	Estimated Entrainment Rate (fish/hour)	Hours of Pumping	Total Estimated Fish Entrained	Dominant Species (Relative Abundance)
1991	18.3	2,789	51,146	Threadfin shad (36.0%) Blueback herring (23.8%) Bluegill (20.6%) White catfish (10.5%) Redbreast sunfish (3.5%) *Total: 94.4%*
1992	5.1	4,385	22,183	Blueback herring (57.5%) Threadfin shad (13.7%) Bluegill (13.4%) White catfish (9.8%) Redbreast sunfish (2.5%) *Total: 96.9%*
1993	45.0	7,070	317,998	Threadfin shad (87.7%) Blueback herring (9.1%) *Total: 96.9%*

Source: Barwick et al. (1984)

Annual fish entrainment estimated for 1993 was considerably higher than the previous two years (Barwick et al. 1994). An estimated 317,998 fish (45.0 fish per hour) were entrained during 7,070 hours of pumping operations (Table E.9-1). Entrainment was highest during fall and early winter. Eighteen taxa were entrained in 1993, with total numbers dominated by threadfin shad (87.7 percent) followed by blueback herring (9.1 percent). All other fish species represented less than two percent of the total estimated entrainment. Most of the entrained fish were small or intermediate in length.

A complication of the study arose when a significant number of fish were entrained a second time (re-entrainment) after being pumped from Lake Jocassee into Bad Creek Reservoir, then returned to Lake Jocassee during generation and entrained again during subsequent pumping (Barwick et al. 1994). An assumption of the study was that all fish entrained during pumping would experience mortality and therefore no live fish would be re-entrained during generating operations. After consultation with the SCDNR, modifications to the sampling plan were made to reduce the statistical errors introduced by re-entrainment; however, re-entrainment was not eliminated completely, and additional studies were conducted in 1993 in an attempt to better understand the rate of re-entrainment (Barwick et al. 1994). Based on these (unpublished) studies, entrainment results were thought to be overestimated (conservative) for years 1992 and 1993. Due to limited hours of pumping in 1991 (i.e., least chance of re-entrainment), the annual entrainment losses were thought to be the most accurate estimate of entrainment rates (Barwick et al. 1994).

Project operations and resulting turbulence and water velocities near the intakes impacted entrainment during the study. An excerpt from Barwick et al. (1994) provides additional details on the relationship between operation and entrainment:

> *Fish entrainment [at the Project] was highest on Bay 1, with entrainment on Bays 2, 3, and 4 being considerably lower and similar. Even though two-unit (simultaneous pumping with Units 1 and 2 or Units 3 and 4) and four-unit (simultaneous pumping with all units) pumping resulted in higher intake velocities and moved a much larger volume of water than one-unit pumping, the number of fish entrained per hour was at times higher during one-unit pumping than during two-unit or four-unit pumping. In 1993, entrainment rates during one-unit pumping were generally more than twice that noted for two-unit and four-unit pumping. Preliminary velocity measurements near the discharge indicated that flow patterns may be responsible for the reduced rate of entrainment during two- and four-unit operation (J. C. Knight, Duke Power Company, personal communication). During one-unit operation laminar flows were noted. However, during two-unit operation (no measurements of velocity were made during 4-unit operation) considerable turbulence was noted some distance from the discharge structure. This turbulence may act as a behavioral barrier that prevented fish from moving into the immediate vicinity of the discharge structure. If this were true, this turbulence may keep fish far enough away from the discharge structure to result in reduced entrainment during two-unit and four-unit pumping.*

Summary of Entrainment Study

The rate of entrainment at Bad Creek was generally low (five fish/hour) during most of the study (October 1991-August 1993) (Barwick et al. 1994). Overall, an estimated 391,327 fish were entrained at the Bad Creek Project during 14,244 hours of pumping from 1991 to 1993. A total of 300,406 of these fish were threadfin shad and most were entrained in late 1993 in response to low water levels in Lake Jocassee (14 ft below full pond elevation). Blueback herring, white catfish, redbreast sunfish, and bluegill were the only other taxa entrained in significant numbers.

Results of entrainment studies indicated: (1) entrainment had no statistical impact on the abundance of prey and sportfish taxa in Lake Jocassee; (2) entrainment had no statistical impact on the effort and harvest of fish by anglers fishing Lake Jocassee; and (3) entrainment had no predicted long-term impact on the prey fish population in Lake Jocassee during normal operating conditions observed in 1991-1993 (Barwick et al. 1994). Results of risk assessment studies predicted low probability of impact by entrainment on threadfin shad during normal operations of the Bad Creek Project; however, a major die-off may occur if there is an extended drawdown period in Lake Jocassee (which congregates fish present in the upper water column in closer proximity to the I/O structure) or low water temperatures due to a colder than average winter. It is important to note the significance of re-entrainment on the overall number of fish entrained at the Bad Creek Project may have had a profound impact on the overall number of fish estimated to be entrained at the Project, however, it could not be determined to what extent.

E.9.1.2.2 Electrofishing of Littoral Fish Population

Duke Energy has monitored spring littoral fish populations in Lake Jocassee via boat-mounted electrofishing since 1996 (SCDNR and Duke Energy 1996) and continues every three years (i.e., 2017, 2020, 2023, and 2026) under the current 10-Year Work Plan (SCDNR and Duke Energy 2016). The electrofishing surveys document fish species by number and weight at 20 representative (300-m long) shoreline sampling locations, consisting of 10 in the upper portions of Lake Jocassee (i.e., Toxaway and Whitewater arms) and 10 in the lower portion (i.e., main body) (Figure E.9-1) (Duke Energy 2014c).

Similar to many reservoir fisheries in the southeastern U.S., warmwater species such as centrarchids (sunfish and black bass) dominated samples numerically, comprising 72 to 92 percent of fish collected in the lower portion reservoir and 63 to 94 percent of fish collected in the upper portion of the reservoir (Table E.9-2) (Duke Energy 2014c, 2016a, 2021a, 2024). Coldwater species such as rainbow trout [*Oncorhynchus mykiss*] and brown trout [*Salmo trutta*] were infrequently collected. A review of biomass in kilograms (kg) shows standing stock was consistently higher in the upper portions of Lake Jocassee than the lower portion of the reservoir (Table E.9-3), which are typical limnological patterns in response to upstream nutrient inputs in reservoir systems (Green et al. 2015).

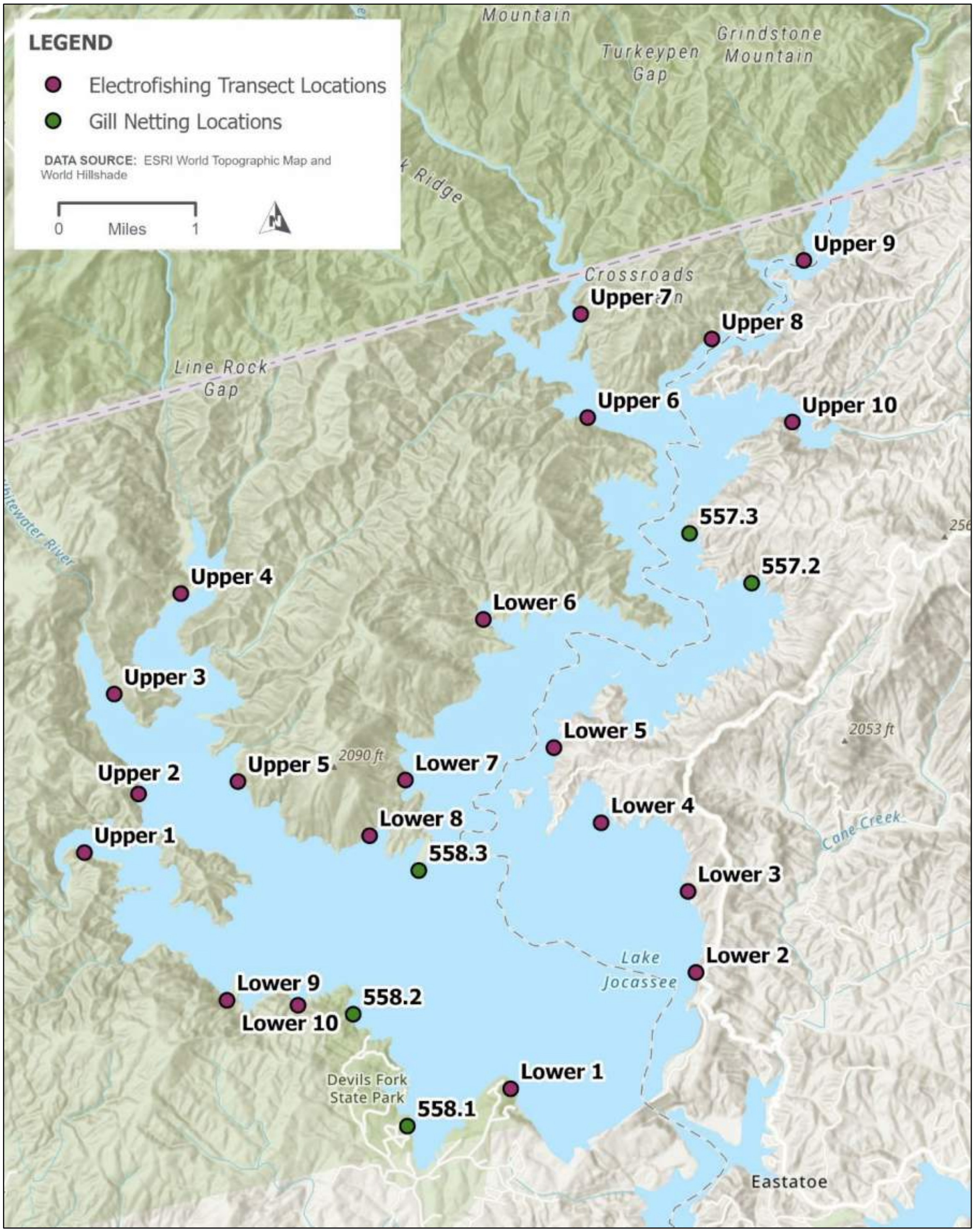


Figure E.9-1. Lake Jocassee Fish Sampling Locations

Table E.9-2. Number of Fish Collected during Spring Electrofishing in Lake Jocassee

Common Name	Species Name	Survey Year									
		1996	1999	2002	2005	2008	2011	2014	2017	2020	2023
Upper Lake Jocassee											
Alabama bass	*Micropterus henshalli*	1	--	--	1	1	2	1	3	14	10
Bartram's bass	*Micropterus* sp. cf. *cataractae*	60	81	96	50	87	87	115	24	12	20
Black crappie	*Pomoxis nigromaculatus*	2	--	1	--	--	--	--	--	--	--
Blackbanded darter	*Percina nigrofasciata*	--	--	--	--	--	2	1	--	--	1
Blueback herring	*Alosa aestivalis*	414	9	17	178	71	23	168	--	559	263
Bluegill	*Lepomis macrochirus*	62	81	288	330	702	273	244	68	41	191
Brassy jumprock	*Moxostoma* spp.	--	1	--	1	--	4	--	--	--	--
Brown trout	*Salmo trutta*	1	--	--	--	--	--	--	--	--	--
Common carp	*Cyprinus carpio*	12	9	5	1	1	--	--	--	--	1
Flat bullhead	*Ameiurus platycephalus*	4	4	4	4	4	8	10	2	1	--
Golden shiner	*Notemigonus crysoleucas*	--	--	--	--	1	1	--	--	--	--
Green sunfish	*Lepomis cyanellus*	14	18	12	29	53	134	37	18	17	38
Hybrid black bass	*Micropterus* spp.	--	--	--	--	1	--	6	--	1	1
Hybrid sunfish	*Lepomis* spp.	--	1	5	10	3	5	4	4	--	16
Largemouth bass	*Micropterus salmoides*	31	37	45	38	58	41	34	43	34	81
Notchlip redhorse	*Moxostoma collapsum*	2	1	--	--	--	--	--	--	--	--
Rainbow trout	*Oncorhynchus mykiss*	--	--	--	--	--	--	--	--	--	1
Redbreast sunfish	*Lepomis auritus*	118	221	212	242	354	357	251	115	80	208
Redear sunfish	*Lepomis microlophus*	--	--	--	--	--	--	--	--	--	--
Smallmouth bass	*Micropterus dolomieu*	1	--	1	1	1	5	2	2	--	--
Snail bullhead	*Ameiurus brunneus*	--	--	1	4	4	3	1	14	7	13
Striped jumprock	*Moxostoma rupiscartes*	--	--	--	1	--	--	--	--	--	--
Threadfin shad	*Dorosoma petenense*	--	649	101	--	--	--	--	--	--	--
Walleye	*Sander vitreus*	--	1	--	--	--	--	--	--	--	--
Warmouth	*Lepomis gulosus*	4	1	3	8	13	17	3	2	1	6
Whitefin shiner	*Cyprinella nivea*	19	31	45	46	75	16	16	14	15	50
Yellow perch	*Perca flavescens*	1	--	--	1	--	--	2	--	--	--
	Total	**745**	**1,145**	**836**	**944**	**1,429**	**978**	**893**	**306**	**768**	**900**
Lower Lake Jocassee											
Alabama bass	*Micropterus henshalli*	--	--	2	4	4	--	5	1	21	13
Bartram's bass	*Micropterus* sp. cf. *cataractae*	55	63	77	38	23	56	77	12	4	6
Black crappie	*Pomoxis nigromaculatus*	--	--	--	--	--	--	--	--	--	--
Blackbanded darter	*Percina nigrofasciata*	--	--	--	--	1	1	--	--	--	1

Common Name	Species Name	Survey Year									
		1996	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**	**2017**	**2020**	**2023**
Blueback herring	*Alosa aestivalis*	6	77	44	171	81	31	45	--	354	--
Bluegill	*Lepomis macrochirus*	133	67	246	270	370	221	251	44	34	258
Brassy jumprock	*Moxostoma* spp.	--	--	--	--	--	--	--	--	--	--
Brown trout	*Salmo trutta*	--	2	2	--	--	--	--	--	2	--
Common carp	*Cyprinus carpio*	17	8	11	1	--	--	3	--	--	--
Flat bullhead	*Ameiurus platycephalus*	1	--	--	--	3	1	12	1	--	--
Golden shiner	*Notemigonus crysoleucas*	2	--	--	--	1	--	--	--	--	--
Green sunfish	*Lepomis cyanellus*	31	12	42	26	42	58	47	19	14	38
Hybrid black bass	*Micropterus* spp.	--	--	--	--	6	1	--	--	3	--
Hybrid sunfish	*Lepomis* spp.	--	--	9	4	6	3	5	3	--	26
Largemouth bass	*Micropterus salmoides*	9	12	13	5	8	9	2	6	9	12
Notchlip redhorse	*Moxostoma collapsum*	--	--	--	--	--	--	--	--	--	--
Rainbow trout	*Oncorhynchus mykiss*	1	--	--	--	--	--	--	--	1	--
Redbreast sunfish	*Lepomis auritus*	264	167	391	259	415	239	500	79	92	327
Redear sunfish	*Lepomis microlophus*	--	--	--	--	--	1	1	--	--	--
Smallmouth bass	*Micropterus dolomieu*	--	2	24	--	4	3	7	8	--	1
Snail bullhead	*Ameiurus brunneus*	4	2	1	12	6	13	2	14	34	14
Striped jumprock	*Moxostoma rupiscartes*	--	--	--	--	--	1	--	--	--	--
Threadfin shad	*Dorosoma petenense*	--	--	98	--	--	--	--	--	--	--
Walleye	*Sander vitreus*	--	--	--	--	--	--	--	--	--	--
Warmouth	*Lepomis gulosus*	5	2	9	6	12	11	1	1	1	10
Whitefin shiner	*Cyprinella nivea*	27	1	11	1	253	65	31	29	9	8
Yellow perch	*Perca flavescens*	--	--	--	--	--	--	--	--	--	--
	Total	**555**	**415**	**980**	**797**	**1,235**	**714**	**989**	**216**	**577**	**714**

-- No fish collected.
Source: Duke Energy 2014c, 2016a, 2021a, 2024.

Table E.9-3. Weight (kg) of Fish Collected during Spring Electrofishing in Lake Jocassee

Common Name	Species Name	Survey Year									
		1996	1999	2002	2005	2008	2011	2014	2017	2020	2023
Upper Lake Jocassee											
Alabama bass	*Micropterus henshalli*	<0.1	--	--	<0.1	0.4	<0.1	0.2	0.1	3.5	2.2
Bartram's bass	*Micropterus* sp. cf. *cataractae*	6.6	10.4	9.5	7	11.9	10	13.4	3.9	2.2	6.2
Black crappie	*Pomoxis nigromaculatus*	0.6	--	1.2	--	--	--	--	--	--	--
Blackbanded darter	*Percina nigrofasciata*	--	--	--	--	--	<0.1	<0.1	--	--	0.0
Blueback herring	*Alosa aestivalis*	10.3	0.1	0.3	2.1	0.7	0.2	1.2	--	3.3	1.4
Bluegill	*Lepomis macrochirus*	1.1	1.8	2.1	3.8	2.8	3.2	3.4	1.7	0.8	3.0
Brassy jumprock	*Moxostoma* spp.	--	0.2	--	0.7	--	1.3	--	--	--	--
Brown trout	*Salmo trutta*	0.1	--	--	--	--	--	--	--	--	--
Common carp	*Cyprinus carpio*	17.3	13.7	6.2	1.7	1.1	--	--	4.9	--	2.8
Flat bullhead	*Ameiurus platycephalus*	1.1	0.4	0.2	0.2	0.2	0.6	0.8	0.1	0.1	--
Golden shiner	*Notemigonus crysoleucas*	--	--	--	--	<0.1	<0.1	--	--	--	--
Green sunfish	*Lepomis cyanellus*	0.5	0.4	0.5	0.7	0.6	2.7	2.2	0.2	0.4	0.8
Hybrid black bass	*Micropterus* spp.	--	--	--	--	0.2	--	0.9	--	0.4	0.9
Hybrid sunfish	*Lepomis* spp.	--	0.1	0.2	0.3	0.1	0.2	0.1	0.2	--	0.4
Largemouth bass	*Micropterus salmoides*	17.2	10.1	17	15.9	19.9	6.1	18.6	9.8	17.5	44.8
Notchlip redhorse	*Moxostoma collapsum*	1.5	1.2	--	--	--	--	--	--	--	--
Rainbow trout	*Oncorhynchus mykiss*	--	--	--	--	--	--	--	--	--	0.1
Redbreast sunfish	*Lepomis auritus*	5	6.4	4.1	6.4	4.9	5.4	6.5	2.5	2.6	4.0
Smallmouth bass	*Micropterus dolomieu*	<0.1	--	<0.1	0.7	1.1	1.4	0.1	1.5	--	--
Snail bullhead	*Ameiurus brunneus*	--	--	0.1	0.1	0.2	0.2	0.1	0.8	0.4	0.9
Striped jumprock	*Moxostoma rupiscartes*	--	--	--	0.1	--	--	--	--	--	--
Threadfin shad	*Dorosoma petenense*	--	1.8	0.3	--	--	--	--	--	--	--
Walleye	*Sander vitreus*	--	1.5	--	--	--	--	--	--	--	--
Warmouth	*Lepomis gulosus*	0.1	<0.1	<0.1	0.1	0.1	0.4	0.1	--	--	0.1
Whitefin shiner	*Cyprinella nivea*	0.1	0.1	0.2	0.1	0.3	0.1	0.1	--	--	0.2
Yellow perch	*Perca flavescens*	<0.1	--	--	<0.1	--	--	<0.1	--	--	
		61.4	**48.2**	**41.8**	**40**	**44.5**	**31.8**	**47.8**	**25.7**	**31.3**	**67.6**
Lower Lake Jocassee											
Alabama bass	*Micropterus henshalli*	--	--	<0.1	0.4	1.1	<0.1	2.8	0.1	2.6	1.8
Bartram's bass	*Micropterus* sp. cf. *cataractae*	5.5	8.5	7.2	7.4	2.3	6.2	12.4	2.7	1.1	2.0
Blackbanded darter	*Percina nigrofasciata*	--	--	--	--	<0.1	<0.1	--	--	--	0.0

Common Name	Species Name	Survey Year									
		1996	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**	**2017**	**2020**	**2023**
Blueback herring	*Alosa aestivalis*	0.2	1.2	0.2	2.4	1.1	0.2	0.3	--	2.4	--
Bluegill	*Lepomis macrochirus*	2.3	2.6	3.2	5.6	2.8	3	4.3	0.8	1.1	4.8
Brown trout	*Salmo trutta*	--	0.2	0.2	--	--	--	--	--	0.2	--
Common carp	*Cyprinus carpio*	20.9	18.5	14.3	1.4	--	--	5.5	--	--	--
Flat bullhead	*Ameiurus platycephalus*	<0.1	--	--	--	0.2	0.1	1.2	--	--	--
Golden shiner	*Notemigonus crysoleucas*	<0.1	--	--	--	<0.1	--	--	--	--	--
Green sunfish	*Lepomis cyanellus*	0.6	0.4	0.5	0.7	0.5	0.7	0.9	0.2	0.3	0.5
Hybrid black bass	*Micropterus* spp.	--	--	--	--	1.4	0.1	--	--	1.2	--
Hybrid sunfish	*Lepomis* spp.	--	--	0.2	0.1	0.1	0.1	0.2	0.3	--	0.4
Largemouth bass	*Micropterus salmoides*	7.1	10.5	8.4	2.9	3.8	3.1	0.9	8	8.5	4.9
Rainbow trout	*Oncorhynchus mykiss*	0.1	--	--	--	--	--	--	--	--	--
Redbreast sunfish	*Lepomis auritus*	6.3	5.4	5.7	6.6	4.6	4.7	10.3	1.6	1.9	6.5
Redear sunfish	*Lepomis microlophus*	--	--	--	--	--	<0.1	<0.1	--	--	--
Smallmouth bass	*Micropterus dolomieu*	--	1.6	1.2	--	0.4	0.5	1.3	0.7	--	0.6
Snail bullhead	*Ameiurus brunneus*	0.2	0.1	<0.1	0.6	0.2	0.7	0.1	0.7	1	1.0
Striped jumprock	*Moxostoma rupiscartes*	--	--	--	--	--	<0.1	--	--	--	--
Threadfin shad	*Dorosoma petenense*	--	--	0.3	--	--	--	--	--	--	--
Warmouth	*Lepomis gulosus*	0.1	0.1	0.1	0.2	0.1	0.1	<0.1	<0.1	--	0.2
Whitefin shiner	*Cyprinella nivea*	0.1	<0.1	0.1	0.1	0.4	0.2	0.1	0.1	--	0.1
	Total	**43.4**	**49.1**	**41.7**	**28.4**	**18.9**	**19.9**	**40.3**	**15**	**20.5**	**22.7**

-- No fish collected.
Source: Duke Energy 2014c, 2016a, 2021a, 2024.

E.9.1.2.3 Gill Net Studies

As part of the 1996-2005 Work Plan, gill netting was performed at five locations annually by SCDNR and funded by Duke Energy (Figure E.9-1) (SCDNR and Duke Energy 1996). The purpose of these studies was to contribute data to the longest-running database on the Jocassee fishery. Gill netting was first implemented in 1975, prior to the development of creel survey or hydroacoustic techniques. Gill netting data also provided information on trout densities, species and strain performance, year class strength, growth, and survival among other population health characteristics. These data were used to inform stocking and management decisions, such as creel and size limits.

From 1999 to 2012, numbers and biomass of brown trout averaged 87 fish and 115.6 kg per 40 gill-net sets (Table E.9-4 and Table E.9-5) (Rodriguez 2013). Fewer rainbow trout were collected (average of 7 fish and 3.7 kg per 40 gill-net sets); however, this species may not be sampled efficiently with gill nets. Numbers and biomass of total black basses averaged 110 fish and 84.1 kg per 40 gill-net sets, the majority of which consisted of Bartram's bass (*Micropterus* sp., 87 percent of black bass numbers and 77 percent of black bass biomass). The remainder of black basses were comprised of largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*). Numbers and biomass of white catfish averaged 40 fish and 10.7 kg per 40 gill-net sets.

Table E.9-4. Number of Fish Collected in Gill Net Sampling on Lake Jocassee, 1999-2012

Year	Brown Trout	Bullhead Catfish	Largemouth Bass	Rainbow Trout	Bartram's Bass	Smallmouth Bass	White Bass	White Catfish
1999	74	24	9	1	107	14	1	57
2000	124	6	5	3	111	3	2	20
2001	126	14	7	3	86	3	0	14
2002	139	17	5	0	85	5	0	17
2003	107	4	3	36	59	8	0	25
2004	80	2	4	4	64	2	0	9
2005	83	13	1	1	102	8	1	58
2006	49	28	2	5	127	8	1	3
2007	51	18	8	22	118	18	4	11
2008	85	7	13	6	120	7	0	23
2009	116	39	9	4	125	15	1	93
2010	53	33	8	3	76	9	0	60
2011	69	61	4	4	91	9	1	100
2012	68	38	6	2	63	8	0	66
Mean	**87**	**22**	**6**	**7**	**95**	**8**	**1**	**40**

Source: Rodriguez 2013.

Table E.9-5. Biomass (kg) of Fish Collected in Gill Net Sampling on Lake Jocassee, 1999-2012

Year	Brown Trout	Bullhead Catfish	Largemouth Bass	Rainbow Trout	Bartram's Bass	Smallmouth Bass	White Bass	White Catfish
1999	114.2	3.3	14.3	0.2	68.1	24.4	1.1	8.4
2000	172.6	0.6	8.6	0.8	69.8	5	2.9	3.8
2001	194.7	1.9	10.6	2.3	54.1	7.6	0	10.7
2002	167.8	1.3	8.1	0	53.4	4.9	0	6.6
2003	132.6	0.3	4.7	12.8	50.6	8.9	0	6.8
2004	89.4	0.1	6.9	1.9	42.3	2.6	0	4.6
2005	111.6	0.6	0.6	0.2	63.9	9	0.7	8.8
2006	80.9	3.8	5.1	4.2	85.3	8.7	1.6	1.1
2007	67.9	2.5	11	17.3	90.7	21.2	5.1	5.9
2008	113.1	2.5	30.4	2.7	86.4	5.7	0	20.7
2009	126.6	3.2	15.8	2.9	78.3	15.6	1	20.9
2010	60.9	2.6	11.4	2.4	53.3	8.4	0	12.7
2011	89.7	5.9	4.7	2	58.3	8.4	0.5	22.2
2012	95.7	3.3	10	1.9	39.9	10.1	0	17.1
Mean	**115.6**	**2.3**	**10.2**	**3.7**	**63.9**	**10**	**0.9**	**10.7**

Source: Rodriguez 2013.

E.9.1.2.4 Lake Jocassee Trout Habitat

Lake Jocassee is one of only a few reservoirs in South Carolina containing a combination of water temperatures and DO levels supporting both a warmwater and a coldwater (trout) fishery year-round (USACE 2014). Soon after the creation of Lake Jocassee in the early 1970's, South Carolina state fishery biologists introduced rainbow and brown trout into the reservoir to diversify the fishery of the waterbody. Annual stockings of these species have continued and are an important part of the state's management goals of creating and maintaining a productive coldwater sport fishery. The success of the fishery is dependent on adequate availability of suitable pelagic habitat, as defined by specific thermal and DO criteria.

Vertical profile surveys of temperature and DO have been conducted in Lake Jocassee since 1973. Water quality data were collected at multiple locations starting at the water surface (0.3 m) and proceeding downward at 2-m intervals to the reservoir bottom (Foris 2008). Locations were selected to assure adequate characterization of the spatial aspects of pelagic trout habitat throughout the reservoir, including up-lake, mid-lake, and down-lake sampling locations (Figure E.9-2). Profile data allow evaluation of the vertical and horizontal distribution of trout habitat conditions, as measured by thickness/depth (m) and volume (cubic meter), throughout the year and prediction of late-summer (i.e., September) trout habitat thickness in the main body of the reservoir using an empirical model developed by Duke Energy (Foris 1991). Pelagic trout habitat is defined as water with temperatures ≤ 20.0 degrees Celsius (°C) and DO concentrations ≥ 5.0 (mg/L) (Oliver et. al. 1978).

The temporal and spatial distribution of trout habitat over the 1973-2015 period were consistent with typical temperature and DO regimes observed in Lake Jocassee (Duke Energy 2014c; Duke Energy 2016a). Seasonally, more habitat was available during the winter cooling period when temperatures were well below 20°C, and DO concentrations generally exceeded 5.0 mg/L. As the seasons progressed and air temperatures increased, habitat availability gradually declined both horizontally and vertically within the reservoir due to warming of the upper water column layers and depletion of DO in the middle and lower portions of the water column (Figure E.9-3). Habitat was consistently at a minimum in late summer (September) just prior to fall cooling, coinciding with the height of thermal stratification in the reservoir. In most years, September pelagic trout habitat was restricted to the main body of the reservoir where water depths exceeded 70 m.

Specifically for the most recent 10-Year Work Plan (2006-2015), measured trout habitat thickness ranged from 17 to 73 m as shown on Figure E.9-4, which indicated sufficient habitat availability in Lake Jocassee to support a robust trout population. Since trout habitat thickness was never predicted to be less than 10 m, additional monitoring under the current 10-Year Work Plan (2017-2027) was not required. However, continued monitoring of trout habitat thickness is performed under the KT Project Relicensing Agreement, which requires a model prediction and verification by temperature and DO survey at the deepest location in Lake Jocassee (station 558.0) in February and September, annually. If trout habitat is projected to be less than 10 m thick by September, Duke Energy will measure temperature and DO in June and August to monitor thickness, as well as consult with SCDNR regarding potential modifications to hydropower operations.

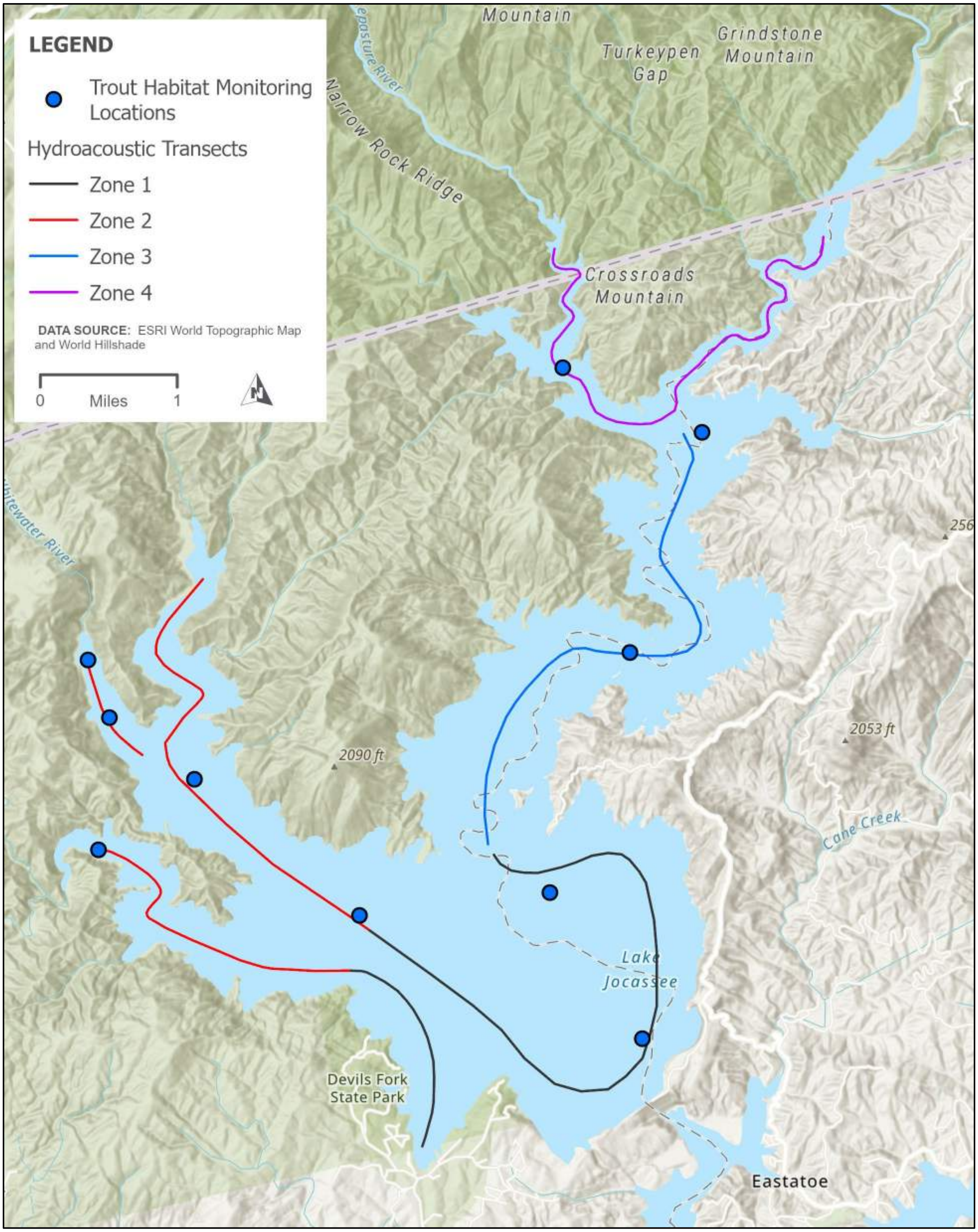


Figure E.9-2. Hydroacoustic Survey Transects and Trout Habitat Monitoring Locations

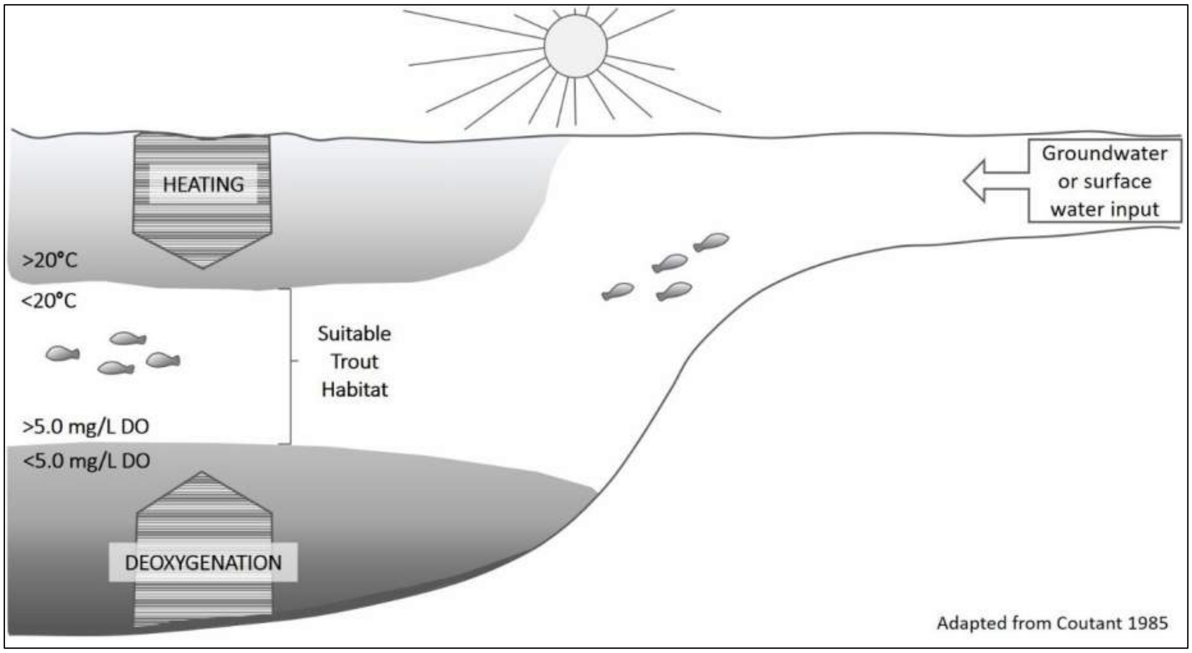


Figure E.9-3. Schematic Depicting Example of Trout Habitat Thickness in the Water Column Depending on Thermal and Dissolved Oxygen Dynamics

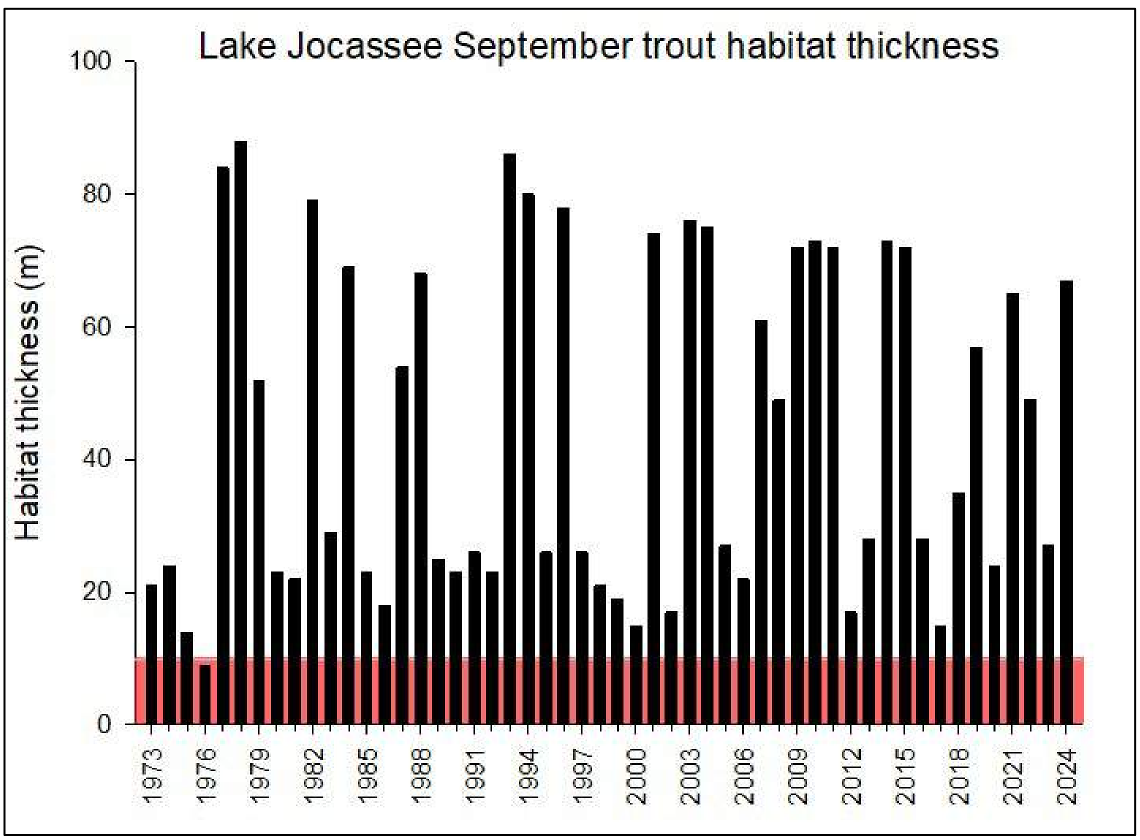


Figure E.9-4. Measured Trout Habitat Thickness 1973-2024 (Source: Duke Energy 2024a)

E.9.1.2.5 Hydroacoustic Monitoring of Small Pelagic Fish

Hydroacoustic monitoring of fish populations by Duke Energy to assess pelagic prey fish (i.e., threadfin shad and blueback herring) abundance and distribution began in 1997 (SCDNR and Duke Energy 1996). Sampling was performed in four zones of the reservoir (Figure E.9-2) in the spring and fall (biannually) from 1997 to 2015, and annually in the fall during the current Work Plan. Hydroacoustic sampling is completed using multiplexing, side-scan, and down-looking transducers (Duke Energy 2014c). Complementary to hydroacoustic sampling, purse seine sampling was also conducted in conjunction with the fall hydroacoustic sampling from 1997 to 2012 in order to characterize species composition of the pelagic forage fish community.

The upper Toxaway River arm of Lake Jocassee (i.e., Zone 4) had the highest forage fish densities during the most recent 10-year Work Plan period; however, the pelagic forage fish populations exhibited a wide degree of variability both spatially and temporally (Figure E.9-5). While species composition has generally varied since 1997, the threadfin shad population has declined substantially from 2009 to 2014 (Figure E.9-6) (Duke Energy 2014c, 2021c, 2024). Although purse seine sampling was discontinued shortly after, population estimates for threadfin shad in 2015 suggest the population is rebounding. Variations in threadfin shad populations may be related to cold winter conditions which can result in die-offs of this sensitive species (Rohde et al. 2009) or could be the result of fluctuating chlorophyll *a* and zooplankton levels which can have a large impact on the threadfin shad population as a planktivore subsisting in oligotrophic waters. Threadfin shad are an ideal species as a forage fish for sought-after sportfish species due to their early age of maturity (within the first year) and high fecundity; this life history strategy also allows for persistent populations despite sensitivity to naturally occurring environmental conditions, such as seasonally cool ambient temperatures (Higginbotham 2010).

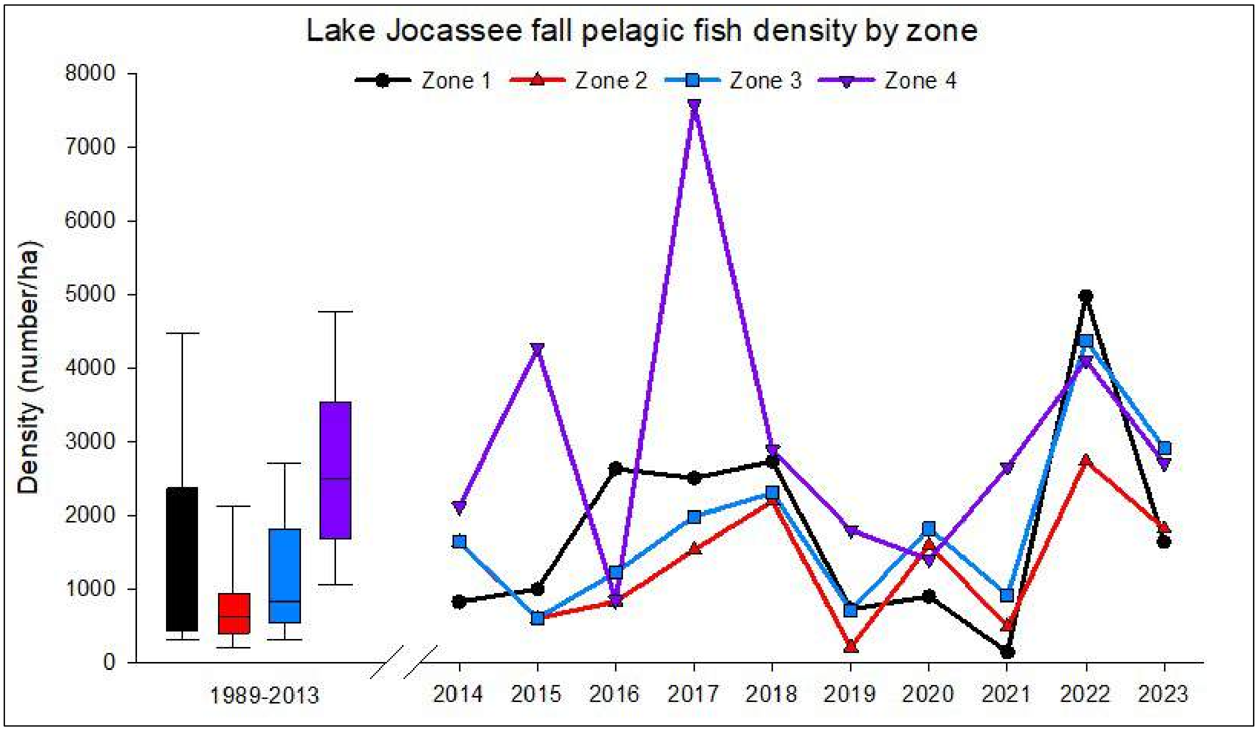


Figure E.9-5. Lake Jocassee Fall Forage Fish Density (fish/hectare) by Zone during Mobile Hydroacoustic Surveys 1989-2024 (Source: Duke Energy 2024a)

Table E.9-6. Estimated Lakewide Number of Forage Fish and Relative Abundance in Lake Jocassee, Fall 1997 through 20231

Year	Lakewide Fall Estimate of Forage Fish (millions)			Relative Abundance (%) in Purse Seine Samples		
	Blueback Herring	Threadfin Shad	Total	Blueback Herring	Threadfin Shad	Total
1997	3.96	0.00	3.96	99.9	0.1	100
1998	4.12	1.39	5.51	74.7	25.3	100
1999	5.95	1.02	6.97	85.3	14.7	100
2000	1.16	3.17	4.33	26.8	73.2	100
2001	3.03	1.42	4.45	68.2	31.8	100
2002	1.73	1.62	3.35	51.5	48.5	100
2003	2.16	0.68	2.84	76.0	24.0	100
2004	2.50	0.79	3.29	76.1	23.9	100
2005	1.14	0.51	1.65	69.1	30.9	100
2006	2.68	0.60	3.28	81.8	18.2	100
2007	3.68	1.72	5.40	68.1	31.9	100
2008	1.64	2.18	3.82	42.9	57.1	100
2009	3.08	0.30	3.38	91.2	8.8	100
2010	3.65	0.22	3.87	94.4	5.6	100
2011	3.84	0.12	3.96	96.9	3.1	100
2012	13.07	0.01	13.08	99.9	0.1	100

Year	Lakewide Fall Estimate of Forage Fish (millions)			Relative Abundance (%) in Purse Seine Samples		
	Blueback Herring	Threadfin Shad	Total	Blueback Herring	Threadfin Shad	Total
2013	7.81	0.52	8.33	93.8	6.2	100
2014	4.80	0.04	4.84	99.2	0.8	100
2015	3.43	1.45	4.88	70.2	29.8	100
2016	--	--	5.38	--	--	--
2017	--	--	10.59	--	--	--
2018	--	--	8.91	--	--	--
2019	--	--	2.78	--	--	--
2020	--	--	4.85	--	--	--
2021	--	--	3.09	--	--	--
2022	--	--	14.6	--	--	--
2023	--	--	7.77	--	--	--
Mean	**3.86**	**0.94**	**5.52**	**77.2**	**22.8**	**100**

[1]Species composition data is unavailable after 2015 due to discontinuation of purse seine sampling.
Source: Duke Energy 2014c; Duke Energy 2021c; 2024

E.9.1.2.6 Cost-share for Fishery Enhancement and Studies

The Bad Creek MOU listed a number of activities eligible for cost-sharing, including fisheries research, water quality studies, trout habitat studies, stream surveys, creel surveys, fish and habitat management, development of bank and stream-side access, and stream protection and enhancement (Table E.9-7). Over the last Work Plan period (2005-2016) and current Work Plan (2017-2027), funding was or will be provided by Duke Energy for activities implemented by the SCDNR such as those listed in Table E.9-7.

Table E.9-7. Fisheries Research or Monitoring Studies, or Special Management Projects Funded under the 2006-2015 Work Plan or with Potential for Funding under the 2017-2027 Work Plan

Fisheries Research or Monitoring Studies, or Special Management Projects	2005-2016 Work Plan	2017-2027 Work Plan
Annual trout stocking	X	X
Triennial creel surveys (Lake Jocassee and Lake Keowee)	X	X
Bioenergetics study	X	--
Redeye Bass study	X	Possible studies (not limited to) under the 2017-2027 Work Plan
Eastern Brook Trout habitat restoration	X	
Black bass exploitation study	--	
Jocassee Trout survival/mortality/exploitation study	--	
Habitat protection/access improvement/erosion control	--	
Evaluation of habitat enhancement projects under the KT Habitat Enhancement Program	--	

E.9.1.3 Other Environmental Studies

E.9.1.3.1 2021 Bad Creek Desktop Entrainment Study

An updated desktop entrainment study was performed by Kleinschmidt Associates (KA 2021) to evaluate potential impacts of Bad Creek II prior to initiation of Project relicensing. Specifically, this study considered the potential for entrainment of Lake Jocassee fishes through the Project under the proposed action (i.e., operation of two powerhouses at the Project). The study was provided as Appendix F of the PAD. Following agency and stakeholder review, modifications to the study methodology were made and a consultation process was developed as part of the ILP study process. The revised study methods and results are discussed in Section E.9.2.1.1.

E.9.1.3.2 Howard Creek Monitoring

Construction of Bad Creek Reservoir and associated roads from 1982 to 1991 resulted in impacts to Howard Creek due to sediment runoff, and as a condition of the Original License, annual fishery assessments were conducted (Duke Energy 2016b). Results from the initial recovery program suggested Howard Creek had returned to pre-construction condition by 1995. Commencing in 1997, additional fishery sampling of Howard Creek was implemented to assess whether the recovered state would persist. Sampling was performed at three locations on Howard Creek, including two sites downstream of the Project and one upstream as a reference location.

The last year of sampling occurred in 2015. All three survey locations maintained a consistent level of species diversity over the 19-year monitoring study. Generally, species diversity was higher at the downstream location (N=11 species) as compared to the upstream location (N=2 species); this is likely due to species immigration from the reservoir as well as a natural barrier (bedrock slide) found between H1 and H6 that hinders fish migration. All three species of trout known to the region (rainbow trout, brown trout, and brook trout [*Salvelinus fontinalis*]) were collected in Howard Creek, but only rainbow trout were collected in significant numbers. The condition of rainbow trout was similar between the locations over time and was considered healthy. Other common species present in Howard Creek included bluehead chub (*Nocomis leptocephalus*), yellowfin shiner (*Notropis lutipinnis*), blackbanded darter (*Percina nigrofasciata*), blacknose dace [*Rhinichtys atratulus*], and northern hog sucker (*Hypentelium nigricans*).

The results of the Howard Creek monitoring study suggest this tributary to Lake Jocassee has maintained a recovered condition from 1995 to at least 2015 (the last survey period); in the absence of any other known impacts, it is likely Howard Creek currently supports fish populations similar to those found in other southern Appalachian streams.

E.9.1.4 Temporal and Spatial Distribution of Fish Communities

Several taxa identified in fish community studies performed on Lake Jocassee may be considered migratory or exhibit localized migratory behavior. Blueback herring, while typically anadromous, has a self-sustaining landlocked population in Lake Jocassee, while other taxa (such as rainbow and brown trout) are stocked (additionally, none of these species are indigenous to this river basin). Rainbow trout, brown trout, and walleye (*Sander vitreus*) may conduct smaller, seasonal migrations from the lake into streams for spawning, but these migrations are not necessarily required for the species to complete their life cycle.

E.9.1.4.1 Species Life History Characteristics

The life history strategies of fish species (such as but not limited to the timing and habitat requirements of spawning, hatching, recruitment, dispersal, feeding, etc.) determines the behavior and movements over the life of a fish. This section details the life history characteristics of several of the most common species or species of interest in Lake Jocassee.

Blueback Herring (*Alosa aestivalis*)

In South Carolina, blueback herring are present in major coastal rivers as a traditionally anadromous species, however there are several landlocked populations in impoundments in the Piedmont and Blue Ridge regions (Rohde et al. 2009; SCDNR 2015). Blueback herring found in Lake Jocassee are likely the result of an inadvertent introduction from a population originating from (and indigenous to) the Cooper River (Prince and Barwick 1981).

Landlocked populations typically reside in open-water habitats and then move closer to shorelines to spawn (Rohde et al. 2009). Blueback herring are prolific spawners, as females can spawn up to 250,000 eggs (SCDNR 2015). This species feeds primarily on zooplankton but will also consume small fish (Prince and Barwick 1981).

Threadfin Shad (*Dorosoma petenense*)

Threadfin shad occur throughout South Carolina, primarily in larger rivers and reservoirs, where they have been introduced as forage fish (Rohde et al. 2009). Threadfin shad are often associated with swiftly moving water and are tolerant of brackish water.

Spawning typically occurs from April to July, from first light to sunrise, and occurs near the shoreline over aquatic plants and other submerged objects (Rohde et al. 2009). Eggs are adhesive and demersal. Threadfin shad occur in large schools in midwater and feed on phyto- and zooplankton. Threadfin shad are sensitive to cool water temperatures which can result in massive die-offs; however, threadfin shad populations are known to dominate the forage-fish communities of reservoirs that do not experience severely cold winters (such as lakes at higher latitudes) or receive thermal effluents.

Redbreast Sunfish (*Lepomis auritus*)

Redbreast sunfish are abundant in upstream reaches of reservoirs and along rocky points or riprap-reinforced shorelines over sandy substrates (Rohde et al. 2009). Habitat also commonly consists of pools and backwaters of streams and rivers with low to moderate gradients typically associated with woody debris, stumps, and undercut banks. Redbreast sunfish are almost always absent from stagnant and heavily vegetated waters. Redbreast sunfish abundance has been observed to decline with decreasing water velocity and increasing depth and cover in smaller streams.

Spawning in South Carolina occurs from late May through the end of July when water temperatures range from 20°C to 31°C (Rohde et al. 2009). Nests consist of large, saucer-shaped depressions in coarse sand or gravel in shallow water; beaver ponds often provide spawning and nursery habitat. Nests can be solitary, in small aggregations, or in dense colonies of 80 nests or more. Redbreast sunfish are opportunistic predators feeding on small fishes, mollusks, insects, crayfish, and other arthropods.

Bluegill (*Lepomis macrochirus*)

Bluegill are widely distributed throughout South Carolina, partly the result of intrastate introductions (Rohde et al. 2009). They are tolerant of a wide range of conditions and can be found in most of the habitats available in South Carolina. Natural habitat consists of pools of creeks and rivers, swamps, oxbows, ponds, and vegetated shorelines of impoundments, but they have often been found in man-made lakes and ponds. They rarely move far from cover such as weed beds, fallen timber, pilings, etc. (Higginbotham 2004).

Spawning occurs from May through August, typically with a peak in June (Rohde et al. 2009). Bluegill are social (colony) nesters; males will fan out 50 or more circular nests in areas 1 to 5 ft deep (Higginbotham 2004). Females produce between 10,000 and 60,000 eggs per spawn and spawn multiple times per year. Bluegill are opportunistic carnivores that prey on adult and larval insects, crayfish, mollusks, and other fishes.

Bartram's Bass (*Micropterus sp. cf. cataractae*)

Redeye bass (*Micropterus coosae*) were originally thought to range from the Mobile River drainage eastward to the Apalachicola and upper Savannah River drainages. However, recent research through genetic analyses suggests this species actually comprises several endemic variants (Freeman et al. 2015). In the Savannah River drainage, the species present is now thought to be an undescribed species informally called the Bartram's bass (*Micropterus* sp. cf. *cataractae*).

Bartram's bass is found in cool, medium-to-high gradient streams typically above the fall line (Judson 2018). It is suspected this species is restricted to streams further upstream due to competition with the Alabama bass, though these two species have been shown to hybridize.

Bartram's bass spawns from May to June (Judson 2018). Water velocity appears to be the strongest microhabitat variable selected by nesting Bartram's bass in the upper Savannah River - approximately 85 percent of nests surveyed were found in velocities less than 0.10 meters per second. Nests were consistently found near the shore, downstream of major flow influences, in pockets of slower water velocity. Approximately 90 percent of nests were found in water less than a meter deep. Nesting Bartram's bass sites contain silt, gravel, and cobble; however, substrate characteristics are likely not necessarily selected but are what is available in accordance with the velocity of the nesting area.

Although literature is not available regarding the Bartram's bass feeding habits, it is likely comparable to redeye bass, which feeds on terrestrial insects, crayfish, small fishes, salamanders, and aquatic insects (Rohde et al. 2009).

Smallmouth Bass (*Micropterus dolomieu*)

Smallmouth bass have been widely distributed beyond their native range, including throughout the Piedmont and Blue Ridge of South Carolina, including Lake Jocassee (Rohde et al. 2009). This species is found in cool and clear streams with rock and gravel substrate and moderate current, although they are also present in lakes, reservoirs, and pools of large rivers.

Spawning in the southeast occurs in April or early May with nests constructed in coarse gravel near the shoreline (Rohde et al. 2009). Multiple females may spawn in the nest of one male, and males guard the nest until fry disperse. Smallmouth bass are voracious predators that consume aquatic insects, crustaceans, and other fishes. Highly regarded as gamefish with strong fighting ability, the South Carolina state record for Smallmouth bass (4.28 kg) was caught in Lake Jocassee in 2001.

Largemouth Bass (*Micropterus salmoides*)

Largemouth bass have been stocked extensively throughout the United States and the world, muddying their native range (Rohde et al. 2009). They are widely distributed throughout South Carolina, occupying a variety of habitats. Preferred habitat includes warm, calm, and clear waters, such as slow streams, farm ponds, lakes, and reservoirs. Some largemouth bass will primarily occupy the littoral zone, while others will prefer open water habitat, and yet others may move between littoral and open water habitats regularly (Matthias et al. 2014). Some studies have found largemouth bass to move toward warm water during the cooler months, however this may also depend on prey availability (Davis and Lock 1997).

Spawning in South Carolina occurs in March and April with nests generally constructed (by males) in sand or gravel at the base of logs, stumps, or emergent vegetation in the littoral zone (Rohde et al. 2009). Females lay an average of 4,000 eggs per pound of body weight (Davis and Lock 1997). Males will care for the nest and eggs until hatching (2 to 4 days) and will guard the fry until dispersal which may be up to two weeks. Adult largemouth bass diet primarily consists of fish; however, they are a gape-limited opportunistic predator and will also consume crayfish, insects, frogs, mice, birds and other animals (Rohde et al. 2009).

Rainbow Trout (*Oncorhynchus mykiss*)

Rainbow trout are native to western North America and have been widely introduced to cold waters throughout the world (Rohde et al. 2009). In South Carolina, SCDNR has repeatedly introduced Rainbow trout into watersheds of the upper Blue Ridge region (Rohde et al. 2009). Rainbow trout are typically found in creeks, rivers, lakes, and reservoirs.

Populations in the mid-Atlantic and southeastern U.S. are often non-reproducing and replenished via stocking (Rohde et al. 1994). Spawning of wild populations typically occurs from late winter to early spring. Adults migrate upstream from lakes or pools to spawning grounds in shallow and swift streams with gravel and sand substrate (Rohde et al. 1994, 2009). Populations already inhabiting small streams do not migrate; there are no anadromous populations in South Carolina. Females construct redds (nests) in gravel substrate into which eggs fall and are covered by displaced gravel from subsequent activities of the spawners. Juvenile rainbow trout consume a variety of aquatic insects while adults prey on terrestrial insects, crayfish, and fishes. The South Carolina state record for rainbow trout (5.14 kg) was caught in Lake Jocassee in 1993 (Rohde et al. 2009).

Brown Trout (*Salmo trutta*)

Brown trout are native to Europe and western Asia, and like rainbow trout have been widely introduced throughout the world including numerous introductions by SCDNR (Rohde et al. 2009). In South Carolina, brown trout may be found in small creeks, rivers, and reservoirs under a wide range of conditions, as they are more tolerant of warmer waters than other trout species; however, they are known to thrive where water temperatures do not exceed 21°C (Rohde et al 1994, 2009).

Spawning typically occurs in the fall and early winter when brown trout migrate into gravelly headwater streams where females construct redds (Rohde et al. 2009). There are no anadromous populations in South Carolina. Growth occurs faster in southern waters and maturity can be reached by the end of the first year. Brown trout are adaptive predators; their diet consists primarily of bottom-dwelling aquatic insects and amphipods and occasionally terrestrial insects. Larger individuals consume crayfish, fishes, salamanders, and frogs (Rohde et al. 1994, 2009). The South Carolina state record for brown trout (7.99 kg) was caught in Lake Jocassee in 1987 (Rohde et al. 2009).

E.9.1.5 Mussels and Benthic Macroinvertebrates Communities

E.9.1.5.1 Mussels

Duke Energy collected mussel shells during major drawdowns in Lake Jocassee in 2007 (Duke Energy 2014c). Three mussel species were documented: paper pondshell (*Utterbackia imbecillis*), eastern floater (*Pyganodon cataracta*), and the Florida pondhorn (*Uniomerus carolinanus*). The paper pondshell appears to be restricted to the upper reaches of the lake. The Florida pondhorn was noted only in the lower regions of the lake and the eastern floater was found only at the confluence of the Toxaway River. Based on the total number of shells found, the paper pondshell (150 shells) was the most abundant mussel in Lake Jocassee, followed distantly by the Florida pondhorn (6 shells) and eastern floater (1 shell). Although not reported in the 2007 drawdown study, Asian clam (*Corbicula fluminea*) was identified in mussel surveys performed in July and August 2023 (see Section E.9.2.1.3).

E.9.1.5.2 Benthic Macroinvertebrates

No other benthic macroinvertebrate information is available for Lake Jocassee. Therefore, presented here are the results of a benthic macroinvertebrate study conducted on downstream Lake Keowee, which characterized littoral benthic macroinvertebrates from 1989 through 1993 (Duke Power Company 1995b).

Benthic macroinvertebrates were sampled quarterly (February, May, August, and November) in the littoral zone at four locations in 1989 (Duke Power Company 1995b). In 1990, frequency of sampling was reduced to three times annually (March, July, and November) at three sites. From 1991 to 1993, two locations were sampled three times per year.

Overall benthic standing crops increased during the sampling time period as compared to estimated standing crops in 1974-1977 (Duke Power Company 1995b). This may be attributable to changes in the community composition due to the introduction of Asian clam and increases in oligochaete densities, which may be a function of increased sediment and nutrient loading from shoreline development. Oligochaete populations stabilized by 1991. Few glassworms (*Chaoborus* sp.) were observed during this time period, which may be due to predation by blueback herring, which are known to feed on glassworms and were inadvertently introduced to lakes Keowee and Jocassee in the early-mid 1970s through threadfin shad stocking (Fuller et al. 2021).

Chironomid densities during the sampling period were generally within ranges of those historically described (Duke Power Company 1995b). Relative abundance had declined due to high densities of Asian clam and oligochaetes; however, a higher number of taxa were identified indicating higher diversity.

E.9.1.6 Invasive Aquatic Species

Many non-native species can coexist with native species and may be beneficial; they typically do not reproduce rapidly or develop large populations (SCDNR 2008). Aquatic invasive species, on the other hand, are non-indigenous species having the potential to adversely affect ecological health or economic activity.

At least 11 non-native (or non-indigenous) fishes have been identified in Lake Jocassee: blueback herring, brown trout, channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), green sunfish (*Lepomis cyanellus*), rainbow trout, smallmouth bass, Alabama bass, threadfin shad, walleye, and white bass (*Morone chrysops*). Many of these species were introduced intentionally to support the sport fishery. Asian clams, mentioned in Section E.9.1.5, are also found in Lake Jocassee. Only three of these species are included in South Carolina's Aquatic Invasive Management Plan (SCDNR 2008); species profiles are provided below.

E.9.1.6.1 Asian clam (*Corbicula fluminea*)

The Asian clam was first reported in South Carolina in the late 1960s or early 1970s (SCDNR 2008). It spread through human activities such as bait bucket dumping, aquaria releases, or intentional releases by people who bought the clams at food markets. They can also spread by passive movement of larvae in water currents. Ecological impacts of the Asian clam include altering of benthic substrates and increased competition with native species for food and habitat resources. The Asian clam has likely caused the decline and/or extirpation of several native freshwater mussel species throughout North America.

E.9.1.6.2 Green Sunfish (*Lepomis cyanellus*)

Green sunfish are native to the central and eastern U.S. west of the Appalachian Mountains and east of the Continental Divide, from the Great Lakes region south to the Gulf Coast states (SCDNR 2008). Green sunfish is one of the most tolerant sunfishes with regard to temperature extremes, turbidity, and disturbed habitat, and therefore can out-compete and/or suppress native fish in these types of habitats (Rohde et al. 2009; Rohde et al. 1994).

E.9.1.6.3 Alabama Bass (*Micropterus henshalli*)

Alabama bass are native to the Mobile River Basin and were likely illegally introduced to South Carolina by anglers (Benson 2021; USGS 2015). They are prolific and can competitively displace largemouth bass populations in upstate Piedmont and mountain lakes. They also hybridize with Bartram's bass, previously thought to be redeye bass (see Section E.9.1.4.1) (Barwick et al. 2006).

E.9.2 Environmental Analysis

E.9.2.1 Studies in Support of the Current Relicensing

In support of the current relicensing, Duke Energy conducted an Aquatic Resources Study in 2023 and 2024. This study consisted of three tasks including: 1) *Consultation on Entrainment*; 2) *Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat*; and 3) *Impacts to Surface Waters and Associated Aquatic Fauna*. A summary of the methods and results of the Aquatic Resources Study is provided in this section, and individual reports are provided in Appendix D. The specific objectives of the Aquatic Resources Study are included below:

- Evaluate the potential for increased fish entrainment due to the addition of Bad Creek II and consult with agencies and other Project stakeholders regarding results of the recent desktop Entrainment Study.
- Assess changes to pelagic and littoral aquatic habitat in Lake Jocassee resulting from the expanded underwater weir and additional discharge, using models developed for the Water Resources Study and KT Project relicensing.

- Evaluate potential direct impacts to aquatic habitat (including wetlands) related to Bad Creek II construction activities and weir expansion by quantifying and characterizing surface waters, including resource quality, and also including presence/absence mussel surveys of streams located in upland areas where spoil deposition may occur will also be conducted.

E.9.2.1.1 Consultation on Entrainment (Task 1)

A desktop entrainment study, using data collected during the empirical study performed in the 1990s, was completed in 2021 and filed as Appendix F of the PAD (KA 2021). The purpose of Task 1 of the Aquatic Resources Study for the Bad Creek relicensing was to consult with agencies and other Project stakeholders regarding results of the desktop entrainment assessment and any proposed study updates or modifications. In the RSP filed with FERC on December 5, 2022, Duke Energy committed to one meeting with agencies and stakeholders to discuss the desktop entrainment study, with additional meetings to be dictated by the Aquatic Resources Resource Committee as necessary. A meeting was held at Duke Energy's Wenwood Operations Center in Greenville, SC on April 6, 2021, with the purpose of discussing the goals and objectives, methods, and results of the desktop entrainment study. As a result of consultation with the Aquatic Resources Resource Committee, the desktop entrainment study was updated to include additional factors such as historical operations data, operations data related to solar generation rates, pumping (versus generating) frequency, time period, lake levels, water temperature, and if possible, intrinsic population growth rates for threadfin shad (if available). The revised desktop entrainment study incorporating agency and stakeholder suggestions was distributed to the Aquatic Resources Resource Committee in November 2023 with the final report filed with the ISR on January 4, 2024.

In the Relicensing Study Progress Report No. 4 filed with FERC on April 1, 2024, Duke Energy stated that optimization studies indicated that variable speed pump-turbine units will be installed at Bad Creek II instead of single-speed units, which would increase the hydraulic capacity compared to original modeling. Therefore, the methodology, results, and conclusions of the updated study with consideration of agency and stakeholder comments during the Consultation on Entrainment study task, as well as incorporation of updates to proposed facility specifications are provided below.

Task 1 Methods

Hourly entrainment data from the 1991-1993 study were used to develop fish-per-hour measurements by unit. Assuming a constant flow rate, the number of fish and total cubic ft pumped was summed for each day and then converted to an entrainment rate of fish per million cubic ft (fish/Mft^3). Each entrainment observation was classified as having occurred at "low" or "high" water surface elevation (1,099 ft msl or 1,110 ft msl, respectively). Entrainment mortality events were simulated with the open-source software package Stryke[26]. It was also assumed that all fish simulated are routed through the Project and Bad Creek II powerhouses and that there is 100 percent mortality.

Scenarios were developed that describe entrainment rates across seasons and forebay operating levels. Seasonal entrainment rates (fish/Mft^3) were described with Log Normal distributions. The Project, under the proposed action of adding an additional twin powerhouse, is intended to pump up to 6 hours per day on weekdays and 2 hours per day on weekends. Duke Energy provided operations data from 2014 to 2018 in 15-minute increments that would also be reflective of the new pumping operations. It was assumed that if a unit was pumping, it was pumping at max capacity for the entire 15-minute period. Therefore, the number of hours operated per day is the number of 15-minute intervals with pumping operations divided by 4. It was assumed that when forebay elevations are below 1,099 ft msl, per the MOU, that units were operated in order of Unit 4, Unit 2, Unit 3, Unit 1 and that operations were dependent. It is assumed that Bad Creek II would reflect the same order of unit prioritization at low water surface elevation. Details for seasonal event scenarios and unit operations are included in the *Desktop Entrainment Analysis Final Report*, and results of additional analysis carried out in 2024 were developed into two addendum reports; these are provided in Appendix D.

Task 1 Results

Target species selected for the entrainment study were based on a previous empirical study conducted at the Project from 1991 to 1993 (see Section E.9.1.2.1) (Table E.9-8). Relative abundance of entrained species (proportions) was applied to entrainment rates measured in fish/Mft^3.

Table E.9-8. Monthly Sum of Entrainment at the Bad Creek Project from 1991 to 1993

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Black crappie				18	73							4
Blackbanded darter					134	9		5				
Blueback herring	2,086	2,093	1,267	2,885	1,753	5,837	5,955	1,854	7,836	7,736	9,170	5,466
Bluegill	8		30	116	2,537	796	6,626	1,388	3,941	2,399	68	80
Brown trout	5			56	149	41						14
Channel catfish			1		60	9		5				
Common carp					277	54			11			
Flat bullhead					55			98				
Golden shiner			2	18	153	9		2				
Green sunfish								3	111	181		
Hybrid sunfish									37			

26 https://github.com/knebiolo/stryke.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Largemouth bass					37	17	97	5	97	410		
Quillback					18							
Rainbow trout	27					6						
Redbreast sunfish				18	220	15	1,392	547	611	480	1	16
Redear sunfish					18							
Redeye bass							14	2	48	62		
Spottail shiner					18							
Striped jumprock												14
Threadfin shad	3,033	4,072	5,290	8,656	2,302	1,588	3,485	425	2,4365	4,1867	71,009	134,314
Warmouth				124	311	63	419	4	49	113		
White Bass					2	16			113		1	
White catfish	3		6	207	2,961	196	2,723	1,765	1,679	1,339	68	2
Whitefin shiner					20				49			
Yellow perch	140	64	54	177	385			55	75		1	7
Yellowfin shiner					18							

Based on exploratory analyses and simulations, risk of entrainment increases at lower water surface elevations. The average entrainment rate at a water surface elevation greater than 1,099 ft msl was estimated to be 3.10 fish/Mft^3, whereas the entrainment rate at water surface elevation below 1,099 ft msl was 18.41 fish/Mft^3. Seasonal analysis showed the highest likelihood of entrainment to be during the fall season at low water levels.

2024 Addenda

Addendum 1

In November 2024, the entrainment analysis was revised to reflect new technology information which provided updated hydraulic capacities (i.e., increased pumping rates) for the proposed units at Bad Creek II, as well as the incorporating the completion of the unit upgrades at the Project. Because the total volume of water pumped at the Project and Bad Creek II did not change, the entrainment estimate remained at 90,825 fish under normal operating conditions, and 119,208 fish during a drought year with a reduced forebay water survey elevation.

Addendum 2

In comments dated March 1, 2024, the FERC requested that an additional literature search be performed to “ensure the best available scientific data is being used for each species of interest to derive accurate population growth rate estimates for the entrainment analysis”. Alternative population growth rates (as opposed to those provided by FishBase [Froese and Pauly 2021] applied in the original study [Kleinschmidt 2021]) were developed using life history parameters obtained from literature. A sensitivity analysis was also completed to assess the risk of population decline in Lake Jocassee during normal and dry years with varying reproductive scenarios. The analysis found that the threadfin shad population would decline in a normal or dry water year with low fecundity, whereas the population would increase with high fecundity rates, despite the effects of entrainment under each scenario. For blueback herring, the population would increase despite entrainment under all scenarios-normal or dry years with low or high fecundity.

Task 1 Conclusions

The estimated rates of entrainment mortality at the Project or Bad Creek II are not expected to affect the long-term sustainability of Lake Jocassee fish populations based on intrinsic population growth rates. The species which experience the greatest amount of entrainment, blueback herring and threadfin shad, are highly fecund species, such that population-level compensatory mechanisms would likely offset the entrainment losses. In addition, while some level of entrainment mortality will inevitably occur, many natural populations have excess reproductive capacity that will compensate for some losses of individuals. No risk to blueback herring was expected because the estimated entrainment rate of 0.7 percent per year is far below the estimated recovery rate of the species (16 to 19 percent per year). The estimated entrainment rate of 12 percent per year for threadfin shad is close to the annual increase for the slowest recovery surrogate, American shad (15 percent per year; or a population doubling rate of more than 20 years), indicating that entrainment mortality may keep the population from substantial increase, but is not likely to cause the population to decrease unless combined with other non-Project stressors. Detailed results from this study are included in *Desktop Entrainment Analysis Final Report*, Appendix D.

E.9.2.1.2 Effects of Bad Creek II and Expanded Weir on Aquatic Habitat (Task 2)

As mentioned in Section E.9.1.1.1, the littoral fish habitat in Lake Jocassee comprises mostly rocky outcrops with smaller proportions of sand, emergent vegetation, stream confluences, residentially developed piers and riprap), clay, and cobble (Duke Energy 2014c). Much of the littoral zone exhibits steep slopes with areas of significant woody debris (large stumps).

The purpose of the Task 2 study was to assess changes to pelagic and littoral aquatic habitat in Lake Jocassee resulting from proposed additional operations from a second powerhouse and expanded submerged weir. This was met through the evaluation of model results developed for the Water Resources Study including the CFD and CHEOPS models as described in Section E.8.2.1.

Task 2 Methods

Pelagic Trout Habitat Assessment

Pelagic Trout Habitat Monitoring Review

In support of the fishery and originally as part of the 10-year work plans under the MOU developed in 1996, Duke Energy monitors Lake Jocassee's pelagic trout habitat as indicated by specific thermal and DO criteria. Pelagic trout habitat is defined as water with temperatures ≤ 20.0°C and DO concentrations ≥ 5.0 mg/L (Oliver et. al. 1978).

Using vertical profile data (temperature and DO) collected in Lake Jocassee since 1973, Duke Energy developed an empirical model (Foris 1991) to predict trout habitat thickness and volume in the main body of Lake Jocassee. The empirical model is used to estimate the amount of pelagic trout habitat in late summer, when water temperatures are highest and the lake has been stratified the longest (i.e., when pelagic trout habitat is expected to be minimal).

CFD Model Results Review

Results of the CFD model (see Section E.8.2.1.3) were assessed and compared to existing pelagic trout habitat data (measured and predicted trout habitat) to evaluate the potential effects on pelagic trout habitat due to increased water column mixing in Lake Jocassee. Several CFD scenarios were modeled for the relicensing, however, the only scenarios considered in this study include (1) generation under maximum lake elevation and (2) generation under minimum lake elevation. The expanded weir configuration was assumed for this evaluation as CFD results indicated similar flow patterns in Whitewater River cove between existing and expanded weir configurations. CFD results are included in the final report *Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse* in Appendix D.

Littoral Habitat Assessment

CHEOPS Model

Operation of Bad Creek II will influence water surface elevations in Lake Jocassee and may affect littoral habitat in the lake. Stable water surface elevations are important for species that use the littoral zone for spawning, including black basses, sunfishes, threadfin shad, and landlocked blueback herring (Stuber et al. 1982a, 1982b; Edwards et al. 1983; Aho et al. 1986; Rohde et al. 2009). Spawning success of fish species in the littoral zone can be influenced by the fluctuation of water levels due to potential for nest dewatering or altering fish behavior (e.g., nest abandonment). The water surface elevation in Lake Jocassee also determines the amount of littoral habitat available for spawning.

The CHEOPS model is designed to evaluate the effects of operational changes and physical modifications at multi-development hydroelectric projects. CHEOPS model results were used to compare the water surface elevations during growing and spawning seasons and the resultant amount of littoral zone habitat in Lake Jocassee under Bad Creek II operations compared to the amount of littoral zone habitat under existing license requirements (i.e., baseline conditions). Additional information on the development of the CHEOPS model and results is provided in Section E.8.2.1.4 and available in *Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat Final Report*, Appendix D.

Performance measures were developed in consultation with the Aquatic and Water Resources Resource Committees; those related to frequency of water surface fluctuations and water surface elevations in the littoral zone for Lake Jocassee were evaluated for this study.

Littoral Habitat Quantification

Secchi depth is a measurement of water transparency achieved by lowering a reflective white disk into the water until it can no longer be observed from the water surface (Wernand 2010). Duke Energy historically collected Secchi depth data across Lake Jocassee by recording depth to the nearest 0.1 meter (m). Duke Energy provided a data set of 1,182 samples with Secchi depth, location sampled, and sampling date spanning from 2003 to 2015 (Duke Energy 2024b). Based on variability of Secchi depth observed through preliminary descriptive statistics, an analysis of variance (ANOVA) was used to assess whether Secchi depth varied by sampling region (cove or open water regions) and/or season (spring, summer, fall, and winter). The littoral zone was defined as the water column that receives between 1 percent and 100 percent of incident radiation (light), from the water surface to the lake bottom (also called the euphotic zone) (Cole 1994). The vertical absorption coefficient (η) (the point at which less than 1 percent of light is detected in the water column) was calculated using known relationships between Secchi depth and light extinction (Poole and Atkins 1929), and the light at a given depth was calculated to find the depth of the euphotic zone (Lee and Rast 1997).

The extent, or spatial area, of the littoral zone was estimated using the calculated littoral zone depth for cove and open water regions, existing bathymetry data, and pre-defined water surface elevations.

Five surface water elevations were evaluated in the littoral zone analysis: maximum elevation, normal minimum elevation, minimum elevation, and two elevations which were defined in the CHEOPS performance measures as maximizing littoral habitat during the growing/spawning season (corresponding to performance measures 26 through 29). Water surface elevations for the scenarios are summarized in Table E.9-9.

Table E.9-9. Summary of Water Surface Elevations for Evaluated Littoral Zone Scenarios

Littoral Zone Scenario	Elevation (ft msl)
Maximum Elevation	1,110
Littoral Zone Habitat During Growing/Spawning Season (High)[1]	1,107[2]
Littoral Zone Habitat During Growing/Spawning Season (Low)[1]	1,105[2]
Normal Minimum Elevation	1,096
Minimum Elevation	1,080

[1]The "growing season" was defined as April 1 to September 30 and "spawning season" was defined as April 1 to May 31 in the CHEOPS performance measures.
[2]Lake Jocassee fish habitat elevations provided by Bill Marshall of SCDNR during KT Project relicensing.

Task 2 Results

Pelagic Trout Habitat Assessment

Pelagic Trout Habitat Monitoring Review

Suitable pelagic trout habitat exists in the water column where specific water quality conditions required by trout are met; that is, water temperature less than 20°C and DO concentrations greater than 5.0 mg/L. During late summer thermal stratification, water in the upper water column (epilimnion) is warmed by solar radiation, eventually exceeding 20°C. In the lower portion of the water column (hypolimnion, below the thermocline), DO becomes limited due to minimal water circulation and consumption by anaerobic bacteria, declining below 5.0 mg/L. Therefore, suitable pelagic trout habitat is found between these two thresholds in the water column.

Pelagic trout habitat "thickness" (i.e., the portion of the water column between the upper 20°C and lower 5.0 mg/L) has varied widely from year to year since monitoring began in 1973, both before and after operation of the Project (Figure E.9-6). Water quality parameters for trout habitat are measured at the deepest part of the lake at location 558.0, and therefore provide the maximum thickness of trout habitat potentially existing in the lake during the late summer period (when trout habitat would be at minimum). Factors driving the variability in trout habitat thickness include severity of summer conditions, depth of preceding winter mixing, and operations at Jocassee Pumped Storage Station.

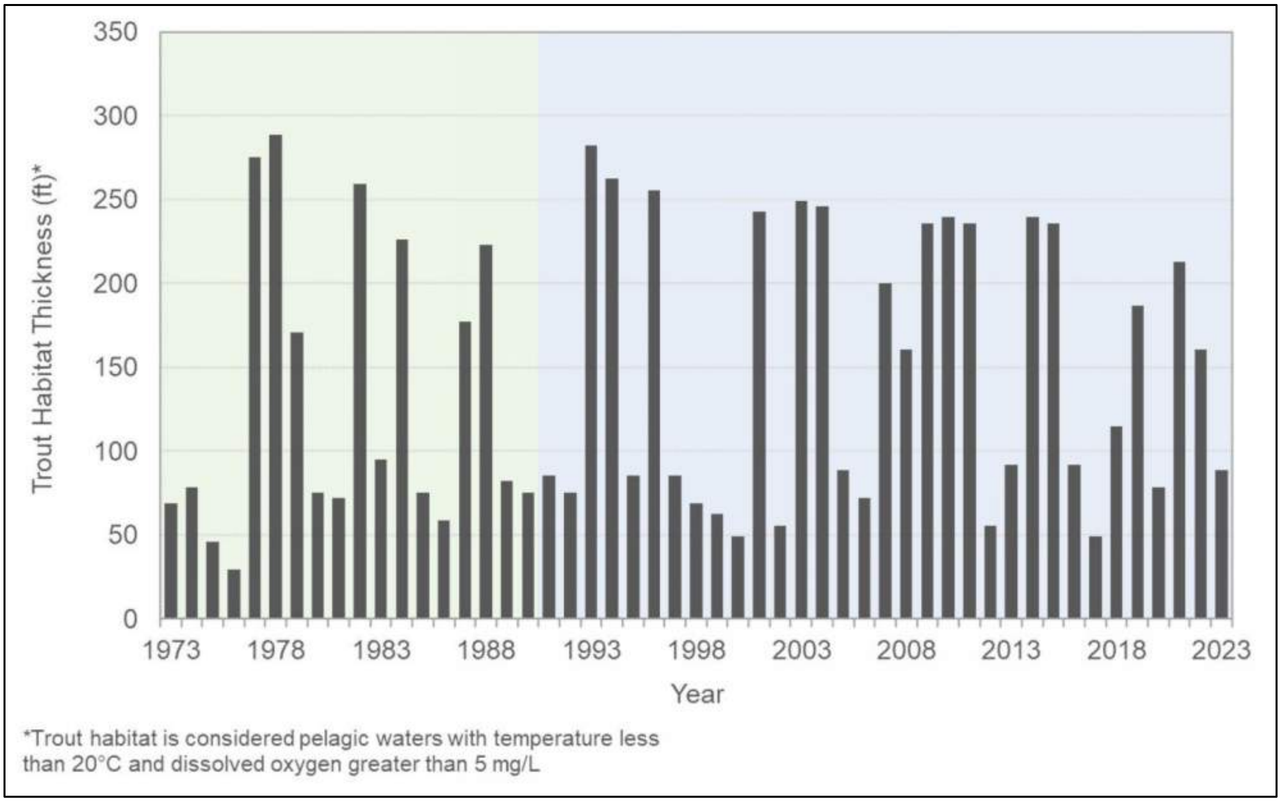


Figure E.9-6. Measured or Predicted Pelagic Trout Habitat Thickness from 1973-2023; green and blue shaded areas represent time prior to and following commencement of Project operations (1991)

A study completed by Foris (2014) depicted the seasonal pelagic trout habitat distribution from just upstream of the submerged weir to Jocassee Dam using water quality data collected in 2013. Contour plots developed from vertical profiles showed the seasonal restriction of pelagic trout habitat across the lake due to summer thermal stratification. More importantly, the Foris (2014) study showed that effects from Project operations were limited to the area upstream of the submerged weir; pelagic trout habitat downstream of the weir and within Whitewater River cove was approximately 29.5 ft "thick" in October 2013. Although more limited than the deepest part of the lake (near Jocassee Dam) due to the shallower bathymetry, pelagic trout habitat was still present at this time of year as compared to uplake locations (i.e., northern headwater coves including Toxaway River arm) where trout habitat was eliminated in early and mid-fall.

CFD Model Results Review

Findings from the CFD study indicate that in generation mode, the energy of the water discharged from operations is dissipated as it is forced across the top of the existing submerged weir and similar vertical mixing patterns result from the existing and proposed expanded weir geometries under existing and proposed generation flows. Additionally, results showed Bad Creek II powerhouse operations will not alter existing stratification patterns in the downstream section of the Whitewater River cove or further downstream into Lake Jocassee.

Under the maximum elevation scenario during generation, the CFD model predicted the expanded submerged weir may cause slight flow acceleration across the top of the weir and downstream into the lower Whitewater River cove. The effect of added generation from the additional powerhouse did not extend beyond the Whitewater River cove. Under the minimum elevation (i.e., maximum drawdown) scenario during generation, velocity effects increase over the weir, however effects were again limited to the Whitewater River cove. Water column mixing effects were confined to the area immediately downstream of the weir.

Littoral Habitat Assessment

CHEOPS Model

The operations of Bad Creek II and resultant lake levels would be constrained by Duke Energy's continued compliance with the existing KT Project FERC license (Duke Energy 2024b). KT license requirements, including the operating band of Lake Jocassee, would not be modified with the relicensing of the Project or the construction and operation of Bad Creek II.

Most performance measures evaluated for the Bad Creek II scenario showed no significant change from the Baseline scenario (Table E.9-10). The operation of Bad Creek II increased generation and pumping volumes that, when offset by Jocassee Pumped Storage Station operations, resulted in more stable surface elevations at Lake Jocassee based on 24-hour elevation fluctuations (Duke Energy 2024b). As a result, some performance measures related to maximizing spawning success for black bass and blueback herring (performance measures 8 through 11, and 17), and sunfish and threadfin shad (performance measures 18, 19, and 23) significantly improved over the Baseline scenario.

The CHEOPS model results also indicated that reservoir levels to support littoral habitat during the growing or spawning season (at or above either 1,107 ft msl or 1,105 ft msl) were not significantly different under the Bad Creek II scenario as compared to the Baseline scenario (see performance measures 26 through 29). Therefore, no significant differences in the amount of littoral habitat would be expected.

Table E.9-10. Summary of CHEOPS Model Results

Performance Measures	Measure Number	Criterion	Scenario	
			Baseline	Bad Creek II
Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	8	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once	71%	100%*
	9	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once	34%	99%*
	10	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once	19%	89%*
	11	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 30 consecutive days at least once	0%	59%*
	12	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 45 consecutive days at least once	0%	0%
Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	13	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once	100%	100%
	14	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once	100%	100%
	15	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once	100%	99%
	16	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 30 consecutive days at least once	95%	97%
	17	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 45 consecutive days at least once	56%	82%*
Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	18	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once	45%	100%*
	19	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once	14%	92%*
	20	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once	0%	3%
Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	21	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once	100%	100%
	22	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once	100%	100%
	23	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once	79%	99%*
Maximize littoral habitat during growing season	26	Percent of days average reservoir level above 1,107 ft msl	46%	42%
	27	Percent of days average reservoir level above 1,105 ft msl	91%	91%

Performance Measures	Measure Number	Criterion	Scenario	
			Baseline	Bad Creek II
Maximize littoral habitat during spawning season	28	Percent of days average reservoir level above 1,107 ft msl	20%	16%
	29	Percent of days average reservoir level above 1,105 ft msl	92%	92%
Minimize days below lake levels that impact Bad Creek efficiency	32	Number of days reservoir level below 1,081 ft msl	0	0

*Performance measure has improved vs. the Baseline scenario based on the minimum increment of significant change.

Littoral Habitat Quantification

Lake Jocassee is an oligotrophic reservoir exhibiting high water clarity and low nutrient concentrations as indicated by a Secchi depth that extends at least 15 ft into the water column (Carlson 1977) (Figure E.9-7). Initial evaluation of Secchi depth data suggests potential spatial differences in Secchi readings depending on proximity to tributary inputs in Lake Jocassee. Further, seasonal changes in precipitation could simultaneously affect water clarity in cove locations due to increased tributary inputs and associated allochthonous material and sediment. Boxplots showed median Secchi depth to be consistently higher (i.e., more elevated) in the water column in cove regions compared to open water areas across all seasons.

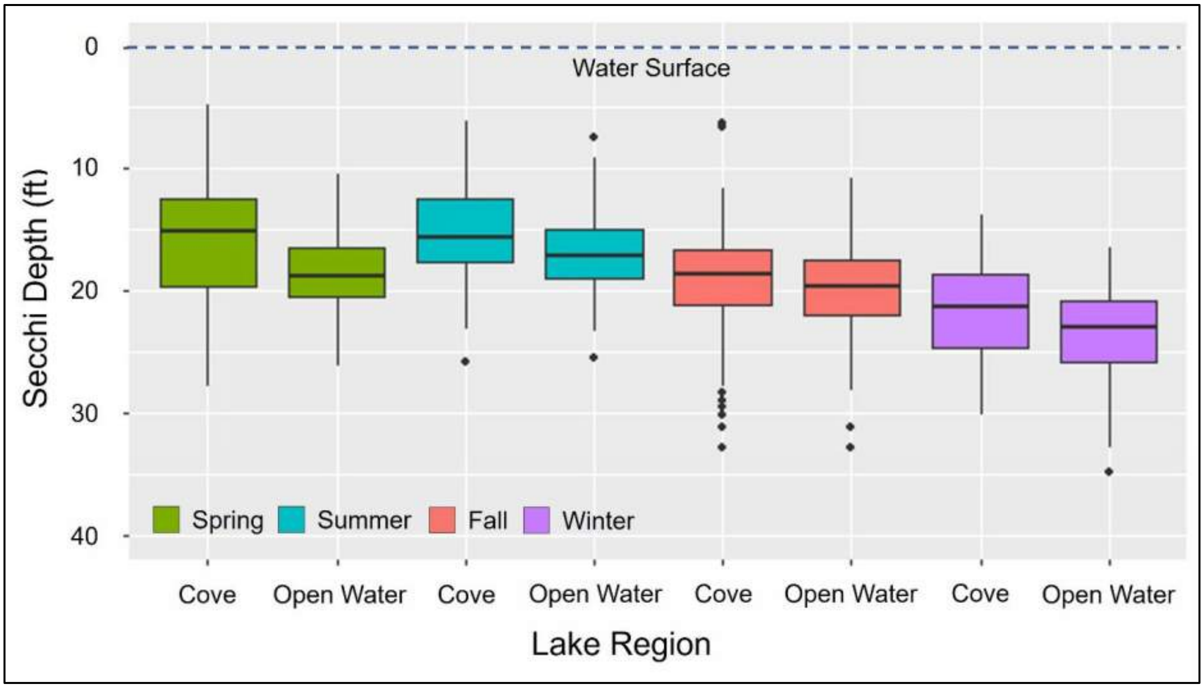


Figure E.9-7. Box Plot of Secchi Depth Data (Duke Energy 2024b) for Cove and Open Water Locations

The ANOVA model showed that both sample location (open water or cove) and season (spring, summer, fall, winter), in combination, had a substantial influence over Secchi depth across all seasons (ANOVA, $p < 0.001$). The greatest difference in Secchi depth between the open water and cove regions was in spring, with open water showing a significantly higher Secchi depth as compared with cove areas (Tukey HSD, $p < 0.0001$), likely due to seasonally (spring) related increase in precipitation. The smallest difference in Secchi depth between regions occurred in the fall and was not significant (Tukey HSD, $p > 0.05$). The difference in highest (open water during winter, mean 7.2 ft standard deviation [SD] = 1.1) and lowest (cove during spring, mean 4.8 ft SD = 1.5) Secchi depth readings was 2.3 ft.

Two performance measures evaluated as part of the CHEOPS model review and included in the littoral zone quantification were “maximum littoral habitat during growing/spawning season” based on water surface elevations of 1,107 ft msl and 1,105 ft msl; a 2-ft difference (Table E.9-11). Since the greatest seasonal difference in Secchi depth was similar to this range (2.3 ft, as stated above) and for the simplicity of littoral zone quantification, average Secchi depth by region across all seasons was used for littoral zone depth calculations. The mean Secchi depth for the open water region was 19.6 ft (SD = 4.1) and 17.9 ft (SD = 5.1) for cove areas.

The littoral zone depth (the depth at which 1 percent of incident radiation penetrates the water column) was calculated to be 48.4 ft in cove areas and 53.0 ft in the open water region. The water surface elevations as listed in Table E.9-11 were assumed to be the maximum extent of the littoral zone (i.e., upper bound), from which the calculated depth of the littoral zone was subtracted to achieve the lower bound of the elevation band. The area of the littoral zone was calculated based on elevation ranges presented in Table E.9-11 and bathymetry data.

Table E.9-11. Summary of Water Surface Elevations (ft msl) for Evaluated Littoral Zone Scenarios

Littoral Zone Scenario	Reservoir Water Surface Elevation	Littoral Zone Bottom Elevation	
		Cove Region	Open Water Region
Maximum Elevation	1,110	1,062	1,057
Littoral Zone Habitat During Growing/Spawning Season (High)[1]	1,107[2]	1,059	1,054
Littoral Zone Habitat During Growing/Spawning Season (Low)[1]	1,105[2]	1,057	1,052
Normal Minimum Elevation	1,096	1,048	1,043
Minimum Elevation	1,080	1,032	1,027

[1]The "growing season" was defined as April 1 to September 30 and "spawning season" was defined as April 1 to May 31 in the CHEOPS model.
[2]Lake Jocassee fish habitat elevations provided by Bill Marshall of SCDNR during the KT Project relicensing.

Lake Jocassee was estimated to support approximately 1,457.3 acres of littoral habitat at maximum water surface elevation (1,110 ft msl) (Table E.9-12). At normal minimum elevation, a total of 1,421.4 acres of littoral habitat was available, a reduction of 2.5 percent from the maximum elevation. At minimum elevation (1,080 ft msl), littoral habitat dropped to 1,288.0 acres (a decline of 11.6 percent from maximum elevation) and shifted spatially toward the center of the reservoir and coves.

CHEOPS performance measures 26 through 29 used reservoir surface water elevations of 1,107 ft msl and 1,105 ft msl to evaluate the amount of time Lake Jocassee's elevation supported littoral zone habitat during the growing season (April 1 to September 31) and spawning season (April 1 to May 31). Littoral habitat acreage at these elevations varied only slightly and was estimated to be 22.1 to 22.7 acres less than the estimated littoral habitat at maximum elevation, a difference of only 1.5 percent (Table E.9-12).

The littoral zone was spread relatively evenly throughout Lake Jocassee with the exception of the Toxaway River arm, where the Toxaway River enters Lake Jocassee. The Toxaway River arm encompassed a substantial portion of Lake Jocassee's total littoral zone, comprising up to 24.8 percent of the littoral zone under the maximum drawdown scenario and 30.9 percent for all others.

Table E.9-12. Estimated Littoral Habitat (acres) in Lake Jocassee

Littoral Zone Scenario	Region		Total	Percent difference from Maximum Elevation
	Cove	Open Water		
Maximum Elevation	718.5	738.8	1,457.3	--
Littoral Zone Habitat During Growing/Spawning Season (High) (1,107 ft msl)	703.9	731.3	1,435.2	-1.5
Littoral Zone Habitat During Growing/Spawning Season (Low) (1,105 ft msl)	701.4	733.2	1,434.6	-1.6
Normal Minimum Elevation	671.7	749.7	1,421.4	-2.5
Minimum Elevation	541.5	746.5	1,288.0	-11.6

Figures showing the littoral zone across lake Jocassee at various water surface elevations are included in the *Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat Final Report*, Appendix D.

Task 2 Conclusions

Pelagic Trout Habitat Assessment

Pelagic trout habitat monitoring in Lake Jocassee since 1973 shows variation in the amount of suitable water conditions which is likely driven by natural environmental fluctuations and to some extent, operations at Jocassee Pumped Storage Station. Trout habitat thickness, as indicated at the deepest part of the lake, did not appear to change before and after Project operations commenced in 1991. The study by Foris (2014) shows sufficient trout habitat throughout the lake and into Whitewater River cove up to the submerged weir during all times of year, but that Whitewater River cove upstream of the weir does not support trout habitat in late summer due to thermal mixing from Project operations.

Water column mixing under the maximum elevation and minimum elevation scenarios occurs upstream of the weir and dissipates within 1,050 ft on the downstream side of the weir. Just as the existing weir reduces water column mixing downstream, the expanded weir is expected to act as a similar mechanism to reduce water column mixing and disruption to pelagic trout habitat in Lake Jocassee even with additional generation of Bad Creek II. Impacts to pelagic trout habitat resulting from increased vertical mixing due to operations from Bad Creek II are not expected based on historical lake dynamics, trout habitat monitoring, and hydraulic modeling.

Littoral Habitat Quantification

The CHEOPS model results indicate the addition of Bad Creek II would not result in impacts to spawning success or littoral zone habitat as compared to conditions currently experienced by aquatic life under the Baseline scenario in Lake Jocassee. In fact, the model suggests that some conditions (e.g., spawning success) would improve with the addition of Bad Creek II operations as indicated by the performance measures.

The maximum drawdown scenario represents the minimum amount of littoral zone habitat that could occur under existing KT Project license conditions. However, during the entire hydrologic dataset evaluated in the CHEOPS model (1939 to 2011), Lake Jocassee never reached maximum drawdown water surface elevation. The CHEOPS model showed zero days where Lake Jocassee water surface elevation would be below 1,081 ft msl (performance measure 32).

Lake Jocassee reservoir surface elevation is between 1,104 ft msl and 1,109 ft msl 90 percent of the period of record (1939 through 2011) under both the Baseline and Bad Creek II scenarios. This range encompasses the “Littoral Zone Habitat (High)” scenarios (which maintain 98.4-98.5 percent of littoral zone habitat) and is greater than normal minimum water surface elevation as required by Article 402 of the KT Project license.

E.9.2.1.3 Impacts to Surface Waters and Associated Aquatic Fauna (Task 3)

Construction of Bad Creek II would impact existing streams and waterbodies, including wetlands. Overburden (i.e., soil and rock) material from the construction activities are proposed to be deposited in spoil locations throughout the site. Siting for spoil location alternatives is ongoing by Duke Energy, with consideration of existing natural resources that are identified during site investigations, existing topography, and quantity of material used to expand the submerged weir in Lake Jocassee. Although Duke Energy will avoid and minimize impacts to surface waters and wetlands to the extent practicable, it is likely that impacts to streams and wetlands will occur as a result of spoil placement.

The purpose of the Aquatic Resources Task 3 Study was to evaluate potential direct impacts to aquatic habitat (including wetlands) related to Bad Creek II construction activities and weir expansion by quantifying and characterizing surface waters, including resource quality. In addition to assessing surface waters that have the potential to be impacted by construction activities, Duke Energy evaluated surface waters that would be crossed by a temporary access road, however the access road is no longer proposed and therefore not summarized for the DLA. Details on aquatic resources evaluated along the temporary access road are included in the *Impacts to Surface Waters Associated with Aquatic Fauna Final Report*, Appendix D.

Task 3 Methods

Stream habitat quality surveys were completed for streams within proposed spoil locations using USEPA RBP and NCSAM. Through consultation with the SCDNR, Duke Energy also applied the

Stream Quantification Tool methodology of stream assessment for streams crossed by the temporary access road. Since the temporary access road is no longer proposed, only stream surveys within the expanded Project Boundary (i.e., those associated with spoil areas or the transmission line corridor) are summarized below. Details on all stream assessment methods are included in the *Impacts to Surface Waters Associated with Aquatic Fauna Final Report*, Appendix D.

Task 3 Results

Surveys for surface waters and wetlands within potential spoil locations were completed in September 2021. The study area for the 2021 Natural Resources Assessment (HDR 2021a, 2021b) was 1,314 acres consisting of all existing Bad Creek Project facilities, maintained ROW areas, and undisturbed forested areas. Resources identified include nine streams, three wetlands, and one open waterbody.

Stream habitat surveys using USEPA RBP and NCSAM were completed in September 2023. According to the USEPA RBP, all streams scored above 100 in the "optimal" or "suboptimal" range (Table E.9-13). Some streams had reduced scores related to limited baseflow conditions (less aquatic habitat) and/or microhabitat characteristics (e.g., presence of epifaunal substrate, level of embeddedness, velocity/depth regime, etc.). Similarly, all streams were rated as high functioning according to the NCSAM with the exception of Streams 4 and 4a within spoil location G, which were rated as "medium" primarily due to limited baseflow conditions or, for Stream 4a, related to suboptimal streamside conditions (limited buffer).

Five streams within spoil locations B, D, and J were not completed due to safety concerns related to inclement weather. As with other streams within potential spoil locations and consistent with the SCDNR determination during the July 2023 site visit (see *Consultation Documentation* attached to the *Impacts to surface Waters and Associated Aquatic Fauna Final Report* in Appendix D), it is likely that these streams also present fully functioning conditions.

Table E.9-13. Summary of Surface Waters and Wetlands Estimated within Potential Spoil Locations

Name	Type	Extent (linear ft or acres)	USEPA Rapid Bioassessment Score	NCSAM Overall Functional Rating
Streams (linear ft)				
Stream 4	Intermittent	942	117 (Suboptimal)	Medium
Stream 4a	Perennial	542	137 (Suboptimal)	Medium
Stream 11	Unknown	148	--	--
Stream 13	Intermittent	227	--	--
Stream 14	Perennial	770	--	--
Stream 17	Perennial	286	143 (Suboptimal)	High
Stream 19 (Devils Fork)	Perennial	1,129	155 (Optimal)	High
Stream 20	Perennial	577	--	--
Stream 21	Unknown	172	--	--

Name	Type	Extent (linear ft or acres)	USEPA Rapid Bioassessment Score	NCSAM Overall Functional Rating
	Total	*4,793*	--	
Wetlands (acres)				
Wetland 4 (isolated)	Emergent	0.37	N/A	N/A
Wetland 7 (isolated)	Forested	1.15		
Wetland 10 (isolated)	Emergent	2.96		
	Total	*4.48*		
Open Waterbodies (acres)				
Lake Jocassee	Freshwater	12.7	N/A	N/A

-- Stream habitat surveys were unable to be completed due to safety concerns related to inclement weather.

Although suitable mussel habitat was observed in Lake Jocassee, no live or dead mussels or remnants were identified. The only species identified was the non-native Asian clam.

Task 3 Conclusions

Habitat quality assessments of streams using the USEPA RBP and NCSAM indicated the streams within potential spoil locations are in fully functioning condition. Although suitable mussel habitat was identified along the shoreline of Lake Jocassee, no mussels were observed.

Impacts to streams and wetlands within potential spoil areas would consist of fill due to the placement of French drains, followed by placement of overburden (rock) generated by the construction of Bad Creek II. French drains would be used to maintain connection of flow to downstream waters, however the surface waters and wetlands within the potential spoil locations would no longer be available as habitat to the organisms currently utilizing them. Not all spoil areas will be used for the construction of Bad Creek II, and Duke Energy is currently evaluating the spoils area alternatives with respect to resulting impacts, mitigation, and constructability. Additional study details and assessment of impacts are included in the *Impacts to Surface Waters Associated with Aquatic Fauna Final Report*, Appendix D.

E.9.2.2 Project Impacts on Aquatic Resources

In SD2, FERC identified the following environmental issues related to aquatic resources to be addressed in its NEPA document:[27]

- Effects of construction-related erosion, sedimentation, and spoils disposal on water quality, aquatic habitat, and aquatic biota in Lake Jocassee and streams in the project vicinity.
- Effects of reservoir fluctuations associated with project operation on aquatic habitat and biota in Lake Jocassee.*

[27] Issues with and asterisk (*) will be analyzed for both cumulative and site-specific effects.

- Effects of vertical mixing of DO associated with project operation on fish populations in Lake Jocassee.
- Effects of project operation on aquatic habitat and biota in Howard Creek.[28]
- Effects of project induced impingement, entrainment, and turbine mortality on fish populations in Lake Jocassee.*
- Effects of project recreation on aquatic resources.
- The effects construction-related erosion, sedimentation, and spoils disposal in the Bad Creek reservoir on Lake Jocassee.

E.9.2.2.1 Effects of Construction-Related Erosion, Sedimentation, and Spoils Disposal on Aquatic Habitat and Aquatic Biota in Lake Jocassee and Streams in the Project Vicinity

Impacts to streams within potential spoil areas would consist of fill due to the placement of French drains, followed by placement of overburden material generated by the construction of Bad Creek II. French drains would be used to maintain connection of flow to downstream waters and for spoil pile stabilization, however the surface waters and wetlands within the potential spoil locations would no longer be available as habitat to the organisms currently utilizing them. Stream segments upstream of spoil locations would also be impacted due to isolation from downstream waters. Additional evaluations are currently underway to determine natural resource impacts for the different potential spoil areas, and these evaluations are expected to inform eventual spoil site selection as Duke Energy plans to describe in the FLA. Impacts to streams due to construction of Bad Creek II, including spoils disposal, is further discussed in Section E.8.2.2.1.

Traffic on access roads during construction has the potential to increase sediment runoff which can be mitigated through BMPs (e.g., vegetation, silt fence, or matting) installed near haul roads and access roads. BMP inspections and the ESC Plan will be developed and implemented through the NPDES construction permitting process.

No impacts to mussels are expected, as no native mussels were observed in the vicinity of the current or future lower reservoir I/O structure, or in the vicinity of the expanded underwater weir. A minor portion of suitable mussel habitat located immediately upstream of the proposed I/O structure for Bad Creek II could be impacted due to construction activities, however, as stated, no mussels were identified in this area during surveys. Aquatic organisms in Lake Jocassee would experience short-

[28] Howard Creek is a tributary of Lake Jocassee and receives seepage flows from the two earthen dams of the Bad Creek upper reservoir.

term, localized water quality effects due to expansion of the weir (i.e., placement of rock/overburden on and in the vicinity of the existing weir) and construction of the Bad Creek II I/O structure.

Compensatory mitigation will be required for unavoidable impacts to surface waters (including wetlands) that are regulated under Section 404 of the CWA to ensure that impacts to aquatic resources are avoided or minimized to the greatest extent possible. Mitigation options may include on-site restoration and/or purchase credits from an approved in-lieu fee mitigation bank to offset unavoidable adverse impacts.

All applicable state and federal authorizations for unavoidable impacts to surface waters will be obtained prior to construction of Bad Creek II. Additionally, a WQMP, which outlines monitoring efforts before, during, and after construction will also be implemented. See Section E.8.3.2 for more information on PM&E measures.

E.9.2.2.2 Effects of Reservoir Fluctuations Associated with Project Operation on Aquatic Habitat and Biota in Lake Jocassee

Existing Bad Creek Project

In support of the KT relicensing process, Duke Energy used the CHEOPS operations model to simulate hourly water levels in Lake Jocassee under four alternative scenarios compared to baseline conditions as related to KT Project operations using hydrology from the years 1939 to 2011 (Duke Energy 2014c). The model included continued operation of the Bad Creek Project. Twelve metrics were defined to assess the effects on spawning conditions for black bass, sunfish, blueback herring, and threadfin shad. Under the most severe hydrologic conditions modeled, hourly model outputs indicate KT Project operations should support reservoir target levels for at least 20 consecutive days, at least 99 percent of the time, and 100 percent of the time for 15 or fewer consecutive days for the black bass spawning period. Given the littoral spawning species hatch and disperse from nests within 5 days of hatching, the 20-consecutive-day period of uninterrupted spawning should enhance an already healthy fish community for shallow water species. Fish and creel surveys in Lake Jocassee since the Project commenced operations has shown a healthy and balanced fish community and does not appear to be affected by past or continued Project operations.

Bad Creek II

Littoral habitat in Lake Jocassee under Bad Creek II operations is expected to remain the same or improve as compared to Baseline (existing) conditions. Increased generation and pumping rates with the addition of Bad Creek II (and coupled with increased Jocassee Pumped Storage Station operations which act to offset Bad Creek II operations) would reduce the range of water surface elevation fluctuation, thereby maintaining higher stability during fish spawning and growing season periods. The amount of littoral habitat estimated for Lake Jocassee at normal minimum water surface elevation (1,096 ft msl), as defined under Article 402 of the KT Project license, is just 2.5 percent less than at maximum elevation. The CHEOPS results show that Lake Jocassee would not be expected to reach maximum drawdown water surface elevations under typical operations. Furthermore, based on the Bad Creek II scenario results, Lake Jocassee is shown to be held most often above 1,104 ft msl which maintains greater than 98 percent of Lake Jocassee's total littoral zone habitat.

Marginal, if any, impacts to pelagic or littoral aquatic habitat in Lake Jocassee are anticipated as a result of the continued operation of Bad Creek or the additional operation of Bad Creek II.

E.9.2.2.3 Effects of Vertical Mixing of DO Associated with Project Operation on Fish Populations in Lake Jocassee

Existing Bad Creek Project

As demonstrated by water quality data collected under tasks of the Water Resources (Tasks 1 and 2) Study, the existing underwater weir reduces water column mixing downstream of Whitewater River cove, preventing impacts to pelagic trout habitat in Lake Jocassee (see Section E.9.1.2.4). Therefore, pelagic trout habitat in Lake Jocassee was not substantially different before or after the development and operation of the Project, or after the recently completed Project upgrades.

Bad Creek II

Based on historic spatial temperature and DO dynamics of Lake Jocassee and the results of the Water Resources (Task 3) Study, water column mixing effects as a result of Bad Creek II operations in addition to the Project is confined to the area immediately downstream of the weir (see Section E.9.2.1.2). No impacts to pelagic trout habitat are expected as a result of the addition of Bad Creek II operations.

E.9.2.2.4 Effects of Project Operation on Aquatic Habitat and Biota in Howard Creek

As discussed in Section E.8.2.1.1 and E.9.1.3.2, Duke Energy evaluated Howard Creek water quality pre-construction (1980-1981) and following construction (1993). Based on the data compiled in the *Summary of Existing Water Quality Standards Final Report* (Appendix D), water quality in Howard Creek downstream of Bad Creek Reservoir is comparable to conditions prior to construction. Correspondingly, aquatic habitat since construction has remained comparable to pre-construction conditions. The Licensee is not proposing changes that would alter water quality or seepage flow into Howard Creek, therefore no effects to aquatic habitat or biota are expected.

E.9.2.2.5 Effects of Project Induced Impingement, Entrainment, and Turbine Mortality on Fish Populations in Lake Jocassee

Existing Bad Creek Project

Results of the Barwick et al. (1994) entrainment study concluded that: (1) entrainment had no statistical impact on the abundance of prey and sportfish taxa in Lake Jocassee; (2) entrainment had no statistical impact on the effort and harvest of fish by anglers fishing Lake Jocassee; and (3) entrainment had no predicted long-term impact on the prey fish population in Lake Jocassee during normal operating conditions observed in 1991-1993 (see Section E.9.1.2.1). Regular fish sampling (see Section E.9.1.2) demonstrates the Lake Jocassee fishery remains in good condition since the start of operation of the Project.

Bad Creek II

The recent entrainment study summarized in Section E.9.2.1.1 also showed that the addition of Bad Creek II is not expected to affect the long-term sustainability of Lake Jocassee fish populations. The species most impacted, blueback herring and threadfin shad, have relatively high fecundity, and population-level compensatory mechanisms will likely offset the entrainment losses in terms of effects on these fish populations. In addition, while some level of entrainment mortality will inevitably occur, many natural populations have excess reproductive capacity that will compensate for some losses of individuals (Sale et al. 1989).

E.9.2.2.6 Effects of Project Recreation on Aquatic Resources

Project-required recreation activities are limited to maintaining approximately 43 miles of the Foothills Trail and two boat-in Foothills Trail access points, none of which are in the Project Boundary. These facilities have been in place for many years and no actions are proposed other than maintaining the trail to remove fallen trees, maintain bridges, repair trail washouts, and address other maintenance issues as needed. Erosion features and clogged culverts were identified in the *Final Foothills Trail Corridor Conditions Assessment* of the Recreation Study Final Report (Appendix D) prepared for relicensing, but the trail is generally in good condition and well-maintained. No new stream crossings or culvert installations are proposed, and no impacts to surface waters or wetlands are proposed along the 43-mile segment of the Foothills Trail.

The Licensee currently monitors trail and access point conditions routinely, repairs the trail as needed, and is proposing to continue doing so during the next license term. This limits the potential for trail-related erosion to adversely affect water quality in tributary streams flowing to Lake Jocassee.

E.9.2.2.7 The Effects of Construction-Related Erosion, Sedimentation, and Spoils Disposal in the Bad Creek Reservoir on Lake Jocassee

Deposit of overburden material in Bad Creek Reservoir would be completed under appropriate BMPs as required by the ESC Plan (see Section E.8.3.2). Spoil placement will be carried out during Bad Creek Reservoir drawdown under dewatered conditions using haul trucks; hauling and haul routes would adhere to requirements in the ESC Plan.

Because water is exchanged directly between the upper reservoir and Lake Jocassee, water in the Whitewater River cove downstream of the I/O structures is representative of water in the Bad Creek Reservoir; under actions proposed in the WQMP (provided in the Water Resources Study, Appendix D), surface water quality will be monitored daily in the Whitewater River cove during construction and for a one-year period following commencement of Bad Creek II operations.

E.9.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.9.3.1 Existing Bad Creek Project

No changes are proposed to the Normal Operating Ranges for Lake Jocassee or Lake Keowee as required in the KT Project license, which will continue to protect aquatic habitat in both reservoirs (as demonstrated in the Aquatic Resources Task 2 study). The Licensee will operate its facilities to minimize fish entrainment, to the extent practical, while Lake Jocassee pool elevations are below 335 m or 1,099 ft (i.e., 89 ft local datum with the full pond elevation of 1,110 ft AMSL referenced as 100.0 ft local datum). The Licensee proposes to continue the following operating measures to minimize fish entrainment associated with Bad Creek pumping operations:

- **Hydro Unit Sequencing:** When operating the Units 1 through 4 in pumping mode, the Licensee will use a start-up sequence of Unit 1, Unit 2, Unit 3, and Unit 4, to the extent practicable to minimize entrainment.
- **Pumping Operations during Lower Elevations:** When pool elevations in Lake Jocassee fall below 1,099 ft msl (89 ft local datum), the Licensee will implement operational changes in coordination with SCDNR based upon hydro unit availability and other operational considerations, to minimize fish entrainment.
- **Inlet/Outlet Lighting Modifications:** The Licensee will revise its FERC Public Safety Plan to redesign and modify lighting for the FERC-required public safety devices on the intake towers to eliminate or reduce the amount of light shining on Lake Jocassee's surface near the I/O

structure(s). Such modifications may include, among other things, replacing white lights with red lights, boxed lighting, and illuminating signage from below rather than above the safety devices. These modifications will be implemented within two years of license issuance.

The Licensee will continue to maintain the 43-mile segment of the Foothills Trail as stated above, which is protective of surface waters and aquatic biota by limiting effects of erosion and sedimentation that may occur as a result of stream crossings (i.e., culverts, footbridges, etc.) or trail destabilization.

As an off-license measure under the BCRA, the Licensee will provide $10,500,000 in one-time funding to the SCDNR, for use in implementation of SCDNR's Fisheries Enhancement and Management Program in Lake Jocassee, Keowee, and associated tributaries to the lakes. These funds will be used to support fisheries management activities including creel surveys, fish stocking, habitat management / enhancement, fish surveys (e.g., electrofishing, gill net, trap net, etc.), research, and other activities to protect and enhance aquatic resources. The funds may also be used to support stream restoration to enhance angling opportunities, land management/acquisition to increase angler access, native brook trout restoration activities, trout stocking and management surveys, creel surveys, research, or development of an additional coldwater hatchery in the area defined as all properties north of the main line of the Norfolk Southern Railroad from the Georgia State line to SC Hwy 183 in Westminster, then north of SC Hwy 183 to the intersection of SC Hwy 183 and the Norfolk Southern Railroad main line in Greenville and then north of the mainline of the Norfolk Southern.

E.9.3.2 Bad Creek II

The License is proposing the following PM&E measures during Bad Creek II construction:

- The Licensee will include French drains in its upland spoil areas to minimize impacts to ephemeral and perennial streams and associated aquatic biota.
- The Licensee will implement an ESC Plan, described in Section E.8.3.2 to reduce the potential effect of construction on headwater streams.
- The Licensee will follow the necessary and required Clean Water Act Section 404/401 permitting conditions as provided by the USACE and SCDES.
- For the protection of water quality as well as aquatic resources in Lake Jocassee and upland streams, the Licensee will implement the WQMP as described in E.8.3.2.

Following Bad Creek II construction (and only if Bad Creek II is constructed), the Licensee is proposing the following PM&E measures:

- In consultation with SCDNR, the Licensee will conduct an ADCP-based flow study within two years following commercial operation to identify unit sequencing to reduce entrainment.
- The Licensee will conduct hydroacoustic monitoring of pelagic forage fish in Lake Jocassee and Lake Keowee for a period of 10 years following commercial operation of Bad Creek II. If Bad Creek II operations change after the 10-year monitoring period, the Licensee will consult with SCDNR regarding the need for additional monitoring.

As an additional off-license measure under the BCRA contingent on the construction of Bad Creek II, the Licensee will provide SCDNR an additional $1,000,000 for use in implementation of SCDNR's Fisheries Enhancement and Management Program (described in E.9.3.1).

E.10 Wetlands, Riparian, and Littoral Habitat

E.10.1 Affected Environment

E.10.1.1 Overview

Wetlands are generally defined as those areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. The USACE and SCDES have jurisdiction over wetlands in South Carolina.

Riparian habitats are the transitional area between wetland/water and upland areas, supporting vegetation found along waterways such as rivers, streams, lakes, and other drainages. The boundary of the riparian area and the adjoining uplands is gradual and not always well defined. However, riparian areas differ from the uplands because of their high levels of soil moisture, frequency of flooding, ability to provide important ecosystem functions, and unique assemblage of plant and animal communities (Mitsch and Gosselink 2000). Riparian habitat in the expanded Project Boundary primarily consists of hardwood forest.

The littoral zone, in the context of a large river system, is the habitat between about a one-half meter of depth and the depth of light penetration. The littoral width varies based on the geomorphology and rate of sedimentation of the stretch of river (Wetzel 1983). Littoral habitat in lentic waterbodies (i.e., ponds and lakes) encompasses the euphotic zone, or the depth to the lake bottom which sunlight penetrates the water column (see Section E.9.2.1.2). Littoral habitat is further discussed in Section E.9.1.1.2.

Extensive desktop and field-based studies were performed to identify environmental resources pertaining to wetlands and waterbodies in the expanded Project Boundary. Natural resources assessments (HDR 2021a, 2021b) were carried out in support of this relicensing were attached to the PAD and are summarized below.

E.10.1.2 Wetlands and Waterbodies Acreage

HDR biologists conducted several surveys of the Project Boundary for waters of the U.S. under Section 404/401 of the CWA) between 2021 and 2024.[29] Jurisdictional waters were delineated according to the methodology and guidance described in the USACE 1987 Wetland Delineation Manual (USACE

[29] Dates of surveys are as follows: June 8 to 10, 2021; September 19 and 20, 2021; October 18 and 19, 2023; May 21 to 23, 2024; July 23 to 25, 2024; July 31, 2024; August 1, 2024; and August 16, 2024.

1987) and the 2012 USACE Eastern Mountains and Piedmont Regional Supplement (Version 2.0) (USACE 2012). Streams were classified utilizing the methodology and guidance provided in the USACE National Ordinary High Water Mark Field Delineation Manual for Rivers and Streams: Interim Version, and the NC Department of Environmental Quality - Division of Water Resources (NCDWR; formerly Division of Water Quality) Methodology for Identification of Intermittent and Perennial Streams and Their Origins (Version 4.11).

Due to challenging and potentially unsafe conditions within the Project Boundary (i.e., rugged terrain with precipitous drops in elevation, waterfalls), some potentially jurisdictional features were not field delineated (flagged in the field); instead, these features were field documented (i.e., photographs, GPS points, and field notes) and delineated via desktop methods. Accessible potential jurisdictional waters of the U.S. were delineated and mapped in the field using a GPS unit capable of sub-meter accuracy.

HDR, on behalf of Duke Energy, submitted a Preliminary/Approved Jurisdictional Determination Request to the USACE for waters of the U.S. within the Project Boundary on September 9, 2024. On December 3, 2024, HDR met with the USACE for a site visit at the Project to field-verify the on-site waters and wetlands. The following results present a summary of the determination from the USACE for waters of the U.S. within the Project Boundary.

E.10.1.2.1 Expanded Project Boundary Excluding Transmission Line Corridor

Wetlands

Eight wetlands were identified in the expanded Project Boundary totaling 1.21 acres of forested wetland, 0.28 acre of emergent wetland, and 0.04 acre of scrub-shrub wetland (Table E.10-1; Figure E.8-3). Five wetlands within the expanded Project Boundary were also determined to be non-jurisdictional following consultation with the USACE.

Table E.10-1. Summary of Jurisdictional and Non-Jurisdictional Wetlands within the Expanded Project Boundary, Excluding the Transmission Line Corridor

Feature ID	Type of Wetland	Total Area (acres)
Jurisdictional Wetlands		
Wetland 01	Forested	0.58
Wetland 01A	Emergent	0.01
Wetland 02	Scrub-Shrub	0.04
Wetland 03	Forested	0.22
Wetland 04	Forested	0.37
Wetland 05	Emergent	0.07

Feature ID	Type of Wetland	Total Area (acres)
Wetland 07	Emergent	0.20
Wetland 30	Forested	0.04
	Total Area (acres)	**1.53**
Non-Jurisdictional Wetlands		
Wetland 02	Forested	0.06
Wetland 05	Emergent	0.21
Wetland 07	Forested	0.16
Wetland 13	Emergent	2.10
Wetland 14	Emergent	0.15
	Total Area (acres)	**2.68**

Riparian Habitat

Based on a riparian buffer width of 32 ft (10 meters; SCDNR 2020), approximately 38.2 acres of riparian habitat exists within the expanded Project Boundary (excluding the Transmission Line Corridor or associated access routes). The riparian buffers primarily consist of forested habitat, comprising 95.8 percent of the total riparian habitat (Table E.10-2).

Table E.10-2. Summary of Riparian Habitat within the Expanded Project Boundary Excluding the Transmission Line Corridor

Land Cover Type	Total Area (acres)	Percent of Total
Forest	36.6	95.8
Shrub/Scrub	0.7	1.8
Herbaceous	0.6	1.6
Developed	0.2	0.5
Open Water	0.1	0.3
Barren	<0.1	0.0
Total	**38.2**	**100.0**

E.10.1.2.2 Transmission Line Corridor

Wetlands

Seventeen wetlands were identified in the transmission line corridor totaling 2.17 acres of emergent wetland, 0.23 acre of forested wetland, and 0.07 acre of scrub shrub wetland (Table E.10-3; Figure E.8-4 through Figure E.8-7). No wetlands were identified as non-jurisdictional.

Table E.10-3.Summary of Jurisdictional Wetlands within the Transmission Line Corridor

Feature ID	Type of Wetland	Total Area (acres)
Wetland 13	Emergent	0.20

Feature ID	Type of Wetland	Total Area (acres)
Wetland 14	Emergent	0.09
Wetland 15	Emergent	0.13
Wetland 16	Emergent	0.04
Wetland 17	Scrub-Shrub	0.03
Wetland 18	Emergent	0.08
Wetland 19	Emergent	0.08
Wetland 20	Emergent	0.94
Wetland 21	Emergent	0.10
Wetland 22	Emergent	0.05
Wetland 23	Emergent	0.09
Wetland 24	Emergent	0.51
Wetland 25	Emergent	0.02
Wetland 26	Scrub-Shrub	0.04
Wetland 27	Emergent	0.04
Wetland 28	Forested	0.20
Wetland 29	Forested	0.03
	Total Area (acres)	**2.67**

Riparian Habitat

Riparian habitat along the transmission line corridor includes approximately half forested habitat, one-third herbaceous habitat, and a smaller portion of shrug/scrub habitat (Table E.10-4). More herbaceous and shrub/scrub habitat occurs within the transmission line corridor due to routine vegetation maintenance for the safe and reliable transmission of power to Jocassee Station from the Project.

Table E.10-4. Summary of Riparian Habitat within the Transmission Line Corridor

Land Cover Type	Total Area (acres)	Percent of Total
Forest	13.8	52.1
Herbaceous	10.3	38.9
Shrub/Scrub	2.3	8.7
Developed	0.1	0.4
Open Water	<0.1	0.0
Total	**26.5**	**100**

E.10.1.2.3 Flood Hazards

Based on a review of the Federal Emergency Management Agency's (FEMA) National Flood Hazard Layer data, FEMA Flood Insurance Rate Map (FIRM) panel numbers 45073C0020C, 45073C0040D, 45073C0100D, 45073C0105D, 45073C0115D, 45073C0120D, and 45073C0110D fall within the proposed Project Boundary (FEMA 2025). The Special Flood Hazard Area borders the proposed Project Boundary at the Whitewater River and crosses into the Project Boundary near Jocassee Pumped Storage Station (Figure E.10-1). Special Flood Hazard Area are classified by FEMA as high flood risk (Zone AE) zones and are subject to inundation by the 1-percent-annual-chance flood event being equaled or exceeded in any given year (i.e., 100-year flood) (FEMA 2020). Approximately 5.9 acres of Zone AE is mapped associated with McKinneys Creek and 2.3 acres associated with Lake Keowee along the powerline right-of-way in the southern portion of the proposed Project Boundary. No Regulatory Floodway areas occur within the proposed Project Boundary.

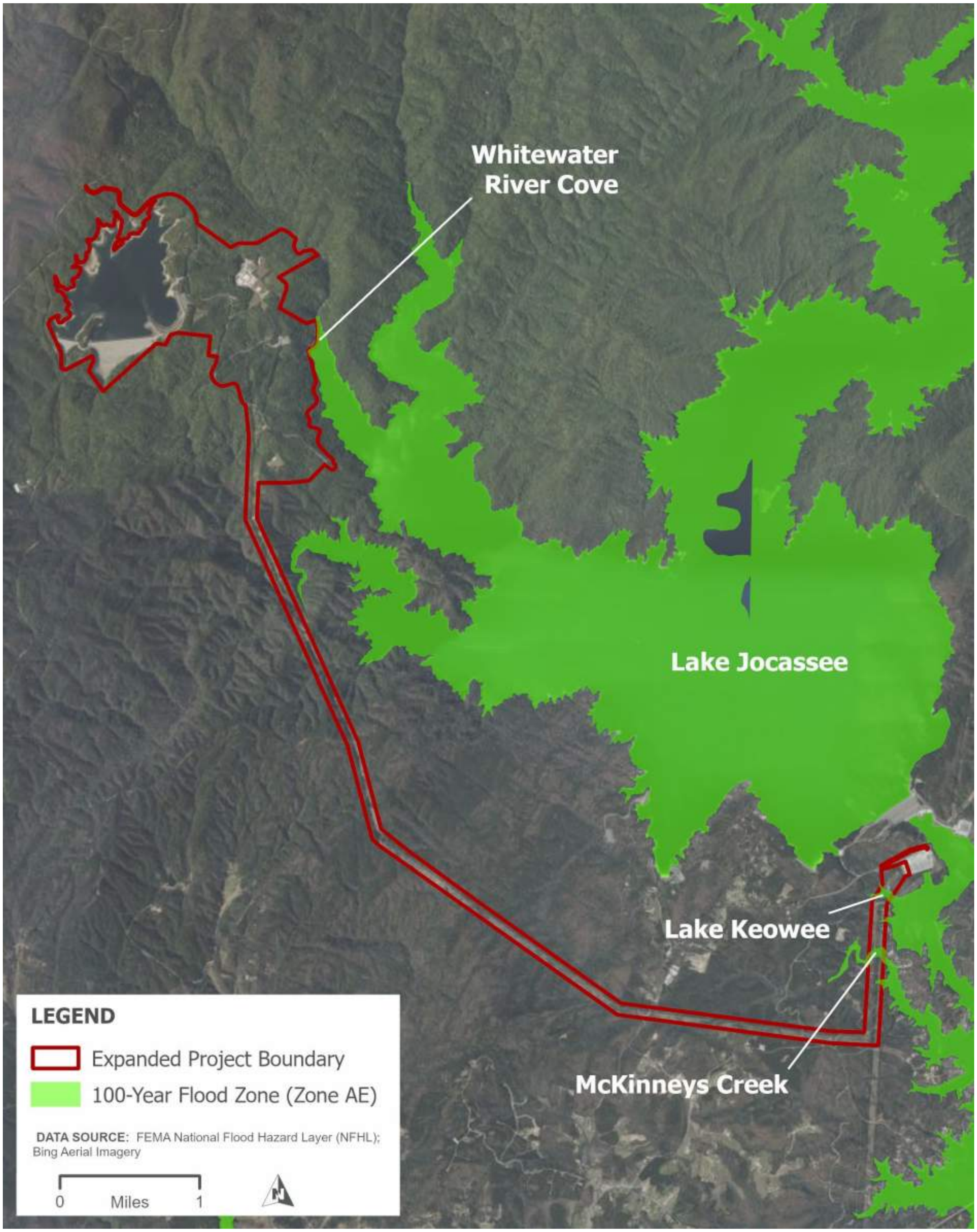


Figure E.10-1. FEMA Flood Zones

E.10.2 Environmental Analysis

E.10.2.1 Studies in Support of the Current Relicensing

In support of the current relicensing, HDR conducted Natural Resource Assessments for Duke Energy in 2021 that involved a desktop review of publicly available data and an on-site investigation that included surveys for wetlands and jurisdictional waters of the U.S., federally protected species habitat, and classification of natural/vegetation communities.

Additionally, an Aquatic Resources Study was completed in 2023 and 2024. This study included the following two tasks related to wetlands and littoral habitat: *Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat* (Task 2) and *Impacts to Surface Waters and Associated Aquatic Fauna* (Task 3). The objectives, methods, results, and conclusions of both studies are summarized in Section E.9.2.1 and final study reports are provided in Appendix D.

E.10.2.2 Project Impacts on Wetlands, Riparian, and Littoral Habitat

In SD2, FERC identified the following environmental issue related to wetlands, riparian, and littoral habitat to be addressed in its NEPA document:

- Effects of project construction, operation, and maintenance activities, including maintenance for roads and transmission line rights-of-way, and project-related recreation on native plant communities, wetlands, and the spread and control of non-native, invasive plants.

E.10.2.2.1 Effects of Project Construction, Operation, Maintenance Activities, and Project-Related Recreation on Wetlands

Existing Bad Creek Project

Effects of continued Project operation would have no effect on wetlands in the Project Boundary as no new actions are proposed.

Bad Creek II

As discussed in Section E.8.2.2 and elsewhere in this document, construction of Bad Creek II would cause unavoidable impacts to waters of the U.S. within the proposed Project Boundary, including wetlands. Impacts would result from facility development (e.g., transformer yard), overburden (i.e., soil and rock) placement, and expansion of the transmission line corridor (Table E.10-5; Figure E.8-14 through Figure E.8-18).

As currently proposed, a new 525-kV transmission line would be constructed between the Bad Creek II switchyard and Jocassee Tie and a short section of the existing 525-kV line will also be rerouted. The ROW for the new 525-kV line will adjoin the existing ROW and use existing ROW access routes for construction, however clearing the ROW could result in the conversion of forested wetlands to herbaceous or shrub/scrub wetlands, and is considered an impact as estimated in Table E.10-5.

Siting for spoil locations alternatives is ongoing by Duke Energy. Due to the amount of material required for construction, existing topography, and prevalence of seeps and wetlands located throughout the site, it is unlikely there would be an alternative identified that will result in zero impacts to wetlands as a result of spoil placement.

Table E.10-5. Preliminary Estimated Impacts to Wetlands due to the Construction of Bad Creek II

Activity	Wetlands (acres)		
	Permanent Impact	Temporary Impact	Isolated Wetlands
Facility Development	0.11	--	--
Transmission Line Corridor Expansion			
Transmission Line Corridor	0.25	--	--
Transmission Line Access Routes	0.29	--	--
Spoil Areas			
A	0	0	0
B1 – B6 [1]	0	0.13	0
C	0	0	0
D	0	0	0
E	0	0	2.1
F	0	0	0.37
G	0	0	0
H1	0	0	0
H2			
I	0	0	0
J	0.16	0.27	0
K	0.04	0	0
L	0	0	0
M1	0	0	0.15
M2	0	0	0
M3	0	0	0

[1] Spoil Areas B1 through B6 overlap one another.

No changes to recreational facilities are proposed for the Project or associated with the construction of Bad Creek II. Project-required recreation is limited to maintaining approximately 43 miles of the Foothills Trail and two boat-in Foothills Trail access points. The Licensee currently monitors trail and access point conditions routinely, repairs the trail as needed, and is proposing to continue doing so during the next license term. This limits the potential for trail-related erosion to adversely affect water quality in tributary streams or associated wetlands.

E.10.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.10.3.1 Existing Bad Creek Project

No changes to facilities or operations of the existing Bad Creek Project are planned and therefore no PM&E measures are proposed for inclusion in the new license.

As a related off-license measure under the BCRA, Duke Energy will contribute to wetlands preservation and/or conservation by providing a one-time payment of $500,000 to the Oconee County Conservation Bank to support future land conservation efforts and will extend the existing Laurel Preserve Tract lease to SCDNR.

As a related off-license measure under the BCRA, Duke Energy will make a one-time funding contribution of $500,000 to the Lake Keowee Source Water Protection Program for initiatives to protect and enhance water quality in the KT Project watershed.

E.10.3.2 Bad Creek II

As described in Sections E.8.3 and E.9.3, Duke Energy will obtain and comply with CWA Section 404/401 permit authorizations and conditions, implement best management practices and ESC during construction, and will implement the WQMP. Impacts to wetlands will be avoided and minimized to the greatest extent practicable, and appropriate compensatory mitigation for impacts that cannot be avoided will be proposed.

As a related off-license measure under the BCRA, if Bad Creek II is constructed, Duke Energy will contribute to wetlands preservation and/or conservation by providing an additional one-time payment of $500,000 to the Oconee County Conservation Bank to support future land conservation efforts and will extend the existing Laurel Preserve Tract lease to SCDNR.

As an off-license measure under the BCRA, if Bad Creek II is constructed, Duke Energy will provide an additional one-time funding contribution of $500,000 to the Lake Keowee Source Water Protection Program for initiatives to protect and enhance water quality in the KT Project watershed.

E.11 Rare, Threatened, and Endangered Species

E.11.1 Affected Environment

E.11.1.1 Federally Listed Threatened, Endangered, and Candidate Species

As part of the information-gathering process conducted to support the development of this license application, the Licensee utilized the USFWS Information for Planning and Consultation (IPaC) database (USFWS 2024a) and the SCDNR Natural Heritage Program for Threatened and Endangered Species consultation report (SCNHP 2024) to evaluate the potential occurrence of federally listed RTE species within the expanded Project Boundary.

Field investigations were carried out by HDR for Duke Energy during summer 2021, and supplemented by field surveys through 2024, to survey for federally protected species habitat and species of concern. These surveys covered (1) a 436-acre area consisting of the maintained Bad Creek to Jocassee transmission line right-of-way (approximately 9.25 miles long and 400-ft wide) with two transmission lines (the 100-kV line [Eastatoe Line] and 525-kV line [Whitewater Line]), and a 50-foot unmaintained buffer and (2) a 1,314-acre area consisting of all existing Bad Creek Project facilities, maintained right-of-way areas, and undisturbed forested areas, including areas that could be impacted by construction of Bad Creek II (HDR 2021a,b). Additional field surveys were later performed to assess the presence/absence of bat species and their potential habitats within the Project vicinity (ERM 2021; Biotope 2024) (Appendix D).

E.11.1.1.1 Endangered Species Act

The purpose of the ESA is to “protect and recover imperiled species and the ecosystems upon which they depend” (USFWS 2013). The Licensee consulted the USFWS IPaC database and the South Carolina Natural Heritage Program (SCNHP) database for records of threatened and endangered species documented in the expanded Project Boundary. The IPaC list summarizes the species and trust resources under the USFWS’s jurisdiction known or expected to be at or near the expanded Project Boundary. The IPaC report also provides any species currently under consideration for listing that may also be found in or near the Project Boundary.

Six federally protected or candidate species were listed on the USFWS IPaC report for the expanded Project Boundary, including three mammals (bats), one insect, and two plants (USFWS 2024a) (Table E.11-1). The IPaC report also noted that bald eagles are likely to be present within the expanded Project Boundary. During an informal consultation meeting with the USFWS held on December 18, 2024, the hoary bat (*Lasiurus cinereus*) and little brown bat (*Myotis lucifugus*) were also requested to be considered under the evaluation of effects for protected species (USFWS 2024b). Both species are considered "at risk" by the SCDNR, and the little brown bat is currently under federal review. Both bats were reported as potentially occurring within Oconee County on the SCNHP (2024) report, but neither for the expanded Project Boundary or within 2 miles of the boundary. Finally, through additional consultation with the USFWS in January 2025, the Indiana bat (*Myotis sodalis*) was also added for consideration (USFWS 2025a).

No critical habitat has been designated for any of the species on the IPaC report, although critical habitat is proposed for the monarch butterfly within its overwintering range in California (Federal Register 89(239): 100692). Therefore, no designated critical habitat falls within the expanded Project Boundary.

Table E.11-1. Federally Protected Species Potentially Occurring within the Project Boundary

Common Name (Scientific Name)	Federal Status[1]	Habitat Requirements	Suitable Habitat within Project Boundary	Likelihood of Presence in Project Boundary
Birds				
Bald Eagle (*Haliaeetus leucocephalus*)	BGEPA	Waterbodies with a good food base, suitable perching areas, and nesting sites.	Yes, tall trees near and around Lake Jocassee could provide perching and nesting habitat.	**Moderate** – bald eagles have been observed on Lake Jocassee (Cornell Lab 2024) and near the Bad Creek Reservoir (Duke Energy, personal communication).
Mammals				
Northern Long-eared Bat (*Myotis septentrionalis*)	FE	Hibernates in caves and mines during winter. Roosts underneath bark of trees or within cavities, crevices, or snags.	Yes, summer roosting and foraging habitat is present in forested areas nearby Bad Creek Reservoir and Lake Jocassee. Winter habitat may also be present in the Project Boundary.	**Low** – last known observations within or in the vicinity of the Project Boundary were in 1992 (SCNHP 2024). No captures or acoustic calls of this species during recent studies (ERM 2021; Biotope 2024). In consultation with the USFWS, they agreed with a determination of low likelihood of presence in the Project Boundary (USFWS 2025a).

Common Name (Scientific Name)	Federal Status[1]	Habitat Requirements	Suitable Habitat within Project Boundary	Likelihood of Presence in Project Boundary
Tricolored Bat (*Perimyotis subflavus*)	FPE	Hibernates in caves and mines during winter, or culverts, tree cavities, or abandoned wells in southern areas. Roosts in live and dead clusters of leaves or pine needles during the non-hibernating season.	Yes, summer roosting and foraging habitat is present. Winter habitat may also be present in the Project Boundary.	**High** – high frequency of acoustic detections during recent surveys (ERM 2021; Biotope 2024). In consultation with the USFWS, they agreed with a determination of high likelihood of presence in the Project Boundary (USFWS 2025a).
Gray Bat (*Myotis grisescens*)	FE	Roosts in caves throughout the year. Foraging habitat parallel to streams over water.	Yes, foraging habitat is present. Roosting habitat may be present in the Project Boundary.	**High** – identified acoustically during the most recent survey (Biotope 2024). In consultation with the USFWS, they agreed with a determination of high likelihood of presence in the Project Boundary (USFWS 2025a).
Hoary Bat[2] (*Lasiurus cinereus*)	At Risk	Roosts in deciduous and coniferous forests, with foraging habitat of open areas, riparian corridors, and over open water.	Yes, roosting and foraging habitat is present in the Project Boundary.	**High** – captured during mist net surveys (2021) and detected acoustically during both recent bat surveys (ERM 2021; Biotope 2024).
Little Brown Bat[2] (*Myotis lucifugus*)	UR	Roosts in trees, artificial structures, bat houses, under rocks and in piles of wood during summer; caves and mines during winter. Forages over streams and other waterbodies.	Yes, summer roosting and foraging habitat is present in the Project Boundary.	**High** – high frequency of acoustic detections during recent surveys (ERM 2021; Biotope 2024).
Indiana Bat[2] (*Myotis sodalis*)	FE	Roosts in trees and snags with exfoliating bark that receive direct sunlight for more than half the day, often in canopy gaps or forest edges. Hibernates in caves and abandoned mines during winter. Forages in semi-open to closed forest habitats with open understory, forest edges, and riparian areas.	Yes, summer roosting and foraging habitat is present in the Project Boundary.	**Moderate** – this species was not detected acoustically or captured during mist net surveys in 2021 or 2024; however, consultation with USFWS determined that this species is tentatively presumed present based on their review of Biotope's (2024) acoustic data (USFWS 2025a).

Common Name (Scientific Name)	Federal Status[1]	Habitat Requirements	Suitable Habitat within Project Boundary	Likelihood of Presence in Project Boundary
Insects				
Monarch Butterfly (*Danaus plexippus*)	FPT	Typically found in herbaceous and early successional habitats during the breeding season. Adults use a wide variety of flowering plants for foraging. Milkweed obligate for breeding. Uses willows, oaks, and pines for nighttime roosting.	Yes, suitable habitat is located throughout the Transmission Line Corridor and in surrounding forested areas.	**High** – abundant habitat available, including milkweed species.
Plants				
Small Whorled Pogonia (*Isotria medeoloides*)	FT	Mature wooded habitats with maple, oak, beech, birch, and white pine and sparse understory or herbaceous layers.	Yes, suitable habitat is present in forested areas within the Project Boundary.	**Moderate** – abundant habitat present. No individuals identified during surveys conducted within the survey window in 2024, however this species may be vegetatively dormant below ground for several years.
Smooth Coneflower (*Echinacea laeviagata*)	FT	Openings in woods, along roadsides and utility line rights-of-way.	Yes, suitable habitat is present throughout the Transmission Line Corridor.	**Moderate** – abundant habitat present, however no incidental observations during any field surveys or listed for the Project Boundary by the Natural Heritage Program (SCNHP 2024).

Source: USFWS 2024a
Notes: BGEPA = Bald and Golden Eagle Protection Act; FE = Federally Endangered; FPE = Federally Proposed Endangered; FT = Federally Threatened; FPT = Federally Proposed Threatened; UR = Under Review

Federally Protected Species Profiles

Bald Eagle (Haliaeetus leucocephalus) [Federally Protected under BGEPA]

Bald eagles (*Haliaeetus leucocephalus*) were once federally listed under the ESA in 1978 as endangered but were removed in 2007 as a result of sufficient population recovery. They are now protected, along with golden eagles (*Aquila chrysaetos*), under the Bald and Golden Eagle Protection Act (BGEPA) (USFWS 1978). The BGEPA prohibits the “taking” of bald eagles, parts, nests, or eggs without a permit from the U.S. Department of the Interior.

Bald eagles require habitats that support a good food base, suitable perching areas, and nesting sites (USFWS 2022a). They are opportunistic hunters feeding on small mammals, birds, reptiles, and carrion; however, they prefer fish as a staple food source and tend to be found more commonly near large bodies of water. Eagle nests typically occur in large, tall trees capable of supporting 4 ft to 6 ft wide nests but have also been observed to build nests on cliffs and human-made structures like power poles and communication towers. Bald eagles are sensitive to the extent of human presence and may avoid heavy urban areas (USFWS 2022a). Generally, the expanded Project Boundary contains suitable foraging or nesting habitat for eagles.

There is no designated critical habitat for the bald eagle. A review of SCNHP (2024) report determined there are no known bald eagle occurrences or nests located within 2 miles of the expanded Project Boundary. However, observations of bald eagles have been reported on the website eBird for Devils Fork State Park and North Lake Jocassee most recently in November 2024. No bald eagles or nests were observed during relicensing field surveys, however, bald eagles have been recently observed by Duke Energy staff (Duke Energy, personal communication) near the Bad Creek Reservoir.

Biological Opinions have been developed for the bald eagle for areas in the west (Oregon, California), midwest (Wyoming, Idaho), and southeast (Florida, Alabama), but none have been written for this species for activities occurring in South Carolina (USFWS 2025b).

Gray Bat (Myotis grisescens) [Federally Endangered]

The gray bat almost exclusively roosts in large caves with an average temperature of 42 to 52 degrees Fahrenheit year-round, but may also roost in barns, dams, and storm drains (USFWS 2024c, Alabama Department of Conservation and Natural Resources [ADCNR] 2024). The gray bat may travel more than 30 miles per night to and from summer foraging sites, which include riparian areas and streams, rivers, and lakes (ADCNR 2024). During winter, the gray bat may migrate up to 465 miles from summer to winter hibernacula between September and November, and emerge in the spring between March and April (USFWS 2024c, ADCNR 2024).

The gray bat occupies a limited geographic range in limestone karst areas of the southeastern United States due to their requirement of cave habitat. They are mostly found in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee. A few can be found in northwestern Florida, western Georgia, southeastern Kansas, southern Indiana, southern and western Illinois, northeastern Oklahoma, northeastern Mississippi, western Virginia, and possibly western North Carolina (USFWS 1997).

Biological Opinions have been developed for the gray bat in Virginia, Missouri, and Oklahoma. No Biological Opinions appear to have been developed for projects in South Carolina, including Oconee County (USFWS 2025b). No official status reports exist for the gray bat; however, the general status of this species, the associated listing, fact sheets, range maps, and other important information are available on the USFWS website (USFWS 2024c). A recovery plan was developed in 1982. No critical habitat has been defined for the gray bat.

Suitable summer foraging habitats are present across water bodies within and adjacent to the expanded Project Boundary Area, however roosting habitat (i.e., caves or mines year-round) is not present. The gray bat was not captured or detected during the 2021 ERM surveys, however it was acoustically detected during the 2024 surveys (ERM 2021; Biotope 2024), therefore the species is likely to occur in the expanded Project Boundary (Biotope 2024). During informal consultation, the USFWS also stated that this species is likely to be present in the expanded Project Boundary (USFWS 2025a).

Northern Long-eared Bat (Myotis septentrionalis) [Federally Endangered]

The USFWS Recommended Survey Window for northern long-eared bat is year-round; however, winter surveys are not as successful. Northern long-eared bats spend winter hibernating in caves and mines called hibernacula. They use areas in various sized caves or mines with constant temperatures, high humidity, and no air currents. Within hibernacula, surveyors find them hibernating most often in small crevices or cracks, often with only the nose and ears visible. During the summer, northern long-eared bats roost in trees smaller than those used by the Indiana bat and measuring three inches in diameter at breast height, in cavities or in crevices of both live trees and snags (dead trees). Males and non-reproductive females may also roost in cooler places, like caves and mines. Northern long-eared bats seem to be flexible in selecting roosts, choosing roost trees based on suitability to retain bark or provide cavities or crevices. Rarely this bat has also been found roosting in structures such as barns and sheds (USFWS 2015).

Forested uplands and riparian areas provide potential roosting and foraging habitat for the northern long-eared bat. USFWS and SCDNR typically recommend any tree clearing activities should be conducted during the inactive season (November 15 through March 31) to avoid negative impacts to this species.

Biological Opinions have been developed for the northern long-eared bat in Alabama, Arkansas, Illinois, Indiana, Kentucky, Main, Michigan, Minnesota, Missouri, New Jersey, New York, Ohio, Tennessee, Virginia, and West Virginia. No Biological Opinions appear to have been developed for projects in South Carolina, including Oconee County (USFWS 2025b). A species status assessment report for the northern long-eared bat was published in August 2022 (USFWS 2022b). Additionally, the general status of this species, the associated listing, fact sheets, range maps, and other important information are available on the USFWS website (USFWS 2017a). A recovery plan has not yet been developed for the northern long-eared bat. No critical habitat has been defined for the northern long-eared bat.

Suitable summer roosting and foraging habitats are present in forested areas in the expanded Project Boundary. Suitable wintering hibernacula (i.e., caves and mines), however, is not present.

The 2021 and 2024 bat studies did not capture this species in mist net surveys, nor was it detected acoustically (ERM 2021; Biotope 2024). The last known observation of northern long-eared bat in the expanded Project Boundary was in 1992 (SCNHP 2024).

The USFWS also reviewed Biotope's (2024) acoustic files and also determined this species is unlikely to be present in the expanded Project Boundary (USFWS 2025a).

Tricolored Bat (Perimyotis subflavus) [Federally Proposed Endangered]

Tricolored bats typically roost during the non-hibernating seasons in the live and dead leaf clusters of deciduous hardwood trees, or within the clusters of Spanish moss (*Tillandsia usneoides*) or bony beard lichen (*Usnea trichodea*) found growing on trees, or among pine needles and/or eastern red cedar (*Juniperus virginiana*) and prefer the dense forest growth of trees and underbrush covering on large tracts of land (USFWS 2022c). They have also been observed roosting in man-made structures such as barns, porch roofs, bridges, and concrete bunkers. During the winter months, tricolored bats hibernate within caves and mines and have been found in southern states hibernating within culverts under roads, tree cavities, and even abandoned wells (USFWS 2022c). These bats often return to the same hibernacula each year, and similarly female bats often return to their same summer roosting and maternity sites each year.

Suitable summer roosting and foraging habitats is located within the expanded Project Boundary. The nearest recorded tricolored bat hibernaculum is 2.7 miles north of the Project in Transyulvania County, North Carolina; no known suitable wintering hibernacula are present in the expanded Project Boundary.

Although the tricolored bat was not captured during mist netting studies in 2021 or 2024, this species was acoustically detected at high frequencies in both years (ERM 2021, Biotope 2024). The USFWS agreed during informal consultation that this species is likely to be present in the expanded Project Boundary (USFWS 2025a).

Hoary Bat (Lasiurus cinereus) [At Risk]

Hoary bats have an extensive range and can be found in a wide variety of habitat types. Hoary bat can be found in pine and coniferous forests as well as treed areas within urban settings. Hoary bats roost in trees during winter and summer. Studies have shown that during the day hoary bats exclusively roost in tree foliage. Preferred tree species include elm black cherry, plum, box elder, and osage orange trees. The species prefers to roost alone in foliage and tree cavities, with preference for trees at the edge of clearings (SCDNR 2020).

During the summer, male bats typically migrate to mountainous regions in western North America while female bats migrate to eastern North America. Female bats will roost with their young, either changing roosting sites daily or returning to the same roosting site for up to two weeks. During the winter, hoary bats migrate to southern California, Central America, or the southeastern U.S. Winter roosting habits for the hoary bat have not been documented (SCDNR 2020).

Like northern long-eared bats and little brown bats, hoary bats utilize riparian areas for foraging, using lakes, wetlands, and stream as foraging sites. The hoary bat also forages above forest canopies and open areas within forests (SCDNR 2020).

The hoary bat is not a federally protected species, therefore there are no biological opinions or recovery plans in place or planned for this species at this time (USFWS 2025b).

Suitable roosting habitats may be located within the expanded Project Boundary. Suitable summer roosting and foraging habitats are present in forested and surface water areas nearby at the Bad Creek Reservoir and Lake Jocassee. Suitable wintering habitat could be present within the expanded Project Boundary.

The 2021 ERM bat survey evaluated all exposed talus slopes or mixed forest for roosting habitat used by the hoary bat. ERM found suitable habitat for the hoary bat, and the bat was a detected species during acoustic surveys and captured during mist net surveys (ERM 2021). Biotope confirmed the presence of the hoary bat during their 2024 acoustic surveys (Biotope 2024); therefore, this species is likely to occur in the expanded Project Boundary.

Little Brown Bat (Myotis lucifugus) [Under Review]

Little brown bats use two types of habitats for winter and summer roosting. In the winter, they hibernate in caves, tunnels, or mines of various sizes with relatively constant temperature and humidity. The little brown bats prefer hibernating mostly along cracks found within caves, commonly in loose clusters (KDFWR 2025).

During the summer season, the little brown bats prefer roosting sites within snags of a variety of tree species, structures, under rocks and in pikes of wood. Reproductive females typically form small maternity colonies in warmer structures or hollow trees (SCDNR 2020 USFWS 2025c). Males and non-reproductive usually roost separately, using a variety of roosting sites such as structures, bridges, hollow trees, and snags (KDFWR 2025).

Little brown bat foraging habitat is generalized and commonly occurs over bodies of water such as streams, ponds, lakes, and forest edges near water (SCDNR 2020). The little brown bat acoustically detected during bat surveys in 2021 and 2024 (ERM 2021; Biotope 2024).

Indiana Bat (Myotis sodalis) [Federally Endangered]

Indiana bats use two types of habitats for winter and summer roosting. In the winter, they hibernate in large caves or abandoned mines with relatively constant temperature and humidity and without air currents. Typically, winter hibernacula are large with vertical or expansive passages and entrances. Preferred caves are high in complexity in order to buffer the environment from sudden changes in temperature (USFWS 2025d).

Outside of their winter hibernation, the Indiana bats prefer roosting sites under the bark of dead or dying trees within forested areas. Indiana bats roost in trees that receive direct sunlight and typically occur adjacent to clearings, fence lines, and wooded edges. Reproductive females form maternity colonies in trees located near riparian zones and wetlands. Males and non-reproductive females a wider range of summer roosting sites (USFWS 2025d).

Indiana bats utilize the open understory of forested areas for foraging, usually in forest edges and riparian areas (USFWS 2025d).

Biological Opinions have been developed for the Indiana bat in Alabama, Arkansas, Georgia, Kentucky, Illinois, Indiana, Michigan, Missouri, New York, Ohio, Oklahoma, Tennessee, West Virginia and Virginia. No Biological Opinions appear to have been developed for projects in South Carolina, including Oconee County (USFWS 2025b). A recovery plan was developed in 2007. Designated critical habitat has been established for the Indiana bat, but not within South Carolina.

Suitable roosting habitats may be located within the expanded Project Boundary. Suitable summer roosting and foraging habitats are present in forested areas nearby at the Bad Creek Reservoir and Lake Jocassee. Suitable wintering hibernacula, however, is not present within the expanded Project Boundary.

While suitable habitat for the Indiana bat was observed, this species was not detected during acoustic surveys or captured during mist net surveys in 2021 (ERM 2021). The Biotope (2024) survey also suggested this species to be absent, however the USFWS determined this species should be tentatively presumed present based on acoustic files (USFWS 2025a).

Monarch Butterfly (Danaus plexippus) [Federally Proposed Threatened]

On December 12, 2024, the USFWS proposed to list the monarch butterfly as threatened under the ESA (Federal Register 89(239): 100662). The monarch butterfly (*Danaus plexippus*) is an orange and black butterfly that lives in a variety of habitats throughout North America and various additional locations across the globe. The butterfly is a milkweed (*Asclepias* spp.) obligate and requires milkweed plants for their reproductive cycle.

In North America the eastern population (east of the Rocky Mountains) migrate north to the United States and Canada in March from the mature oyamel fir forests in the mountains of central Mexico. The fall migration back to overwintering sites in Mexico is from August to November. Monarchs are typically found in open grass areas during the breeding season. Adults use a wide variety of flowering plants throughout migration and breeding. Important nectar sources during the spring migration typically include *Coreopsi*s spp., *Viburnum* spp., *Phlox* spp., and early blooming milkweeds. Important nectar sources during fall migration include goldenrods (*Solidago* spp.), asters (*Symphyotrichum* spp. and *Eurybia* spp.), gayfeathers (*Liatris* spp.), and coneflowers (*Echinacea* spp.) (USFWS 2019d).

Monarch butterflies were not identified during the on-site survey; however, the site investigation was not conducted during the recommended survey window. Nonetheless, potential habitat for the monarch butterfly was identified within the expanded Project Boundary for migrating and breeding adults. The maintained right-of-way offers a variety of flowing plants for nectar, including plants from the milkweed genus, as well as nighttime roosting trees such as willows and pines are present within the forested areas of the expanded Project Boundary.

Small Whorled Pogonia (Isotria medeoloides) [Federally Threatened]

The USFWS Optimal Survey Window for small whorled pogonia is mid-May through early July. Small whorled pogonia is an orchid occurring in young as well as maturing (second to third successional growth) mixed-deciduous or mixed-deciduous/coniferous forests. The species does not appear to exhibit strong affinities for a particular aspect, soil type, or underlying geologic substrate. Sometimes it grows in stands of softwoods with a thick layer of dead leaves, often on slopes near small streams. The species may also be found on dry, rocky, wooded slopes; moist slopes; ravines lacking stream channels; or slope bases near braided channels of vernal streams. The orchid, often limited by shade, requires small light gaps or canopy breaks, and typically grows under canopies that are relatively open or near features like logging roads or streams creating long-persisting breaks in the forest canopy (USFWS 2019e). Small whorled pogonia can also remain dormant for one to four years when environmental conditions are unfavorable (Fryer 2019).

Biological Opinions have been developed for small whorled pogonia in Virginia and West Virginia, but not in the State of South Carolina (USFWS 2025b). No species status reports exist for small whorled pogonia (USFWS 2016a). A recovery plan was developed in 1992. No critical habitat has been defined for the small whorled pogonia.

As stated above, no individuals of this species were identified during the 2024 field survey. In addition, the USFWS IPaC report, and the SCNHP report did not indicate records for the species within a 2.0-mile of radius of the proposed Project Boundary; however, potential habitat is present within the expanded Project Boundary.

Smooth Coneflower (Echinacea laevigata) [Federally Threatened]

The USFWS Optimal Survey Window for smooth coneflower is late May through October. Smooth coneflower, a perennial herb, is typically found in meadows, open woodlands, the ecotonal regions between meadows and woodlands, cedar barrens, dry limestone bluffs, clear cuts, and roadside and utility rights-of-way. In South Carolina, the species normally grows in magnesium- and calcium-rich soils associated with diabase and marble parent material, and typically occurs in Iredell, Misenheimer, and Picture soil series. It grows best where there is abundant sunlight, little competition in the herbaceous layer, and periodic disturbances (e.g., regular fire regime, well-timed mowing, and careful clearing) preventing encroachment of shade-producing woody shrubs and trees. On sites where woody succession is held in check, it is characterized by several species with prairie affinities (USFWS 2017b). Data from SCDNR indicate one occurrence of smooth coneflower within the Project Boundary and one known occurrence within 2 miles of the Project Boundary.

No Biological Opinions or species status reports have been developed for smooth coneflower (USFWS 2021a). A recovery plan was developed in 1995. No critical habitat has been defined for smooth coneflower.

Potential habitat for smooth coneflower was identified within the maintained right-of-way, specifically within the open and regularly maintained portions of the transmission line corridor; however, a survey for the species during the optimal survey window did not reveal the presence of any plants from this species within this area. The SCNHP query report indicates a population for smooth coneflower occurs both within the expanded Project Boundary, and within a 2-mile radius of the expanded Project

Boundary. HDR coordinated with the SCDNR regarding the population indicated on the SCNHP report and the agency indicated the population has been extirpated by the filling of Lake Jocassee in the 1970's.

E.11.1.1.2 Migratory Bird Treaty Act of 1918 (MBTA)

The Migratory Bird Treaty Act of 1918 (MBTA) states it is unlawful to pursue, hunt, take, capture or kill, attempt to take, possess, offer to sell or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried, or received any migratory bird, part, nest, egg, or product, manufactured or not (USFWS 2020a). Nearly all bird species that migrate through South Carolina are protected under the federal MBTA. South Carolina is part of the Atlantic Flyway migratory bird route (Audubon 2022). Woodlands, wetlands, riparian vegetation, and early successional habitat types are present within the Action Area that may provide suitable habitat (including wintering habitats) and nesting sites for some migratory bird species protected under the MBTA.

The USFWS IPaC database identified 12 migratory birds as Birds of Conservation Concern (BCC) that may occur within the expanded Project Boundary and may have the potential to be adversely affected during certain periods of the year by associated Project activities (USFWS 2024a) (Table E.11-2). The IPaC list also included the bald eagle, which is not a BCC in the area. Two additional species, the American kestrel (*Falco sparverius*) and American peregrine falcon (*Falco peregrinus anatum*) were also reported by the SCNHP (2024). The American kestrel is a BCC in some areas but is not considered a BCC in the Bird Conservation Region in which the Project lies (USFWS 2021b). The American peregrine falcon is not a BCC. Publicly available information from the eBird website (Cornell Lab 2024) was used to assess whether these species have been observed at the nearest bird reporting location, "Bad Creek Recreation Area" (Lower Whitewater Falls trail). Seven (7) of the 13 BCC species were observed over at this reporting location, however some have not been documented since 2013.

Table E.11-2. Protected Birds that May Occur within the Expanded Project Boundary

Common Name (*Scientific Name*)	Breeding Season[1]	Probability of Presence[2]	Observed in or near the Action Area[3] (last known observation)
American Kestrel (*Falco sparverius*)	Early spring – late summer	Year-round	1998
American Peregrin Falcon (*Falco peregrinus anatum*)	March – May	Uncommon	1999
Bald eagle (*Haliaeetus leucocephalus*)	September 1 – August 31	Sporadically January – June, September - December	Yes (2025)[4]
Bobolink (*Dolichonyx oryzivorus*)	May 20 – July 31	Late August	Yes (2013)

Common Name (*Scientific Name*)	Breeding Season[1]	Probability of Presence[2]	Observed in or near the Action Area[3] (last known observation)
Canada warbler (*Cardellina canadensis*)	May 20 – August 10	Mid-April – mid-May	No
Cerulean warbler (*Dendroica cerulea*)	April 27 – July 20	Early – mid-May	No
Chimney swift (*Chaetura pelagica*)	March 15 – August 25	Mid-April – late June, intermittently mid-July – mid-October	Yes (2024)
Chuck-will's-widow (*Antrostomus carolinensis*)	May 10 – July 10	May – mid-June	No
Eastern whip-poor-will (*Antronstomus vociferus*)	May 1 – August 20	Intermittently April – August	Yes (2024)
Golden-winged warbler (*Vermivora chrysoptera*)	May 1 – July 20	Late August	Yes (2013)
Kentucky warbler (*Oporornis formosus*)	April 20 to August 20	Intermittently June, mid-September	No
Prairie warbler (*Dendroica discolor*)	May 1 – July 31	Mid-April – late June, late August	Yes (2024)
Prothonotary warbler (*Protonotaria citrea*)	April 1 to July 31	Early May	No
Red-headed woodpecker (*Melanerpes erythrocephalus*)	May 10 – September 10	Sporadically year-round	Yes (2015)
Wood thrush (*Hylocichla mustelina*)	May 10 – August 31	Late April – late July, late mid-September – mid-October	Yes (2024)

[1] Breeding season is a liberal estimate (i.e., wide window) of the dates inside which the bird breeds across its entire range, as provided in USFWS (2024a). Breeding season for American kestrel and American peregrine falcon were obtained from Animal Diversity Web (2025).
[2] Probably of presence is based on USFWS survey events that detected the species within a 10-kilometer grid cell that overlaps the expanded Project Boundary (USFWS 2024a). Probability of presence for American kestrel and American peregrine falcon were obtained from Audubon Society (2025).
[3] Public observations results recorded on eBird.com at Bad Creek Recreation Area (Lower Whitewater Falls trail). Observations posted on eBird.com are from birding enthusiasts and may or may not represent a positive species identification by a qualified biologist. These observations are being utilized for the potential of a positive occurrence for MBTA and BGEPA species within the expanded Project Boundary (Cornell Lab 2024). Observations for American kestrel and American peregrine falcon were reported by the SCNHP (2024).
[4] Observation in 2025 near Bad Creek Reservoir (Duke Energy, personal communication).

E.11.1.1.3 At Risk Species

The Southeast Region of the USFWS in conjunction with states, federal agencies and other partners has begun evaluating over 400 animal and plant species for potential listing under the ESA. These species are commonly known as "At-Risk species" and are defined as those that are: (1) proposed for listing under the ESA by the USFWS; (2) candidates for listing under the ESA; or (3) petitioned by a third party for listing under the ESA. The USFWS's South Carolina At-Risk Species List for Oconee

County and/or in the Project vicinity identified 10 species potentially residing within or near the expanded Project Boundary (Table E.11-3) (USFWS 2021c).

HDR conducted on-site surveys for At-Risk plant and animal species including an on-site survey for at-risk terrestrial plants. The survey, however, was conducted outside the optimal survey windows for Georgia aster (*Symphyotrichum georgianum*) and sun-facing coneflower (*Rudbeckia heliopsidis*). The following subsections include a summary of habitat descriptions and the presence/absence of habitat within the expanded Project Boundary for the At-Risk species provided in Table E.11-3.

Table E.11-3. South Carolina List of At-Risk Species – Oconee County

Species	Preferred Habitat	Survey Window	Habitat Present in Expanded Project Boundary
Amphibian			
Chamberlain's dwarf salamander (*Eurycea chamberlain*)	Under leaf litter and small debris in wet areas, particularly seepages near small streams, and other wetland types.	Spring and Fall	Yes
Birds			
Golden-winged warbler (*Vermivora chrysoptera*)	Shrubby, tangled thickets and other early successional habitats during breeding. Mature forest habitats after breeding.	April-July (nesting surveys)	Yes
Insect			
Edmund's snaketail (*Ophiogomphus Edmundo*)	Larvae are found in medium- to large-sized, clear streams and rivers with moderately fast currents but spend most of their adult lives in the treetops, only returning to the water to breed. During the breeding stage, males are typically found perched on rocks in riffles or rapids as they patrol their territories.	Year-round	Yes
Monarch butterfly (*Danaus plexippus*)[1]	Monarchs are typically found in open grass areas during the breeding season. Adults use a wide variety of flowering plants throughout migration and breeding.	August-December	Yes
Smokies needlefly (*Megaleuctra williamsae*)	Restricted to high elevation springs and seeps in relatively undisturbed forested areas. Nymphs sprawl in accumulations of decaying leaves and other debris covered with a thin film of flowing water.	April-June	Yes
Mammal			
Little brown bat (*Myotis lucifugus*)	The little brown bat lives along streams and lakes. It forms nursery colonies in buildings. In the winter it hibernates in caves and mines.	Year-round	Yes
Tricolored bat (*Perimyotis subflavus*)[1]	Forested landscapes, often in open woods. They can also be found over water and adjacent to water edges.	Year-round	Yes
Plants			
Carolina hemlock	Rocky slopes, ridgelines and gorges in the	Year-round	Yes

Species	Preferred Habitat	Survey Window	Habitat Present in Expanded Project Boundary
(*Tsuga caroliniana*)	Southern Blue Ridge mountains.		
Georgia aster (*Symphyotrichum georgianum*)	Woodlands or piedmont prairies dominated by native plants, with acidic soils varying from sand to heavy clay.	Early October-mid-November	Yes
Sun-facing coneflower (*Rudbeckia heliopsidis*)	Moist to wet sites and acidic soils such as those found in pine-oak woodlands, peaty seeps in meadows, and sandy alluvium along streams. Occurs in full sun to partial shade.	July - October	Yes

[1] Federally proposed for listing under the ESA.

Chamberlain's Dwarf Salamander (*Eurycea chamberlain*)

USFWS Optimal Survey Window: Spring/Fall

The Chamberlain's dwarf salamander is typically found in wet areas, particularly seepages near small streams, and other wetland type areas. This species is typically found under leaf litter and small debris; however, has been observed with leaf or pine straw litter along the edge of seep streams, or small debris piles in the terrestrial uplands adjacent to seepage wetlands (USFWS 2016b).

Potential habitat for the Chamberlain's dwarf salamander is present within the expanded Project Boundary, however this species was not identified during herptile surveys conducted in September 2023 (see Section E.12.2.1.2).

Golden-winged Warbler (*Vermivora chrysoptera*)

USFWS Optimal Survey Window: April-July (nesting surveys)

The Golden-winged warbler uses wet shrubby, tangled thickets and other early successional habitats during breeding. Females select a nest site, which is typically on the ground in a grassy opening or along the shaded edge of a field near a forest border. The nest is typically well concealed by overhead grasses and leafy material. Golden-winged warblers move into mature forests immediately after fledging. This means mosaics of shrubby, open areas (for nesting) and mature forest habitats (which offer cover for fledglings from predators like hawks) are important landscape features (Cornell Lab 2019).

Potential habitat for the golden-winged warbler is present within the expanded Project Boundary (emergent and scrub/shrub wetland areas surrounded by forested communities). This species has also been identified by a recreationalist at the Bad Creek Recreation Area according to publicly available information from the eBird website, with a last observed date of 2013 (Cornell Lab 2024).

Edmund's Snaketail (*Ophiogomphus Edmundo*)

USFWS Optimal Survey Window: Year-round

Edmund's snaketail larvae are found in medium- to large-sized, clear streams and rivers with moderately fast currents but spend most of their adult lives in the treetops, only returning to the water to breed. During the breeding stage, males are typically found perched on rocks in riffles or rapids as they patrol their territories. Mating takes place while perched; once fertilized, females deposit their eggs in the water near the same riffles guarded by the male and return to the treetops. This species is restricted to the southern Blue Ridge of North Carolina, Tennessee, South Carolina, and Georgia (USFWS 2019b; GDNR 2025).

Potential habitat for the species may be present within the expanded Project Boundary. However, this species was not identified during macroinvertebrate surveys conducted in Limber Pole and Howard creeks in 2023 (see the *Impacts to Surface Waters and Associated Aquatic Fauna Final Report* provided in Appendix D). Surveys were performed during the appropriate index period for the Blue Ridge ecoregion.

Monarch Butterfly (*Danaus plexippus*)

USFWS Optimal Survey Window: August-December

Refer to Monarch Butterfly (*Danaus plexippus*) [Federally Proposed Threatened] in Section E.11.1.1.1 for additional details regarding habitat description and the presence/absence of habitat within the expanded Project Boundary.

Smokies Needlefly (*Megaleuctra williamsae*)

USFWS Optimal Survey Window: April-June

These slender, brown to black stoneflies ranging from 4 to 15 millimeters (0.2 to 0.6 inches) in length are restricted to high elevation springs and seeps in relatively undisturbed forested areas and water temperatures below 25°C. Nymphs sprawl in accumulations of decaying leaves and other debris covered with a thin film of flowing water (USFWS 2019c).

Potential habitat may be present for the Smokies needlefly in the higher elevation seeps and steams found within the expanded Project Boundary. However, this species was not identified during macroinvertebrate surveys conducted in Limber Pole and Howard creeks in 2023 (see the Aquatic

Resources Task 3 report provided in Appendix D). Surveys were performed during the appropriate index period for the Blue Ridge ecoregion.

Little Brown Bat (*Myotis lucifugus*)

USFWS Optimal Survey Window: Year-round

Refer to Little Brown Bat (*Myotis lucifugus*) [Under Review] in Section E.11.1.1.1 for additional details regarding habitat description and the presence/absence of habitat within the expanded Project Boundary.

Tricolored Bat (*Perimyotis subflavus*)

USFWS Optimal Survey Window: Year-round

Refer to Tricolored Bat (*Perimyotis subflavus*) Section E.11.1.1.1 for additional details regarding habitat description and the presence/absence of habitat within the expanded Project Boundary.

Carolina Hemlock (*Tsuga caroliniana*)

USFWS Optimal Survey Window: Year-round

Carolina hemlock occur in a variety of landscapes ranging from xeric ridgelines to gorges in the Southern Blue Ridge Mountains. These occurrences are mostly on cliffs, rocky slopes and ridges, less commonly on gentle slopes and flat areas in valleys. Soils are usually nutrient-poor and rocky. Carolina hemlocks are very shade tolerant and are often associated with the following species: eastern hemlock (*Tsuga canadensis*), chestnut oak (*Quercus prinus*), northern red oak (*Quercus rubra*), Virginia pine (*Pinus virginiana*) and others (USFWS 2019a).

Potential habitat for Carolina hemlock is found in the northern portion of the expanded Project Boundary along the forested ridges and gorges, however no Carolina hemlock was identified during vegetation surveys conducted in support of the *Impacts to Surface Waters and Associated Aquatic Fauna Final Report* (attached as Appendix D to this Exhibit E).

Georgia aster (*Symphyotrichum georgianum*)

USFWS Optimal Survey Window: Early October-mid-November

Georgia aster is found in woodlands or piedmont prairies dominated by native plants, with acidic soils varying from sand to heavy clay. The primary controlling factor appears to be the availability of light.

The plant tends to compete well for resources until it begins to get shaded out by woody plants. Since the plant prefers open areas, disturbance (fire, native grazers, etc.) is a part of this plant's habitat requirements. The historic sources of disturbance have been virtually eliminated from its range, except where road, railroad, and utility rights-of-way maintenance are mimicking the missing natural disturbances (USFWS 2014).

Like smooth coneflower, potential habitat for the species is present within the maintained portions of the right-of-way.

Sun-facing coneflower (*Rudbeckia heliopsidis*)

USFWS Optimal Survey Window: July-October

Sun-facing coneflower prefers moist to wet sites such as acidic swales in pine-oak woodlands, peaty seeps in meadows, and sandy alluvium along streams. It occurs in full sun to partial shade. The species can also be found in upland oak-hickory or oak -pine-hickory or open pine-mixed hardwoods. It grows in seeps, bogs, sandy wet clear crop areas or in places with many boulders. The seeps where it is found are acidic with grasses, sedges, and herbs (USFWS 2017c).

Potential habitat for this species is present within the maintained portions of the right-of-way near streams and wetlands.

E.11.1.2 State-listed Threatened, Endangered, and Candidate Species

Additional species are protected in South Carolina by the Nongame and Endangered Species Conservation Act (Code 1976§50-15-10 to 90) and tracked as sensitive by SCDNR under the South Carolina State Wildlife Action Plan (SWAP). Species with SWAP priorities of High, Highest or Moderate are designated as having conservation priority under the SWAP. SWAP species are those species of greatest conservation need not traditionally covered under any federal funded programs. Species are listed in the SWAP because they are rare or designated as at-risk due to knowledge deficiencies; species common in South Carolina but listed rare or declining elsewhere; or species that serve as indicators of detrimental environmental conditions.

Only one state-protected species, Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) was reported on the SCNHP list as having potential to occur in the Project Boundary, with a last observed date of July 1992 (SCNHP 2024). Rafinesque's big-eared bat is state-endangered and considered highest priority under the SWAP. They roost in caves during the winter and large hollow trees in the summer

(NatureServe Explorer 2025). Foraging habitat primarily consists of mature forests in upland and lowland areas. Threats to this species include habitat loss (e.g., loss of bottomland habitat, removal of snags during certain forest management practices), insecticide applications, and anthropogenic disturbance of wintering roosting sites.

Suitable summer roosting and foraging habitat for Rafinesque's big-eared bat exists in the expanded Project Boundary. This species was not identified acoustically or during mist net surveys in 2021 (ERM 2021), however it was identified from acoustic surveys in 2024 (Biotope 2024).

E.11.2 Environmental Analysis

E.11.2.1 Studies in Support of the Current Relicensing

E.11.2.1.1 Bat Acoustic and Mist-net Surveys (2021 and 2024)

ERM completed bat habitat assessments, acoustic surveys, and mist net surveys in the expanded Project Boundary in 2021 (ERM 2021). Habitat assessments were conducted in locations with exposed talus slopes or mixed forest, and acoustic and mist net surveys were established in flyways near water resources, following guidelines outlined in the *2020 Range-wide Indiana Bat Survey Guidelines* (USFWS 2020b). Acoustic detectors were placed within potential foraging habitat, including locations adjacent to water resources and along forest edges. Detectors were programmed to start recording 30 minutes prior to sunset and to stop recording 30 minutes following sunrise. Nets were placed in the best available locations within the Project area to maximize the likelihood of capturing foraging or commuting bats. Specifically, nets were places within likely flight corridors (along roads or near water sources), and if possible, where forest canopy would overhang at least part of the upper net. Nets were deployed at sunset and monitored every 10 minutes for a total of 5 hours.

Acoustic and mist net surveys were conducted from July 22 to 25, 2021, and additional mist net surveys were completed from October 18 to 21, 2021 (ERM 2021). Abundant suitable habitat was observed for the northern long-eared bat (*Myotis septentrionalis)* and Indiana bat, however neither species was detected during acoustic surveys or captured in mist net surveys and both were determined to be "not likely present" (ERM 2021). No roosting habitat for gray bats (i.e., caves) are within the expanded Project Boundary and no acoustic detections were observed for this species. High frequency of acoustic detections suggest high probability of presence for the tricolored bat, little brown bat, and hoary bat. No federally protected bat species were captured during mist net surveys, however one hoary bat was captured.

Biotope Forestry & Environmental completed a presence/absence bat survey in June 2024 (Biotope 2024). Fifteen summer mist-net surveys were conducted over two calendar nights, totaling 62 net nights of survey effort across the expanded Project Boundary. Twelve of the 15 mist-net sites were placed along the transmission line corridor. Survey methods followed those outlined in the *Range-wide Indiana Bat & Northern Long-eared Bat Survey Guidelines* (USFWS 2024d).

The 2024 bat survey results did not initially confirm the presence of either the northern long-eared bat or Indiana bat, therefore these species were considered not likely to be present in the expanded Project Boundary as documented in the study report (Appendix D); however, following their review of acoustic data, USFWS indicated that Indiana bat is considered tentative presumed present for the Project area. The tricolored bat, little brown bat, and gray bat were detected by the acoustic surveys and are likely using foraging and/or roosting habitat (tricolored bat and little brown bat only) in the expanded Project Boundary. USFWS concurred with these findings.

E.11.2.1.2 Small Whorled Pogonia Survey

A survey for the federally threatened small whorled pogonia was completed within the USFWS-recommended survey window (mid-May to early July) 2024 and the final report is included in Appendix D. The most up to date LOD and spoil areas, as well as the expanded transmission line corridor and associated access roads were surveyed for the small whorled pogonia and suitable habitat. The survey methodology consisted of slowly traversing back and forth across transects; surveyors were spaced approximately 25-ft apart focusing the immediate area within a 10-to-15-foot radius depending on habitat type and visibility.

No small whorled pogonia were identified during the surveys, however potential habitat was observed in all study areas.

E.11.2.2 Project Impacts on Rare, Threatened, and Endangered Species

In SD2, FERC identified the following environmental issue related to RTE species to be addressed in its NEPA document:

- Effects of project construction, operation, maintenance, and project-related recreation on the endangered persistent trillium, smooth coneflower, and gray bat, and the threatened northern long-eared bat and small whorled pogonia.

E.11.2.2.1 Effects of Project Construction, Operation, Maintenance, and Project-Related Recreation on RTE Species

Existing Bad Creek Project

The existing Project has external lighting structures which have the potential to disrupt the natural behavior of nocturnal species, such as bats, which could avoid the area. However, as noted above, suitable foraging and potential roosting habitat for bats is common in the expanded Project Boundary and across the landscape, which supports a range of upland, riparian, wetland, and open water habitats. The upland forested areas and riparian habitats used by these species are not affected by normal Project operations.

Vegetation maintenance within the existing transmission line corridor would continue in order to ensure the safe and reliable transmission of power from the Project to Jocassee Station. Maintenance of the transmission line corridor results in the creation of potential habitat for some RTE species or habitats, or BCC, such as smooth coneflower, sun-facing coneflower, Georgia aster, golden-winged warbler, and the monarch butterfly. However, the transmission line corridor does present risk of bird strikes of protected bird species, particularly bald eagle and American peregrine falcon.

No actions for continued operations or maintenance are proposed for the existing Project which would cause impacts to the RTE species evaluated herein. Duke Energy does not expect continued operation of the Project over the term of the new license to affect RTE species or their habitats.

Project-related recreation consists of the 43-mile segment of the Foothills Trail currently maintained by Duke Energy and private contractors with coordination and assistance from the FTC. No changes to the trail are proposed which would result in impacts to RTE species or their habitats.

Bad Creek II

As stated in sections above, various protected species surveys were completed in support of this relicensing. The bat studies and informal consultation with the USFWS found low likelihood of presence for northern long-eared bat, high likelihood of presence for gray, hoary, and little brown bats, and moderate likelihood of presence for Indiana bat. Habitats consisting of forested areas and those associated with waterbodies (i.e., summer roosting habitat, foraging habitat) are present in the expanded Project Boundary, however overwintering habitat consisting of caves or mines are not present.

Construction activities associated with the development of Bad Creek II would result in impacts to protected bat species summer roosting and foraging habitat due to the removal of forested areas and impacts to riparian habitat. Some areas, such as the spoil areas, would regenerate over the long-term and eventually provide potential bat habitat, however permanent forest removal for development of facilities would result in habitat loss. The removal of forested areas for the transmission line corridor expansion may result in a loss of roosting habitat, but may provide areas for foraging.

Abundant habitat for small whorled pogonia and smooth coneflower exists within the expanded Project Boundary, however neither species was identified during field surveys (HDR 2021a, 2021b; *Small Whorled Pogonia Study Report* in Appendix D). Persistent trillium was also not observed during field surveys and it is unlikely that this species is present as it is as it is only known from one location, Tallulah Gorge, which is approximately 30 miles southwest of the Project. Persistent trillium is also no longer reported on the USFWS IPaC list (USFWS 2024a). Impacts to the small whorled pogonia primarily consists of potential habitat loss due to the removal of forested habitat, both from the deposit of spoil material and the clearing for the transmission line corridor expansion. Spoil areas would regenerate to forested areas over the following years, but forest removed for the transmission line corridor would be a permanent habitat loss. For the smooth coneflower, impacts would primarily consist of temporary disturbance of habitat within the existing transmission line corridor.

Construction activities resulting in habitat removal or disturbance could also affect protected avian species in the area, such as bald eagle or birds protected under the MBTA. If birds are in the area, they would likely move to areas without construction activity unless actively nesting.

The operation of Bad Creek II, if pursued, would have limited effects to RTE species. External lighting of facilities will be necessary to maintain safe environments, which could disrupt some natural behaviors of nocturnal species, such as bats. However, Duke Energy is committed to limiting external lighting which could affect wildlife. The new transmission lines would also present a bird strike risk to larger species such as bald eagle or peregrine falcon.

E.11.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.11.3.1 Existing Bad Creek Project

- Duke Energy will work towards reducing the amount of external lighting at the site. Consistent with this goal, as external lights require maintenance or replacement, the Licensee will evaluate each light consistent with the “Five Principles of Outdoor Lighting” (DarkSky 2024) and implement recommendations as practicable. As existing light poles and light fixtures are replaced, the Licensee will paint them a dark non-reflective color in dark brown, tan, green, or gray, darker than the background exposed rock or forested surroundings (see draft VRMP in Appendix E)

- Protections for raptors and bald eagles
  - Duke Energy is committed to the protection of migratory, and threatened and endangered birds while providing safe and reliable power to customers. Duke Energy is an active member of the Avian Power Line Interaction Committee (APLIC), working with the organization and its membership in the advancement and implementation of electric utility best practices for avian protection. Duke Energy currently holds a Special Use Utility Permit with the USFWS-Region 4. With this permit, Duke Energy's Environment, Health and Safety-Natural Resources department also maintains and operates an Avian Hotline that employees and staff can call to report avian interactions at our facilities and assets. In review of the annual Special Use Utility Permit report and our avian incident records, there have been no avian incidents (e.g., interactions, electrocutions, collisions) regarding the Bad Creek Pumped Storage facilities' transmission lines, distribution lines, or switchyard over the last three years. Duke Energy's existing 100-kV and 525-kV transmission structures have conductor separation protective of avian species, which is consistent with the APLIC and the USFWS guidelines to minimize adverse interactions. Duke Energy also implements the Avian Protection Plan with the purpose of ensuring compliance with requirements of all bird protection regulations and laws promulgated to reduce avian mortality (Duke Energy 2024c).
  - The Licensee will install eagle and raptor protection measures (i.e., pole retrofits, substation caps and covers, flight diverters) at several strategic eagle use and flyway areas. Eagle/raptor protection measure retrofits to existing structures will be made within five years following new license issuance, the end of all appeals, and closure of all rehearing and administrative challenge periods, while similar protection measures for those structures associated with Bad Creek II will be outfitted during construction/installation. (see Relicensing Agreement in Exhibit B)
- The Licensee will implement Species Protection Plans that may include federal or state listed species and/or SWAP species agreed upon between the Licensee and SCDNR at the time of submittal of the Species Protection Plans with the Application for New License. The Species Protection Plans agreed upon by the Licensee and SCDNR may be developed to focus on an individual species or species guilds that could address multiple species in an ecosystem or

ecological community. The Licensee will develop and maintain up to ten (10) SPPs, including a Special Status Bat Protection Plan. Species Protection Plans will be included in the FLA.

- Provided SCDNR, Friends of Lake Keowee, Advocates for Quality Development, South Carolina Wildlife Foundation, Upstate Forever, and Naturaland Trust are Parties to the Relicensing Agreement, and the new license is consistent with the BCRA for species protection and wildlife management requirements, the Licensee will implement a Pollinator Enhancement Program. The Pollinator Enhancement Program will consist of the following elements (see BCRA in Exhibit B).
    - Planting of milkweed species (seeds and plugs) in strategic locations within the Project. This enhancement would benefit monarch butterflies and other similar insect species (e.g., bumble bees) and would support Duke Energy's participation in the Monarch Candidate Conservation Agreement with Assurances.
    - Add up to two monarch Candidate Conservation Agreement with Assurances monitoring sites on the Bad Creek transmission line corridor.
- Plant areas in the Bad Creek Project Boundary with native wildflower/grass pollinator and wildlife friendly seed mixes. There are several open areas (not going to be designated for spoil placement) that could support such activity.

E.11.3.2 Bad Creek II

- The Licensee will limit the use of lighting during construction to only those areas with active construction and the presence of personnel. (see draft VRMP in Exhibit E)

- For activities related to the construction of Bad Creek II, Duke Energy will follow the Minimum Conservation Measures (MCM) outlined in the *Northern Long-eared Bat and Tricolored Bat Voluntary Environmental Review Process for Development Projects* (USFWS 2024d). Many of the conservation measures, although originally for the northern long-eared bat and tricolored bat, also apply to other tree-roosting species of bats (such as little brown bat and hoary bat). Specific mitigation measures, such as avoidance of tree clearing during certain periods, will be detailed in the Biological Assessment which is under development in support of the FLA and CWA 404/401 permitting and in consultation with the USFWS, and is expected be filed with the FLA.

E.12 Terrestrial Resources

E.12.1 Affected Environment

The Project Boundary and vicinity includes several natural community types and a wide variety of terrestrial habitats and wildlife, including potential for the presence of protected plant and animal species. The Project is located primarily within the Level IV Southern Crystalline Ridges and Mountains ecoregion (within the Blue Ridge Level III ecoregion), with the lower portion of the transmission line corridor crossing into the Level IV Southern Inner Piedmont ecoregion (Piedmont Level III ecoregion) (Griffith et al. 2002). The Blue Ridge ecoregion is considered a transitional area between the mountainous ecoregions of the Appalachians to the northwest and the rolling hills of the Piedmont to the southeast. The Southern Crystalline Ridges and Mountains ecoregion is characterized by crystalline rock types of gneiss and schist and soils tend to be well-drained, acidic, and loamy. This ecoregion is mostly forested with chestnut oak dominating on most slopes and ridges (Griffith et al. 2002). The Piedmont ecoregion is a transitional area between the mostly mountainous ecoregions of the Appalachians/Blue Ridge and the relatively flat coastal plain to the southeast. The Southern Inner Piedmont ecoregion specifically is characterized by rolling to hilly terrain with gneiss and schist bedrock covered with clayey and micaceous saprolite. This ecoregion is generally forested with oak-pine, oak-hickory, and loblolly-shortleaf pine forest throughout (Griffith et al. 2002).

E.12.1.1 Terrestrial Habitats

Terrestrial habitat surveys were conducted within the Project Boundary and transmission line corridor from June 8 to 10 and September 19 and 20, 2021. Several natural communities in both areas were identified using The Ecological Zones in the Southern Blue Ridge Escarpment: 4th Approximation (Simon 2015) and are summarized below.

Expanded Project Boundary Excluding Transmission Line Corridor

On September 1-3, 2021, HDR biologists conducted a survey of the balance of the expanded Project Boundary – an area of 1,314 acres—for existing natural communities. According to the Natural Communities of South Carolina Initial Classification and Description (Nelson 1986) and the Nature Serve community classification system (Nature Serve 2013), five ecological groups and community types were identified within the expanded Project Boundary: 1) Shortleaf Pine-Oak Forest and Woodland, 2) Rhododendron Forest, 3) Montane Oak- Hickory Forest, 4) Acidic Cove Forests, and 5) Floodplain Forest. Open maintained areas and existing right-of-way areas were also documented.

Shortleaf Pine-Oak Forest and Woodland

This habitat type is characterized by shortleaf pine and oak-dominated forested areas on exposed ridges and sideslopes (Simon 2015). Dominant tree canopy cover observed included white oak, scarlet oak, northern red oak (*Quercus rubra*), chestnut oak, mockernut hickory, tulip poplar (*Liriodendron tulipifera*), white pine, sugar maple (*Acer saccharum*), eastern hemlock, Virginia pine, and sourwood. Saplings and shrubs consisted of similar canopy species as well as American holly (*Ilex opac*a), highbush blueberry (*Vaccinium corymbosum*), lowbush blueberry (*Vaccinium angustifolium*), mountain laurel, rhododendron (*Rhododendron maximum*), cucumber magnolia (*Magnolia acuminata*), witch-hazel (*Hamamelis* spp.), bear oak (*Quercus ilicifolia*), and sassafras. Herbaceous and vine species consisted of rattlesnake weed (*Hieracium venosum*), spotted wintergreen (*Chimaphila maculate*), Christmas fern (*Polystichum acrostichoides*) and muscadine grape (*Vitis rotundifolia*).

Mixed Oak/Rhododendron Forest

This habitat type is characterized by rhododendron-dominated thickets found on mountains and in the upper Piedmont, with sparse herbaceous cover. Dominant species observed for this habitat type included northern red oak, shortleaf pine, mountain laurel, rhododendron, deerberry (*Vaccinium stamineum*), white pine, sourwood, red maple, and black gum (*Nyssa sylvatica*).

Montane Oak-Hickory Forest (Cove and Slope)

This habitat type is characterized by a mix of hardwood tree species on lower elevations within mountains and upland slopes between rivers and headwater tributaries. Dominant tree species observed for this habitat type included northern red oak, chestnut oak, pignut hickory, white pine, red maple tulip poplar, mountain laurel, sourwood, black gum, magnolia, and high bush blueberry.

Acidic Cove Forest

This habitat type is characterized by hemlock and mixed hardwood-conifer forests, typically dominated by an evergreen understory occurring in narrow coves (ravines) and extending to adjacent protected, north-facing slopes (Simon 2015). Dominant tree species observed for this habitat type consisted of red maple, sweetgum (*Liquidambar styraciflua*), black gum, eastern hemlock, rhododendron, tulip poplar, sourwood, chestnut oak, sweet birch (*Betula lenta*), and white ash (*Fraxinus americana*). Shrubs consist of mountain doghobble, deerberry, witch hazel, elderberry (*Sambucus nigra*), magnolia, spicebush, and pawpaw (*Asimina triloba*). The herbaceous and vine layer is dominated by Galax (*Galax urceolata*), black cohosh (*Actaea racemosa*), jewelweed (*Impatiens capensis*), Indian cucumber (*Medeola virginiana*), violets (*Viola* spp.), Christmas fern, wood ferns (*Dryopteris* spp.), and Virginia creeper (*Parthenocissus quinquefolia*).

Floodplain Forest

This habitat type is found in regularly or seasonally flooded areas adjacent to river systems with a diverse herbaceous cover. Dominant trees consisted of white oak, sweetgum, red maple, eastern hemlock, sourwood, red oak, and yellow birch (*Betula alleghaniensis*). The shrub and vine layer consists of pawpaw, alders (*Alnus* spp.), and muscadine. The herbaceous layer consists of black cohosh, Indian cucumber, wild ginger (*Asarum* spp.), running cedar (*Diphasiastrum digitatum)*, partridge berry (*Mitchella repens*), wood fern, Christmas fern, jewelweed, and nettled chain fern (*Woodwardia areolata*).

Transmission Line Corridor

On June 8-10, 2021, HDR biologists surveyed the approximately 9.25-mile-long, 400-ft wide transmission line corridor extending between the existing Project and the Jocassee powerhouse switchyard for existing natural communities. In addition to the maintained transmission line corridor, four natural communities were identified: Cove Forest, Chestnut Oak Forest, High Elevation Seep, and Mesic Mixed Hardwood Forests (Nelson 1986). These natural communities were observed within the 50-foot buffer on either side of the Bad Creek to Jocassee transmission line corridor and within the unmaintained areas of the right-of-way.

Maintained Right-of-Way and Fields

Maintained ROW areas and fields are comprised of early successional woody, herbaceous, and vine species including red maple, hickories, black cherry, black locust (*Robinia pseudoacacia*), mutilfora rose (*Rosa multiflora*), sawtooth blackberry (*Rubus argutus*), goldenrods (*Solidago* spp.), curly dock (*Rumex crispus*), dogfennel (*Eupatorium capillifolium*), pokeberry (*Phytolacca* spp.), rabbit tobacco (*Pseudognaphalium obtusifolium*), asters (*Aster* spp.), beggars tick (*Bidens* spp.), bushy bluestem (*Andropogon glomeratus*), broomsedge (*Andropogon virginicus*), foxtails (*Seteria* spp.) boneset, fescue (*Fescue* spp.), crabgrass (*Digitaria* spp.), Johnson grass (*Sorghum halepense*), Japanese stiltgrass, deer-tongue grass, white clover (*Trifolium repens*), morning glory (*Ipomoea* spp.) greenbrier (*Smilax rotundifolia*), ragweeds (*Ambrosia* spp.), Japanese honeysuckle (*Lonicera japonica*), and muscadine grape.

Chestnut Oak Forest

Chestnut Oak Forest is predominantly present within the northern portion of the Project with higher mountains and ridges. Plant species observed within these communities include Virginia pine, shortleaf pine (*Pinus echinate*), white pine (*Pinus strobus*), chestnut oak, black oak (*Quercus velutina*), scarlet oak (*Quercus coccinea*), white oak (*Quercus alba*), mockernut hickory (*Carya tomentosa*), pignut hickory (*Carya glabra*), sourwood (*Oxydendrum arboreum*), black cherry (*Prunus serotina*), Piedmont rhododendron (*Rhododendron minus*), mountain laurel (*Kalmia latifolia*), doghobble (*Leuothoe fontanesiana*), sassafras (*Sassafras* albidum) and huckleberry (*Vaccinium stamineum*).

Cove Forests

Cove Forests were observed in ravines and steep slopes adjacent to stream channels in forested areas outside of the maintained right-of-way for the Bad Creek to Jocassee transmission line. Plant species observed within this community included American basswood, American beech (*Fagus grandifolia*), eastern hemlock, silver maple (*Acer saccharinum*), birch (*Betula lenta*), rhododendron, mountain laurel, spicebush (*Lindera benzoin*), flowering dogwood (*Cornus florida*), galax (*Galax* spp.), maiden hair fern (*Adiantum* sp.) and woodferns (*Dryopteris* sp.).

High Elevation Seeps

High Elevation Seep communities were observed throughout the transmission line corridor and were mostly associated with ephemeral or intermittent streams down gradient. Plant species identified within these areas are umbrella leaf (*Diphylleia cymosa*), beaksedge (*Rhynchospora capitellata*), mountain laurel, jewelweed (*Impatiens capensis*), and sphagnum.

Maintained Bad Creek-to-Jocassee transmission line right-of-way areas are comprised of early successional woody, herbaceous, and vine species including red maple, hickories, black cherry, black locust (*Robinia pseudoacacia*), mutilfora rose (*Rosa multiflora*), sawtooth blackberry (*Rubus argutus*), horseweed (*Conyza canadensis*), goldenrods (*Solidago* sp.), New York ironweed (*Vernonia noveboracensis*), curly dock (*Rumex crispus*), dogfennel (*Eupatorium capillifolium*), pokeberry (*Phytolacca* sp.), bushy bluestem (*Andropogon glomeratus*), broomsedge (*Andropogon virginicus*), fescue (*Fescue* sp.), Johnson grass (*Sorghum halepense*), Japanese stiltgrass (*Microstegium vimineum*), deer-tongue grass (*Dichanthelium clandestinum*), white clover (*Trifolium repens*), morning glory (*Ipomoea* sp.) greenbrier (*Smilax rotundifolia*), devil's walking stick (*Aralia spinosa*), Japanese honeysuckle (*Lonicera japonica*), muscadine grape (*Vitis rotundifolia*), bracken fern (*Pteridium aquilinum*), and nettled chain fern (*Woodwardia areolata*).

Mesic Mixed Hardwood Forests

Mesic Mixed Hardwood Forests were dominant in areas of less steep terrain, where the canopy was comprised of hardwood species such as red maple, eastern red cedar (*Juniperus virginiana*), tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), ironwood (C*arpinus caroliniana*), and pignut hickory.

E.12.1.2 Terrestrial Wildlife Resources

Terrestrial communities in the Project vicinity comprise mature forested habitats with areas of early successional habitats that may also support a diverse number of wildlife species. Representative mammal, bird, reptile, and amphibian species commonly occurring in these habitats are listed below. Note individual species and/or evidence of species observed during HDR's field surveys are indicated with an asterisk (*). Information on species typically using these habitats in the Piedmont ecoregion was obtained from relevant literature, mainly the Biodiversity of the Southeastern United States, Upland Terrestrial Communities (Martin et al. 1993). Mammal species commonly occurring in the Appalachian Oak Forest Region include eastern cottontail (*Sylvilagus floridanus*), North American beaver *(Castor canadensis),* black bear (*Ursus americanus*)*, coyote (*Canis latrans*), gray squirrel (*Sciurus carolinensis*)*, white-tailed deer (*Odocoileus virginianus*)*, raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), red fox (*Vulpes vulpes*), least weasel (*Mustela nivalis*), and various vole, rat, and mice species. Bird species commonly using these habitats include yellow-billed cuckoo (*Coccyzus americanus*), black-billed cuckoo (*Coccyzus erythropthalmus*) wild turkey (*Meleagris gallapava*), American crow (*Corvus brachyrhynchos*), northern cardinal (*Cardinalis cardinalis*), field sparrow (*Spizella pusilla*), prairie warbler, eastern towhee (*Pipilo erythrophthalmus*), wood thrush, ovenbird (*Seiurus aurocapillus*), red-eyed vireo (*Vireo olivaceous*), chickadees (*Parus sp*), and woodpeckers (Family Picadae). Predatory birds may include American kestrel (*Falco sparverius*), barred owl (*Strix varia*), peregrine falcon (*Falco peregrinus*), red-shouldered hawk (*Buteo lineatus),* red-tailed hawk (*Buteo jamaicensis*), sharp-shinned hawk (*Accipiter striatus*), owl species, and turkey vulture (*Cathartes aura*).

Reptile species using these terrestrial communities include the northern scarlet snake (*Cemophoroa coccinea copei*), timber rattlesnake (*Crotalus horridus*), copperhead (*Agkistrodon conttortrix*), eastern ratsnake (*Pantherophis obsoletus*), common five-line skink (*Plestiodon fasciatus*), amphibians include tree toads (*Bufo* spp.), spadefoot (*Scaphiopus holbrooki*), and frog species (*Hyla* spp., *Rana* spp., and *Pseudacris* spp.). The dominant salamander community are the dusky salamanders (*Desmognathus* spp.).

Species that are considered important because of their commercial, recreational, or cultural value include large game such as white-tailed deer, black bear, wild turkey, as well as small game animals such as possums, raccoons, and foxes, which are considered recreationally valuable for hunting (NCWRC 2022). The Eastern Band of Cherokee Indians consider hickory tree species culturally significant. Hickory tree wood is used to craft equipment for a popular Cherokee sport called Cherokee Stickball. Hickory trees are also used to create traditional Cherokee style meals using hickory ash which is used to cook hominy, and hickory nut soup (Knuchi) (NCWF 2022).

E.12.1.2.1 Invasive Species

Invasive species are non-native plant, animal, or fungal species causing or are likely to cause economic or ecological harm or harm to human health. Numerous invasive species have been introduced to South Carolina which can cause, or are presently causing, the extirpation of native species, alterations to natural ecological communities, impacts to agricultural production, adverse impacts to threatened and endangered species, and direct harm to people.

Disturbed areas within the expanded Project Boundary, especially adjacent to existing structures, have been encroached on by invasive species including princess tree (*Catalpa bignonioides*), Japanese stiltgrass, mimosa tree (*Albizia julibrissin*), Japanese honeysuckle, and sawtooth oak. In addition, sounds and visual signs of invasive feral hogs (*Sus scrofa*) such as unrooted plants and hoof prints were identified during field surveys.

While not a complete list of all invasive species in South Carolina, Table E.12-1 provides invasive species of concern in South Carolina (Natural Resource Conservation Service 2011; Defenders of Wildlife 2021; USDA 2021a; and USDA 2021b). Species observed in the field during other surveys performed by HDR for the Bad Creek to Jocassee transmission line corridor are indicated with an asterisk (*).

Table E.12-1. Invasive Species of Concern in South Carolina

Common Name	Scientific Name	General Habitat
Mammals		
Feral Hog	*Sus scrofa*	Terrestrial
Insects		
Ambrosia Beetle	*Xylosandrus crassiusculus*	Terrestrial
Asian Longhorn Beetle	*Anoplophora glabripennis*	Terrestrial
Emerald Ash Borer	*Agrilus planipennis*	Terrestrial

Common Name	Scientific Name	General Habitat
European Cherry Fruit Fly	*Rhagoletis cerasi L.*	Terrestrial
Gypsymoth	*Lymantria dispar*	Terrestrial
Hemlock Wooly Adelgid	*Adelges tsugae*	Terrestrial
Imported Fire Ant	*Solenopsis invicta*	Terrestrial
Spotted Lanternfly	*Lycorma delicatula*	Terrestrial
Fish and Mollusks		
Flathead Catfish	*Pylodictus olivaris*	Aquatic
Asian Clam	*Corbicula fluminea*	Aquatic
Plants		
Alligator Weed	*Alternanthera philoxeroides*	Aquatic
Autumn Olive, Russian Olive, Thorny Olive	*Elaeagnus umbellata, E. angustifolia, E. pungens*	Terrestrial
Bamboo	*Phyllostachys aurea*	Terrestrial
Beach Vitex	*Vitex rotundifolia*	Terrestrial
Bull Thistle*	*Cirsium vulgare*	Terrestrial
Chinaberry Tree	*Melia azedarach*	Terrestrial
Chinese Parasol Tree	*Firmiana simplex*	Terrestrial
Chinese Silvergrass	*Miscanthus sinensis*	Terrestrial
Chinese Tallow Tree, Popcorn Tree	*Sapium or Triadica sebiferum*	Terrestrial
Chinese/Japanese Privet	*Ligustrum sinense L. japonicum*	Terrestrial
Common Salvinia	*Salvinia minima*	Aquatic
Coontail	*Myriophyllum heterophyllum*	Aquatic
Crested Floating Heart	*Nymphoides cristata*	Aquatic
English Ivy	*Hedera helix*	Terrestrial
Giant Reed	*Arundo donax*	Terrestrial
Giant Salvinia	*Salvinia molesta*	Aquatic
Golden Bamboo	*Phyllostachys aurea*	Terrestrial
Hydrilla	*Hydrilla verticallata*	Aquatic
Japanese Climbing Fern	*Lygodium japonicum*	Terrestrial
Japanese Honeysuckle*	*Lonicera japonica*	Terrestrial
Japanese Knotweed*	*Polygonum cuspidatum*	Terrestrial

Common Name	Scientific Name	General Habitat
Japanese Stilt-Grass*	*Microstegium vimineum*	Terrestrial
Johnson Grass*	*Sorghum halepense*	Terrestrial
Kudzu	*Pueraria montana*	Terrestrial
Mimosa*	*Albizia julibrissin*	Terrestrial
Multiflora Rose*	*Rosa multiflora*	Terrestrial
Musk Thistle, Nodding Thistle, Plumeless Thistle	*Carduus nutans*	Terrestrial
Oriental Bittersweet	*Celastrus orbiculatus*	Terrestrial
Parrot Feather	*Myriophyllum aquaticum*	Aquatic
Periwinkle (Bigleaf and Common)	*Vinca major, Vinca minor*	Terrestrial
Phragmites	*Phragmites australis*	Aquatic
Princess Tree/Royal Paulownia*	*Paulownia tomentosa*	Terrestrial
Sericea/Chinese Lespedeza*	*Lespedeza cuneata*	Terrestrial
Showy Rattlebox	*Crotalaria spectabilis*	Terrestrial
Shrub/Shrubby Lespedeza*	*Lespedeza bicolor*	Terrestrial
Tree-Of-Heaven*	*Ailanthus altissima*	Terrestrial
Trifoliate Orange	*Poncirus cuspidatum*	Terrestrial
Vasey's Grass, Dallis Grass	*Paspalum urvillei, P. dilatatum*	Terrestrial
Water Hyacinth	*Eichhornia crassipes*	Aquatic
Water Lettuce	*Pistia stratiotes*	Aquatic
Water Primrose	*Ludwigia hexapetala*	Aquatic
Weeping Lovegrass	*Eragrostis curvula*	Terrestrial
Wisteria -Chinese Wisteria/Japanese Wisteria	*Wisteria sinensis. W. floribunda*	Terrestrial
Fungi		
Chestnut Blight	*Cryphonectria parasitica*	Terrestrial
Dutch Elm Disease	*Ophiostoma ulmi, Ophiostoma himal-ulmi*	Terrestrial

* Observed in the field during other surveys performed by HDR for the Bad Creek to Jocassee transmission line corridor.

E.12.2 Environmental Analysis

E.12.2.1 Studies in Support of the Current Relicensing

In addition to the Natural Resources Assessment, several studies were completed during relicensing to support understanding of terrestrial resources and wildlife within the expanded Project Boundary and in the Project vicinity.

E.12.2.1.1 Bat Surveys

2021 Bat Surveys

As discussed in Section E.11.2.1.1, ERM conducted field surveys in 2021 to assess the presence/likely absence of bat species and their potential habitats within the Project vicinity (ERM 2021). Habitat surveys, acoustic surveys, and mist net surveys were carried out to determine the presence and identification of bat species. Details of the methods, analyses, and findings of the surveys are included in the ERM Bat Survey Report (ERM 2021).

The acoustic analysis suggested the presence of 12 bat species within the Project, including protected and proposed-protected species. Common species identified from acoustic calls with high or medium probability of presence included the big brown bat (*Eptesicus fuscus*), eastern red bat (*Lasiurus borealis*), Seminole bat (*Lasiurus seminolis*), eastern small-footed bat (*Myotis leibii*), evening bat (*Nycticeius humeralis*), and Brazilian fere-tailed bat (*Tadarida brasiliensis*). Protected and proposed-protected species are discussed in Section E.11.

Four mist surveys were conducted including two sites in July 2021 and two sites in October 2021. Each site deployed multiple net sets and sites were surveyed for two nights for a total of 26 net nights. Two sites were located within road corridors adjacent to the reservoir, one site was located on the service road extending from the existing transmission line right-of-way, and one site was located south of the reservoir dam at the intersection of a field and road corridor. A total of 14 bats, representing four different species were captured during the surveys: big brown bat, eastern red bat, hoary bat, and eastern small-footed bat.

The results of the 2021 bat survey indicated a diversity of bat species present within the Project vicinity, including protected, proposed-protected, and common species.

2024 Bat Surveys

Mist-net surveys and acoustic surveys were conducted in 2024 by Biotope Forestry & Environmental to assess the presence/probable absence of the federally proposed tricolored bat and federally endangered northern long-eared bat and gray bat, as well as state listed species of concern known to be present in Oconee County, including little brown bat, Rafinesque's big-eared bat (state endangered), eastern small-footed bat (state threatened), and hoary bat (Biotope 2024). The Project area of interest consists of both linear and non-linear areas of potential summer habitat for target species (i.e., trees greater than three inches diameter at breast height) that could be impacted by the construction of Bad Creek II.

A total of thirty-seven acoustic surveys were conducted across the area of interest from June 1st through June 19th, 2024, resulting in the collection of a total of 144 detector nights (see the *Bad Creek Pumped Storage Presence/Absence Acoustic and Mist-net Surveys for Threatened & Endangered Bat Species* report provided in Appendix D).

Acoustic surveys auto identified calls from 15 bat species with 10 of those determined to have high likelihood of presence in the expanded Project Boundary. Common species identified included eastern red bat, big brown bat, evening bat, eastern small-footed bat, and Brazilian free-tailed bat. Several protected or proposed-protected species were also identified from acoustic calls (see Section E.11.2.1.1).

In addition to acoustic surveys, a total of fifteen summer mist-net surveys were conducted for two calendar nights, totaling 62 net nights of survey effort across the Project from June 1st to June 14th, 2024. Twelve of the mist-net sites were placed along the linear section of the area of interest. The remaining three mist-net sites were placed within the nonlinear portion of the area of interest.

A total of 41 bats were captured on the Project comprising three species: big brown bat, eastern small-footed bat, and eastern red bat. Approximately 51 percent and 41 percent of the captures were big brown bats and eastern red bats respectively, with the remaining 7 percent accounted for by eastern small-footed bats.

Like the 2021 survey, the acoustic and mist net surveys performed in 2024 show a diverse bat community with both protected, proposed-protected, and common bat species. USFWS (by email dated January 10, 2025) provided their determination that the results of the study report are acceptable for probable absence of northern long-eared bat and presence of gray bat and tricolored bat, and indicated Indiana bat should have a determination of tentative presumed presence in the Project area. Copies of consultation are attached to the *Bad Creek Pumped Storage Presence/Absence Acoustic and Mist-net Surveys for Threatened & Endangered Bat* report in Appendix D.

E.12.2.1.2 Herptile Survey

Terrestrial herptile surveys were completed in September 2023 within proposed spoil areas B1, B2, B5, B6, C, D, E, F, G, I, and J. Target species included those on the SWAP priority list. The herptile surveys were conducted through visual encounter or patch sampling at specific microhabitats (e.g., rock ledges, rock piles, logs, wet depressions). Transects were generally spaced 75-ft apart depending on habitat type and/or visibility. Observed species and their locations were recorded using a handheld GPS. Observed specimens that could be captured were taxonomically identified with photographic documentation.

The eastern box turtle (*Terrapene carolina*) was the only SWAP species identified in the expanded Project Boundary (Table E.12-2). No reptiles or amphibians were observed in proposed spoil area F.

Table E.12-2. Reptiles and Amphibians Observed within Spoil Areas

Common Name	Scientific Name	Spoil Areas[1]
Black Racer	*Coluber constrictor*	E
Black-bellied Salamander	*Desmognathus quadramaculatus*	G and I
Chattooga Dusky Salamander	*Desmognathus perlapsus*	C and G (N=2)
Eastern Box Turtle[2]	*Terrapene carolina*	B1 and I
Eastern Copperhead	*Agkistrodon contortrix*	B1
Eastern Fence Lizard	*Sceloporus undulatus*	B2, B6
Fowler’s Toad	*Anaxyrus fowleri*	I
Green Anole	*Anolis carolinensis*	B5/B6 and G
Green Frog	*Rana [Lithobates] clamitans*	G
Red Salamander	*Pseudotriton ruber*	G
Red-spotted Newt	*Notophthalmus viriascens*	D
Seal Salamander	*Desmognathus monticola*	B1 and I
Southern Appalachian Slimy Salamander	*Plethodon teyahalee*	E
Southern Gray-cheeked Salamander	*Plethodon metcalfi*	C (N=2), D (N=2), G (N=5), and I (N=4), J

[1]N = number of locations within spoil area identified
[2]SWAP priority species

E.12.2.2 Project Impacts on Terrestrial Resources

In SD2, FERC identified the following environmental issues related to terrestrial resources to be addressed in its NEPA document:

- Effects of project construction, operation, and maintenance activities, including maintenance for roads and transmission line rights-of-way, and project-related recreation on native plant communities, wetlands, and the spread and control of non-native, invasive plants.

- Effects of the existing and proposed project transmission lines on raptors and other birds, including electrocution and collision hazards.
- Effects of permanent and temporary wildlife habitat loss due to construction of proposed project features and disposal of spoils, including potential loss of habitat that supports foraging and/or nesting raptors and other birds.
- Effects of noise, lighting, vehicular traffic, and human presence during project construction, operation, and maintenance activities on wildlife, including special-status wildlife species, especially during sensitive periods (e.g., migrating or breeding).
- Effects of project construction, operation, maintenance, and project-related recreation on special status species, including the monarch butterfly, a federal candidate species, Birds of Conservation Concern, and their habitats.
- Effects of climate change and other reasonably foreseeable effects on natural resources, including wildlife habitat corridors, in the project boundary, to the extent possible.

E.12.2.2.1 Effects of Project Construction, Operation, Maintenance Activities, and Project-Related Recreation on Native Plant Communities, and the Spread and Control of Non-Native, Invasive Plants

Existing Bad Creek Project

Continued Project operations are not anticipated to affect wildlife and botanical resources of the Project vicinity. Protection of upland habitat around Lake Jocassee is provided by the requirements and agreements of the KT Project Relicensing Agreement and license. As described previously, operation of the Project does not significantly impact Lake Jocassee water levels. Project operations are not likely to affect vegetation dispersal in the Project Boundary.

The SMP for the KT Project includes conditions for native vegetation plantings allowing the use of plantings to supplement existing native vegetation for protection and enhancement of important habitat areas. Continued implementation of the SMP will provide protection for vegetation communities at Lake Jocassee.

Vegetation on faces of dams at the Project is maintained in accordance with the FERC-approved Dam Safety Surveillance and Monitoring Plan while vegetation maintenance of access areas is conducted on an as-needed basis. Vegetation along the transmission line corridor is maintained on a regular basis.

Bad Creek II

Land clearing for facility development or spoil placement would result in native plant community loss. The habitats within and surrounding the expanded Project Boundary primarily consist of high quality, native species communities. Land disturbance and the presence of construction equipment inherently raises the risk of invasive species introduction and/or spread. Land clearing and soil disturbance could potentially enable the introduction or facilitate the spread of invasive plant and insect species. Project construction and operation also have the potential to affect (positively or negatively) the spread of invasive species.

E.12.2.2.2 Effects of Transmission Lines on Raptors and Other Birds

Both existing and proposed expansion of transmission lines are capable of contributing to collisions of raptors, including bald eagles. Electrocution with Project or Bad Creek II transmission lines is unlikely given current and planned design, which have conductor separation which offer avian protection to large birds such as bald eagles and turkey vultures. Duke Energy has had no known incidents (e.g., electrocutions or collisions) involving Project transmission/distribution lines in the last five years.

E.12.2.2.3 Effects of Permanent and Temporary Wildlife Habitat Loss Due to Construction

Construction of Bad Creek II will result in habitat loss from tree clearing required within the limits of disturbance, as well as associated access roads. Loss of forested communities will permanently impact native plant communities and will affect wildlife communities by displacement, habitat fragmentation and interrupting migration corridors. Habitat loss will likely disperse mobile wildlife into surrounding areas in an attempt to find new food sources and shelter. Impacted areas will, however, be concentrated in the vicinity of existing Project structures and spoil (excavated soil) disposal areas sited to reduce impacts. Since construction of Bad Creek II would not require construction of new dams or reservoirs, the scale of impact and disturbance is significantly reduced compared to development of a new (“greenfield”) energy storage and generation project of this size.

E.12.2.2.4 Effects of Noise, Lighting, Vehicular Traffic, and Human Presence During Project Construction, Operation, and Maintenance Activities on Wildlife

Existing Bad Creek Project

Noise levels associated with existing Project operations are low given the subterranean powerhouse and remote area in which the Project is situated. The existing Project does have external lighting structures which have the potential to disrupt the natural behavior of wildlife in the area, although some may be habituated to it. Similarly for vehicular traffic and human presence, some wildlife may be habituated to human activities but many likely avoid high traffic areas given the abundance of available habitat in the Project vicinity. Maintenance activities, especially of vegetated areas, could be disruptive to wildlife both around facilities and within the transmission line corridor, however these activities have been on-going for decades and occur at regular intervals.

Bad Creek II

Noise, lighting, and human activity, including vehicular traffic, would be elevated during the period of construction and wildlife would likely avoid the area currently under development. Operations of Bad Creek II would be similar to the Project, with limited noise disruption but would also be lighted consistently. Maintenance of the facilities and transmission line corridor would be similar to that completed for the original Project, and at the same time, limiting the number of disruptions to wildlife.

E.12.2.2.5 Effects of Project Construction, Operation, Maintenance, and Project-Related Recreation on special Status Species, including the Monarch Butterfly, Birds of Conservation Concern, and their Habitats

Effects of continued operation of the Project and the construction and operation of Bad Creek II on special status species, BCC, and their habitats is evaluated and discussed in Section E.11.2.2.

E.12.2.2.6 Effects of Climate Change on Natural Resources in the Project Boundary

A summary of climate data and future operations on water resources in support of this relicensing is attached as Appendix C to this Exhibit E. The evaluation of South Carolina's climate data found that impacts from climate change on the Project or proposed Bad Creek II would primarily be the result of higher temperatures and resulting increased evapotranspiration. The overall pattern of average temperatures across South Carolina has increased since the mid-1970s, driven largely by an increase in minimum temperatures (SCDNR 2022). Most climate stations in the state report significant increases in maximum temperatures in winter, spring, and summer, along with a significant increase in minimum summer temperatures (SCOR 2023). Furthermore, the number of freezing days has been below average since 1990. Heatwaves are common in the southeast and can worsen drought conditions, stress agriculture and water resources, and impact human health.

Rainfall in upstate South Carolina averages 45 to 55 inches of precipitation per year, with no distinct wet or dry season. There has not been a significant change in average annual precipitation trends since the beginning of the 20th century, however summer precipitation has decreased significantly at two-thirds of the stations monitored, particularly those further from the coastal area.

Projections for "low" or "high" emissions scenarios show that by the end of the century, the number of days in which state-averaged maximum temperature would exceed 95°F doubles in the lower emissions scenario, and increases five-fold in the higher emissions scenario. Such increases would likely have ecological impacts, as well as implications for human health and cooling costs during the warm season. The increase in temperature will cause more rapid loss of soil moisture during dry spells, increasing the intensity of future droughts.

Drought can impact aquatic resources in the Project Boundary by decreasing water levels and limiting habitat for aquatic organisms and wildlife depending on the aquatic resources. Increased temperatures and evapotranspiration can also impact vegetation growth and survival, changing habitat structures and availability.

E.12.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.12.3.1 Existing Bad Creek Project

- The Licensee will implement an Integrated Vegetation Management Plan at the Project to include: (1) proposed detailed methods for vegetation management around Project facilities and rights-of-ways that includes protection of sensitive native plant and wildlife species and habitats, including riparian habitats; and (2) a schedule for implementing vegetation management at the Project. The Licensee distributed the draft Integrated Vegetation Management Plan to stakeholders on February 19, 2025, and the draft plan is included in Appendix E. The final Integrated Vegetation Management Plan will be provided with the FLA.
- Protections for raptors and bald eagles are described in Section E.11.3 and include Duke Energy's participation and compliance with APLIC and USFWS guidance on minimizing adverse interactions (i.e., electrocutions and collisions), the possession of Special Use Utility Permit, and operation of an Avian Hotline. Duke Energy also implements an Avian Protection Plan across its facilities with the explicit purpose to ensure compliance with requirements of all bird protection regulations and laws promulgated to reduce avian mortality (Duke Energy 2024c).
    - As stated in Section E.11.3, Duke Energy will install eagle and raptor protection measures (i.e., pole retrofits, substation caps and covers, flight diverters) within five years following new license issuance, the end of all appeals, and closure of all rehearing and administrative challenge periods, while similar protection measures for

those structures associated with Bad Creek II will be outfitted during construction/installation.

As off-license measures under the BCRA, the Licensee will implement the following actions:

- The Licensee will sponsor an annual wildlife viewing/education event in the fall at the Project consistent with the BCRA. The signatory Parties to the BCRA will meet in January annually to discuss planning details of the event. The first sponsored event will occur three years following the start of commercial operation of Bad Creek II. If Bad Creek II is not constructed, the first sponsored event will occur within three years following issuance of new license.

- The Licensee will provide one-time funding of $500,000 to support the existing KT Habitat Enhancement Program consistent with the BCRA. The Licensee will provide its one-time contribution within two years following issuance of the new license.

- The Licensee will provide a one-time payment of $500,000 to the Oconee County Conservation Bank to support future land conservation efforts in Oconee County consistent with the BCRA. The Licensee will provide the funding within two years following issuance of the new license.

E.12.3.2 Bad Creek II

- The Licensee will revegetate areas disturbed by construction activities consistent with its Erosion and Sediment Control Plan.

- Duke Energy will follow the same avian protection measures as described above.

As off-license measures under the BCRA, the Licensee will implement the following actions:

- The Licensee will provide one-time funding of $500,000 to support the existing KT Habitat Enhancement Program consistent with the BCRA. The Licensee will provide its one-time contribution within one year following the start of commercial operation of Bad Creek II.

- The Licensee will provide a one-time payment of $500,000 to the Oconee County Conservation Bank to support future land conservation efforts in Oconee County consistent with the BCRA. The Licensee will provide its one-time contribution within one year following the start of commercial operation of Bad Creek II.

- The Licensee will provide one-time funding of $2,500,000 to support the development of a Wildlife Enhancement Program consistent with the BCRA. Wildlife under this plan includes native terrestrial and aquatic wildlife including invertebrate, and vertebrate species. The Wildlife Enhancement Program would support species conservation including, but not limited to propagation/restocking/re-establishment efforts, habitat restoration and protection, research to address questions regarding species of interest, such as species geographic distribution, population size and status, habitat suitability modeling; and genetics work.
  - This program and its funding would not be used to introduce non-native species.
  - This funding would be used in the area defined as all properties north of the main line of the Norfolk Southern Railroad from the Georgia State line to SC Hwy 183 in Westminster, then north of SC Hwy 183 to the intersection of SC Hwy 183 and the Norfolk Southern Railroad main line in Greenville and then north of the mainline of the Norfolk Southern Railroad to the Spartanburg County line.
  - The Licensee will provide funding within one year of the start of construction of Bad Creek II.
- Provide no-cost leases of approximately 1,886 ac of land to SCDNR as discussed in E.13.3.2.1. While SCDNR will manage the lands consistent with provide public hunting lands, the leases will benefit terrestrial species inhabiting the properties.

E.13 Recreation and Visual Resources

E.13.1 Affected Environment

E.13.1.1 Existing Recreation Facilities and Opportunities

The Project is located in a remote area in the Blue Ridge Mountains in South Carolina, just south of the North Carolina state border. Lake Jocassee, which serves as the Project's lower reservoir but is not included within the Project Boundary, provides nearby recreational opportunities for visitors. Lake Jocassee is surrounded by a series of steep-sided gorges with minimal residential development along the shoreline; the only developed public access is via Devils Fork State Park. As a result, the lands surrounding Lake Jocassee provide for a predominately natural setting. Lake Jocassee provides opportunities for boating (i.e., motor, sailing, canoeing, kayaking, paddle boarding, etc.), fishing, swimming, and scuba diving. The surrounding area also offers visitors opportunities for hiking, camping, hunting, whitewater rafting, and viewing wildlife and waterfalls.

There are no License-required recreation facilities within the Project Boundary. The Foothills Trail is the only recreational facility associated with the Project and is a 77-mile trail linking Oconee and Table Rock State Parks. The Foothills Trail was constructed in 1981 and is managed by the FTC (previously the Foothills Trail Conference). The FTC, with which Duke Energy is considered a partnering organization, is a non-profit 501(c)(3) membership organization composed of government agencies, recreational outfitters, and non-governmental organizations.

E.13.1.1.1 FERC-Approved Recreation Facilities at the Project

There are no FERC-approved recreation facilities within the Project Boundary, and there is no public access to Bad Creek Reservoir due to safety concerns from large fluctuations in water levels on a daily basis. The Bad Creek Reservoir is fenced to prohibit public access. However, under the terms of the Original License, Duke Energy developed a segment of the Foothills Trail and continues to maintain this segment, along with eight access points.

Through the licensing of the Project, Duke Energy agreed to build and maintain a central section of the Foothills Trail linking Table Rock State Park to Oconee State Park as mitigation for the loss of land and water resources, restricted public access to the upper reservoir, and in response to stakeholder demand for a trail near the Project area. Duke Energy constructed an approximately 43-mile trail[30]

[30] While the original Exhibit R states 31 miles of trail were to be constructed, and the updated Exhibit R identifies approximately 38 miles, modern documents and the easement for the trail corridor identify 43 miles of main trail and 3 miles of spur trail. The spur trails are managed by Duke Energy.

with approximately 3 miles of spur trails from Pinnacle Mountain (Table Rock State Park) west to the Whitewater River (Nantahala National Forest), following the northern shoreline of Lake Jocassee (FERC 1981), helping to create the now 77-mile-long trail completed in 1981 (FTC 2021). All facilities were constructed in accordance with Appalachian Trail Conference design standards. While this 43-mile trail segment is located on non-Project lands[31], it is maintained by Duke Energy and private contractors with coordination and assistance from the FTC. Duke Energy also maintains five spur trails which include the Bad Creek Spur, Coon Branch Spur, Lower Whitewater Falls Overlook, Hilliard Falls Spur, and Laurel Fork Falls Spur. The FTC is responsible for major and minor maintenance for the rest of the Foothills Trail.

Duke Energy maintained access areas along the Foothills Trail comprise of four trailheads with vehicular access including Bad Creek Hydro, Laurel Valley, Chimneytop Gap, and Sassafras Mountain; and four trailheads with boat-in or hike-in access only including Laurel Fork Falls, Toxaway River, Canebrake, and Horsepasture River. See the Recreational Resources Final Study Report in Appendix D for more details on Duke Energy maintained access areas. See Figure E.13-1 for a map identifying the locations of the Duke Energy maintained trail segment and recreational access areas.

[31] Duke Energy holds a 200-ft wide (100-ft from center line) lease for the main portion of the trail, 4 spur trails, and Sassafras Mountain, Chimney Top Gap, and Laurel Valley Access Areas.

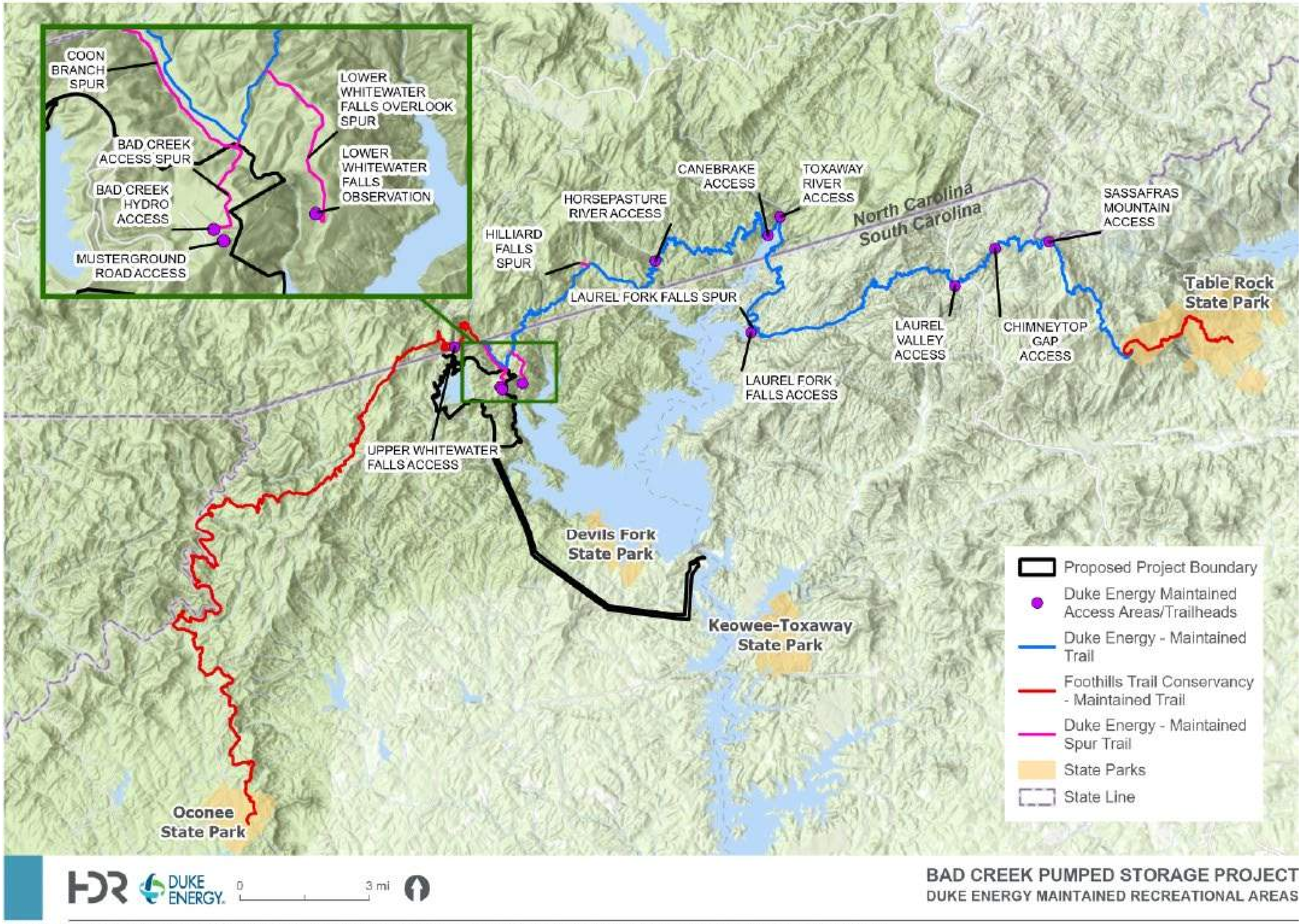


Figure E.13-1. Recreational Facilities and Opportunities

E.13.1.1.2 Non-Project Recreation Facilities and Opportunities

The Project is surrounded by public non-Project recreation facilities and opportunities including the Whitewater River, Lake Jocassee, Jocassee Gorges, Devils Fork State Park, Keowee-Toxaway State Park, and Sumter National Forest, among others, providing a wide range of recreational activities. The majority of the surrounding land is managed by SCDNR as either owned, leased, or conserved areas[32]. Figure E.13-2 provides a map of the surrounding public non-Project recreational opportunities.

The Whitewater River flows from its headwaters in North Carolina into Lake Jocassee at the Whitewater Cove. The "Base of Upper Falls to Lake Jocassee" is a 3-mile whitewater segment adjacent to the Project Boundary that attracts whitewater enthusiasts. American Whitewater rates the difficulty of this whitewater segment between II-V+ with an average gradient of 440 ft per mile. Within the 3 miles there are only two short stretches usable for rafting while the rest is unsafe for rafting or flatwater use (American Whitewater 2019). The Whitewater River also provides desirable trout fishing, although anglers must hike the Foothills Trail to reach the deep pools and runs. The river is managed and stocked by the SCDNR as a wild-trout stream, and wild and stocked rainbow and brown trout are abundant (On the Fly South n.d.).

Jocassee Gorges is largely managed by the SCDNR and is approximately 43,000 acres of forested hills and mountainous terrain with numerous streams and waterfalls. This vast landscape was protected in part by the SCDNR, Duke Energy, and the Richard King Mellon Foundation (assisted by the Conservation Fund). Duke Energy previously owned all of the Jocassee Gorges tract and has since retained only the land required for current and future Project operations (i.e., these lands are now under conservation easement to the SCDNR[33]).

Jocassee Gorges natural area offers recreational opportunities for hunting, fishing, bird watching, hiking and camping. Within the Jocassee Gorges, there are populations of black bears, white-tailed deer, wild turkeys, raccoons and feral hogs which attract hunters to the area. Anglers are drawn to the trout streams and reservoirs for trout, largemouth and smallmouth bass, and sunfish (SCDNR n.d.).

[32] SCDNR "owned" land indicates that they own the property(s). "Leased" land typically falls within the WMA program and indicates SCDNR leases it from another property owner. "Conservation easements" are properties that SCDNR holds and can be on owned, leased or neither. The management terms can vary on conservation easements.

[33] Duke Energy's land conservation efforts in the 1990's resulted in selling approximately 47,000 acres to state/federal agencies for permanent protection (the land was later divided up into Gorges State Park, Nantahala National Forest, Toxaway Game Land, Jocassee Gorges, and Sumter National Forest).

Devils Fork State Park is the only developed public access on Lake Jocassee and is operated by SCPRT. Development of the park is a result of the Original KT License. Devils Fork encompasses 622 acres and includes two hiking/walking trails (the Oconee Bell Trail and the Bear Cove Trail), along with public lake access. A second access to Lake Jocassee is the Double Springs Campground (also a fulfillment of a license requirement under the KT Project), which has 25 boat-in primitive tent pads, two primitive restrooms, and one composting toilet (Duke Energy 2021d)[34].

Keowee-Toxaway State Park consists of 1,000 acres donated by Duke Energy in 1970 to the South Carolina State Parks. The State Park provides a half-mile trail to Lake Keowee where anglers can enjoy freshwater fishing for bass, bream, crappie and catfish. Other hiking opportunities include Raven Rock Hiking trail which is a little over four miles and Natural Bridge Nature Trail, a half-mile loop. There is also a canoe/kayak access for non-motorized boat access to Lake Keowee. Swimming is also permitted. Several geocaches are located throughout the park (SC Parks 2021). In 2018, new amenities were constructed including camping facilities, fishing pier, picnic shelters, restrooms, and an event center.

Sumter National Forest borders the Project to the west and is part of the Andrew Pickens Ranger District. This district encompasses over 80,000 acres providing recreational opportunities such as hiking, canoeing/kayaking/whitewater, horseback riding, autumn leaf viewing, fishing and hunting (U.S. Forest Service [USFS] n.d.).

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34 Note that these amenities were included in the 2021 KT Project RMP under “proposed enhancements”, however, they have since been completed.

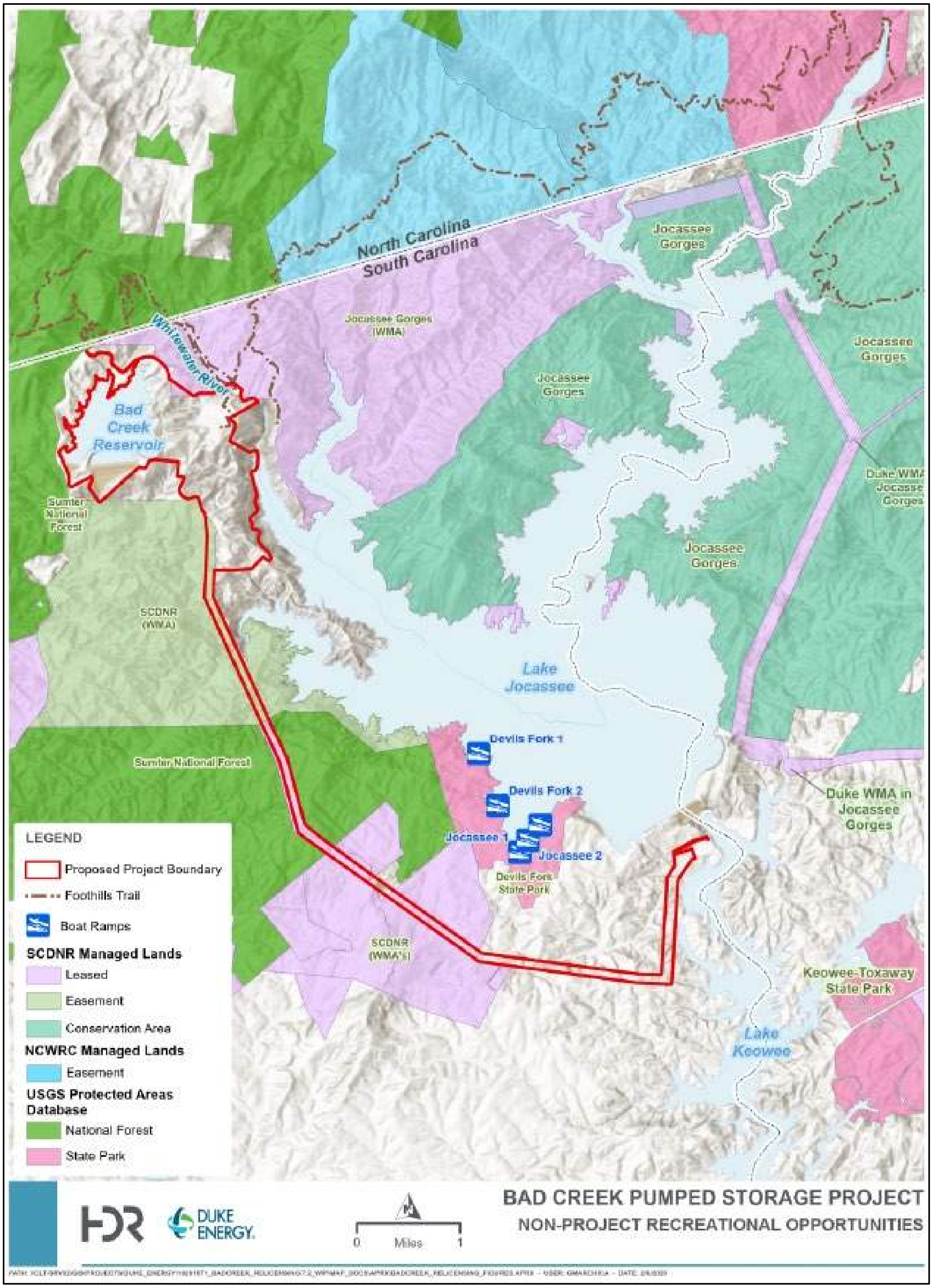

Figure E.13-2. Non-Project Recreation near the Project

E.13.1.2 Specially Designated Recreation Areas in the Vicinity of the Project

E.13.1.2.1 Wild, Scenic, and Recreation Rivers

There are no Wild, Scenic, and Recreational designated waterways within the Project Boundary or the Project vicinity. Waters within the Project Boundary or the Project vicinity are not protected under the S.C. Scenic Rivers Program administered by the SCDNR.

E.13.1.2.2 Nationwide Rivers Inventory

There are no Nationwide Rivers Inventory designated waterways within the Project Boundary. The closest Nationwide Rivers Inventory waterway is the Whitewater River from its confluence with Silver Run Creek in North Carolina to the South Carolina State line.

E.13.1.2.3 Scenic Byways

There are no scenic byways within the Project Boundary. West of the Project in Sumter National Forest is the Oscar Wigington Scenic Byway, a two-lane road with overlooks, easy access to waterfalls, and hiking trails. Wigington Overlook provides a view of Lake Jocassee and the surrounding Blue Ridge Mountains (SCPRT 2021).

E.13.1.2.4 National Trails System and Wilderness Areas

Other than the previously discussed Foothills Trail, there are no National Recreation Trails or Wilderness Areas within or adjacent to the Project Boundary or Project vicinity. The Foothills Trail is not under study for inclusion.

E.13.1.2.5 Regionally or Nationally Important Recreation Areas

There are no regionally or nationally important recreation areas, other than the opportunities discussed previously in Section E.13.

E.13.1.3 Recreation Needs Identified in SCORP

The 2019 State Comprehensive Outdoor Recreation Plan (SCORP) is South Carolina’s five-year recreation plan serving as a guide for federal, state, and local government and private sector entities involved with recreation planning or development. The SCORP also considers current residents and out of state visitors, provides an inventory of recreational amenities, analyzes future demand, and develops a program to address needs or issues arising during the development of the SCORP (SCPRT 2019).

The 2019 SCORP estimates South Carolina has nearly 1.7 million acres of public recreational land and over half is managed by federal agencies. Local governments account for approximately 40,000 acres of recreation access (or 3 percent). The most common type of facilities in South Carolina are baseball/softball fields, playgrounds, tennis courts, picnic shelters and basketball courts, while the least common are water parks, skate parks, and archery ranges. South Carolina has almost 4,000 miles of trails and established greenways/blueways, managed by a variety of stakeholders (federal, state, local, private, not-for-profit). Hiking and walking trails are the most common type of trail available and mountain biking and all-terrain vehicle single use trails are the least common.

As part of the research of the 2019 SCORP, two online surveys were distributed and nearly all (98 percent) respondents indicated they had visited a local or state park or recreation area in the past year. The most popular outdoor activity was hiking (70 percent), followed by walking (67 percent) and camping (59 percent). The most popular water-related activity was canoeing/kayaking (37 percent). Respondents rated the outdoor recreation facilities as very good (50 percent).

The 2019 SCORP concluded maintaining existing facilities and demand for new facilities should be the top two priorities of the state. The 2019 goals of the SCORP are to:

1) Improve access to public recreation areas;
2) Promote stewardship of resources;
3) Ensure sustainable economic benefits; and
4) Adapt to changes in recreation demand.

E.13.1.1 Existing Visual Opportunities

There are numerous opportunities to enjoy nature and scenery in the immediate vicinity of the Project such as hiking, camping, fishing, hunting, scenic and wildlife viewing, and boating. Duke Energy has played a significant role in protecting large amounts of nearby public recreational and conservation lands that enhance the scenery of the area.

Excluding the Project primary transmission line, the Project is not generally visible from any state highway - it is only visible from the Bad Creek access road. The existing lower reservoir I/O structure in the Whitewater River cove of Lake Jocassee, a portion of the existing transmission yard, and the primary transmission line are the only Project structures visible to the public from Lake Jocassee.

E.13.1.2 Non-Recreational Land Use and Management

Duke Energy is not aware of non-recreational land use and management of lands owned or under easement within the Project Boundary.

E.13.1.3 Existing Shoreline Buffer Zones

There are currently no dedicated shoreline buffer zones within the Project Boundary.

E.13.1.4 Licensee's Shoreline Permitting Policies

There is no public access to the Bad Creek Reservoir shoreline, and thus no shoreline permitting policies at the Project. Under the KT Project License, Lake Jocassee is subject to the KT Shoreline Management Plan and is managed by Duke Energy to protect and enhance the scenic, recreational, and other environmental values of the KT Project. Non-Project use as defined by the SMP includes private docks, shoreline stabilization and public recreational access, but does not allow for marina facilities[35]. The SMP is a comprehensive management tool for managing requests for shoreline development activities within the existing FERC Project Boundary in a manner consistent with KT Project purposes. The SMP includes shoreline classification maps, lake use restrictions for each classification, and management guidelines for construction, stabilization, excavation, and vegetation management (Duke Energy 2014b).

The Lake Jocassee shoreline adjacent to the proposed Project Boundary is classified Public Infrastructure, Project Operations, and Environmental. The Environmental shoreline classification area is located at the confluence with Whitewater River and is protected to provide spawning, rearing, and nursery habitat for fish and habitat for amphibians, reptiles, and birds. No vegetation removal, construction, excavation, or shoreline stabilization is permitted within the Environmental shoreline classification area.

E.13.2 Environmental Analysis

E.13.2.1 Studies in Support of the Current Relicensing

In support of the current relicensing, Duke Energy conducted a Recreational Resources Study and a Visual Resources Study in 2023 and 2024. A summary of the methods and results of the Recreational Resources Study and Visual Resources Study are provided in this section and final study reports are

35 No marina facilities, except those multi-slip facilities associated with license-required KT Project Access Areas (e.g., Devils Fork State Park) are allowed on Lake Jocassee.

provided in Appendix D. The draft Recreational Management Plan and draft Visual Resource Management Plan are provided in Appendix E.

E.13.2.1.1 Recreational Resources Study

Goals and objectives of the Recreational Resources Study were met through four study tasks described below:

(1) **Recreation Use and Needs (RUN) Study:** The goals of the RUN Study are to assess current recreation use and identify any future recreation needs along the 43-mile-long segment of the Foothills Trail and associated access areas that are maintained by Duke Energy and referenced in the existing Recreation Plan for the Project.[36] Information collected during the RUN Study will be used to develop an updated RMP for the new license term and will support characterization of existing recreational use levels for areas that could be temporarily impacted by Bad Creek II construction. See *the Foothills Trail Corridor RUN Study Final Report* in Appendix D for additional information.

(2) **Foothills Trail Conditions Assessment:** The goal of the Foothills Trail Conditions Assessment is to evaluate the current condition of trail surface and corridor included in the 43-mile segment of the Foothills Trail maintained by Duke Energy and identify key areas of future maintenance needs or improvements. Data collected during the Foothills Trail RUN Study and Foothills Trail Conditions Assessment were used to estimate the Foothills Trail's hiking and backpacking carrying capacity. See *the Foothills Trail Corridor Conditions Assessment Final Report* in Appendix D for additional information.

(3) **Whitewater River Cove Existing Recreational Use Evaluation**: The goal of the Whitewater River Cove Existing Recreational Use Evaluation is to characterize recreation use in Whitewater River cove and inform Duke Energy of the level of boating use disruption that could occur associated with Bad Creek II construction. See the *Whitewater River Cove Existing Recreational Use Evaluation Final Report* in Appendix D for additional information.

(4) **Recreational Public Safety Evaluation:** The goal of the Recreational Public Safety Evaluation is to evaluate potential public safety risks, specifically those associated with recreation activities at or near Whitewater River cove, that may be created or exacerbated by

[36] Duke Energy filed a copy of the 1980 document, "A Plan for Development and Management of the Foothills Trail and a Supplement to the Bad Creek Pumped Storage Project #2740 Exhibit R," with the Commission on July 25, 2022, in response to additional information requested by FERC staff.

Bad Creek II during the construction and operation phases. See the *Whitewater River Cove Public Recreational Safety Evaluation Final Report* in Appendix D for additional information.

Recreation Use and Needs (RUN) Study (Task 1)

Task 1 Methods

A variety of data collection methods were employed to characterize current recreational use and determine future needs at the access areas on the Foothills Trail (Table E.13-1). Data collection methods included completion of a recreation site inventory, deployment of traffic and trail counters at access areas, collection of in-person user surveys, and collection of online user surveys accessed via QR code at ten access areas. Overall, data collection occurred between March 1, 2023, and May 10, 2024, although the timing of each collection method varied. Data were used to evaluate parking demand analysis, trail carrying capacity, future recreation use, and future recreation needs.

Table E.13-1. Summary of Data Collection Methods by Location

Locations	Data Collection Methods				
	Recreation Site Inventory	Traffic Counts	Trail Counts	In-Person User Survey	Online User Survey
Table Rock State Park			X		
Long Ridge Trail[1]			X		
Sassafras Mountain Access	X	X	X		X
Chimneytop Gap Access	X		X		X
Laurel Valley Access[2]	X	X	X	X	X
Laurel Fork Falls Access	X		X		X
Toxaway River Access	X		X	X	X
Canebrake Access	X		X		X
Horsepasture River Access	X		X	X	X
Lower Whitewater Falls Overlook	X		X		X
Bad Creek Hydro Access	X	X	X	X	X
Coon Branch Spur Trail			X		X
Musterground Road Access		X			
Upper Whitewater Falls Access		X			

[1] The trail counter at Long Ridge Trail was added after FERC issued the SPD following discussions with stakeholders and was therefore not included in the RSP.
[2] Spot counts were collected at Laurel Valley Access to support traffic counts.

Task 1 Results

Current Use Estimates

Duke Energy-Maintained Access Areas

Trail counter data were used to estimate use of the Foothills Trail at the eight Duke Energy-maintained access areas and at the Lower Whitewater Falls Overlook and Coon Branch Spur. Trail counter data were also collected just before the eastern terminus of the Foothills Trail within Table Rock State Park and between Table Rock State Park and Sassafras Mountain at Long Ridge Trail. The total and average daily number of visitors at these points along the Foothills Trail are included in Table E.13-2 and Table E.13-3, respectively.

Locations that received the highest use during the study period were Table Rock State Park (65,788 total visitors with an average of 239 visitors per day), Sassafras Mountain west of the observation tower (26,140 total visitors with an average of 95 visitors per day), and Bad Creek Hydro (9,223 total visitors with an average of 67 visitors per day).

Locations that received the least amount of use during the study period were Laurel Fork Falls (2,522 total visitors or an average of 9 visitors per day) and Canebrake Access (2,702 total visitors or an average of 10 visitors per day).

Overall, use was generally higher at the boat-in access areas during late spring and summer and lower in the fall. This coincides with typical boating patterns in the region. Use at areas with close access to large viewsheds, such as Sassafras Mountain, Bad Creek Hydro, Coon Branch and Lower Whitewater Falls, tended to increase in the fall, coinciding with the peak leaf season.

Table E.13-2. 2023 Use Estimates – Foothills Trail from Bad Creek Hydro Access to Table Rock State Park – Total Visitors by Month

Month	Total Visitors at Trail Counter Locations by Month												
	Bad Creek Hydro	Coon Branch Spur	Lower Whitewater Falls	Horsepasture River	Canebrake	Toxaway River	Laurel Fork Falls	Laurel Valley	Chimneytop Gap	Sassafras Mountain 1[a]	Sassafras Mountain 2[a]	Long Ridge Trail[b]	Table Rock State Park
March	1,605	358	384	192	259	297	279	531	776	1,815	708	-	6,711
April	2,155	988	341	397	508	939	288	872	592	1,966	771	218	6,876
May	1,896	891	369	520	338	781	273	590	425	1,357	525	430	6,637
June	2,372	845	291	369	213	907	201	418	329	4,023	503	344	8,063
July	2,018	692	253	590	374	1,074	340	286	246	1,112	356	186	9,359
Aug	1,842	579	178	395	115	744	254	221	215	1,297	187	171	6,031
Sept	1,965	677	311	310	217	705	333	401	222	1,080	418	424	7,017
Oct	2,385	945	481	77	411	772	329	667	741	6,134	1,024	836	8,812
Nov	1,606	943	430	90	267	254	227	521	518	7,356	815	445	6,284
Total	**9,223**	**6,916**	**3,035**	**2,939**	**2,702**	**6,473**	**2,522**	**4,507**	**4,064**	**26,140**	**5,307**	**3,054**	**65,788**

[a] The trail counter identified as "Sassafras Mountain 1" was located on the Foothills Trail approximately 200 ft west of the observation tower; the trail counter identified as "Sassafras Mountain 2" was located southeast of the observation tower where the parking area meets the Foothills Trail.
[b] The trail counter at Long Ridge Trail was not installed until April 20, 2023.

Table E.13-3. 2023 Use Estimates – Foothills Trail from Bad Creek Hydro Access to Table Rock State Park – Average Daily Visitors by Month

Month	Total Visitors at Trail Counter Locations by Month												
	Bad Creek Hydro	Coon Branch Spur	Lower Whitewater Falls	Horsepasture River	Canebrake	Toxaway River	Laurel Fork Falls	Laurel Valley	Chimneytop Gap	Sassafras Mountain 1[a]	Sassafras Mountain 2[a]	Long Ridge Trail[b]	Table Rock State Park
March	70	28	12	8	12	13	9	23	25	59	23	-	216
April	72	33	11	13	17	31	10	29	20	66	26	22	229
May	61	29	12	17	11	25	9	19	14	44	17	14	214
June	79	28	10	12	7	30	7	14	11	134	17	11	269
July	65	22	8	19	12	35	11	9	8	36	11	6	302
Aug	59	19	6	13	4	24	8	7	7	42	6	6	195
Sept	65	23	10	10	7	23	11	13	7	36	14	14	234
Oct	77	30	16	2	13	25	11	22	24	198	33	27	284
Nov	54	31	14	3	9	8	8	17	17	245	27	15	209
Total	**67**	**27**	**11**	**11**	**10**	**24**	**9**	**17**	**15**	**95**	**19**	**14**	**239**

[a] The trail counter identified as "Sassafras Mountain 1" was located on the Foothills Trail approximately 200 ft west of the observation tower; the trail counter identified as "Sassafras Mountain 2" was located southeast of the observation tower where the parking area meets the Foothills Trail.
[b] The trail counter at Long Ridge Trail was not installed until April 20, 2023.

Musterground Road

Access to the Musterground property of Jocassee Gorges is available seasonally between September 15 - January 15 and again between March 20 - May 10. During this time, the gate at the entrance to Musterground Road is open to vehicular traffic. Various hunting seasons coincide with public access to Musterground Road. A traffic counter was installed and collected data from September 15, 2023, through January 15, 2024, and from March 20 through May 10, 2024. Data are summarized as total vehicles and average daily vehicles in Table E.13-4.

Table E.13-4. Musterground Road – Total and Average Daily Vehicles by Month, 2023-2024

Timeframe	Total Vehicles	Average Daily Vehicles
September 15-30, 2023	187	12
October 1-31, 2023	410	13
November 1-30, 2023	399	13
December 1-31, 2023	307	10
January 1-15, 2024	148	10
March 20-31, 2024	151	13
April 1-30, 2024	312	10
May 1-10, 2024	62	7
Total	**1,976**	**-**

Use at Musterground Road peaks during the last week of bear season (October 24 - 30) and the last week of deer season (December 26 - January 1). Use is also high during the first 10 days after Musterground Road is opened (September 15 - 24), the first week of bear season (October 17 - 23), the week that includes Thanksgiving (November 21 - 27) and generally throughout the month of November, and the end of March through mid-April (March 20 - April 4).

User Survey Summaries

User surveys were conducted in-person at Bad Creek Hydro, Horsepasture River, Laurel Valley, and Toxaway River between March and November 2023. An online version of the survey was also available for access between March and November 2023. During the study period, 315 surveys were collected (Table E.13-5).

Table E.13-5. Foothills Trail User Surveys Collected in 2023

Site	Number of Surveys
Bad Creek Hydro	96
Horsepasture River	32
Laurel Valley	72
Toxaway River	54
Online	61
Total	**315**

User Demographics

Survey respondents were asked to report on the country, state, and county in which they reside. All survey respondents indicated they lived in the USA, except for one who reported living in Brazil. Of the respondents living in the USA, 60.6 percent reported South Carolina as their home state, with North Carolina (16.5 percent), Georgia (6.1 percent) and Florida (4.5 percent) also commonly reported. The most common counties survey respondents reported living in include Greenville, (23.6 percent), Pickens (10.5 percent), Oconee (10.5 percent), and Anderson (6.2 percent) counties, South Carolina.

Survey respondents were asked to report their age within a specific range, how many people were in their group, and the age ranges of those in their group. The most common group size was two people except at Laurel Valley, where the group size was most commonly one person. The average group size as reported by interview site was 2.7 people at Bad Creek Hydro, 1.9 people at Horsepasture River, 2.3 people at Laurel Valley, 3.6 people at Toxaway River, and 3.7 people from online survey respondents. Age ranges of survey respondents by interview site are presented in Table E.13-6. Overall, survey respondents were more likely to be in the 55+ range, except those interviewed at Horsepasture River and Toxaway River, where they were more likely to be in the 45-54 range or 35-44 range, respectively. Less than 10 percent of groups included children or youth, and slightly under 50 percent included seniors (Table E.13-7).

Table E.13-6. Age Ranges of Survey Respondents

Age Range	Bad Creek Hydro	Horsepasture River	Laurel Valley	Toxaway River	Online Survey	Total
18-24	6%	3%	6%	6%	7%	6%
25-34	17%	22%	13%	11%	10%	14%
35-44	17%	16%	24%	35%	21%	22%
45-54	20%	31%	28%	31%	21%	25%
55+	41%	28%	31%	17%	41%	33%

Table E.13-7. Reported Age Ranges Included in Groups

Age Range	Bad Creek Hydro	Horsepasture River	Laurel Valley	Toxaway River	Online Survey	Total
Children (infants – 12)	10%	0%	7%	9%	13%	9%
Youth (13-17)	4%	3%	1%	7%	13%	6%
Adults (18-55)	72%	91%	78%	91%	75%	79%
Senior Adults (over 55)	47%	44%	35%	30%	53%	42%

User Visitation and Access

Respondents were also asked how many times, including the day of their interview, they had visited the Foothills Trail in the previous 30 days. More than half (52 percent) of in-person survey respondents reported that this was their only visit, 38 percent reported 2-4 total visits, and 3 percent reported 11-

33 visits in the previous 30 days. For the online survey, 48 percent of respondents reported one visit, 41 percent reported 2-4 visits, and 2 percent reported 20 visits in the previous 30 days.

Survey respondents were asked if they had a vehicle parked at one of the following access areas, and if so, which one: Sassafras Mountain, Chimneytop Gap, Laurel Valley, Bad Creek Hydro, or Upper Whitewater Falls. Where interview sites included parking areas, specifically Bad Creek Hydro and Laurel Valley, survey respondents most often indicated they were parked at that site (96 percent and 72 percent, respectively). Where interview sites didn't include parking areas, specifically Horsepasture River and Toxaway River, survey respondents were varied in the parking area they reported. 13 percent and 15 percent of survey respondents at Horsepasture River and Toxaway River, respectively, indicated they had a vehicle parked at Bad Creek Hydro. However, visitors at Horsepasture River and Toxaway River indicated they had a vehicle parked at a location other than one of the five listed most often (47 percent and 67 percent, respectively). The most common other parking areas used by survey respondents were Table Rock State Park, Devils Fork State Park, and Oconee State Park, although several others were also noted.

User Activities and Experiences

Survey respondents were asked to report their primary reasons for visiting the Foothills Trail on the day of their interview. Most respondents indicated that a primary reason for visiting the Foothills Trail was for hiking (72 percent) or backpacking (35 percent). Other popular primary activities were camping, wildlife viewing, picnicking, swimming, and shoreline relaxation. Some respondents noted other reasons for visiting besides the ones listed in the survey. These include photography, boating and Jet-skiing, trail running, ATV use, drone use, and sightseeing/waterfall viewing.

Survey respondents were also asked to rate their current experience on the Foothills Trail. Across all surveys, most respondents indicated their experience was very good (85 percent) or good (13 percent). Across all surveys, only 4 were collected where respondents rated their experience as poor (1 percent) or very poor (less than 1 percent). When rating their experience as poor or very poor, survey respondents were asked to explain why. Reasons provided were for poor signage and open hazards/pits.

Survey respondents were also asked to rate the quality of various facilities and other aspects of the Foothills Trail. Most survey respondents were favorable when rating the facilities they utilized on the Foothills Trail. Responses regarding restroom quality were varied with 6 percent of survey respondents across all surveys indicating restrooms were of poor quality. Few survey respondents rated the quality of fishing areas, although most noted they were of very good quality. Nearly all survey respondents noted the cleanliness of the trail was very good (80 percent) or good (15 percent). During in-person surveys, respondents most often noted crowding on the trail was very low and during online surveys, respondents noted crowding was low.

At the end of the survey, respondents were provided an opportunity to list any specific improvements they recommended for the Foothills Trail and/or associated access areas and provide any additional comments or suggestions if so desired. A complete list of responses available in the *Foothills Trail Corridor RUN Study Final Report* in Appendix D. Common suggested improvements include better markers/signs at Bad Creek Hydro Access, removal of downed trees, improved and/or repaired bridges, better trail maintenance, additional and/or improved restrooms, and additional and/or improved bear cables.

Parking Demand Analysis

Parking Occupancy

Average daily vehicles, parking capacity, and turnover were used to estimate each access area's parking occupancy rate. Traffic counter data collected at Bad Creek Hydro Access, Laurel Valley Access[37], Sassafras Mountain Access, and Upper Whitewater Falls Access were used to estimate average daily vehicles at each site's parking area. Based on the data collected during the study, the calculated occupancy rates for Bad Creek Hydro, Laurel Valley, Sassafras Mountain, and Upper Whitewater Falls are shown in Table E.13-8 by month and in Table E.13-9 by day type.

Table E.13-8. Parking Occupancy Rates by Month

Month	Parking Occupancy Rate (%)			
	Bad Creek Hydro	Laurel Valley	Sassafras Mountain	Upper Whitewater Falls
March	5%	65%	36%	16%
April	7%	72%	38%	22%
May	5%	63%	34%	24%
June	5%	64%	38%	19%
July	3%	67%	46%	29%
August	3%	52%	33%	26%
September	5%	79%	46%	27%
October	7%	106%	93%	44%
November	6%	79%	45%	21%

Table E.13-9. Parking Occupancy Rates by Day Type

Month	Parking Occupancy Rate (%)			
	Bad Creek Hydro	Laurel Valley	Sassafras Mountain	Upper Whitewater Falls
Weekday	3%	46%	31%	20%
Weekend	10%	133%	80%	38%
Holiday	8%	139%	73%	43%

[37] Spot count data was also used qualitatively to inform parking demand at Laurel Valley Access.

Parking Demand by Access Area

To assess parking demand, many factors were considered including average daily vehicles and parking occupancy rates, access area use types, access area locations, and user feedback on parking facilities. Parking demand for Bad Creek Hydro Access, Laurel Valley Access, Sassafras Mountain Access, and Upper Whitewater Falls Access is discussed below.

Bad Creek Hydro Access

Although the Bad Creek Hydro Access trailhead is a hub for vehicular use, due to its size and parking capacity, parking occupancy rates are low over all months and day types. Survey respondents did not indicate that additional or improved parking was needed or that crowding at the site was issue. The parking area easily accommodates existing use levels.

Laurel Valley Access

Throughout the year, the parking occupancy rate was moderate with available parking between 60-70 percent occupied, except during October when parking occupancy was high (106 percent). Weekday occupancy was also moderate (46 percent) however weekend and holiday occupancies were very high (133 percent and 139 percent, respectively). Although these parking occupancy rates are conservative, based on the estimated parking capacity of 20 vehicles and an average length of stay of 7 hours, the Laurel Valley Access parking area is highly used and doesn’t always accommodate existing use levels.

Sassafras Mountain Access

Parking occupancy rates at Sassafras Mountain Access are conservative, based on the estimated parking capacity of 37 vehicles, and the average length of stay of 7 hours, which may be a high estimate. Parking occupancy rates during October (93 percent) were higher than other months of the year, indicating the parking area may not always accommodate existing use levels during this month.

Upper Whitewater Falls Access

While not many survey respondents noted they were parked at Upper Whitewater Falls Access, those that did indicated the parking lot was very good and crowding was low to moderate. While the area received high average daily vehicles, parking occupancy rates over all months and day types at the access area were low due to the high parking capacity. Slight elevations occurred in October (44 percent) and on holiday weekends (43 percent), however the parking area easily accommodates existing use levels.

During construction of Bad Creek II, the Bad Creek Hydro Access trailhead and parking area could be closed to the public. Upper Whitewater Falls Access is the closest public vehicular access to the Bad Creek Hydro Access (approximately 2.3 miles between accesses) and is likely to experience increased use during the construction period. Based on the parking occupancy rates for both Bad Creek Hydro Access and Upper Whitewater Falls, Upper Whitewater Falls should be able to accommodate all use from Bad Creek Hydro Access during the construction period. However, Upper Whitewater Falls is a day use site and may not accommodate overnight parking.

Trail Carrying Capacity Assessment

Applied Trails Research assessed carrying capacity of the Duke Energy-maintained Foothills Trail and associated campsites using data collected during this study, and supplemental information collected while on-site in November 2023. The assessment is documented in the *Foothills Trail Corridor RUN Study Final Report* in Appendix D and summarized below.

Resource Conditions

While trail conditions on the Foothills Trail vary, much of the trail utilizes old road corridors which do not provide a long-term sustainable tread surface or a desirable experience for many trail users. In addition, some portions of trail that do not utilize historic road infrastructure have very steep segments with many wooden steps. Wooden staircases are used on steep slopes where earthen trail has eroded or is not feasible to support users. Many segments of trail have better alignments (contour aligned) but suffer from half-bench construction utilizing wooden cribbing wall that is rotting rapidly contributing to long-term maintenance needs and sustainability issues. The significant amount of wooden infrastructure requires time consuming maintenance, and increased use could require more frequent maintenance; replacement with rock or other durable materials and reroutes to avoid the need for such infrastructure are recommended. As of 2023, use levels documented by the RUN study and current trail conditions across the Duke Energy managed portion of the Foothills trail are aligned with low-use backcountry trail experiences and conditions. Trail degradation due to use is minimal and appropriate for the setting. The trail could be modified for long term sustainability such as realigning the trail to avoid steep wooden steps and shorter wooden staircases over gullies. Redevelopment to full bench trail construction at these locations will reduce the long-term maintenance needs, by eliminating the wooden structures which rot rapidly.

Camping activities are often responsible for damage to vegetation, soil, water, and wildlife, however, resource impacts can be minimized by limiting pioneering activities and instead constraining camping activities to designated or pre-established locations. The Duke Energy section of the Foothills Trail has a developed system of campsites, which are signed and include facilities such as bear cables, cisterns, metal fire rings, and developed tent pads. There is not significant expansion of developed sites, proliferation of user-created campsites, or unacceptable levels of other resource impacts, suggesting that in the context of camping related resource impacts, the current use levels on the Foothills Trail are below the carrying capacity.

Day Use and Overnight Use Capacities

Campsites are well distributed along the trail with 29 locations along a 40-mile section. The average distance between campsite locations is 1.52 miles and the maximum distance between campsite locations is 4.4 miles. Each average campsite capacity is 4-5 tents or 8-16 backpackers. Considering the available campsites, the total capacity across all campsites in the trail segment is over 350 backpackers. At the time of assessment, the campsite system provides ample capacity for overnight backpacking use and resource impacts due to campsite enlargement, human waste, trash/litter or fire related impacts are not a concern.

The overnight use estimates for 2023 indicate that an average of 17.8 overnight users per night are on the Duke Energy managed portion of the Foothills Trail. The maximum use estimated to occur over one night is 71 overnight users. These numbers are well below the campsite capacity, however continued monitoring of use and impacts at campsites along the trail is encouraged.

Day use capacity is assessed by examining parking occupancy and related parking demand, as discussed previously in this section, and considering visitor feedback collected during user surveys. As noted previously, parking capacity appears to be an issue only at Laurel Valley Access, specifically during the fall season and on weekends and holidays. High to moderate crowding was reported on rare occasion (1.3 percent and 8.4 percent, respectively) by survey respondents at all interview sites typically during the months of October and November. However, survey respondents most often noted that crowding was not a concern.

Future Use Estimates

The state and county data collected during the study indicates most visitors to the Foothills Trail reside within six counties in South Carolina (Greenville, Pickens, Oconee, Anderson, Spartanburg, and Charleston counties) and four counties in North Carolina (Mecklenburg, Jackson, Buncombe, and Wake counties). Therefore, population projections from those counties plus Transylvania County, North Carolina were used to estimate future use of the trail over the next 10-15 years. Based on projections, populations are expected to increase in the six South Carolina counties by approximately 13.1 percent by 2035 and in the five North Carolina counties by approximately 28.5 percent by 2040 and 42.6 percent by 2050.

Future Needs Analysis

Future recreation needs on the Duke Energy-maintained portion of the Foothills Trail can be assessed in part by comparing the current use estimates and parking occupancy rates determined for 2023 to the projected growth rate of the 11 South Carolina and North Carolina counties analyzed for Future Use Estimates. Assuming trail use would increase at the same rate as population growth, future use would be approximately 16.8 percent higher by 2035 than it was in 2023. This increase in demand is not expected to affect the ability of most access areas to accommodate use. However, considering this increase and the closure of Bad Creek Hydro Access during Bad Creek II construction, access areas providing vehicular access to the trail may experience temporary crowding or inability to accommodate demand. Specifically, Laurel Valley Access, which already experiences high use, may not have adequate parking capacity to accommodate higher frequencies of increased use. However, additional parking opportunities near Laurel Valley Access include Chimneytop Gap Access, Sassafras Mountain Access, and Table Rock State Park. Survey respondents did not indicate that crowding on the trail was an issue or concern at this time, however depending on their desired recreation experience, some dissatisfaction may occur in the future. In addition, increased use of the trail corridor may require the need for additional or more frequent maintenance of the trail's wooden infrastructure and tread. Gradual replacement of existing infrastructure with more sustainable materials (e.g., pressure treated lumber or naturally decay-resistant wood) should be considered.

Task 1 Conclusions

Characterization of Current Use

Trail counters were used to record the number of visitors that utilized a specific access area, trailhead, or trail segment. Locations that received the highest use during the study period were the Foothills Trail trailhead at Table Rock State Park (65,788 total visitors with an average of 239 visitors per day), Sassafras Mountain west of the observation tower (26,140 total visitors with an average of 95 visitors per day), Bad Creek Hydro (9,223 total visitors with an average of 67 visitors per day), and Toxaway River (6,473 total visitors with an average of 24 visitors per day). Locations that received the least amount of use during the study period were Canebrake Access (2,702 total visitors or an average of 10 visitors per day) and Laurel Fork Falls (2,522 total visitors with an average of 9 visitors per day). The portion of the trail in the vicinity of Bad Creek Hydro Access, Coon Branch Spur, and the Upper and Lower Whitewater Falls, as well as Horsepasture River Access, Toxaway River Access, and Sassafras Mountain Access are highly utilized activity hubs. Other access areas, including Canebrake, Chimneytop Gap, Laurel Fork Falls, and associated trail segments provide greater potential for solitude and wilderness experiences.

Parking areas at Bad Creek Hydro, Laurel Valley, Sassafras Mountain, and Upper Whitewater Falls experience high use throughout the year, particularly on weekends and holidays and during the fall season. Some areas (i.e., Bad Creek Hydro and Upper Whitewater Falls) are better equipped to handle this use, while others (i.e., Laurel Valley) experience periods of crowding. The campsite system dispersed throughout the Duke Energy-maintained portion of trail provides ample capacity for overnight backpacking use, and resource impacts due to campsite enlargement, human waste, trash/litter or fire related impacts are not a concern.

Hiking and backpacking were the most popular activities on the Foothills Trail, although other activities including camping, picnicking, swimming, and shoreline relaxation were also popular in available areas. Survey respondents were typically pleased with their hiking experience and their overall experience on the Foothills Trail and generally rated the quality of the facilities available on the trail as good or very good. Respondents also typically noted the trail was clean and not crowded.

Characterization of Future Use

Population growth in surrounding counties is recognized as a primary contributing factor in future use of local recreation facilities. Based on projected population growth in the 11 counties in which most survey respondents live, recreation use is likely to increase by 16.8 percent. This may strain some areas in their ability to accommodate use and may affect user satisfaction of their desired recreation experience. Trail conditions may deteriorate at a faster rate due to increased use, requiring the need for modified trail infrastructure and/or increased maintenance.

Considerations Related to Bad Creek II Construction

In addition to current and future use of the Duke Energy-maintained portion of Foothills Trail and associated access areas, this study examined potential impacts to recreation around the Bad Creek II construction area. During construction, public access to Musterground Road would be closed for approximately seven years, resulting in a temporary impact to recreation in the area. While recreation opportunities in the Musterground area would still be available to the public via foot or boat access, vehicular access would be restricted, resulting in a sharp decline in public use. During construction, Bad Creek Hydro Access trailhead and parking area would also be closed for the construction duration. This access area is a popular location to access the Foothills Trail and several spur trails and sightseeing destinations in the vicinity. Other access areas nearby, such as Upper Whitewater Falls Access, would be available to offset use and provide vehicular access to the area, although overnight parking may need to be pursued in other areas of the trail.

The 77-mile Foothills Trail provides a distinctive trail experience in the Upstate of South Carolina and the Mountains of North Carolina that ties together a bevy of unique recreational experiences, significant natural resources, and one-of-a-kind viewscapes and has become integral to the region. Duke Energy, along with the FTC and many other partners, are essential to the continued care and protection of the trail.

Foothills Trail Conditions Assessment (Task 2)

Task 2 Methods

Duke Energy subcontracted Long Cane Trails to perform a trail conditions assessment involving analyzing sections of trail and determining its maintenance needs. Long Cane Trails divided the 43-mile segment of the Foothills Trail maintained by Duke Energy into six sections using the Foothills Trail Guidebook (Foothills Trail Conservancy 2018) as a reference for location descriptions. All 43 miles of the main trail corridor as well as spur trails were assessed for trail tread, out slope, backslope, drainage, constructed structures (not including engineered bridges) and corridor condition. Trail standards from the Trail Solutions guide (Felton 2004) on building singletrack was used as a base for trail condition analysis. Constructed structures (such as stairs, hand railings, bridges, etc.) were identified and recorded and location tracked geospatially. Structures in need of significant maintenance or replacement were recorded in detail with photo documentation. Similarly, trail condition and corridor features requiring maintenance or repair as well as areas of significant erosion, areas with significant drainage issues (i.e., standing water), or obstructed areas along the trail (i.e., downed trees), and notable occurrences of litter and vandalism were recorded and tracked geospatially.

Task 2 Results and Conclusions

During the Trail Conditions Assessment, Long Cane Trails identified 89 issues within the study area primarily related to trail maintenance and safety. Specifically, 75 issues were identified on the Foothills Trail, seven on the Bad Creek Access Spur, four on Coon Branch, and three on the Lower Whitewater Falls Spur. Issues identified include culvert cleaning, erosion control, steps replacement, signage improvement, bridge maintenance, fallen tree removal, and trail washout repair. Table E.13-10 describes the key findings identified by Long Cane Trails for the Foothills Trail and spur trails. Detailed results and photographs are included in the *Foothills Trail Corridor Conditions Assessment Final Report* in Appendix D.

Table E.13-10. Key Findings of Foothills Trail Conditions Assessment

Trail	Mile	Key Findings
Bad Creek Access Spur	0.1-0.7	• Culvert Maintenance: A culvert with a clogged drain spanning 80 ft requires cleaning to allow proper water flow. • Wet Areas: Low areas on the trail with standing water need gravel addition to raise and level the path, covering 60 ft and 30 ft sections. • Erosion Control: Removal of barricades placed on the side of the trail to address water retention issues. • Steps Replacement: Several steps need replacement due to rot. • Interpretive Signage: Approximately 100 ft of trail has been rerouted, and new blazes are needed to guide hikers.
Coon Branch Spur	0.2	• Bridge Maintenance: Railing and decking replacement for a bridge, involving handrails and decking boards. • Railing Replacement: Two handrails need replacement.
Coon Branch Spur	0.4	• Bog Bridge Installation: Installation of a bog bridge measuring 4 ft x 2 ft. • Drain Clearing: Major drain unclogging is required to prevent overflow onto the trail.
Foothills Trail	31.6-72.8	• Erosion Control: Multiple sections of the Foothills Trail require erosion control measures such as grade reversals, knicks, or drainage improvements. • Steps Replacement: Various steps along the trail need replacement or repair due to damage. • Fallen Trees: Several fallen trees across the trail need removal. • Bog Bridges: Installation of new bog bridges. • Signage: Adding new trail blazes and interpretive signage. • Brush Removal: Clearing overgrown sections of the trail. • Washout Repair: Addressing trail washouts and water diversion. • New Trail Sections: Creating new trail segments to address erosion and trail conditions.
Lower Whitewater Falls Spur	0.4-1.0	• Washout and Erosion: Trail washouts, the need for stairs, and grade dips have been identified, impacting a significant portion of this spur.

Whitewater River Cove Existing Recreational Use Evaluation (Task 3)

Task 3 Methods

Duke Energy deployed a drone over the Whitewater River cove of Lake Jocassee to capture aerial images of recreation use to determine the number, type, and location of boats within the study area. Drone flights occurred on 20 individual days scheduled between Memorial Day weekend and Labor Day weekend to evaluate use. Drone flights were conducted on a mix of weekdays, weekends, and holidays and imagery was collected every hour generally between 9:00 AM and 4:00 PM, as weather allowed. Data were extrapolated to draw conclusions related to the rate and patterns of recreational use in Whitewater River cove of Lake Jocassee and used to quantify the impacts of temporary closures in Whitewater River cove related to the proposed construction of Bad Creek II.

Task 3 Results

During the study period, the majority of boats in Whitewater River cove were motorboats (83 percent), followed by personal watercraft (10 percent), kayaks (7 percent), and canoes (less than 1 percent). The highest use occurred on weekends and holidays, where an average of 32 boats entered the cove per weekend day, and an average of 29 boats entered the cove per holiday day. The highest use occurred in the month of July, where an average of 30 boats entered the cove per day.

Aerial imagery was analyzed to estimate the duration of time boats were in Whitewater River cove by documenting the first time a particular boat appeared in the cove and the last time the same boat was observed in the cove. Approximately 90 percent of boats spent less than one hour in the cove, approximately 9 percent spent between one and two hours in the cove, and approximately 1 percent spent more than two hours in the cove. The cove is known to be a sightseeing attraction due to the waterfalls located at the mouth of the Whitewater River. Data suggest that a majority of visitors spent a minimal amount of time in the cove, likely boating to the waterfall and then leaving shortly thereafter. It can be assumed that boaters who spent more than 1 hour in the cove were likely there for other activities, such as fishing.

Year-round use in the Whitewater River cove was estimated by extrapolating data collected during the 20 survey days in the peak recreation season. Average use per day during the survey months was extrapolated to determine total estimated use for the entire survey period. Approximately 3,647 boats are estimated to have entered the Whitewater River cove between April and October 2023. Assuming off-season use is 3 percent of peak season use, it is estimated that 3,756 boats entered the Whitewater River cove during 2023.

Based on population projections in Oconee County, if construction of Bad Creek II were to begin in 2030, closure of the Whitewater River cove could displace between approximately 19,895 and 27,852 boats during the construction period (approximately 7 years). It can be assumed that most of these boats would be motorboats and most displaced visitors would be sightseers.

Task 3 Conclusions

The Whitewater River Cove Existing Recreational Use Evaluation found that the Whitewater River cove is primarily visited by recreators in motorboats. While the entire cove is used by boaters, boats tend to follow the eastern shoreline of the cove and congregate in the north end near the waterfall. It is assumed that most visitors to the cove are there to view the waterfall, although anglers are also common visitors.

Projected annual use in 2030 at Lake Jocassee is estimated to be 343,266 recreation days[38] (Duke Energy 2013). Based on the results of the drone surveys, it is estimated that between 19,895 and

[38] FERC defines a recreation day as a visit by a person to a project development for recreational purposes during any portion of a 24-hour period.

27,852 boats could be displaced from visiting the Whitewater River cove during the Bad Creek II construction period, or nearly 4,000 boats per year. Each year during construction, between 1-2 percent of recreation days could be lost (displaced) at Lake Jocassee in the Whitewater River cove due to Bad Creek II construction and temporary closure of the Whitewater River cove.

Recreational Public Safety Evaluation (Task 4)

Task 4 Methods

To evaluate recreational public safety in the Whitewater River cove following Bad Creek II construction and during Bad Creek II operations, boater information gathered during the Whitewater River Cove Existing Recreational Use Evaluation (Task 3, described above) was applied to expected conditions in the cove during and flows during pumping and generation were assessed from a recreational (boating) perspective, as determined by the CFD model. Potential boating safety concerns associated with water surface velocities in the cove during minimum pond and full pond were identified and recommendations for public safety measures are provided.

Task 4 Results

Proposed Public Safety Measures

Boater Use in Whitewater River Cove During Bad Creek II Construction

Boaters will be completely restricted from accessing the Whitewater River cove during Bad Creek II construction due to public safety concerns. Displaced boaters will be able to access the remainder of Lake Jocassee during construction, which includes a multitude of other coves and waterfall viewing opportunities. Duke Energy will work with the SCPRT to post information at Devils Fork State Park kiosks regarding the cove closure and where to access similar recreation opportunities around Lake Jocassee. Information will also be posted to the Duke Energy website[39] regarding the cove closure and other Lake Jocassee boating destinations for fishing and waterfall viewing.

Boater Use in Whitewater River Cove Following Bad Creek II Construction

Following completion of Bad Creek II construction, Duke Energy plans to reopen the Whitewater River cove for public recreational use. However, the proposed additional and modified Project structures (including the additional I/O structure and expanded submerged weir) may impact localized surface velocities in the Whitewater River cove, potentially impacting boater recreation within the cove under certain operational scenarios.

[39] https://www.duke-energy.com/community/lakes/recreation-information.

Table E.13-11 summarizes how water surface velocities are anticipated to change between the existing Project configuration and with the proposed addition of Bad Creek II during pumping and generating operations at various pond elevations. Changes in water surface velocities are localized and do not affect the entire cove; contour velocity maps showing locations and changes in surface velocities under different operations and pond levels are provided in the *Whitewater River Cove Recreational Public Safety Evaluation Final Report*, Appendix D.

Table E.13-11. Existing and Proposed Project Impacts on Maximum Water Surface Velocities at Project Structures

	Maximum Water Surface Velocities (fps) at Project Structures			
Pond Elevations	**Existing I/O Configuration (without Bad Creek II)**	**Proposed I/O Configuration (with Bad Creek II)**	**Existing Submerged Weir**	**Proposed Expanded Submerged Weir**
Pumping Operations				
Full Pond	< 1.0-2.0 fps	1.5 fps	1.0 fps	1.0 fps
Minimum Pond	5.0 fps	10.0 fps	3.5 fps	3.5 fps
Generating Conditions				
Full Pond	2.5 fps	2.5 fps	2.0 fps	2.0 fps
Minimum Pond	4.0 fps	6.5 fps	2.0 fps	4.0 fps

Task 4 Conclusions

The following conclusions can be made based on the information summarized in Table E.13-14.

- When pumping at full pond elevation, the addition of Bad Creek II is not anticipated to cause a significant change in maximum water surface velocities in the Whitewater River cove.
- When pumping at minimum pond elevation, the addition of Bad Creek II is anticipated to cause maximum water surface velocities to double in the area immediately adjacent to the proposed I/O structure when compared to current conditions. However, the proposed expansion of the submerged weir is not anticipated to impact water surface velocities.
- When generating at full pond elevation, the addition of Bad Creek II and the proposed expansion of the submerged weir are not anticipated to impact maximum water surface velocities in the Whitewater River cove; however, slightly modified flow patterns are anticipated near the I/O structures.
- When generating at minimum pond elevation, the addition of Bad Creek II is anticipated to cause maximum water surface velocities to increase by approximately 60 percent (from 4.0 to 6.5 fps) at the lower reservoir I/O structures when compared to current conditions.

- When generating at minimum pond elevation, the proposed expansion of the submerged weir is anticipated to cause maximum water surface velocities to increase (from 2.0 to 4.0 fps) in the immediate vicinity of the weir, with increased velocities continuing to the cove's confluence with the main body of Lake Jocassee.
- Most changes (i.e., increases) in maximum surface velocities due to operational and pond level scenarios would likely go unnoticed for operators of motorboats with the exception of increased (up to 10.0 fps) velocities adjacent to the proposed I/O in the recessed intake alcove during pumping operations at minimum pond.

In general, no significant impacts to water surface flows are anticipated when Lake Jocassee is at full (and intermediate) pond elevations that would impact boating safety in the Whitewater River cove; however, impacts to boating safety could occur if the Project operates at minimum pond elevation. Some localized areas of increased water velocities could result in hazardous boating conditions, particularly for non-motorized boats and inexperienced boaters.

The Whitewater River Cove Existing Recreational Use Evaluation found that over 90 percent of boats in the cove were motorized boats, including personal watercraft, while the remaining boats were non-motorized. Most motorized boats and personal watercraft should not have trouble navigating currents in the cove following Bad Creek II construction when the reservoir is at minimum pond. It is possible that surface currents and resulting eddies in Whitewater River cove could match, or exceed, the ability of a paddler (or non-motorized boat) if the conditions were sustained over a long distance. However, as determined by the CFD model, the location and extent of increased surface velocities in the cove would occur in a small or localized area; therefore, it is likely even beginner paddlers could increase their speed to overcome surface currents and/or change course to avoid the higher current.

It is likely from a recreational boater safety perspective that boats would be able to navigate in Whitewater River cove during operations by keeping to the east side of the cove along the shore opposite the proposed I/O structure since it would be situated approximately 200 ft back from the existing shoreline in a recessed alcove. Closer to the Project and proposed Bad Creek II I/O structure, surface velocities have the potential to increase during pumping (at maximum drawdown) to challenging levels for flatwater paddlers. For this reason, access to boaters should be restricted from the immediate vicinity of the I/O structures.

The Bad Creek Project has operated between full pond and intermediate pond for 100 percent of the time since the Project's creation and has never operated at minimum pond. Current (2016–2020) operations since the KT license issuance, indicate the reservoir has been maintained between maximum and intermediate pond levels nearly 100 percent of the time. Therefore, maximum drawdown scenarios under pumping and generation evaluated by the CFD model provide the most conservative hypothetical conditions and are unlikely to occur.

Further, under minimum pond levels, the northernmost portion of the Whitewater River cove near the Bad Creek II I/O structure would be dewatered and therefore inaccessible for boating, regardless of Bad Creek II operations.

Proposed Public Safety Measures

Although any public safety concerns related to recreational boating in the Whitewater River cove are unlikely to be realized under typical operations, Duke Energy is proposing to implement some public safety measures primarily to educate the public about potential hazards and to restrict public access in the immediate vicinity of the I/O structures.

Duke Energy is proposing to restrict public boating access near the I/O portals however boats would still be able to navigate up and down the eastern side of the cove. Signage will be posted that reads "Warning: Restricted Area, No Trespassing." In addition, signage will be posted on each bank at the confluence of the Whitewater River cove with the main body of Lake Jocassee and signage prohibiting swimming may also be added. Signs that include information on the Bad Creek Project and associated website and that encourage boaters to check Project operation schedules prior to boating in the Whitewater River cove will be posted at the information kiosks at Devils Fork State Park.

E.13.2.1.2 Visual Resources Study

The Visual Resources Study consisted of nine tasks including: (1) Existing Landscape Description, (2) Seen Area Analysis, (3) Field Investigation, (4) Key Views Selection, (5) Existing Visual Quality Assessment, (6) Visual Analysis, (7) Visual Management Consistency Review, (8) Mitigation Assessment, and (9) Conceptual Design of Bad Creek II Complex.

Task 1 Methods

Available information for the study area was reviewed to characterize the existing landscape and develop a baseline description for key scenic characteristics and scenic quality of the landscape within the proposed expanded Project area. The Project area and surrounding lands expected to potentially be within visual range of Bad Creek II facilities were assessed and key elements including landforms and terrain (i.e., slope); water features; vegetative cover type, pattern, height, and distribution; soils; geology; and cultural features (i.e., developed uses and structural modifications of the natural landscape) were identified. Information sources included USGS topographic maps and the Multi-Resolution Land Characteristics Consortium National Land Cover Database; federal, state, and local government planning documents that include information on scenic and visual resource conditions; and photographs and aerial/satellite imagery. While the study area for the Visual Resources Study focuses on the upper reservoir, lower reservoir, primary transmission line alignment, and main (expanded) facility site, the area included in the existing landscape description evaluation encompasses a larger area to provide a description and understanding of the landscape context of the Project area.

Relevant management activities and/or regulation of the scenic resources within the Visual Resources Study area, including vegetation management and Project operations, were also reviewed.

Task 2 Methods

The seen area (viewshed) analysis identified areas within the existing landscape from which elements of the proposed Bad Creek II facilities would potentially be visible. The seen area analysis evaluated the locations for the proposed I/O structures for the upper and lower reservoirs, switchyard, transformer yard, spoil areas, potential temporary access road, and expanded primary transmission line corridor. The seen area analysis was used to identify potential Key Views for field investigation and the visual quality assessment and impact analysis.

The seen area analysis methodology was based on the use of standard Geographic Information System tools for calculating viewsheds based on a digital elevation model and a set of observer points. The model analysis used the observer dataset and a digital elevation model raster dataset to analyze which cells can be seen by the observer and which cannot, typically because a landform feature blocks the sight line.

Task 3 Methods

This task involved a field investigation of the potential Key Views identified during Task 4 as described below. The field work to collect photos included a three-person field crew. The field crew recorded location points for each simulation viewpoint to ensure repeatability and multiple site photographs were collected at each location. For each inventory point, the following information was collected:

- Location (i.e., coordinates);
- Heading of camera view;
- Time; and

- Conditions – atmospheric conditions[40], field notes.

This field investigation was conducted on December 11, 2023, during leaf-off conditions.

Task 4 Methods

The objective of Task 4 was to identify a set of Key Views (up to four) that adequately covers the range of visibility and potential scenic and visual impacts of Bad Creek II. Considerations in selecting specific Key Views included viewing distance to ensure adequate representation of potential foreground, middle ground, and background views of the proposed Bad Creek II features; viewing direction; and the types of viewer groups (residents, recreational users, and motorists) that might experience views of the Project facilities.

Task 5 Methods

This task involved assessing the existing scenic and visual quality at each Key View identified in the Key Views Selection task. The assessment was based on consideration of the standard visual elements (form, line, color, texture, and pattern), the apparent naturalness of the landscape as seen from the specific Key View, and the degree of human modification of the landscape.

Scenic and visual quality were evaluated using concepts from the USFS Scenery Management System (SMS), which includes landscape character descriptions and scenic integrity objectives for USFS landscapes that can be used to help assess the compatibility of a proposed project with the surrounding landscape. The evaluation considered a wide variety of landscape characteristics, such as:

- Slope;
- Vegetative cover type, pattern, height, and distribution;
- Water;
- Color, texture, line;
- Effects of adjacent scenery; and
- Cultural modifications.

Distance zones are used to describe how viewers see the landscape. The SMS identifies four distance zones:

- Immediate foreground (0 to 300 ft);

40 Humidity and windspeed were obtained from Lake Jocassee Station Greer, SC undefined | Weather Underground(wunderground.com). Accessed on February7, 2024.

- Foreground (300 ft to 0.5 mile);
- Middle ground (0.5 mile to 4 miles); and
- Background (4 miles to the horizon).

Task 6 Methods

This task involved specific assessment of the expected scenic and visual impact at each Key View, based on changes in landform and changes to or additional structures, to determine the potential extent of visual contrast introduced by the proposed Bad Creek II, and the expected viewer response to those changes.

Visual simulations of Bad Creek II features were developed and used to provide the basis for the visual analysis, which included assessing the effect of Bad Creek II on landscape character and scenic integrity. In the visual simulation process, a rendered image from a digital three-dimensional model of the proposed project-build scenario was integrated with the existing conditions photography. Using project design and location specific information, a three-dimensional model was built using Autodesk 3DS Max. The model included the topography of the Project area and sufficient perimeter (i.e., buffer) around Bad Creek II features to include, at a minimum, the area between Bad Creek II features and the subject Key Views. All proposed facility components (i.e., Bad Creek II primary transmission line, transformer yard, switchyard, lower reservoir I/O structure, spoil disposal areas, temporary access road, etc.) were also built and simulated in the model. A virtual sun was created in the model with real-world attributes, such as locational data along with date and time, to match the selected photographs, and virtual cameras were also created in the model with the same parameters as the actual Key View photos used to match the perspective of each photograph. Finally, V-Ray rendering engine for 3DS Max was used to produce the rendering of proposed conditions, and Photoshop was used to combine the rendering with the photographs.

These proposed facility elements were then assessed in terms of their level of impact based on setting and viewer characteristics. Contrast was assessed by considering the differences in form, line, color, texture, scale, and landscape juxtaposition between existing conditions and proposed conditions. Considered in terms of the setting, the assessment of impacts was made based on proximity to views—that is, whether the Project element is within the foreground, middle ground, or background in relation to the viewpoint. The visual impact assessment consists of an overlay of Contrast, Landscape Characteristic, and Views to determine whether the alternative is dominant to the characteristic landscape, subordinate to the characteristic landscape, or somewhere in between. Impact results derived for the individual Key Views were aggregated and evaluated to provide an overall assessment of the visual impacts of the proposed Bad Creek II.

Task 7 Methods

This task involved review of the consistency of the proposed Bad Creek II and expanded Project area with visual resource protection guidance established in applicable land use plans and regulations, to the extent that such guidance exists. This task involved review of USFS forest management plans, SCDNR's plan for the management of the Jim Timmerman Natural Resources Area at Jocassee Gorges, Oconee County's Comprehensive Plan, and the KT SMP.

Task 8 Methods

This task involved identification and assessment of potential mitigation measures that would address the scenic and visual effects of Bad Creek II identified during the visual quality assessment and visual management consistency review. Measures that could reduce the contrast created by the proposed Bad Creek II facilities, and thereby reduce the level of scenic and visual impact, were identified. Potential measures were evaluated in terms of their physical feasibility, approximate cost, and effectiveness in reducing contrast and visual impact.

Task 9 Methods

This task assessed, to the extent possible, visual resource conditions relative to site layout, conceptual designs, proposed construction processes, and lighting. A rendering of the conceptual Bad Creek II site layout was produced. In addition, relevant existing management plans and guidance documents related to lighting were evaluated.

Results

The Project is located in the mountainous region of Upstate South Carolina, an area known and marketed as a wilderness recreation destination. This area is part of the Blue Ridge Escarpment, or the "Blue Wall", which is the tectonic divide between the Blue Ridge Mountains and the rolling hills of the Piedmont. This geology has created dramatic ridges, waterfalls, and long views. Lake Jocassee, numerous streams and waterfalls, including the highest waterfall east of the Rockies, hiking trails, fishing opportunities, and scenic roads and overlooks draw people from across the region to this area. Most of the area surrounding the Project site are protected wilderness recreation areas, including Sumter, Nantahala, and Pisgah National Forests, Jocassee Gorges, and Devils Fork State Park. Contiguous mixed pine-hardwood forests cover much of the region, with limited human development visible. The area has very high scenic value as a mountain wilderness and is aesthetically appealing.

The Seen Area Analysis results are shown on Figure 6-14 through Figure 6-25 in the *Visual Resources Study Report*, Appendix D. As shown in these figures, views of Bad Creek II features are greatly affected by the topography of the area. The expanded (i.e., widened) primary transmission line would have the greatest visibility of Bad Creek II features while views of the lower reservoir I/O structure would be restricted to the smallest area.

The Resource Committee selected six potential Key Views (out of the original 11 proposed) for field investigation. During the evaluation of the views, the Resource Committee reviewed the seen area analysis results, accessibility of potential Key Views to the public, and prior visualization work associated with initial project planning.

The Resource Committee elected to use the existing visualization of the lower reservoir intake/outlet area (Key View 3) as viewed from the Whitewater River cove that was developed during initial project planning instead of re-creating it (i.e., duplicating the effort). While this visualization was not done during leaf-off conditions, views of the structure are unobstructed given there is very little vegetation between the structures and the lake. Photos of Key Views and summaries of each Key View under existing conditions and proposed conditions are provided in the *Visual Resources Study Report* in Appendix D.

The Project and its facilities are situated within a landscape of high visual and environmental quality. The Project area provides access to Jocassee Gorges Wildlife Management Area, Lower Whitewater Falls, and an overlook of Lake Jocassee. It is partially visible from surrounding public use areas and properties including the Sumter National Forest, Lower Whitewater Falls Overlook area, the Visitor Overlook off Fisher Knob Road.

Task 7 of the study included a review of applicable resource protection guidance established in applicable land use plans and regulations to determine alignments or conflicts with the proposed landscape interventions. There are no conflicts between current visual management plans and the Project or Bad Creek II.

Duke Energy has designed Bad Creek II to utilize existing Project features to the maximum extent possible to reduce additional impacts to the surrounding lands. This includes using the same upper and lower reservoirs, existing Bad Creek site roadways, and existing ancillary support structures as feasible. The new transmission line will adjoin the existing primary transmission line, so it will be consistent with existing visual effects. Other than some potential upland spoil areas, most Bad Creek II features are located in areas of the site that have previously been developed including some proposed spoil areas.

Conclusion

The Project is in an area of high scenic attractiveness due to the sparsely populated rural nature of the area, surrounding mountainous terrain, the forested landscape, and the proximity of Lake Jocassee. Views of the Project are limited by the steep topography of the area and the heavily vegetated landscape surrounding the site. These conditions would remain in place during and following construction of Bad Creek II and would continue to limit the effect of both the Project and Bad Creek II on visual resources. Views of construction activities would be further limited by restrictions on public access to the construction site as well as the Whitewater River cove in Lake Jocassee.

The scenery will be permanently altered through the addition of Bad Creek II structures although these features will be similar in appearance and adjacent to existing Project structures.

E.13.2.2 Project Impacts on Recreation and Visual Resources

In SD2, FERC identified the following environmental issues related to recreation resources to be addressed in its NEPA document:

- Effects of proposed project construction, operation, and maintenance on recreational use in the project boundary, including access to the existing Foothills Trail.
- Use of project lands for recreation activities, including fly fishing and birdwatching.
- Effects of project construction, operation, and maintenance existing land uses in the project-affected area.
- Effects of land management activities within the project boundary on environmental resources.
- Effects of project construction, operation (including the presence of project facilities), and maintenance activities on visual resources.

Duke Energy has played a role in the protection of a significant amount of public recreational land in the vicinity of the Bad Creek Project. Duke Energy has donated lands for public recreational use and maintains and plans to continue to honor, under the new license term, its commitments to recreation in the vicinity of the Bad Creek Project. Duke Energy expects to continue to maintain the 43-mile segment of the Foothills Trail and eight access areas as non-Project facilities in the new license term.

There are no recreation opportunities immediately within the Project Boundary. The majority of the recreation in the vicinity of the Project consists of water-based activities on Lake Jocassee and use of the Foothills Trail. For the benefit of natural, cultural, and recreation resources, Duke Energy proposes to continue to operate the Project in the existing mode and with the existing protections for restrictions on land and shoreline development in the vicinity of the Project Boundary. Duke Energy has developed a draft RMP that is included in Appendix E.

Since major elements of the Project are not visible to the public except from the access road and Whitewater River arm of Lake Jocassee, Duke Energy expects there to be no temporary or permanent impacts on visual resources from the continued operation of the Project. There is no need to reduce visual impacts due to the continued operation of the Project.

E.13.2.2.1 Effects of Project Construction, Operation, Maintenance on Recreational Use in the Project Boundary

There are no public recreational facilities or opportunities within the Project Boundary; the Licensee-maintained portion of the Foothills Trail would not be affected by construction. With the exception of the Bad Creek Hydro access area and Musterground Road, which will be closed throughout construction (approximately 7 years), impacts to recreation due to construction of Bad Creek II will be limited to water-based recreation in the Whitewater River arm of Lake Jocassee.

Bad Creek II will include an I/O structure on the west bank of the Whitewater River cove of Lake Jocassee upstream from the existing Bad Creek Project I/O structure. During construction activities, recreational activities will be prohibited in Whitewater River cove to protect the public. Recreation at the remainder of Lake Jocassee, including the boat ramps and access areas will not be impacted by construction of Bad Creek II.

During construction, public access to Musterground Road would be closed for approximately 7 years, resulting in a temporary impact to recreation in the area. While recreation opportunities in the Musterground area would still be available to the public via foot or boat access, vehicular access would be restricted, resulting in a sharp decline in public use. During construction, Bad Creek Hydro Access trailhead and parking area would also be closed. This access area is a popular location to access the Foothills Trail and several spur trails and sightseeing destinations in the vicinity. Other access areas nearby, such as Upper Whitewater Falls Access, would be available to offset use and provide vehicular access to the area, although overnight parking may need to be pursued in other areas of the trail.

Operation of Bad Creek II, alone or in combination with operation of the existing Project powerhouse, has the potential to impact surface water velocities in the Whitewater River cove of Lake Jocassee. As discussed in Sections E.8.2.1.3 and E.13.2.1.4, a three-dimensional CFD model was developed to support the evaluation of the effect of the second I/O within the Whitewater River cove. Once Bad

Creek II operations begin, CFD modeling of this area indicates surface velocities may exceed 5 fps in some areas near the Bad Creek II lower I/O structure under Normal Minimum Elevation conditions as a result of the combined operations of the two projects. It is possible that surface currents and resulting eddies in Whitewater River cove could match, or exceed, the ability of a paddler if the conditions were sustained over a long distance. However, as determined by the CFD model, the location and extent of increased surface velocities in the cove would occur in a small or localized area; therefore, it is likely that even beginner paddlers could increase their speed to overcome surface currents and/or change course to avoid the higher current. It is likely from a recreational boater safety perspective that boats would be able to navigate in Whitewater River cove during operations by keeping to the east side of the cove along the shore opposite the proposed I/O structure since it would be situated approximately 200 ft back from the existing shoreline in a recessed alcove. Under minimum pond elevations during pumping operations, surface velocities adjacent to the Bad Creek II I/O structure could reach 10.0 fps, therefore, Duke Energy would implement boater safety measures.

E.13.2.2.2 Use of Project Lands for Recreation Activities

As discussed above, no Project lands are used for public recreation. Duke Energy proposes to continue its maintenance of its portion of the Foothills Trail and access areas for the term of the new license. The Foothills Trail will continue to be available during Bad Creek II construction.

E.13.2.2.3 Effects of Project Construction, Operation, and Maintenance on Existing Land Uses in the Project-Affected Area

No changes to land uses outside the proposed Project Boundary are expected as the result of continued operation of the existing Project or construction, operation, and maintenance of Bad Creek II. Land use in Oconee County must conform to the county-administered Comprehensive Plan (Oconee County 2020).

E.13.2.2.4 Effects of Land Management Activities within the Project Boundary on Environmental Resources

Land management activities within the Project Boundary including the primary transmission line are limited to management of vegetation to maintain the safe and reliable operation of the Project. These effects are considered minimal given these practices have been in place for more than 30 years. The Licensee does not propose changes to its site management practices over the new license term and, therefore, does not anticipate additional effects to environmental resources.

E.13.2.2.5 Effects of Project Construction, Operation, and Maintenance Activities on Visual Resources

The construction of Bad Creek II will include a new powerhouse and associated structures as well as the new I/O structure to Lake Jocassee. Similar to the existing I/O structure, the new I/O structure will be viewable via boat (from the Whitewater River cove). With the construction of the proposed Project expansion, the visual landscape will be altered both during and after construction; however, the impact of this is considered minor as the facility is not readily viewed from public access areas. See Figure E.13-3 for a digital rendering of the Project post-construction.

Short-term visual impacts will occur during construction of Bad Creek II, due to land clearing and grading activities; creation of new upland spoil areas; temporary, localized turbidity impacts in the Whitewater River cove; construction traffic; temporary construction facilities; and the continued presence of heavy construction equipment.

The scenery will be permanently altered through the addition of Bad Creek II structures although these features will be similar in appearance and adjacent to existing Project structures in already disturbed areas. Potential PM&E measures to reduce impacts to visual resources during and after construction of Bad Creek II are described in Section E.13.3 below.

Figure E.13-3. Preliminary Rendering of the Bad Creek Existing Project and Proposed Bad Creek II, following Completion of Construction

E.13.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

The Licensee distributed a draft RMP to stakeholders on February 17, 2025, for review and comment. The draft RMP, developed in consultation with relicensing stakeholders and included in Appendix E, includes measures to provide for public recreation prior to, during, and following Bad Creek II construction.

The Licensee distributed a draft VRMP to stakeholders on February 19, 2025, for review and comment. The draft VRMP, developed in consultation with relicensing stakeholders and included in Appendix E, includes measures to address the visual effects of existing Project facilities as well the visual effects associated with the design, construction, and operation of Bad Creek II.

E.13.3.1 Existing Bad Creek Project

E.13.3.1.1 Recreation Management Plan

A summary of maintenance measures and proposed enhancements that are included in the draft RMP are provided below:

- Foothills Trail Maintenance
    - Duke Energy will continue maintaining the approximately 43-mile-long section of the Foothills Trail it currently maintains.
    - Routine Maintenance: Duke Energy will conduct periodic inspections of the trail corridor on a year-round basis. Duke Energy also proposes to conduct trail maintenance and inspections annually, with most maintenance activities occurring between the months of April and October.
    - Maintain vehicle access points.
    - Duke Energy will address the maintenance needs identified in the Foothills Trail Corridor Conditions Assessment listed in Appendix B of the draft RMP.
- Foothills Trail Enhancements
    - Duke Energy proposes to enhance and/or improve the Foothills Trail segments according to recommendations made during the Foothills Trail Corridor Conditions

Assessment and associated consultation. Trail enhancements include widening existing bridges and adding handrails for safety reasons, installation of new or improved stairs, installation of new bog bridges and other bridges, and the addition of standard signage at access points. A list of the proposed enhancements is in Appendix C of the draft RMP.

- The Licensee will work with the existing landholders of the Foothills Trail to extend the property easement(s) associated with the Duke Energy-maintained portion of the Foothills Trail for a period concurrent with the new license term. The Licensee will extend the easement for the Foothills Trail on property owned in fee by Duke Energy for the term of the new license.

- Pit Privies: Duke Energy is proposing to install ten primitive privies/outhouses at the campgrounds located along the Duke Energy Foothills Trail segment. Duke Energy will conduct a two-year pilot study that includes installing and monitoring two privies in two locations to be determined in consultation with the FTC. Following the conclusion of the pilot study and resulting feasibility assessment, Duke Energy and FTC will determine the locations of the remaining privies in consultation with the applicable landowners and regulatory/resource agencies.

    - If vandalism occurs, Duke Energy will replace the affected privy once; any following vandalism will result in moving the privy to an alternate location to be determined in consultation with FTC, applicable landowners, and regulatory/resource agencies. Installation of the ten privies will be contingent upon approval by applicable landowners and regulatory/resource agencies in South Carolina and North Carolina.

    - If continual vandalism of the privies occurs at any of the ten locations, Duke Energy reserves the right to abandon the privies that have been repeatedly damaged and to not install additional privies.

    - Duke Energy proposes to install the two pilot study privies within one year following FERC approval of the RMP and the remainder of the privies, if needed, within five years following FERC approval of the RMP.

E.13.3.1.2 Additional Recreational PM&E Measures

Additional PM&E measures proposed by the Licensee include:

- Public Information and Signage - The Licensee will improve the public information signage at the kiosk at the main boat ramp at Devils Fork State Park within two years following the date of FERC approval of the RMP.

- Bad Creek Visitor Overlook**:** The existing Bad Creek Visitor Overlook will be closed during Bad Creek II construction. The Licensee will upgrade the Bad Creek Visitors Overlook with new amenities including viewing telescopes, interpretive signage, and a picnic area. New amenities will be provided within five years following FERC approval of the RMP or within one year following construction of Bad Creek II, whichever is later.

E.13.3.1.3 Off-License PM&E Measures

In addition to the measures proposed above, the License is proposing the following off-license measures under the BCRA:

- The Licensee has donated all available trail and traffic counters used in the 2023 RUN Study to the FTC.

- Foothills Trail Interpretative Exhibit - The Licensee will develop an interpretative exhibit for the Foothills Trail at the Bad Creek Visitors Center located in the proposed Hydro West Regional Support Building near Bad Creek. If the planned new Hydro West Regional Support Building is not constructed by December 31, 2030, the Licensee will work with applicable stakeholders to develop the Foothills Trail Interpretative Exhibit at a county park or other identified location in the KT area to be determined in consultation with the signatory Parties to the BCRA. The Licensee will complete the exhibit within two years following completion of the Hydro West Regional Support Building or selecting an alternate exhibit location if the Hydro West Regional Support Building is not constructed.

- The Licensee will construct a storage building on Duke Energy property for use by FTC to store trail maintenance equipment and to provide office/working space for FTC volunteers. The building will have electricity and storage space for vehicles and FTC will have key access to the storage facility. Duke Energy will provide this building to the FTC under a low-cost lease for the term of the new license, provided FTC continues volunteer maintenance support of the Foothills Trail. The Licensee will construct the storage facility within one year following commercial operation of Bad Creek II or within six years following issuance of the new license.

- The Licensee will provide the states of North Carolina and South Carolina, as applicable, the right of first refusal to purchase all or part of Duke Energy's portion of the Foothills Trail should the Project license be terminated. The Licensee will provide rights of first refusal within two years following FERC approval of the RMP.

- The Licensee will continue consulting with the FTC on Foothills Trail expansion (spur lands) on Duke Energy-owned property provided the FTC, SCPRT, Oconee County, Upstate Forever, FOLKS, and Advocates for Quality Development are signatory Parties to the BCRA. The Licensee will provide a map of Duke Energy owned property and coordinate with FTC to develop spur trail(s) on Duke Energy property should mutually agreeable locations be identified in the future.

- Pumped Storage Operations Interpretative/Informative Exhibit – Duke Energy will develop an interpretative/informative exhibit for pumped storage operations at Devils Fork State Park within five years following FERC approval of the RMP, consistent with the BCRA (Exhibit B).

- If the new license is consistent with the BCRA regarding public recreation, the Licensee will provide one-time funding of $1,500,000 to SCDNR for road maintenance on SCDNR's Jocassee Gorges road system. The Licensee will provide the funding within one year following issuance of the new license.

- The Licensee will provide a one-time payment of $500,000 to the Oconee County Conservation Bank[41] within two years following issuance of the new license to support future land conservation efforts in Oconee County.

- The Licensee will offer no-cost leases to SCDNR of the Beaty Tract (557 acres); Smeltzer Tract - North (189.7 ac); Smeltzer Tract – South (120.5 acres) and Jocassee Tract (1,019 acres), a combined total of approximately 1,886 acres shown on Figure E.13-4 to support hunting and wildlife viewing, and recreation opportunities. The leases will extend for the term of new license. Should the Licensee decide in the future to sell these lands, the SCDNR will have right of first refusal.

[41] The Oconee County Conservation Bank protects Oconee County lands with significant natural, cultural, and/or historic resources.

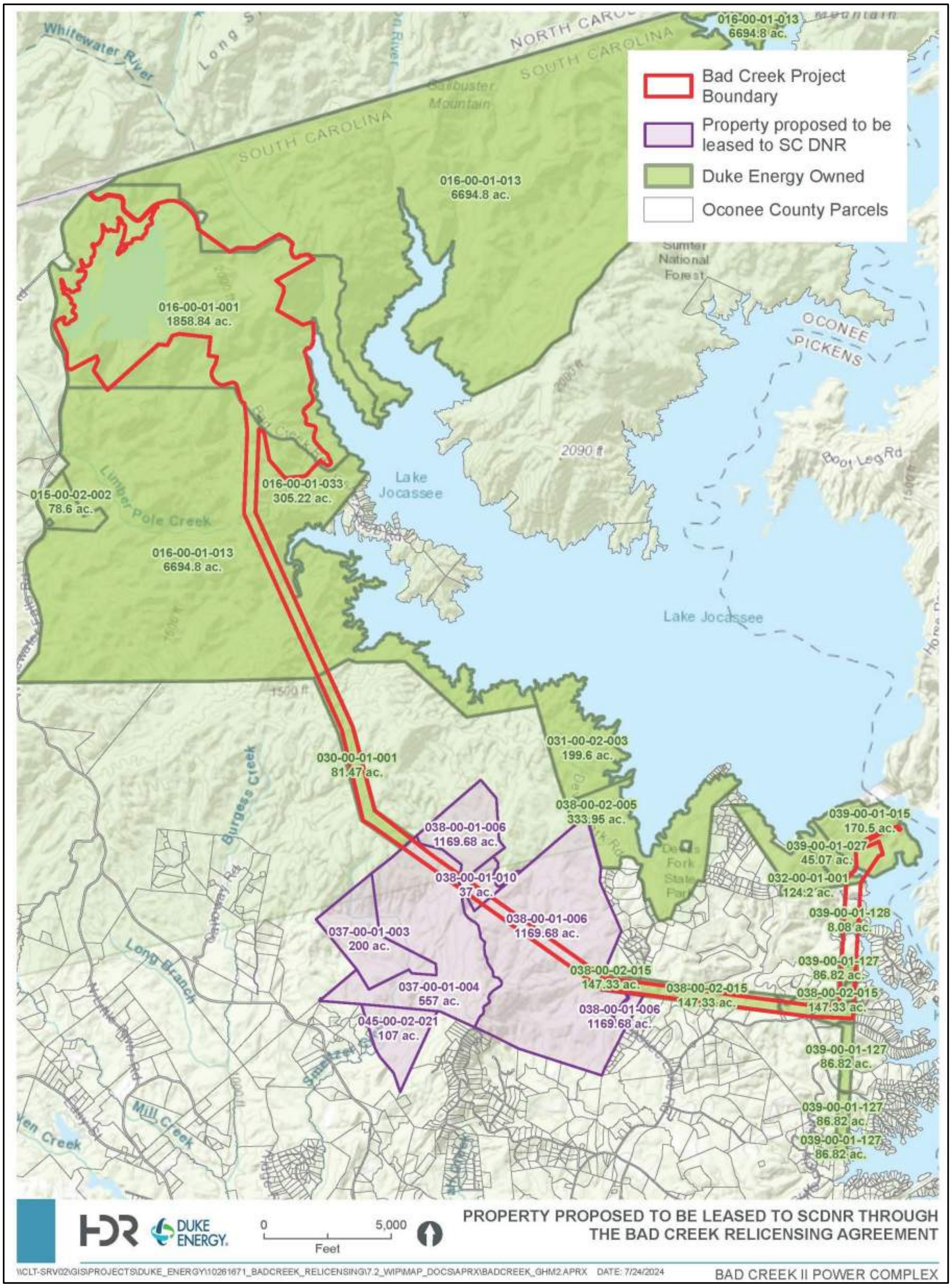

Figure E.13-4. Duke Energy Property to be Leased to SCDNR

E.13.3.1.4 Visual Resources Management Plan

The Licensee proposes to implement the VRMP, included in Appendix E, developed in consultation with the Recreation and Visual Resources Resource Committee. While the overall aesthetic effects associated with the existing Project are limited, PM&E measures to further reduce visual effects were identified in consultation with relicensing stakeholders. These include the following:

- Facility colors and finishes: As Project buildings and exterior structures that are visible from offsite are repainted during the license term, the Licensee will select colors and non-reflective finishes that more closely match background colors. Over time, this will result in a further reduction of visual effects associated with the Project:

- Lighting: As outdoor lighting is maintained or replaced at the Project, the Licensee will use a 5-step evaluation process to eliminate outdoor lighting when possible. When it's not possible to eliminate outdoor lighting, the Licensee will look to reduce the amount of time the light shines, the brightness of the illumination, and the amount of unshielded lighting at the Project. The Licensee will also select outdoor lighting with longer wavelengths (i.e., warmer colors) as opposed to shorter wavelengths.

- Vegetation Management: Vegetation at the Project and surrounding it limits views of Project facilities. The Licensee already restricts Project vegetation management to only areas where it is necessary to provide for energy transmission and safe employee and visitor access to Project facilities. The Licensee proposes to continue these practices with implementation of an Integrated Vegetation Management Plan.

E.13.3.2 Bad Creek II

E.13.3.2.1 Recreation

The following proposed measures address public recreational access at the Project during and following construction of Bad Creek II. These measures provide alternatives that mitigate the effects of eliminating public access to the Bad Creek Spur Trail parking lot, the entrance to Musterground Road, and Whitewater River cove during construction. Measures to address each closure are discussed below.

- Bad Creek Spur Trail Parking Lot**:** As an alternative to the Bad Creek Spur Trail parking lot which will be closed during Bad Creek II construction, the Licensee will provide temporary security monitoring at the existing gravel lot on the trail crossing at Highway 281 located on USFS lands (Figure E.13-5). This security monitoring device will be deployed in the form of a mobile surveillance trailer and is contingent on USFS agreement. The security device will be installed upon the start of Bad Creek II construction and closure of Musterground Road and the Bad Creek spur trail. The security device will be removed once the Bad Creek spur is reopened to the public.

At the conclusion of Bad Creek II construction, the Bad Creek Spur Trail parking lot will be reconfigured. The reconfigured parking lot will be approximately the same size as the existing lot and accommodate the same number or more vehicles.

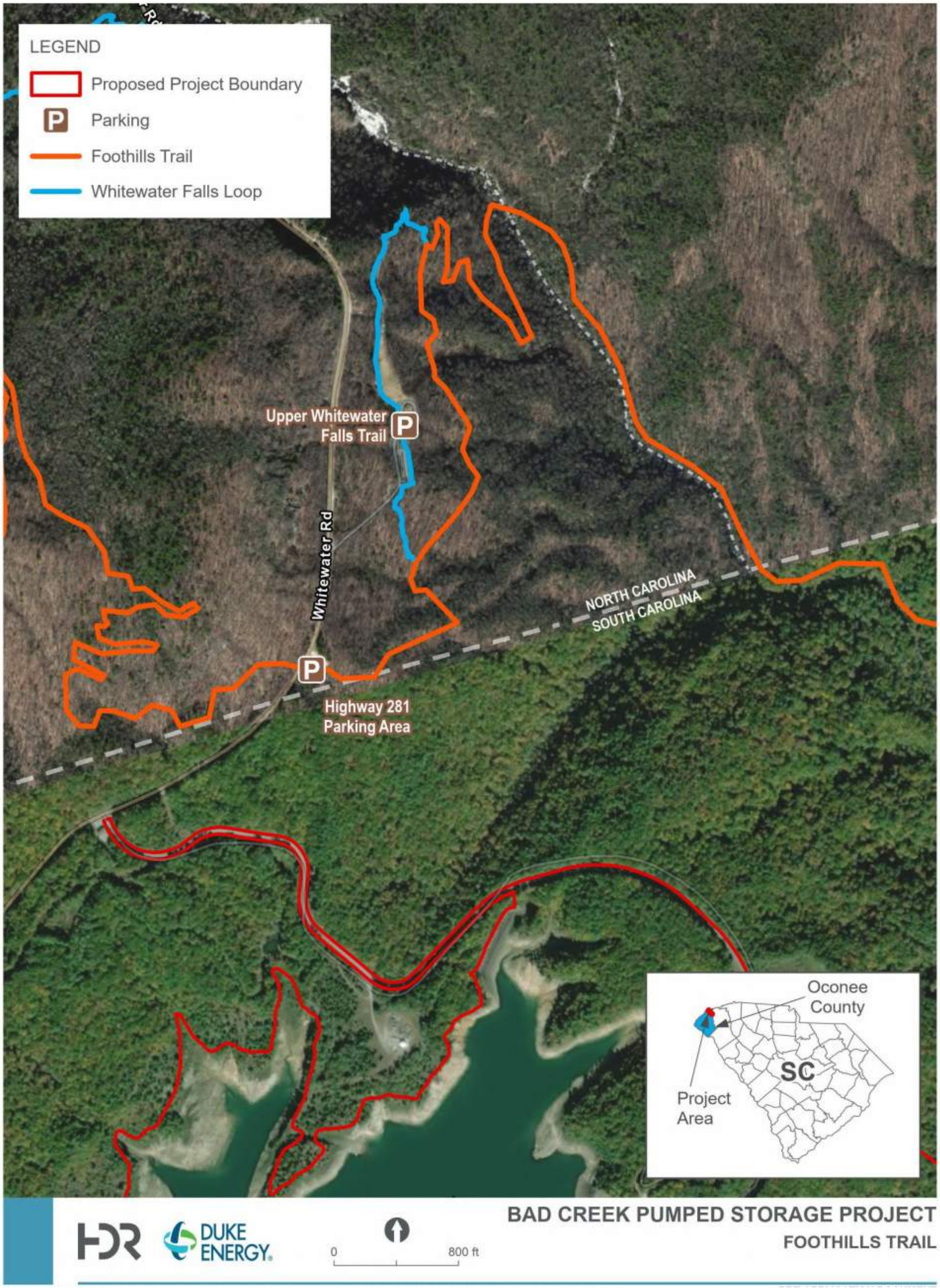

Figure E.13-5. USFS Highway 281 Parking Area

- Musterground Road entrance: During Bad Creek II construction and for safety reasons, the Licensee will block access to the site from Musterground Road and will not allow the public to access Musterground Road from the Project. The Licensee will mitigate for this closure and the access it provides to public hunting lands by improving, maintaining, and providing public access during hunting season the Musterground Wildlife Management Area via Brewer Road (Figure E.13-6). The Licensee will install up to three gates at locations to be determined in consultation with SCDNR and FTC to restrict vehicles from the Foothills Trail and to manage access to Brewer Road. The Licensee will make improvements to Brewer Road to allow public use during the fall of the first or second year of Bad Creek II construction. Brewer Road will be closed to public use when the Musterground Road entrance is reopened.

  During Bad Creek II construction, the Licensee will work collaboratively with FTC to provide limited access to Musterground Road via Bad Creek Road for Foothills Trail maintenance activities and SCDNR to support SCDNR's land management activities in the Jocassee Gorge's property, consistent with the forthcoming Bad Creek Road Traffic Management Plan.

  In conjunction with Bad Creek II, the parking area and entrance to Musterground Road will be reconfigured. The Licensee will replace the existing information kiosk and provide enhanced signage prior to reopening the Musterground Road entrance.

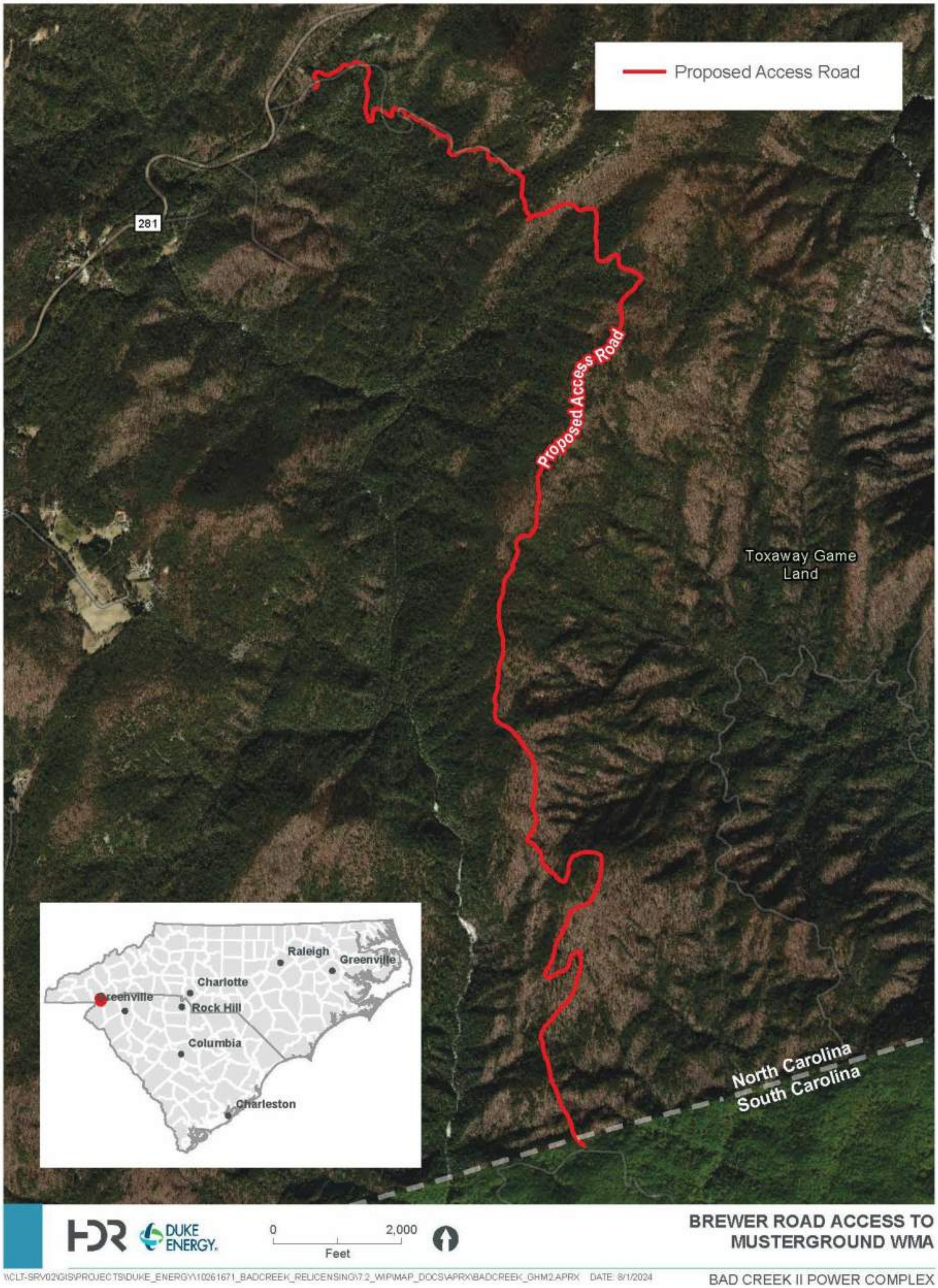

Figure E.13-6. Brewer Road

- Whitewater River cove: During Bad Creek II construction, the Licensee will install a boat barrier preventing public access to the Whitewater River cove of Lake Jocassee (Figure E.13-5). The Licensee will provide notice of the restriction at the information kiosks at Devils Fork State Park[42] within two years following the date of FERC approval of the RMP. Following Bad Creek II construction but prior to commercial operation of Bad Creek II, the Licensee will revise its FERC Public Safety Plan as necessary and install additional public safety measures in Whitewater Cove to educate recreational boaters on potential hazards associated with the addition of Bad Creek II and associated operations.

As mitigation for the loss of public access to Whitewater River cove during Bad Creek II construction, the Licensee will construct a courtesy dock at both the Devils Fork State Park Villa Ramp and the boat-in campground ramp (Figure E.13-8). The courtesy dock at the Villa Ramp will include two boat slips with one slip outfitted with a boat lift designated solely for Oconee County emergency responders use. The Licensee will construct the new courtesy docks within two years (at the boat-in campground ramp) and within four years (at the Villa Ramp) following issuance of the new license and FERC approval as may be required per the KT RMP [43].

[42] Devils Fork State Park is a KT Project FERC License-required public recreation site leased by SCPRT and subject to the KT RMP.

[43] Should this activity require approval under the KT Project FERC license, the Licensee requests FERC issue such approval in conjunction with Project license issuance.

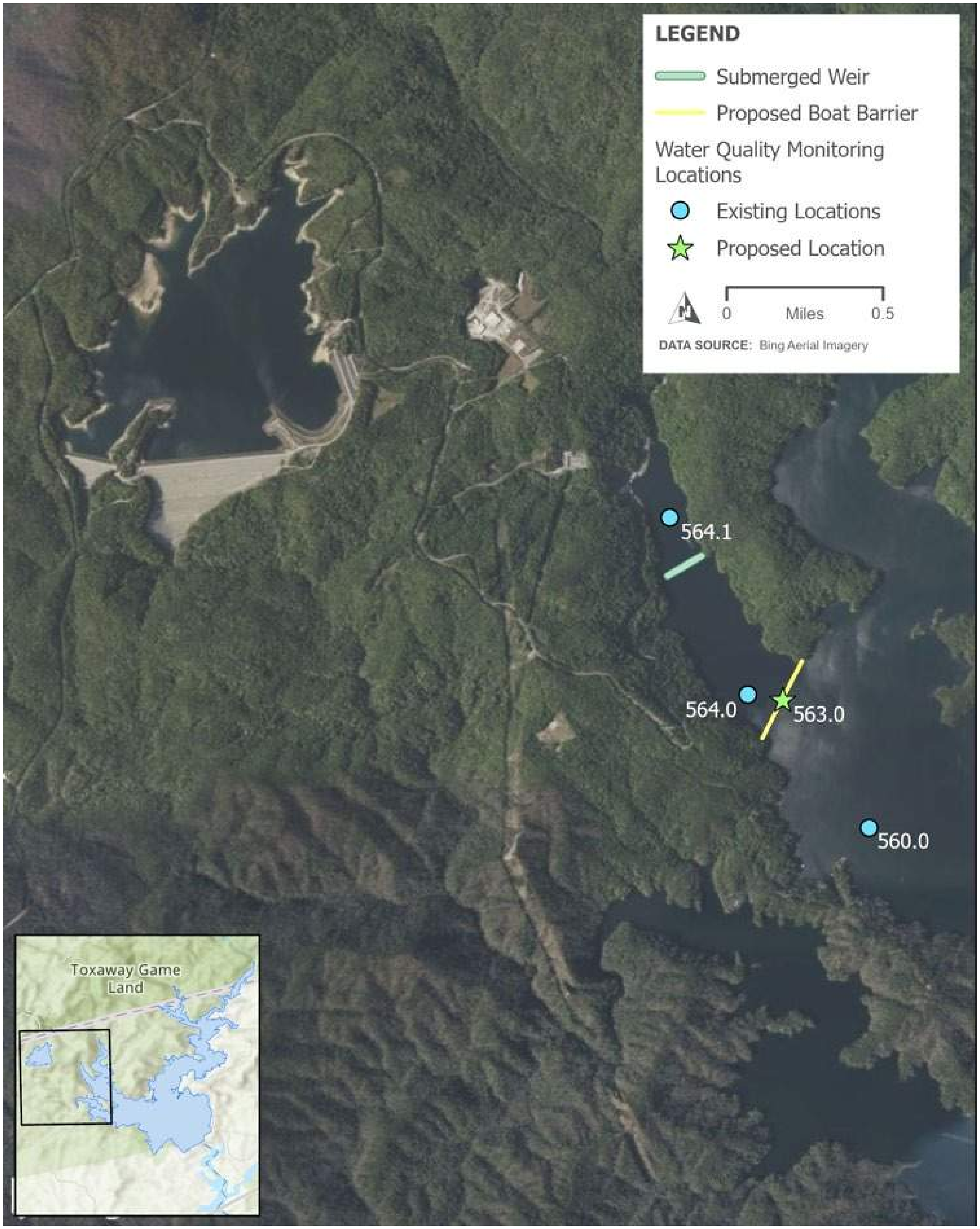

Figure E.13-7. Proposed Whitewater River Cove Boat Barrier to be Installed and Remain in Place for the Duration of Bad Creek II Construction.

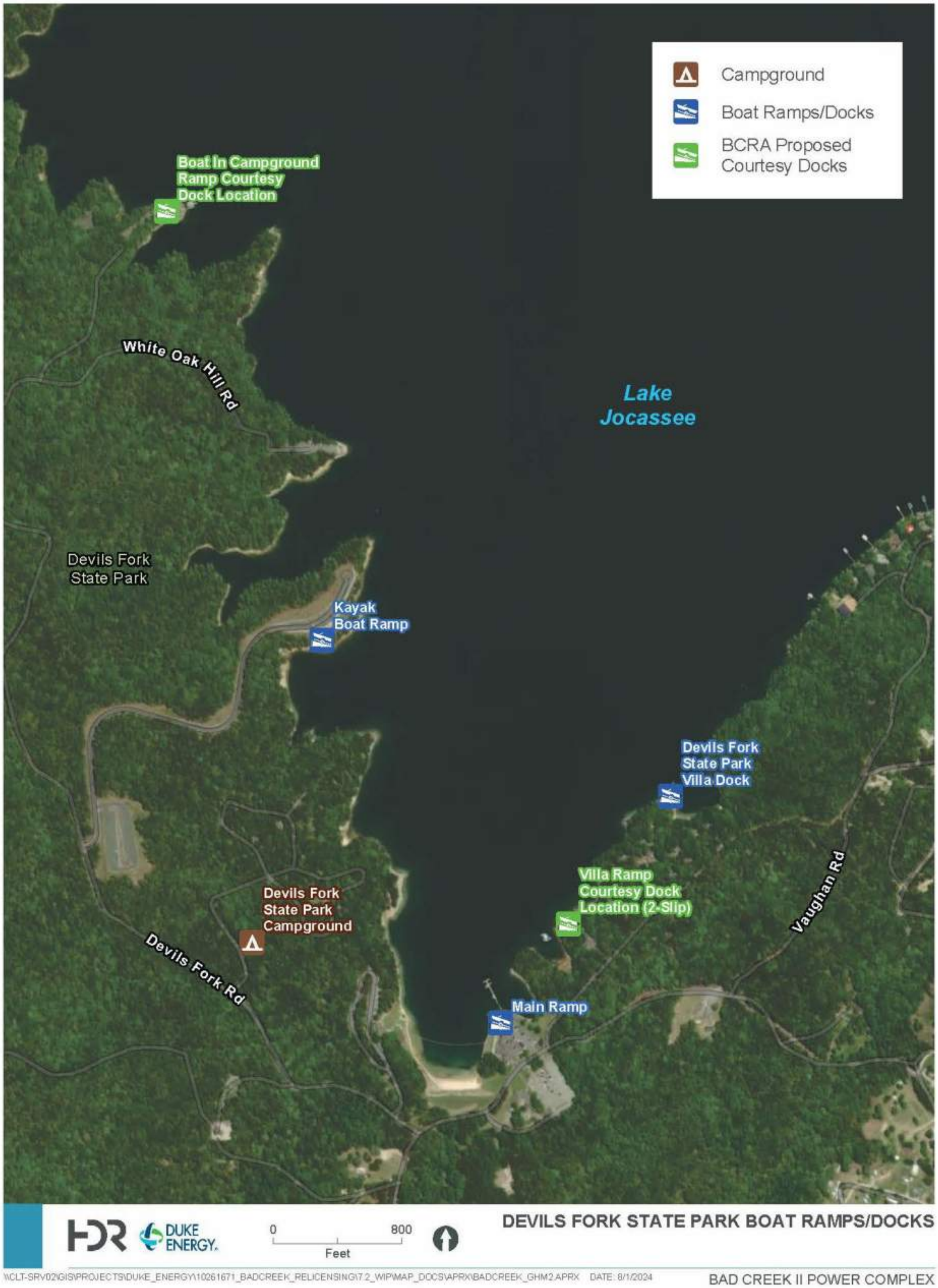

Figure E.13-8. Devils Fork State Park Boat Ramps and Docks

E.13.3.2.2 Off-License PM&E Measures

Under the BCRA, the Licensee is proposing additional off-License recreation and land conservation measures to mitigate for unavoidable effects to public recreation associated with construction activities (i.e., increased construction traffic and public access limitations). While these measures may not have a direct nexus to individual Project effects on recreation and visual resources, they will benefit recreation at and near the Project as well as protection of regional aesthetic resources that could be cumulatively affected by construction activities.

- Game carcass disposal and processing area: The Licensee will construct a game carcass disposal pit on Duke Energy's property in partnership with SCDNR. SCDNR will monitor use of and maintain the facilities as needed. The game carcass disposal pit/area will be signed, fenced, and have a game processing/cleaning station.
- The Licensee will provide a one-time payment of $500,000 to the Oconee County Conservation Bank within one year following commercial operation of Bad Creek II to support future land conservation efforts.
- The Licensee will also extend the existing Laurel Fork Tract lease with SCDNR for the term of the new license (Figure E.13-9).

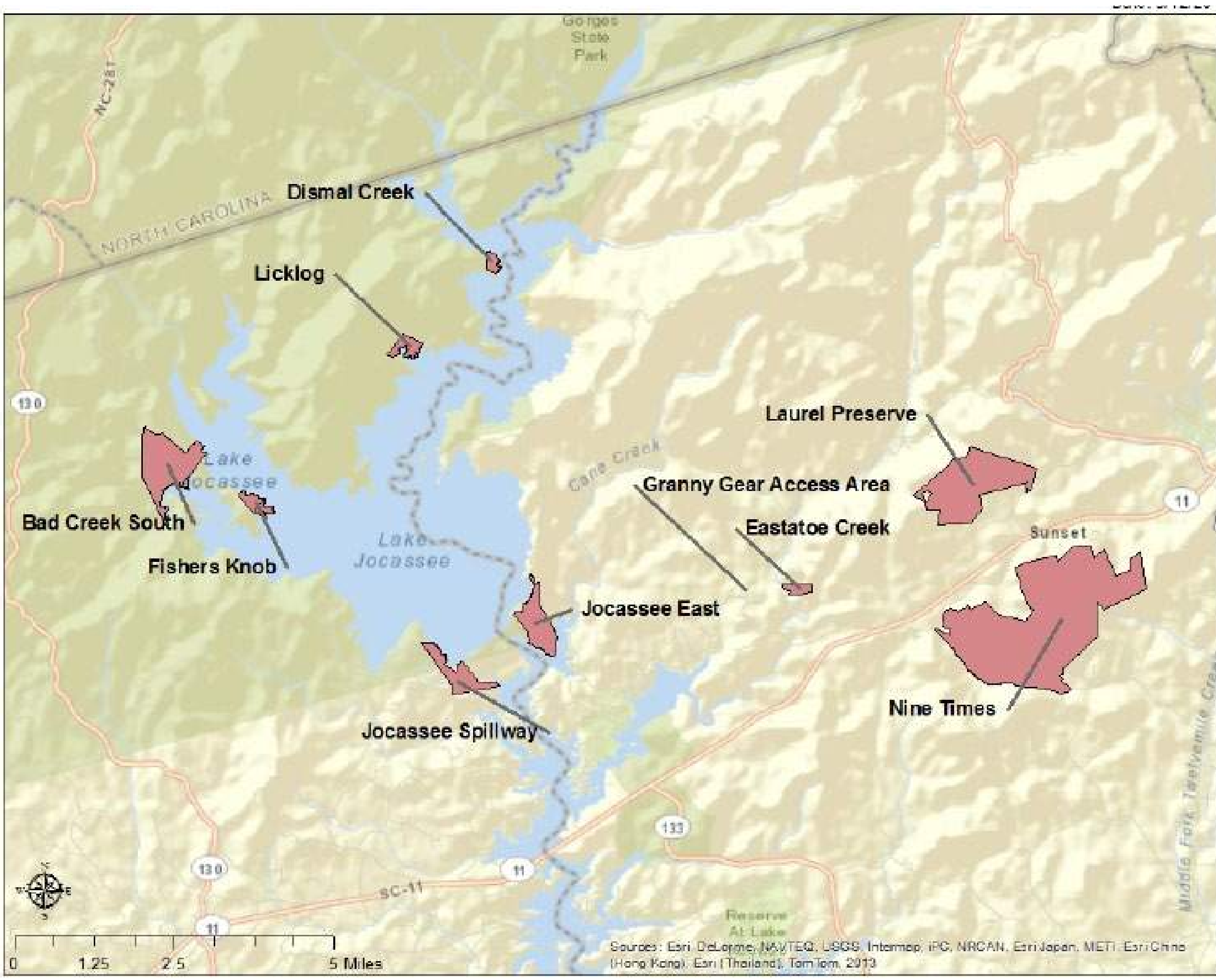

Figure E.13-9. Laurel Preserve Tract

E.13.3.2.3 Visual Resources

The VRMP includes PM&E measures for design and construction of Bad Creek II. (Measures to address the visual effects of operation of Bad Creek II are identical to the measures that will be used for the existing Project.)

Bad Creek II exterior "structures" including exterior fencing; exterior piping, platforms, and equipment; buildings including roofs; and handrails will have a non-reflective finish in dark brown, tan, green, or grey similar to those provided in the BLM Standard Environmental Color Tool (BLM 2021). Selected exterior colors will be darker than the background conditions. Depending on the location of the structure, background conditions may consist of exposed rock or forested areas, so colors will be selected based on the specific location.

The Licensee will evaluate new external lighting associated with Bad Creek II facilities using the same 5-step evaluation process described in Section E.13.3.1.4 with the overall goal of limiting the addition of new permanent external light sources at the Project. New external lighting poles and components will be made of dark non-reflective surfaces. Corten steel or similar low maintenance products will be selected as practicable. The Licensee anticipates construction may occur at night which would require external lighting to ensure personnel and equipment safety and security. However, the Licensee will limit use of construction lighting to only those areas with active construction and the presence of personnel.

Spoil areas will be designed and constructed to have stable side slopes that will not require on-going maintenance following closure. Spoil area design will require the use of native seed mixes for revegetation following spoil area closure. Over time, the revegetation effort will limit the visual effects of spoil areas on the surrounding landscape.

The Bad Creek II primary transmission line will adjoin the existing Project primary transmission line. It will be designed to be consistent with the appearance of the existing line and towers and the corridor will be maintained as early successional stage vegetation through implementation of integrated vegetation management.

Following construction, the Bad Creek Foothills Trail Spur Trail trailhead and parking area will afford the public a direct view of existing and proposed structures. It is adjacent to the Bad Creek II transformer yard and within view of the operations area. To limit visual effects of the operations area, Duke Energy will ensure a vegetated buffer of trees and shrubs is established between the operations area and the parking lot.

Construction-related measures address facility design, dust control, construction lighting, limits for public access, and construction methods. During construction, the Licensee will:

- Limit track-out of mud at the intersection of Bad Creek Road and Highway 130. These could include the use of track-out or gravel pads where dirt/gravel roads intersect Bad Creek Road, watering of dirt/graveled roads, wheel washing systems, use of street sweepers on Bad Creek Road, or similar practices
- Minimize exposed earth surfaces to only areas that need to be disturbed.
- Limit the amount of time disturbed areas remain destabilized through use of temporary and permanent seeding and mulching.
- Apply dust control measures to work and haul areas during dry periods.
- Cover, shield, or stabilize material stockpiles.
- Use covered haul trucks if material is transported off-site.

Public access to the site will be limited during construction which will also limit the visual effects of construction. In addition to limiting public vehicular access, the Licensee will also limit boating access to Whitewater River cove as discussed in Section E.14.3.2.1.

Primary Transmission Line Construction

The Licensee will use standard BMPs during construction of the primary transmission line to limit visual effects. BMPs include:

- Trees and brush will be properly disposed in accordance with local, state, and federal ordinances or by cutting and leaving stumps a maximum of two inches tall and chipping and spreading chips evenly on the right-of-way.
- Seeding will be completed immediately following completion of land disturbance and prior to project completion.
- Seeding will progress closely with construction and be completed immediately following project completion.
- Stream and lake buffers will be maintained between soil disturbing activities and waters.

Off-License PM&E Measures

As an off-License PM&E measure under the BCRA, the Licensee will provide no-cost leases of approximately 1,900 acres of land to SCDNR as discussed in E.13.3.2.1. SCDNR will manage the lands for public recreation purposes (i.e., public hunting and wildlife viewing) SCDNR will maintain the property in its current forested condition which will maintain existing visual conditions in the vicinity of the Project.

E.14 Historic and Archaeological Resources

E.14.1 Affected Environment

In considering a new license for the Project, FERC has the lead responsibility for compliance with applicable federal laws, regulations, and policies pertaining to historic properties, including the NHPA, as amended.[44] Section 106 of the NHPA (Section 106)[45] requires federal agencies to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation a reasonable opportunity to comment.

The Section 106 process (defined at 36 CFR Part 800) is intended to accommodate historic preservation concerns with the needs of federal undertakings through a process of consultation with agency officials, the SHPO, federally recognized Indian Tribes, and other parties with a potential interest in an undertaking's effects on historic properties. The goals of the Section 106 process are to:

- Identify historic properties that may be affected (directly and/or indirectly) by an undertaking;
- Assess the effects of an undertaking on historic properties; and
- Seek ways to avoid, minimize, or mitigate adverse effects on historic properties through consultation.

Historic properties are defined in 36 CFR Part 800 as any pre-contact or historic period district, site, building, structure, or individual object listed in or eligible for inclusion in the NRHP. This term includes artifacts, records, and remains that are related to and located within historic properties, as well as properties of traditional religious and cultural importance (often referred to as "traditional cultural properties") that meet the NRHP criteria.

The Secretary of the Interior has established the criteria for evaluating properties for inclusion in the National Register (36 CFR Part 60). In accordance with the criteria, properties are eligible if they are significant in American history, architecture, archaeology, engineering, or culture. The quality of significance present in historic properties that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

- Are associated with events that have made a significant contribution to the broad patterns of our history; or
- Are associated with the lives of persons significant in our history; or

44 54 USC §300101 et seq.
45 54 USC §306108.

- Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant or distinguishable entity whose components may lack individual distinction; or
- Have yielded or may be likely to yield information important in prehistory or history.

Generally, a cultural resource must be 50 years old or older to be considered for NRHP eligibility, although more recent resources may possess exceptional historical significance and be considered.

E.14.1.1 Cultural Context

The earliest known Native American presence within the Project vicinity dates to the Paleoindian period from 10,000 to 7900 Before Common Era (BCE). During this period, it is believed the hunter gatherer population was small and nomadic. Paleoindian tool forms were lanceolate (and usually fluted) projectile points, flake knives, and scrapers.

The Archaic period (c. 8000 to 1000 BCE) is generally divided into three smaller periods: Early, Middle and Late Archaic. During the Early Archaic period (until 1000 BCE), populations of hunter gatherers in the Project vicinity became larger due to the transition from hunting large game to hunting smaller game and gathering wild foods, however the population was still relatively small and seasonal. The Early Archaic period is marked by a change in lithic technology. Notched and stemmed projectile points, such as Kirk Corner-Notched, Taylor Side- Notched, and Palmer Corner-Notched define sites occupied during this period. The Middle Archaic (c. 6000 to 3000 BCE) was still a period of small mobile settlements with populations that practiced the seasonal rounds, but there was a wider range of tools used including Stanly, Morrow Mountain, and Guilford projectile points. In addition, new tools were introduced, such as atlatl weights, net sinkers, mortars, and nutting stones. It was not until the Late Archaic period (c. 3000 to 700 BCE) that Native Americans became more sedentary. This period is marked by the appearance of large shell midden sites and fiber tempered ceramics in the Savannah River Valley and along the coast. The development of pottery began around 2500 BCE, about the same time as the beginning of plant cultivation. In the Piedmont and the Blue Ridge, inhabitants used soapstone-cooking tools and practiced freshwater shellfish procurement. Pottery use did not occur in the regions above the Fall Line until after 1700 BCE.

The Woodland period, 700 BCE through approximately 1000 Common Era (CE), was marked by the use of ceramics, the greater exploitation of agriculture, and a heightened ceremonialism in the Project vicinity. The Woodland period, also divided into three subperiods, is most widely known for the emergence of the Hopewell phenomenon characterized by the construction of earthen mounds, often containing burials. This was all part of the development of a ceremonial exchange network spanning over half the continent. Artifacts typical of the Early Woodland period (700 to 300 BCE) in the Project vicinity include Dunlap and Swannanoa ceramics and Savannah River Stemmed and Swannanoa Stemmed projectile points. For the Middle Woodland (300 BCE to CE 600), pottery consists of the Pigeon and Cartersville series and projectile points are of the Pigeon Side and Corner Notched types. Small triangular projectile points, such as the Connestee Triangular, and Napier and Connestee Series pottery are diagnostic of the Late Woodland period (CE 600 to 1000) in the region.

The Mississippian period, from CE 1000 to 1600, marked the transition into a heavy reliance on agriculture and the establishment of sedentary populations in major river valleys and fertile bottomlands. The Mississippian period is known for the increase in social and ceremonial complexity. It was a period of hierarchical social rankings and paramount chiefdoms with permanent mound communities within the major river valleys and the fertile bottomlands. The communities were reliant on agriculture with an emphasis on maize, beans, and squash, but continued the hunting and gathering tradition in the vast tracts of surrounding forest. Early Mississippian artifacts (circa CE 900 to 1200) include Etowah series ceramics. The Middle Mississippian period (CE 1200 to 1450) was marked by the construction of large platform mounds, the spread of the Savannah ceramic complex, and a wide array of artifacts such as copper breastplates, conch shell bowls, and shell gorgets. The Late Mississippian period (CE 1540 to 1600) was marked by the Lamar ceramic complex, generally characterized by grit tempered and complicated stamp pottery.

Southeastern Native Americans were first introduced to Europeans by Spanish explorers during the early 1500s. Spanish explorer Hernando de Soto (c. 1540-1542) encountered the “Ocute” chiefdom on the Oconee River in Georgia, the “Cofitachequi” along the Wateree River in South Carolina, and the “Coosa” in the Tennessee and Coosa valleys. While there were inhabitants near the headwaters of the Savannah in and around the Project at the time, there is no record of de Soto visiting the Project vicinity.

Many Cherokee towns, known as the Lower Towns, were located near the Project vicinity. By the 1700s, Keowee was the main town of the Lower Cherokee along the trade route through the Project vicinity. The towns of Sinica, Toxaway, Eastatoe, Tamassee, Jocassy, and Aconnee are the source of the names of many towns or landmarks near the Project today. Permanent European settlement in the Project vicinity did not begin until the late 18th century. In 1730, the British sent an emissary to the Cherokee Nation along the Keowee River to claim land for the King of England and to discuss trade concerns.

While the British provided the main European influence over the Lower Cherokees through the 1700s, the French began to enter the area in the 1730s and 1740s. In order to counter the French influence, the British proposed building forts on Cherokee lands. The Cherokee agreed due to their own problems with the Creek Indians. The Creeks were soon after defeated and driven further south into Georgia. Fort Prince George was constructed near Keowee Town in 1753. The years that followed were marked by tension and skirmishes between the Cherokee and the British. By 1760, the British military had launched a full effort to destroy the Lower Towns of the Cherokee.

Many of the Cherokee Lower Towns were destroyed by South Carolina and Georgia forces in early 1776. White settlement of the Keowee Valley began in the 1780s with the issuance of land grants by the State of South Carolina. The Treaty of Hopewell between the U.S. and Cherokees was signed in 1785 and ended hostilities among the Lower Towns and South Carolina. By 1785, Lower Town Cherokees were beginning to move farther south and east, and the Project vicinity became part of the Ninety-Six District. Due to the growing population, the large districts were soon split up. By the 1790s, the entire Project vicinity was part of the Pendleton District. By the time of the Indian Removal Act of 1838, the Cherokees had abandoned the Lower Towns. The Indian Removal Act of 1838 resulted in the Cherokee people being forcibly moved from their lands east of the Mississippi River via the Trail of Tears to an area in present-day Oklahoma. It is estimated that of the 17,000 Cherokees forced to relocate from North Carolina, between 4,000 and 5,000 died during the journey.

Beginning in 1784–1785 and for several years after, the State of South Carolina issued many land grants for most of the Project vicinity. Many prominent settlers moved into the area to occupy large tracts of land that previously made up the Cherokee Lower Town region. A number of historic houses had their beginnings during this period. One such house was the “Alexander-Hill House,” built in 1831 near Roberton’s Ford in the community of Old Pickens. The house is currently located in High Falls County Park and is listed in the NRHP. The Jocassee Valley was settled later than the Keowee Valley, in the early 1800s, due to its location farther upstream. Most settlers in the region were relatively poor compared to the plantation owners farther south in the state. Most homes were constructed of logs, and grain farming was a common practice.

The 1810s brought growth in the region to a halt as westward expansion boomed. Growth in the Carolinas was at a standstill through the 1830s. The next economic stimulus to the region came by way of the railroad. In the 1840s, the “Blue Ridge Railroad” was built to connect the port of Charleston and the rest of South Carolina with other southern and western states. At the same time, a group of German immigrants had plans to create a colony in the Project vicinity. This new colony, called “Walhalla,” was planned and laid out by Charleston’s German Colonization Society. By the mid-1850s Walhalla had over 1,000 people within the settlement. When the town was only three years old, it consisted of 65 buildings. The businesses in town included smiths, tailors, shoemakers, carpenters, painters, cabinet makers, a tinsmith, a coppersmith, a mechanic, a druggist and a doctor, four storekeepers, masons, brick-makers, miners, a baker, a butcher, a gardener, a teacher, a preacher, and four beer brewers. There were also two hotels in town. Many farming families lived nearby, as well as a large number of Blue Ridge Railroad Company workers. Laborers working on the railroad, including the nearby Stumphouse Mountain Tunnel located approximately 14 miles southwest of the Project, numbered over 3,000 during peak times. The onset of the American Civil War in 1861 led to financial problems that dissolved the Blue Ridge Railroad Company.

Despite economic and social disruption, the Civil War and Reconstruction periods had less impact in the Project vicinity than in other parts of the state, as there were very few slaves in the Upstate at the time and cotton was not a major crop in years before the war. Cotton became more prevalent in the Keowee Valley in the years after the war, as sharecropping became more common. It was during this Reconstruction period that South Carolina switched from the district systems in favor of the county system. The Pickens District was split into Pickens and Oconee counties.

Around 1890, there was a dramatic increase in the number of textile mills throughout the state. Most new mills were located in the upper Piedmont where the railroads provided easy access. The upper Piedmont soon became the most industrial portion of the state. By 1905, there were over 37,000 mill workers in the State of South Carolina. By the 1920s, the number of textile workers had reached over 50,000 and approximately 44 percent of all American textiles were produced in the State of South Carolina. While other industries collapsed during the Great Depression of the 1930s, the cotton mills and the textile industry remained viable. The Newry Mill located on the Little River is a prime example of regional textile history. The mill, founded around 1890, remained in operation until 1975.

Timber and agriculture also became important economic activities during the same time as the cotton mills. By the late 1800s, there was a relatively thorough net of railroad lines throughout the lower portion of the Project vicinity. This spurred other economic activities; timber clear-cutting was taken as far up the Blue Ridge as railroad spur lines would allow. Railroads and timbering made possible a number of small communities during this period. Towns like Salem, which consisted of a church, a school, a few stores, and six sawmills, were developed to support timber operations in and around the Project vicinity. With the use of modern fertilizers, agricultural production increased. Sumter National Forest was established in 1936; the Nantahala National Forest had been established in 1920. The Project vicinity remained dominated by rural communities and small farms through the 1950s.

Development of the Jocassee Valley took a path different from the downstream Keowee Valley. Though originally settled in the early 1800s, there was never a large population in the Jocassee Valley. Most were poor, working as subsistence farmers. The valley remained unchanged until the 1890s when increasing numbers of people began to visit the valley at the foot of the Blue Ridge Mountains to escape the summer heat. By the early 1900s, there were at least three hotels or inns within the valley, most of which only operated from May to October. Atakulla Lodge, A.L. Whitmire Hotel, and Brown's Hotel were the three most popular inns. Visitors often came from distant locations to stay in the Jocassee Valley during the hot summer months. Many guests used the nearby railroad system to get to larger towns, such as Seneca, before making their way to the valley. The resorts and tourism industry continued through the 1950s and 1960s until the land within the Project vicinity was purchased and plans were made for construction of the KT Project.

By the early 1900s, electricity was becoming increasingly more prevalent in larger cities throughout the south, such as Atlanta and Charleston. Southern Power Company, a precursor to Duke Power and later Duke Energy, showed interest in the Keowee River Basin as early as 1916. The plan for a potential hydroelectric plant seemed to have fallen by the wayside until the 1940s and 1950s when Duke Energy began acquiring land in the Keowee and Jocassee Valleys. Duke Power publicized its plans to construct two hydroelectric facilities and additional steam electric facilities in 1965. The Federal Power Commission licensed the KT Project in 1966, and Oconee Nuclear Station was licensed the following year. Construction of the Keowee and Jocassee Dams began soon afterward. Keowee Hydro Station began commercial operation in 1971, and Jocassee Pumped Storage Station began operation in 1973. The Bad Creek Project facilities associated with the greater KT Project (the upper reservoir and dams, I/O structures in the upper and lower reservoirs, water conveyance system, underground powerhouse, tailrace tunnels, transmission facilities, and a 9.25-mile-long transmission corridor extending from the Bad Creek Project to the Jocassee switchyard) were licensed in 1977 and added to the system.

E.14.1.2 Identification of Archaeological and Historic Resources

E.14.1.2.1 Area of Potential Effects

The area of potential effects (APE) is defined as the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. The APE is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking. In the context of the relicensing process, FERC generally defines the APE as follows: "The APE includes all lands within the Project Boundary. The APE also includes any lands outside the Project Boundary where cultural resources may be affected by Project-related activities that are conducted in accordance with the FERC license."

Because the Project Boundary encompasses all lands necessary for Project purposes, Project-related operations, potential enhancement measures, and routine maintenance activities associated with the implementation of a license issued by the Commission are expected to take place within the Project

Boundary. This includes lands within the full pond elevation of Bad Creek Reservoir, License-required recreational access areas, and additional lands associated within the powerhouse and dam complex.

Duke Energy initially proposed an APE in 2022 with which the SC SHPO and Tribes concurred. As Bad Creek II design progressed, the License has revised the APE with the most recent revision in September 2024 (Figure E.14-1). SC SHPO concurred with the revised APE in November 2024 and the Catawba Indian Nation provided concurrence on December 30, 2024. Copies of consultation are included in the *Cultural Resource Investigations at the Bad Creek Hydroelectric Project Final Report*, filed as CUI // PRIV with the DLA due to sensitive archaeological information contained therein.

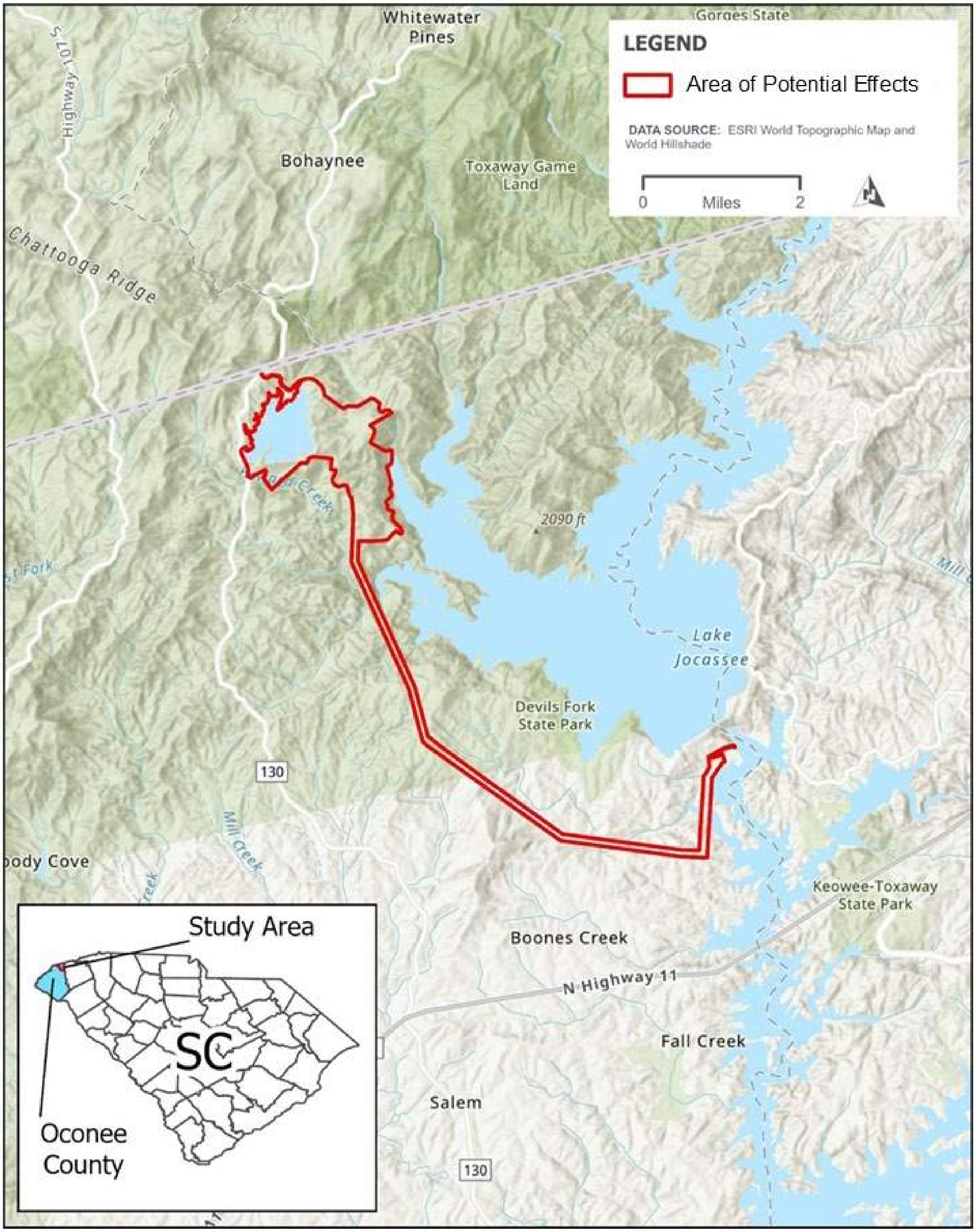

Figure E.14-1. Area of Potential Effects

E.14.1.2.2 Studies in Support of the Current Relicensing

Multiple archaeological surveys of the Project APE have been conducted, most recently in conjunction with Project relicensing. Initial fieldwork occurred from April to June 2023 which was supplemented with additional work along the expanded transmission corridor in the summer of 2024, resulting in an addendum to the final study report. In addition to the archaeological investigations, an architectural survey was conducted to determine whether the proposed Project would affect above-ground historic resources within the APE. The final cultural resources study report and addendum are being filed as CUI // PRIV with this DLA[46].

Archaeological Resources

Only one NRHP-eligible archaeological site, 38OC0250, has been located within the APE. Site 38OC0250 is a dense, multicomponent series of rockshelters containing evidence of Early Archaic through Mississippian period occupations. A possible Paleoindian component may also be present. The site is recommended as being eligible for inclusion in the NRHP under Criterion D15 (National Register Bulletin16 15:21-24).

Historic Architectural Resources

The only known historical architectural resources adjoining the Project APE are SHPO Site Number 0155 Keowee Hydroelectric Development and SHPO Site Number 0156 Jocassee Hydroelectric Development,[47] which has been determined eligible for the NRHP (Terracon 2022).

Bad Creek Project construction was completed in 1991; since the Project is not 50 years of age, it will not require NRHP evaluation until 2041.

Tribal Resources

The Licensee is not aware of tribal resources within the Project APE as none have been identified during the numerous consultation efforts completed during implementation of the cultural resource studies.

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[46] The Cultural Resources Study Report and addendum is being filed as CUI // PRIV pursuant to 18 CFR § 388.112, as this report contains information regarding the specific location and nature of historic and archaeological resources.

[47] The Jocassee substation, also called the Jocassee “Switch Yard,” is not a contributing element to the historic features of the Jocassee Development (Terracon 2022).

E.14.2 Environmental Analysis

E.14.2.1 Project Impacts on Historic, Archaeological, and Tribal Resources

In SD2, FERC staff identified the following environmental issues to be addressed in their NEPA document:

- Effects of project construction, operation, and maintenance activities on historic and archaeological resources, traditional cultural properties, and access to exercise traditional practices and treaty rights.

Site 38OC0250 is currently not affected by Project operations. During Bad Creek II construction, the Licensee will avoid the site by directionally drilling several hundred feet below the site. No other archaeological, historic, and tribal resources are known within the APE.

E.14.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.14.3.1 Existing Bad Creek Project

The Licensee is proposing to implement the proposed HPMP, which will be included in the FLA[48]. The HPMP will include the following measures:

- Listing Eligibility – Recommend Site 38OC249 for inclusion in the National Register of Historic Places.
- Archaeological Site Monitoring – Annually monitor Site 38OC249 to document its status.
- Cultural Resources Awareness Training – The Licensee will ensure its employees receive annual awareness training regarding the protection of archaeological and historic sites.
- Public Outreach – Develop a Cultural Resources Interpretive Exhibit Plan in consultation with relevant stakeholders for the interpretive signage or other materials that display the cultural history of the Bad Creek Project area at the Bad Creek Visitors Center. The Bad Creek Visitors Center will be located in the planned new Hydro West Regional Support Building near Bad Creek and Bad Creek Visitors Overlook. The Cultural Resources Interpretive Exhibit Plan will include but may not be limited to: 1) identifying the final location of the exhibit (Bad Creek

[48] The HPMP will be filed as CUI // PRIV because it includes the location of site 38OC0250.

Visitors Center or other location); 2) interpretive signage and materials; 3) identifying the content(s) of the exhibit; and 4) finalizing a schedule for completing the exhibit. The Licensee will complete the exhibit within two years following completion of the Hydro West Regional Support Building or selecting an alternate exhibit location if the Hydro West Regional Support Building is not constructed.

E.14.3.2 Bad Creek II

While no specific activities related to Bad Creek II construction are included in the HPMP, the protection measures in the HPMP regarding inadvertent discoveries, site monitoring, and cultural resources awareness training will apply to construction activities and construction workers. These measures will ensure appropriate measures are implemented if unanticipated discoveries of sites occur during construction.

E.15 Socioeconomic Resources

E.15.1 Affected Environment

E.15.1.1 Population

The Project is located in Oconee County, which was first formed in 1868. The county seat is Walhalla, while the largest city in Oconee County is Seneca, located approximately 30 miles south of the Project. Oconee County is included in the Seneca, SC Micropolitan Statistical Area, which is also included in the Greenville-Spartanburg-Anderson, SC Combined Statistical Area (South Carolina Association of Counties [SCAC] 2021).

Oconee County has a total area of 674 mi^2 with 626 mi^2 of land and 47 mi^2 of water. Large nearby population centers include the City of Greenville, SC, approximately 35 miles to the southwest (population 72,824 in 2023); Asheville, NC (population 95,056 in 2023) approximately 45 miles to the northeast; and Clemson, SC (population 17,838 in 2023) 25 miles to the south. In 2020 there were approximately 125 people per mi^2 and the average annual growth rate between 2000 and 2023 was 22.7 percent (U.S. Census Bureau [USCB] 2024). Population trends are shown in Table E.15-1.

Table E.15-1. Oconee County Population Estimates (1970-2023)

Year	Population Estimate
2023	81,221
2020	78,607
2019	79,546
2017	77,270
2016	76,407
2010	74,273*
2000	66,215*
1990	57,494*
1980	48,611*
1970	40,728*

Source: USCB 2024.
*Census Population

E.15.1.2 Economics and Housing

The primary market sectors in Oconee County are manufacturing; trade, transportation and utilities; and leisure and hospitality, together accounting for 64 percent of the employed workforce (Upstate SC Alliance 2024). Economic data for Oconee County show a 0.1-percent annual average job growth rate between 2010 and 2020 and an unemployment rate (annual average 2023) of 3.6 percent. There were approximately 25,507 jobs in Oconee County in 2023, where the average annual income per job was

$54,498, and per capita personal income (2022) was $54,415 (SCAC 2024). Total employment in 2022 was 21,044. There were 33,653 households with an average of 2.34 people per household (average 2019-2023) (USCB 2024). The median value of owner-occupied housing units was $217,200 and 75.4 percent owned their home (USCB 2024).

E.15.1.3 Demographics

Persons of 65 years of age and older make up 25.4 percent of Oconee County's population, while people under 18 years make up 18.8 percent. The county is equally divided by gender, with 50.6 percent of the total population being female. Per the Vintage 2023 Population Estimates Program, the racial makeup of the county is 89.2 percent white, 7.4 percent black, 6.3 percent Hispanic or Latino, 0.5 percent American Indian and Alaska Native, 0.9 percent Asian, Z[49] percent Native Hawaiian and Other Pacific Islander, and 2.0 percent from two or more races (USCB 2024).

E.15.1.4 Environmental Justice

Following the submittal of the PAD, the Commission filed a letter on June 16, 2022, requesting that Duke Energy conduct an EJ Study for the Bad Creek Project relicensing pursuant to Section 5.9 of the Commission's regulations. The request for an EJ Study aligns with the socioeconomic resource issues identified by the Commission in SD2 issued for Project relicensing on August 5, 2022. Resource issues identified in SD2 address the effects of continued operations under the existing license as well as potential construction and operation of Bad Creek II during the new license term.

The EJ study evaluated impacts to EJ communities as they relate to 1) relicensing the existing Project without construction of Bad Creek II, and 2) relicensing the existing Project and including construction of Bad Creek II. The methods, results, and conclusions of the EJ Study are summarized in Section E.15.2 below, with additional details provided in the *Environmental Justice Study Final Report* in Appendix D.

E.15.2 Environmental Analysis

E.15.2.1 Studies in Support of Current Project Relicensing

In support of the current relicensing, Duke Energy conducted an EJ Study in 2023. The specific objectives of the Environmental Justice Study are included below:

[49] Value greater than zero but less than half unit of measure shown.

- Identify the presence of EJ communities that may be present within the study area.
- Identify the presence of non-English speaking populations that may be present within the study area.
- Identify sensitive receptor locations in the study area.
- Identify outreach strategies to engage EJ communities and non-English speaking populations in the relicensing if present within the study area.
- Discuss:
  - The effects of the relicensing and Bad Creek II construction on identified EJ communities;
  - Effects that are disproportionately high and adverse; and
  - Potential effects on non-English speaking communities and sensitive receptor locations, if present within the study area.
- Identify mitigation measures to avoid or minimize Project effects on EJ communities, non-English speaking communities, and sensitive receptor locations, if present within the study area.

E.15.2.1.1 Methods

The methodology used to identify the presence of Environmental Justice communities within the Project vicinity was adopted from USEPA's Promising Practices for EJ Methodologies in NEPA Reviews (USEPA 2016). A table was prepared that included the racial, ethnic, and poverty statistics for each state, county, and census block group within the geographic study area (Table E.15-2). The table includes information from the USCB's American Community Surveys 5-Year Estimates for each state, county, and block group within the scope of this study (USCB 2020, 2020a, 2020b)[50]. Racial data was obtained using Table B03002, and poverty data was obtained using Table B17017.

The presence of non-English speaking populations was identified using Table B16004 from the USCB American Community Survey 5-Year Estimates for each state, county, and block group within the scope of this study.

Sensitive receptor locations include, but are not limited to, schools, daycare centers, hospitals, and elderly care facilities. Sensitive receptor locations within the scope of this study were identified using the USGS National Structures Dataset. The dataset consists of the name, function, and location of manmade facilities as determined by disaster planning and emergency response needs (USGS 2022).

[50] The study utilized the most recent USCB data (2020 5-Year Estimates) at the time the study was conducted. Duke Energy anticipates updating this section using the most recent USCB dataset for the FLA.

The data from The National Map viewer was downloaded as an Esri™ File Geodatabase, and then populated onto a map of the Bad Creek Project vicinity showing the 1-mile and 5-mile buffers around the proposed expanded Project Boundary.

Potential effects to EJ communities were identified using the USEPA's Promising Practices for EJ Methodologies in NEPA Reviews (USEPA 2016) document and regional and site-specific conditions that may contribute to impacts. These potential effects are discussed below.

E.15.2.1.2 Results

Using the meaningfully greater analysis method, one EJ community based on race was identified out of the thirteen census block groups within the scope of this study. Located in Transylvania County, North Carolina, the one race-related EJ community is primarily within the 5-mile buffer zone around the Project, with the southwestern portion located within the 1-mile buffer. Two EJ communities were identified based on income below poverty level, measured by household: one in Oconee County, South Carolina, and one in Transylvania County, North Carolina, both of which are located within the 5-mile buffer zone (Table E.15-2; Figure E.15-1). None of the identified EJ communities are in block groups that border Project lands.

Within the thirteen block groups in the study area, one block group includes a population of non-English speaking individuals. This block group is located in Pickens County, South Carolina, with one percent of the population unable to speak English (Table E.15-2).

No sensitive receptor locations are present within the 1-mile radius surrounding the proposed expanded Bad Creek Project Boundary (Figure E.15-2). Within the 5-mile radius around the proposed expanded Bad Creek Project Boundary there are two sensitive receptor locations: two schools, located within the 5-mile radius, on the southwestern extremity of the potentially effected zone. A table depicting the distances of identified sensitive receptor locations to the Bad Creek Project Boundary, the primary area within which proposed activities would take place, is provided as Table E.15-3.

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Table E.15-2. Race and Ethnicity, Low Income, and Non-English Speaking Data for the 5-Mile Radius Around the Bad Creek Project

Geographic Area	Total Population (Count)	White Alone, note Hispanic (Count)	African American/Black (Count)	Native American/Alaska Native (Count)	Asian (Count)	Native Hawaiian & Other Pacific Islander (Count)	Some Other Race (Count)	Two or More Races (Count)	Hispanic or Latino (Count)	Total Minority Population (%)	Below Poverty Data (%)	Non-English Speaking Persons Aged 5 Years and Greater (%)
Georgia	10,403,847	5,485,855	3,244,348	19,382	410,705	5,164	32,810	213,189	992,394	47%	14%	1%
Rabun County	1,6645	14,598	316	55	188	0	41	113	1,334	12%	16%	0%
Census Tract 970202, Block Group 1	1,348	1,335	0	0	0	0	0	0	13	1%	14%	0%
North Carolina	10,264,876	6,474,688	2,165,301	11,2504	290,525	5,640	22,962	230,591	962,665	37%	14%	1%
Jackson County	42,938	34,635	928	3,283	302	0	56	1,182	2,552	19%	18%	0%
Census Tract 950900, Block Group 2	1,425	1,410	0	0	0	0	0	0	15	1%	9%	0%
Macon County	34,813	30,998	541	240	302	0	91	201	2,440	11%	14%	0%
Census Tract 970502, Block Group 1	2,128	2,023	6	0	18	0	0	0	81	5%	9%	0%
Transylvania County	33,775	30,528	1,560	89	47	17	0	410	1,124	10%	13%	0%
Census Tract 960600, Block Group 3	1,143	1,019	0	0	19	0	0	0	105	11%	18%	0%
South Carolina	5,020,806	3,196,421	1,333,876	14,748	78,102	3,784	9,139	99,278	285,458	36%	15%	0%
Oconee County	77,528	65,463	5,288	231	570	11	44	1,686	4,235	16%	16%	0%
Census Tract 030200, Block Group 1	1,340	1,261	0	0	0	0	15	36	28	6%	9%	0%
Census Tract 030100, Block Group 2	679	671	0	0	0	0	0	0	8	1%	12%	0%
Census Tract 030100, Block Group 1	1,167	1,142	7	0	0	0	0	4	14	2%	8%	0%
Census Tract 030200, Block Group 5	872	872	0	0	0	0	0	0	0	0%	6%	0%
Census Tract 030200, Block Group 2	1,109	1,090	16	0	0	0	0	3	0	2%	25%	0%
Census Tract 030200, Block Group 3	1,201	1,201	0	0	0	0	0	0	0	0%	8%	0%
Pickens County	124,029	106,292	8,392	306	2,424	26	178	1,854	4,557	14%	17%	0%
Census Tract 010200, Block Group 2	2,267	2,216	24	0	0	0	0	0	27	2%	9%	0%
Census Tract 010100, Block Group 1	1,443	1,331	76	0	16	0	0	20	0	8%	4%	0%
Census Tract 010200, Block Group 1	2,279	2,164	27	0	0	0	0	20	68	5%	14%	1%

Source: USCB 2020 , 2020a, 2020b.

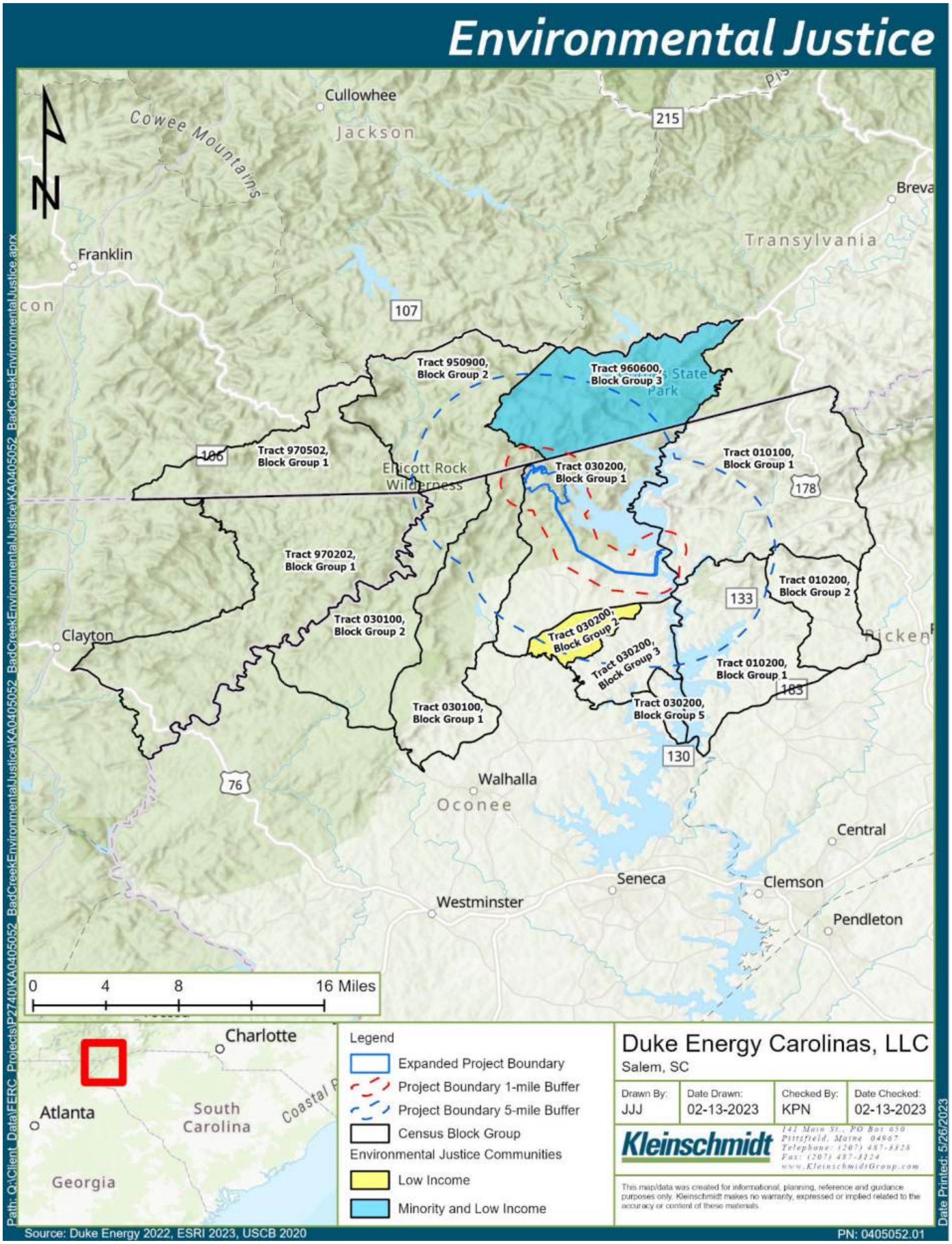

Figure E.15-1. Census Block Groups within a 1-mile and 5-mile Radius of the Bad Creek Project

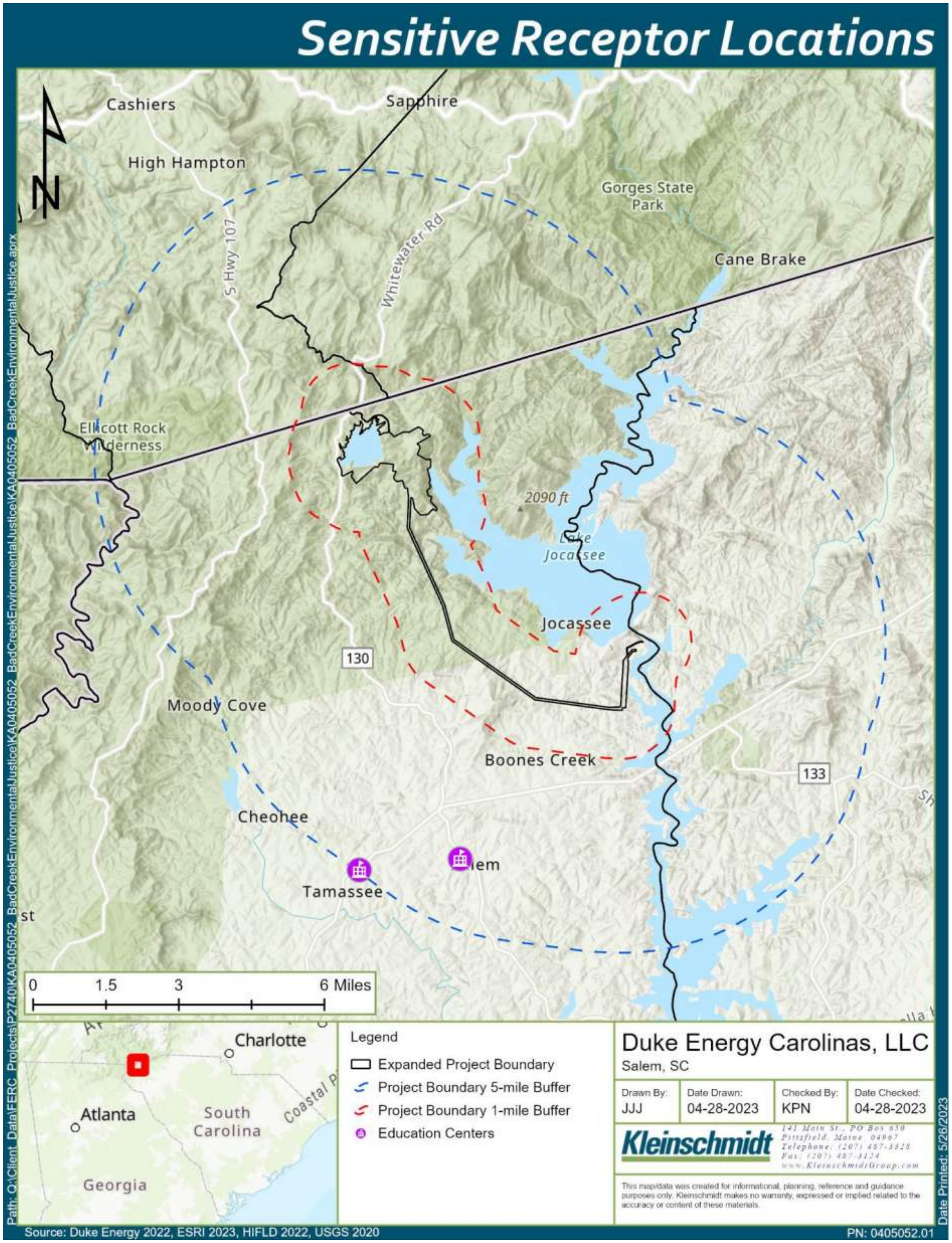

Figure E.15-2. Sensitive Receptor Locations within a 1-mile and 5-mile Radius of the Bad Creek Project

Table E.15-3. Distances of Sensitive Receptor Locations to Proposed Expanded Bad Creek Project Boundary

Sensitive Receptor Location	Distance from Project Boundary (miles)
NEXT School Eagle Ridge	3.62
Tamassee Salem Elementary School	4.96

E.15.2.1.3 Conclusions

The existing Project's continued operation is not expected to cause any noise or air quality-related effects due, in part, to the Project's relative distance to identified EJ communities. Subsistence fishing opportunities will remain unchanged in the vicinity with the continued operation of the existing Project. In addition, no changes to the local traffic, road networks, or aesthetics will occur as a result of relicensing, nor will there be effects to local non-English speaking communities and sensitive receptor locations.

Due to the history of inequitable siting of highly polluting facilities and industries within EJ communities, the potential for unequal distribution of impacts to these communities exists with any construction project or industrial site proposed today. The natural way in which sound and air pollution travel may result in temporary impacts outside the main construction area, necessitating the 1-mile and 5-mile radius analyses. Overall, the impacts to EJ communities from construction of Bad Creek II would be minimal due to the distance between construction activities and the nearest residential areas with Environmental Justice populations, and disproportionately adverse impacts to Environmental Justice communities should not occur due to the healthy baseline environmental conditions in the region.

Construction of Bad Creek II has the potential for beneficial impact to the local economy by creating local jobs in areas such as contracting and construction work, plumbing, electrical, masonry, welding, and engineering (HoldRite 2023). Additional local economy benefits include increased business from the construction work force to establishments providing food and hospitality, entertainment, and retail sales. Though the direct sales impact from the construction work force will be temporary, it will contribute to indirect and cumulative benefits by giving the area a boost that will aid in the continuation of self-sufficiency and potentially providing resources for future improvements.

E.15.2.1.4 2024 Outreach

During the ISR meeting held January 17, 2024, FERC staff recommended that Duke Energy conduct outreach efforts to engage identified EJ communities in the Bad Creek Project relicensing. In order to engage and encourage feedback from identified EJ communities, a Community Outreach Plan was developed that described hosting two public meetings in counties of the communities, developing informational material, and distributing that material through newspapers, community leaders, and the

Licensee's Project website. This informational document was distributed to six organizations who play a key role in supporting and securing resources for members of the local EJ communities.

Additionally, Duke Energy hosted two town-hall style public meetings in counties of identified EJ communities at the following dates and times: December 10, 2024, beginning at 6:00 PM in Salem, South Carolina (Oconee County); and December 11, 2024, beginning at 10:00 AM in Sapphire, North Carolina (Transylvania County). Notice of the meetings were published in two newspapers of local distribution approximately one week in advance of the meetings and on Duke Energy's Project website. A Spanish-speaking interpreter was in attendance for both meetings. There was no attendance of either meeting by members of the EJ community. EJ outreach related to the Project are further detailed in the *Environmental Justice Outreach Summary Report* provided in the *Environmental Justice Report* in Appendix D.

E.15.2.2 Project Impacts on Socioeconomic Resources

Operation of the Project has, and will continue to have, a positive impact on local economies in the region. The Project workforce payroll as well as sales of materials and supplies to support Project operations, including fuel, vehicle maintenance, plant-related consumables and equipment, and office supplies, among others, support local businesses and contribute to the local economy. Duke Energy is also a large property owner in the region and paid approximately $36.1M to Oconee County, South Carolina, in local property taxes for 2024. In addition, Duke Energy pays business taxes to the states of North Carolina and South Carolina. These benefits to the regional economy will continue when the existing Project is relicensed and increase with the construction and operation of Bad Creek II.

In SD2, FERC identified the following issues related to socioeconomic resources to be addressed in its NEPA document:

- Effects of project construction and operation activities on local roads (including traffic), housing, businesses, employment opportunities, and government services.
- Effects of project construction and operation activities on human health or the environment in identified environmental justice communities.

E.15.2.2.1 Effects of Project Construction and Operation Activities on Local Roads, Housing, Businesses, Employment Opportunities, and Government Services

Existing Project

The Licensee does not expect new effects on local roads, housing, businesses, employment opportunities, and government services under the new license term. As proposed, the Licensee would continue to be a significant source of Oconee County's tax base, would continue to employ local residents, and continue to provide recreational opportunities to local residents as well as attract visitors to the region. The Licensee would continue to maintain its portion of the Foothills Trail, a recreational feature that attracts visitors to the region.

Bad Creek II

During Bad Creek II construction, public use of Bad Creek Road will be limited to Fisher Knob residents, their guests, and their service providers consistent with the Bad Creek Road Traffic Management Plan, which Duke Energy expects to provide in the FLA. Most houses at Fisher Knob are seasonal residences or operated as short-term vacation rentals. Fisher Knob property owners may see a temporary decrease in short-term rentals during the construction period due to the inconveniences associated with construction activities, but it is possible longer-term rentals associated with construction may offset the decrease. Regional roads, primarily SC Highway 130 will likely experience higher traffic volume associated with construction workers accessing the site as well as material deliveries.

Construction workers would likely temporarily relocate to the area and acquire housing in the region during the Bad Creek II construction period. As of 2021, Oconee County had approximately 40,370 housing units with a vacancy rate of approximately 20.8 percent (SC Housing 2021). Given the relative availability of existing housing stock as well as existing campgrounds, construction workers will likely access existing housing stock during the construction period. These construction workers will contribute to the regional economy as they acquire goods and services from local businesses. Likewise, the Licensee and its contractors will temporarily increase their workforce during Bad Creek II construction, providing employment opportunities for local residents and others. During construction, the Licensee expects a positive effect to the regional economy including increased revenues for local taxing entities.

During operation of Bad Creek II, the Licensee expects impacts to local roads, housing, businesses, employment opportunities, and government services to be comparable to current effects.

E.15.2.2.2 Effects of Project Construction and Operation Activities on Human Health or the Environment in Identified Environmental Justice Communities

Existing Project

Duke Energy does not anticipate continued operation of the Project for the term of the new license would adversely affect socioeconomic resources or environmental justice populations. The Project provides a variety of socioeconomic benefits to the region through the generation of clean, renewable energy, preservation of wildlife habitat, protection of cultural and aesthetic resources, and provision of recreation opportunities.

Bad Creek II

Duke Energy does not anticipate construction, operation, or maintenance of Bad Creek II would adversely affect socioeconomic resources or environmental justice populations.

Construction and operation of the proposed Project is anticipated to bring economic growth and opportunities to the surrounding communities, including the small minority population in the Project vicinity. Construction and operation of the Project would support local employment and income, and economic output, as well as generate state and local tax revenues.

E.15.3 PM&E Measures Proposed by the Applicant, Resource Agencies, and/or Other Consulting Parties

E.15.3.1 Existing Bad Creek Project

No adverse effects to socioeconomic resources associated with operation of the Project have been identified so no PM&E measures are currently proposed.

E.15.3.2 Bad Creek II

The Licensee is proposing to implement a Bad Creek Road Traffic Management Plan, which Duke Energy expects to provide in the FLA. As set forth in the plan, Fisher Knob property owners, their guests, and service providers would access the Fisher Knob community using scheduled escorts. This will allow use of Bad Creek Road by both property owners and for construction use.

The plan includes provisions for emergency access by first responders (i.e., law enforcement, fire department, etc.) as well as general access by SCDNR and FTC as they perform their official duties.

E.16 Economic Analysis

This section will be included in the FLA and will include annualized, current cost-based information to address the following:

- Cost of operating and maintaining the Project under the existing license;
- Cost of constructing, operating, and maintaining the expanded Project, as proposed;
- Estimated costs of PM&E measures proposed by the Licensee or recommended by FERC staff or Project stakeholders;
- Value of resources associated with the Project, under the existing license and as proposed by the Licensee; and
- Estimated reduction in value of the Project's developmental resources due to proposed and recommended PM&E measures.

E.17 Consistency with Comprehensive Plans

Section 10(a)(2) of the Federal Power Act (16 USC §803(a)(2)(A) requires the Commission to consider the extent to which a project is consistent with federal and state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by a project. Under 18 CFR §5.18(b)(5)(ii)(F) each license application must identify relevant comprehensive plans and explain how and why the proposed project would, would not, or should not comply with such plans. In addition, the license application must include a description of any relevant resource agency or Indian Tribe determination regarding the consistency of the project with any such comprehensive plan.

Comprehensive plans determined to be potentially relevant to the Bad Creek Project and reviewed for consistency with this license application are summarized below.

Forest Service. 2004. Sumter National Forest Revised Land and Resource Management Plan. Department of Agriculture, Columbia, South Carolina. January 2004.

The Sumter National Forest borders the Project to the west and the Project does not include any public land managed by the USFS, so this plan is not directly applicable to the Project. However, several proposed measures are consistent with objectives contained in the plan, such as protecting water quality, visual resources, and maintaining or enhancing aquatic and terrestrial habitat.

National Park Service. The Nationwide Rivers Inventory. Department of the Interior, Washington, D.C. 1993.

The Project is consistent with designations for rivers on this list because the designated portions of the Whitewater and Thompson rivers terminate at the border between North and South Carolina, which is upstream of and not affected by the Project. The designated portion of the Toxaway River terminates at Lake Jocassee; however, proposed Project operation would not affect lands above the Normal Full Pond Elevation.

South Carolina Department of Health and Environmental Control. 1989. Non-point Source Management Program for the State of South Carolina. Columbia, South Carolina. April 1989.

The Project, as proposed, would not contribute to sources of non-point pollution. There is no public access to the Bad Creek Reservoir shoreline. Duke Energy implements an SMP for the KT Project that requires landowners to implement measures for vegetation protection, shoreline stabilization, and erosion control, which should decrease non-point source inputs into Lake Jocassee.

South Carolina Department of Parks, Recreation, & Tourism. 2008. South Carolina State Comprehensive Outdoor Recreation Plan. Columbia, South Carolina. April 2008. (Superseded by the 2019 SCORP)

The Project includes measures to address identified priorities, including: (1) maintaining and enhancing trails; (2) providing interpretive/informative exhibits for visitors, and (3) providing funding to SCDNR and Oconee County Conservation Bank to support road maintenance and future land conservation efforts.

The Project is also consistent with the SCORP because it contains provisions to work with landowners to continue leasing lands associated with the Duke Energy-maintained portion of the Foothills Trail in order to provide continued public access.

South Carolina Department of Parks, Recreation, & Tourism. 2002. The South Carolina State Trails Plan. Columbia, South Carolina. 2002.

The continued maintenance and enhancements to the existing Foothills Trail, as proposed, support the goals identified in the plan. Specifically, the measures support trail development, promote public health through exercise, provide opportunities for a variety of trail uses (e.g., hiking, bicycling) and abilities, and provide access to public natural resources.

South Carolina Department of Natural Resources. 2014. South Carolina's State Wildlife Action Plan 2015. Columbia, South Carolina. October 2014.

Duke Energy is proposing several measures that would benefit SWAP species including: (1) developing up to ten SPPs, (2) providing funding to SCDNR and Oconee County Conservation Bank to support road maintenance and future land conservation efforts, and (3) providing funding to the Lake Keowee Water Protection Program for initiatives to protect and enhance water quality in the KT Project watershed. As such, the Project is consistent with the plan's goals to: (1) increase baseline biological inventories with emphasis on natural history, distribution, and status of native species; (2) increase commitment by natural resource agencies, conservation organizations, and academia toward establishing effective conservation strategies; (3) increase financial support and technological resources for planning and the implementation of these strategies; and (4) create public-private partnerships and educational outreach programs for broad-scale conservation efforts.

South Carolina Department of Natural Resources. 2004. South Carolina Water Plan, Second Edition. Columbia, South Carolina. January 2004.

The operations proposed by Duke Energy include the KT Project LIP, which is designed to improve water management during drought periods to benefit downstream water users. The LIP has been developed in consultation with stakeholders including the USACE and downstream water users to manage storage and to mitigate the negative impacts that water shortages have on surface-water uses, consistent with the water plan.

South Carolina Water Resources Commission. National Park Service. 1988. South Carolina rivers assessment. Columbia, South Carolina. September 1988.

This document assesses rivers located in South Carolina to provide a systematic, comprehensive database concerning the relative importance of rivers within the state based on a spectrum of attributes. Because the document does not specify goals or objectives for management, it does not provide any standards for assessing compliance. However, based on the value class system used for the assessment, it does not appear the Project as proposed would change any of the ratings for the water bodies discussed in the report.

South Carolina Wildlife and Marine Resources Department. 1989. South Carolina Instream Flow Studies: a Status Report. Columbia, South Carolina. June 1, 1989.

This document presents a general philosophy and approach for establishing minimum flows that should be protective of natural resources. Flow releases from Project dams balance numerous public benefits within and downstream of the Project reservoirs. Duke Energy operates the Bad Creek Project in concert with operation of its downstream KT Project. Proposed Project operations, including the LIP and the 2014 Operating Agreement achieve this balance by establishing reservoir storage and release criteria that reflect variable inflows to the Project.

U.S. Fish and Wildlife Service. Canadian Wildlife Service. 1986. North American Waterfowl Management Plan. Department of the Interior. Environment Canada. May 1986.

The goals of the plan are to protect and enhance wetlands and associated waterfowl habitat. Impacts to wetlands resulting from the construction of Bad Creek II will be avoided and minimized to the greatest extent practicable, and appropriate compensatory mitigation for impacts that cannot be avoided will be proposed. Additionally, under the BCRA, Duke Energy is proposing off-license measures that would contribute to wetlands preservation and/or conservation include providing a one-time payment of $500,000 to the Oconee County Conservation Bank to support future land conservation efforts; extension of the existing Laurel Preserve Tract lease to SCDNR; and making a one-time funding contribution of $500,000 to the Lake Keowee Water Protection Program for initiatives to protect and enhance water quality in the KT Project watershed. The Project is not anticipated to have adverse effects on waterfowl and would protect or enhance existing waterfowl habitat.

U.S. Fish and Wildlife Service. n.d. Fisheries USA: The Recreational Fisheries Policy of the U.S. Fish and Wildlife Service. Washington, D.C.

Duke Energy is proposing several measures that would benefit recreational fisheries including: (1) maintaining and enhancing aquatic habitats, (2) providing one-time funding to SCDNR for both Bad Creek and Bad Creek II to support fisheries management activities, (3) reducing the level of entrainment at the Project to the extent practical, and (4) maintaining water quality and protecting aquatic biota. No aspects of Duke Energy's proposed operations or the measures included in this license application are expected to adversely affect recreational fisheries.

E.18 Consultation Documentation

Duke Energy consulted extensively with federal, state, interstate and local resource agencies, Indian Tribes, non-governmental organizations, and unaffiliated members of the public throughout the relicensing process. Consultation correspondence for individual resource studies is included with respective study reports in Appendix D. FERC consultation documentation is provided in Appendix A.

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Appendix A

Appendix A – Consultation Documentation

Appendix B

Appendix B – Bad Creek Relicensing Agreement

<<Explanatory Statement will be included with FLA>>

Appendix C

Appendix C – Climate Summary

Appendix D

Appendix D – Relicensing Study Reports

Water Resources

Aquatic Resources

Visual Resources

Recreational Resources

Environmental Justice

Bat Study

Small Whorled Pogonia

Appendix E

Appendix E – Management Plans

Draft Visual Resources Management Plan

Draft Integrated Vegetation Management Plan

Draft Recreational Management Plan