WATER STRATEGY, HYDRO LICENSING & LAKE SERVICES

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June 28, 2024

Electronically Filed

Debbie-Anne A. Reese, Acting Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Subject: **Bad Creek Pumped Storage Project (P-2740-053)**
Relicensing Study Progress Report No. 5

Dear Secretary Reese:

Duke Energy Carolinas, LLC (Duke Energy or Licensee) is the Licensee, owner, and operator of the 1,400-megawatt (MW) Bad Creek Pumped Storage Project (FERC Project No. 2740) (Project), located in Oconee County, South Carolina, approximately eight miles north of Salem. 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 serves as the lower reservoir and is licensed separately as part of Duke Energy's Keowee-Toxaway Hydroelectric Project (FERC Project No. 2503).

The existing (original) license for the Project was issued on August 1, 1977, by the Federal Energy Regulatory Commission (FERC or Commission) and 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.

Relicensing Studies

Pursuant to 18 Code of Federal Regulations (CFR) § 5.15(c), Duke Energy filed the Initial Study Report (ISR) with the Commission on January 4, 2024, which summarized study activities performed in 2023, as well as ILP activities expected to be completed in 2024. An ISR meeting was held on January 17, 2024. A fourth Quarterly Study Progress Report was filed on April 1, 2024, detailing activities performed since the ISR was filed. This fifth Quarterly Study Progress Report describes activities performed since the fourth Quarterly Study Progress Report, including activities that occurred in quarter 2 (Q2) of 2024 and activities expected to be conducted in quarter 3 (Q3) of 2024. Unless otherwise described, all relicensing studies are being conducted in conformance with the approved Revised Study Plan (RSP) and the Commission's Study Plan Determination (SPD).

Duke Energy is filing this Quarterly Study Progress Report with the Commission electronically and is distributing this letter to the parties listed on the attached distribution list. For parties listed on the attached distribution list who have provided an email address, Duke Energy is distributing this letter via email; otherwise, it will be distributed via U.S. mail.

Duke Energy looks forward to continuing to work with Commission staff, resource agencies, Indian Tribes, local governments, non-governmental organizations, and interested members of the public throughout the relicensing process. If there are questions regarding this filing, please contact me at Alan.Stuart@duke-energy.com or via phone at 980-373-2079.

Sincerely,

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Enclosure

cc (w/enclosure): Jeff Lineberger, Duke Energy

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Bad Creek Pumped Storage Project
Relicensing Study Progress Report No. 5
June 28, 2024

1.0 BACKGROUND

Duke Energy Carolinas, LLC (Duke Energy or Licensee) is the Licensee, owner, and operator of the 1,400-megawatt (MW) Bad Creek Pumped Storage Project (FERC Project No. 2740) (Project), located in Oconee County, South Carolina, approximately eight miles north of Salem. 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 serves as the lower reservoir and is licensed separately as part of Duke Energy's Keowee-Toxaway Hydroelectric Project (FERC Project No. 2503).

The existing (original) license for the Project was issued on August 1, 1977, by the Federal Energy Regulatory Commission (FERC or Commission) and 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.

2.0 STUDY PLAN DEVELOPMENT

In accordance with 18 CFR §5.11, Duke Energy developed a Proposed Study Plan (PSP) in consultation with agencies and stakeholders and filed it on August 5, 2022. After the filing of the PSP, Duke Energy held a site visit and Project tour on August 16, 2022, and the PSP meeting on September 7, 2022. Duke Energy also continued to consult with agencies and other stakeholders regarding its proposed studies.

Duke Energy evaluated the comments submitted by the Commission and stakeholders in response to the PSP. Based on Duke Energy's review of these comments, FERC criteria for study requests under the ILP, and readily available information (e.g., associated with the previous licensing effort or resulting from ongoing monitoring activities), Duke Energy proposed six resource studies in the

Revised Study Plan (RSP) filed with FERC on December 5, 2022. The RSP includes copies of and summarizes comments received and Duke Energy's responses.

The six studies in the RSP will support evaluation of the potential effects of continued operation of the Project as well as potential effects of construction and operation of the proposed Bad Creek II complex. These studies are:

- Water Resources Study;
- Aquatic Resources Study;
- Visual Resources Study;
- Recreational Resources Study;
- Cultural Resources Study; and
- Environmental Justice Study.

In FERC's Study Plan Determination (SPD) letter on January 4, 2023, FERC approved the proposed studies as submitted in the RSP except the Recreational Resources Study which was approved with modifications. The Recreational Resources Study was modified to include the following:

- An additional traffic counter was added at the Laurel Valley Trail Access.[1]
- Revisions to the Recreation Site Inventory Form to include the number and height of bear cables and number of latrines.

Pursuant to 18 Code of Federal Regulations (CFR) § 5.15(c), Duke Energy filed the Initial Study Report (ISR) with the Commission on January 4, 2024, which summarized study activities performed in 2023, as well as ILP activities expected to be completed in 2024. An ISR meeting was held on January 17, 2024 and the ISR Meeting Summary was filed with FERC on February 1, 2024. The following sections summarize progress implementing the relicensing studies since the April 1, 2024 Study Progress Report.

[1] Although the SPD referenced "Laurel Fork Gap", Duke Energy assumes the Foothills Trail Conservancy and FERC meant to reference the Laurel Valley Trail Access.

3.0 ACCESS ROADS

In its Study Progress Report No. 2, Duke Energy provided information on a potential temporary access road to the Fisher Knob community (Fisher Knob Access Road). The study areas for the Water Resources, Aquatic Resources, Visual Resources, and Cultural Resources studies were expanded to incorporate the areas potentially affected by the road. Duke Energy initially proposed activities for Fisher Knob Access Road construction to occur prior to license issuance; however, early construction of the Fisher Knob Access Road is no longer part of the licensing proposal and road development, if proposed, will follow license issuance. Studies are unaffected by this change in schedule and still incorporate the areas potentially affected by the proposed Fisher Knob Access Road.

Primary site access for construction is provided by the existing Bad Creek Road. Duke Energy is presently evaluating and siting additional access roads on property owned by Duke Energy or under easement, or existing U.S. Forest Service roads that would be subject to authorization under a non-commercial/road use agreement, for construction of the proposed additional 9.3-mile-long 525-kV transmission line for Bad Creek II.

4.0 WATER RESOURCES STUDY

The components of the Water Resources Study and status of each are provided below:

- **Summary of Existing Water Quality Data and Standards**: No additional work for this study task is anticipated; the final study report was provided in the ISR as Appendix A, Attachment 1.
- **Water Quality Monitoring in the Whitewater River Arm**: A draft interim report with preliminary water quality results from study year 1 was included in the ISR as Appendix A, Attachment 2. Activities for the second study year commenced in June 2024 with redeployment of water quality instrumentation in the Whitewater River arm to collect water quality information. A draft report will be distributed in Q4 and will include a summary of data for both study years.
- **Computational Fluid Dynamics (CFD) Modeling of Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse:** A final study report was provided in the ISR as Appendix A, Attachment 3. While the original scope and objectives of this study task have been met, recent optimization studies for Bad Creek II have indicated that variable speed pump-turbine units will be implemented at Bad Creek II

instead of single-speed units, which would result in increased hydraulic capacities compared to what was originally modeled. Therefore, additional CFD modeling has been carried out to incorporate these updated hydraulic capacities. A summary report presenting the effects of updated pumping capacities in Whitewater River cove was developed for Duke Energy and distributed for 30-day stakeholder review on June 12, 2024. The final report will be attached as an addendum to the CFD study report (Appendix A, Attachment 3) in the Updated Study Report (USR).

- **CHEOPS Modeling of Water Exchange Rates and Lake Jocassee Reservoir Levels:** The CHEOPS model was used to evaluate potential effects of Bad Creek II on the frequency, timing, and range of Lake Jocassee and Lake Keowee reservoir level fluctuations. Duke Energy held a joint meeting with the Water Resources, Aquatic Resources, Operations, and Recreational & Visual Resources RCs on April 4, 2024, to review model results. Following the meeting, Duke Energy provided a draft report to the RCs for review and comment (no comments were received). The final CHEOPS report was distributed to the RCs on April 27, 2024, and is provided as Attachment A to this Study Progress Report.
- **Future Water Quality Management Plan (WQMP) Development:** Initial work to develop the WQMP began in Q2 and a draft plan will be presented to the Water and Aquatics RCs for input in Q4 of 2024.

Variance from Approved Study Plan

The study is proceeding in accordance with the approved study plan except the study area has expanded to incorporate the proposed Fisher Knob Access Road. Additional CFD modeling was carried out to incorporate increased hydraulic pumping capacities associated with recently proposed variable-speed units at Bad Creek II, as described above.

5.0 AQUATIC RESOURCES STUDY

The components of the Aquatic Resources Study and status of each are provided below:

- **Entrainment Study:** The final report was reviewed by stakeholders and provided in the ISR as Appendix B, Attachment 1. As described above, recent optimization studies for Bad Creek II have indicated that variable speed pump-turbine units will be implemented at Bad Creek II instead of single-speed units, which would result in increased hydraulic capacities compared to what was originally modeled for entrainment. Therefore, additional modeling is being carried out to incorporate these updated hydraulic capacities and an addendum to the final report will be distributed to the Aquatic Resources RC by August 31, 2024, and included in the USR (Appendix B, Attachment 1). Also, per the Commission's request in their ISR comments, a literature review will be carried out for the intrinsic population growth rate of threadfin shad. If recent literature is identified with this information, it will be considered for inclusion in the entrainment analysis and presented in the USR.

- **Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat:** CFD modeling results were used to qualitatively evaluate potential effects to Lake Jocassee stratification, dissolved oxygen, and temperatures throughout the water column. CHEOPS modeling results were used to assess potential effects within the littoral zone with a focus on lake level fluctuation effects. The draft report was provided to the Aquatic Resources RC for review on May 3, 2024. No comments were received; the final report was issued to the RC on June 3, 2024 and is included as Attachment B to this Study Progress Report.
- **Impacts to Surface Waters and Associated Aquatic Fauna:** A final report was distributed to the Aquatic Resources RC on February 14, 2024, and was filed as Attachment A of the fourth Quarterly Study Progress Report.

Variance from Approved Study Plan

The Entrainment Study and Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat were completed in accordance with the approved study plan. The Impacts to Surface Waters and Associated Aquatic Fauna study area was expanded to include the proposed Fisher Knob Access Road. Stream habitat surveys for five streams within spoil locations were not completed due to safety concerns related to inclement weather. These variances were reported in the ISR.

6.0 VISUAL RESOURCES STUDY

Duke Energy provided the draft study report to the Recreation and Visual Resources RC on May 22, 2024. No comments requiring revision to the study report were provided during the 30-day comment period. The final study report is attached to this report as Attachment C.

Variance from Approved Study Plan

The study is proceeding in accordance with the approved study plan. The proposed Fisher Knob Access Road has been incorporated into the viewshed model.

7.0 RECREATIONAL RESOURCES STUDY

The Recreational & Visual Resources RC met on May 9, 2024, to discuss the status of the Recreational Resources Study as described below.

- **Foothills Trail Recreation Use and Needs (RUN) Study**: Data collection including traffic and trail counts, in-person and online user surveys, and spot counts was completed in 2023 and data were processed in early 2024. During the May 9, 2024 meeting, results of the study were discussed, and the draft study report was provided to the RC for review on May 16, 2024 with comments due on June 16, 2024. Comments were received from the Foothills Trail Conservancy (FTC) and will be addressed in the USR. The draft Foothills Trail carrying capacity analysis report (to be included with the RUN Study Report as Appendix F) is complete and was distributed to the RC for review on June 26, 2024.
- **Foothills Trail Condition Assessment**: Fieldwork was completed in 2023 and the draft study report was submitted to the RC in November 2023 as well as included in the ISR. Duke Energy received comments on the draft report from the FTC, SCDNR, and Friends of Lake Keowee Society. The RC discussed these comments during the February 2024 meeting. Additional information was collected by Long Cane Trails to address some of the RC comments. A memo summarizing the additional information was prepared and distributed to the RC for review on June 26, 2024. The final report, which will include the additional information memo as an appendix, will be filed with the USR.
- **Whitewater River Cove Existing Recreational Use Evaluation**: This effort has been completed and the final report was included in the ISR as Appendix D, Attachment 3. No further work in association with this task is planned.
- **Whitewater River Cove Recreation Public Safety Evaluation:** This effort will integrate the CFD modeling surface velocity data developed in the Water Resources Study with the Whitewater River cove recreational use data captured during the 2023 boating season. Development of the draft report is underway and distribution to Recreational & Visual Resources RC members will occur in Q3 2024.

Variance from Approved Study Plan

The study is proceeding in accordance with the study plan as modified by FERC.

8.0 CULTURAL RESOURCES STUDY

The final report was attached as Attachment B of the fourth Quarterly Progress Report[2].

Variance from Approved Study Plan

The study was completed in accordance with the approved study plan; the geographic scope of the study area was expanded to encompass the proposed Fisher Knob Access Road.

9.0 ENVIRONMENTAL JUSTICE STUDY

The final report was filed as Appendix F of the ISR. No written comments were provided requesting modifications to the final study report. Duke Energy will continue to evaluate the need for additional outreach activities prior to the filing of the final license application.

Variance from Approved Study Plan

The study was conducted in accordance with the study plan as modified by FERC.

10.0 WILDLIFE AND BOTANICAL UPDATE

Duke Energy has developed a bat study plan in consultation with the South Carolina Department of Natural Resources (SCDNR) and U.S. Fish and Wildlife Service (USFWS) to carry out additional surveys for bats at the Project due to potential clearing associated with the proposed Fisher Knob Access Road, spoil areas, transmission line, and other areas of proposed power complex infrastructure. The final bat study plan was distributed to the Wildlife and Botanical RC on May 31, 2024. Copies of the study plan were also distributed to the U.S. Department of Agriculture (J. Magniez) and FERC staff (S. Salazar), per individual requests. Surveys were carried out between June 1 and June 20 in proposed impact areas including potential spoil sites and the proposed Fisher Knob Access Road, as well as areas potentially impacted by the proposed transmission line construction and maintenance. The potential impact areas contain suitable summer habitat, as outlined by 2024 USFWS guidelines, that require bat surveys according to linear and non-linear project protocols since tree clearing needs to take place during the restricted cutting timeframes. Bat surveys followed the 2024 Range-wide Indiana Bat and Northern Long-eared Bat Survey Guidelines.[3] The final Bat Study Plan prepared is provided with this Study Progress Report as Attachment D.

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[2] Consistent with FERC policy, the Cultural Resources report was submitted as Controlled Unclassified Information (CUI)/Privileged information.

[3] Range-wide Indiana Bat and Northern Long-eared Bat Survey Guidelines | FWS.gov

In response to a written request from the SCDNR in comments submitted to the Commission on the ISR, Duke Energy developed a study plan for the federally threatened small whorled pogonia. This study was designed to determine the presence or absence of this protected species prior to land disturbance activities associated with the access road and overall construction of the Bad Creek II Power Complex and to aid in the quality and comprehensiveness of the statewide dataset for rare, threatened, and endangered species. This survey and other fieldwork components were completed in June, 20024. Additionally, field biologists recorded incidental observations of priority plant species identified in the SC Wildlife Action Plan (SWAP) during the survey. The small whorled pogonia draft study plan was distributed to the SCDNR and USFWS for review and comment on May 24, 2024; neither agency had comment on the draft study plan, therefore, the final study plan was distributed to the Wildlife and Botanical RC on June 5, 2024 for review and comment. The final Small Whorled Pogonia Study Plan is provided with this Study Progress Report as Attachment E.

These studies will also support Clean Water Act 404 permitting to avoid and minimize impacts to endangered species, as well as preparation of the Biological Assessment (BA) for submittal to the USFWS [to comply with Section 7 of the Endangered Species Act] for the 404 permitting and license application.

11.0 PERMITTING ACTIVITIES

Initial work in support of Clean Water Act Section 404 / 401 permitting has begun; a pre-application meeting request was submitted to the U.S. Army Corps of Engineers (USACE) on February 23, 2024, and the meeting was held on March 28, 2024, in Columbia, South Carolina. Attendees includes representatives from USACE, USFWS, SCDNR, S.C. Department of Health and Environmental Control (SCDHEC), Catawba Indian Nation, Duke Energy, and Duke Energy's consultant (HDR Engineering, Inc.). The final meeting summary, which incorporated comments and feedback from the SCNDR and USACE, was distributed to meeting participants on June 7, 2024. A follow-up meeting with additional USACE staff was held at the USACE office in Columbia, SC on April 11, 2024, to discuss permitting activities and strategies associated with Bad Creek II Complex.

Attachment A: Water Exchange Rates and Lake Jocassee Reservoir Levels

(Final Report)

WATER EXCHANGE RATES AND LAKE JOCASSEE RESERVOIR LEVELS

FINAL REPORT

WATER RESOURCES STUDY

Bad Creek Pumped Storage Project
FERC Project No. 2740

Oconee County, South Carolina

March 26, 2024

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WATER EXCHANGE RATES AND LAKE JOCASSEE RESERVOIR LEVELS
BAD CREEK PUMPED STORAGE PROJECT
FERC PROJECT NO. 2740
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ACRONYMS AND ABBREVIATIONS

Bad Creek (or Project)	Bad Creek Pumped Storage Project
Bad Creek II	Bad Creek II Power Complex
Bad Creek Reservoir	upper reservoir
CFR	Code of Federal Regulations
cfs	cubic feet per second
CHEOPS	Computerized Hydro Electric Operations Planning Software
DCP	Drought Contingency Plan
Duke Energy or Licensee	Duke Energy Carolinas, LLC
EPD	Environmental Protection Division
ft	feet/foot
ft msl	feet/foot above mean sea level
FERC or Commission	Federal Energy Regulatory Commission
HDR	HDR Engineering, Inc.
HEC-DSS	Hydrologic Engineering Center Data Storage System
KT Project	Keowee-Toxaway Hydroelectric Project
LIP	Low Inflow Protocol
OSC	Operating Scenario Committee
PM	Performance Measures
RC	Resource Committee
RSP	Revised Study Plan
SCDNR	South Carolina Department of Natural Resources
SEPA	Southeastern Power Administration
sq mi	square miles
SR	Savannah River
TAF	thousand acre-feet
UIF	unimpaired incremental flow
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
1968 Operating Agreement	1968 Operating Agreement between USACE, SEPA, and Duke Energy
2014 Operating Agreement	2014 Operating Agreement between USACE, SEPA, and Duke Energy

1 Project Introduction and Background

Duke Energy Carolinas, LLC (Duke Energy or Licensee) is the owner and operator of the 1,400-megawatt Bad Creek Pumped Storage Project (Project) (FERC Project No. 2740) located in Oconee County, South Carolina, approximately eight miles north of Salem. The Project utilizes the Bad Creek Reservoir as the upper reservoir and Lake Jocassee, which is licensed as part of the Keowee-Toxaway (KT) Hydroelectric Project (FERC Project No. 2503), as the lower reservoir.

The existing (original) license for the Project was issued by the Federal Energy Regulatory Commission (FERC or Commission) for a 50-year term, with an effective date of August 1, 1977, and expiration date of July 31, 2027. The license has been subsequently and substantively amended, with the most recent amendment on August 6, 2018, for authorization to upgrade and rehabilitate the four pump-turbines in the powerhouse and increase the Authorized Installed and Maximum Hydraulic capacities for the Project.[1] Duke Energy is pursuing a new license for the Project pursuant to the Commission’s Integrated Licensing Process, as described at 18 Code of Federal Regulations (CFR) Part 5.

In accordance with 18 CFR §5.11 of the Commission’s regulations, Duke Energy developed a Revised Study Plan (RSP) for the Project and proposed six studies for Project relicensing. The RSP was filed with the Commission and made available to stakeholders on December 5, 2022. FERC issued the Study Plan Determination on January 4, 2023, which approved the Water Resources Study in the RSP as proposed.

This study was conducted in consultation with the Water Resources Resource Committee (RC), Aquatic Resources RC, Operations RC, and other interested stakeholders. Copies of consultation records are included in Appendix A of the Updated Study Report. This report includes the findings for Task 4 (Water Exchange Rates and Lake Jocassee Reservoir Levels) of the Water Resources Study.

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[1] *Duke Energy Carolinas LLC, 164 FERC ¶ 62,066 (2018)*

2 Study Goals and Objectives

Tasks carried out for the Bad Creek Water Resources Study have been consistent with the scope and level of effort described in the RSP filed with the Commission on December 5, 2022. This report is intended to provide sufficient information to support an analysis of the potential Project-related effects on water resources with clear nexus to the Project.

Operation of the proposed Bad Creek II Power Complex (Bad Creek II), which will add pumping and generating capacity to the Project, has the potential to affect the magnitude, rate, and frequency of water surface elevation changes[2] in downstream reservoirs. Therefore, the objective of this task is to update the existing Computerized Hydro Electric Operations Planning Software™ (CHEOPS) model developed during KT Project relicensing to evaluate reservoir elevation effects associated with water exchange rates, magnitude, and duration between Bad Creek Reservoir and Lake Jocassee. In addition, potential impacts to Lake Keowee levels and fluctuations resulting from operation of Bad Creek II are presented.

3 Study Area

The study area for the modeling effort includes the Bad Creek Reservoir, Lake Jocassee (i.e., the lower reservoir), Lake Keowee (Figure 3-1), and to a lesser extent, the three downstream reservoirs owned and operated by the U.S. Army Corps of Engineers (USACE).

[2] Water levels would be required to conform to the existing requirements of the KT Project License and associated agreements. Additionally, the originally licensed operating band of the upper Bad Creek reservoir (i.e., 160 feet) is not proposed to be modified.

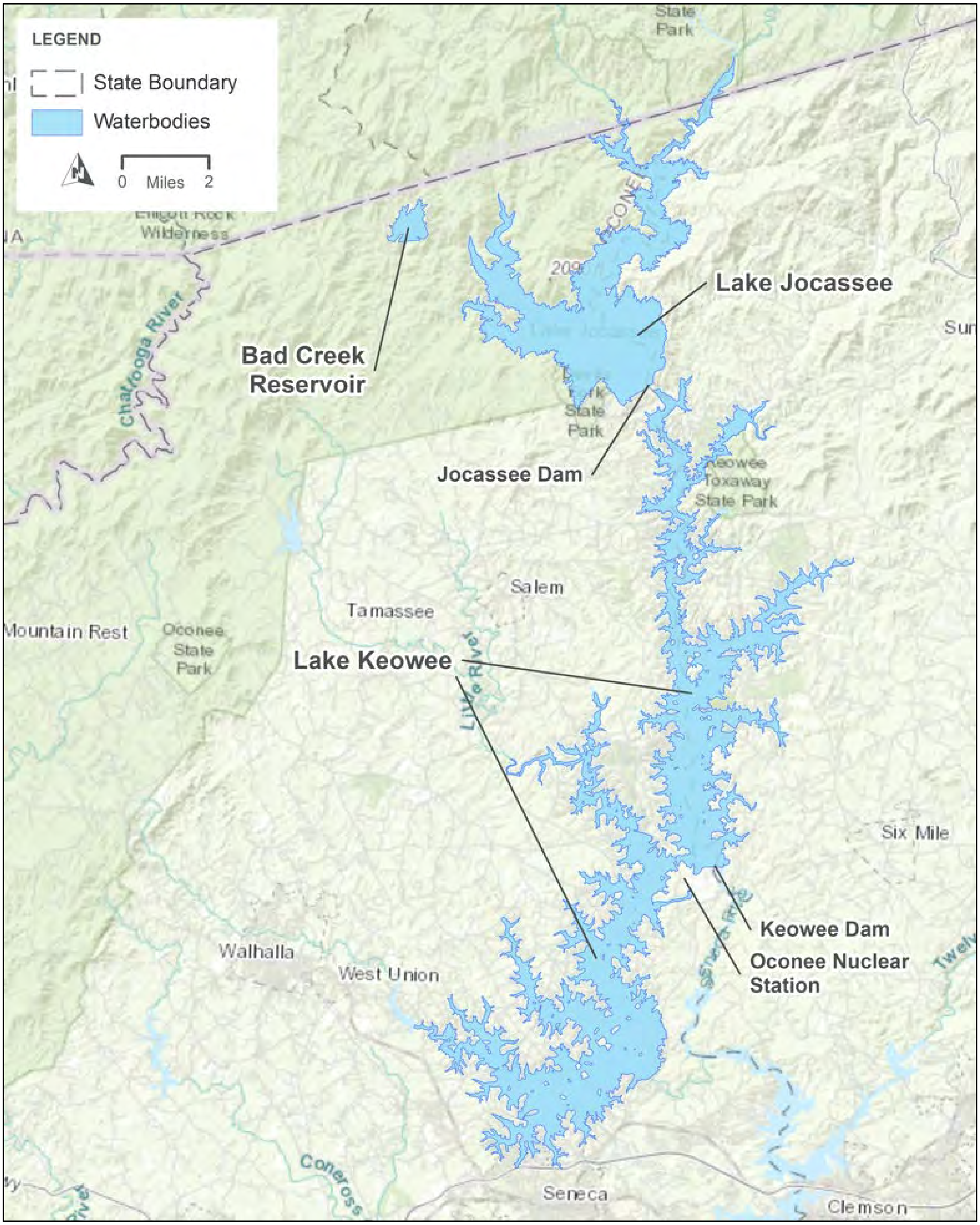

Figure 3-1. Study Area for CHEOPS Evaluation

4 Model Development

4.1 Model Overview

Duke Energy elected to use HDR's proprietary CHEOPS model to assess the effects of operations associated with the addition of Bad Creek II on the system's overall water exchange between the Bad Creek Reservoir and Lake Jocassee. CHEOPS is specifically designed to evaluate the effects of operational changes and physical modifications at multi-development hydroelectric projects. The model is a tool for evaluating a wide range of physical changes and operational constraints associated with relicensing and upgrading hydro facilities. One of the many strengths of the CHEOPS model is the degree of customization available to modelers; it can be tailored to meet the demands of the system being modeled. The CHEOPS program architecture provides a platform for investing project-specific features as defined by stakeholder interests.

CHEOPS utilizes daily flows, plant generating characteristics, and operating criteria of the system to simulate operations, allocate flow releases, and calculate energy production within the system. The model calculates headwater elevation, headlosses, net head, turbine discharge and spill, and power generation. CHEOPS is designed for long-term analysis of the effects of operational and physical changes made to the modeled hydroelectric system.

Modifications to the CHEOPS platform during KT relicensing to support the Savannah River (SR) CHEOPS Model included functionality enhancements enabling simulation of conditions (e.g., Duke Energy Low Inflow Protocol [LIP], and USACE Drought Contingency Plan [DCP]), which were developed during the KT Project relicensing process, as well as improved logic for upstream/downstream plant interactions, specifically with pumped storage plants in the system. The model was also enhanced to add wicket gate leakage for pumped storage plants when in partial pumping operations and the model administrative capabilities were modified to use OpenOffice instead of Microsoft Excel as the application which reads the model input files.

Additionally, a series of SR CHEOPS Model modifications were developed to support specific KT Relicensing Operating Scenario Committee (OSC) member group requests. The modifications included:

- The ability to specify reservoir fluctuation limits that are not a fixed elevation, but rather dependent upon the start-of-period elevation. This feature was added to support the request for fish spawning reservoir stabilization periods identified by the South Carolina Department of Natural Resources (SCDNR), and later was modified to be able to turn off this requirement when the LIP stage is other than "Normal."
- Enhanced support by upstream plants of downstream plant outflow requirements. The outflow enhancements take into account the sum of all required flows on the downstream plant, including required powerhouse outflows, wicket gate leakage, withdrawal requirements, and evaporation. This change prevents an upstream pumped storage or hybrid-pumped storage plant from pumping the downstream reservoir elevation too low when the downstream plant cannot meet its required flows releases.
- Pumped storage plant discharge operations may also be triggered/required without the requisite ability to pump back to support downstream plant outflow requirements.

A CHEOPS model is coded to run day-to-day operations based on a single set of operating conditions or rules. Actual hydroelectric operations generally follow the operating rules; however, human intervention periodically deviates from the general operating rules to accommodate day-to-day realities such as equipment failure and maintenance, changing hydrologic conditions, power demands, and other factors. In addition to differences between model operations versus actual operations that include human interventions, there are also inherent discrepancies due to input data inaccuracies (e.g., differences in calculated hydrology data, turbine or generator efficiencies, or reservoir storage curves). It is important to note CHEOPS model results cannot completely match historical or future operations due to these differences between actual operating conditions and modeled conditions.

4.2 Savannah River (SR) CHEOPS Model

The 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 (HDR 2014b). 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). Model output was evaluated by the OSC whose members represented relicensing stakeholder interests.

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 KT 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.[3]
- 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.

4.3 Model Verification

Model verification is intended to validate the input data and ability of the programmed logic in simulating daily hydroelectric and reservoir operations. HDR performed model verification of the SR CHEOPS Model during KT relicensing by using comparisons of actual and model-simulated generation and total discharge.

Verification of the model was completed using two different scenarios or model runs. The first performed a verification of the model input data, logic, and conditions for calendar years 1998 through 2008. This scenario is referred to as the historical baseline (A1). In addition to the historical baseline scenario, a second verification scenario (v2007) was developed to simulate the

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[3] On April 23, 2018, Duke Energy filed a Non-Capacity License Amendment Application to upgrade and refurbish the four Francis-type pump-turbines in the powerhouse, replace existing runners with Francis-type pump-turbine runners, and rehabilitate and/or upgrade the remaining components of the pump-turbine runners at the Bad Creek Project. Authorized Installed and Maximum Hydraulic capacities for the Project were increased to 1,400 megawatts (based upon the definition provided by 18 CFR §11.1[i]) and 19,760 cfs respectively.

detailed operations for calendar year 2007. Based on available historical generation records, modeled and historical generation were compared for the period 1998 through 2008 at all facilities except for Richard B. Russell. Generation at the Richard B. Russell development was only compared for the time period 2006 through 2008 because prior to 2006, Richard B. Russell pump units (four) were rarely operated. Generation data is commonly available for hydropower developments and is a metered value that has good accuracy compared to other forms of data that are not metered or based on estimated values with lower accuracy. The verification simulation was completed for hydrologic years with the best available historical reservoir operations over a wide range of hydrologic and reservoir operations conditions.

Generation is a measure of available flow and storage volume, which relates to inflows and reservoir elevations. When performing verification of water quantity models with power generation, it is common to find discrepancies between observed data and modeled output for generation and reservoir elevation when looking at a small sample of time periods (day, week, or month). This is due to the difference between the set of rules provided in the model vs. the day-to-day decisions common in large power developments that respond to power grid demands as well as storm forecasts and other non-measured impacts on the reservoir and equipment. Modeled results for each verification scenario were compared with historic generation, powerhouse flow, and reservoir levels. In addition to verifying the model under different hydrologic conditions, it was also important to select relatively recent years for model verification under conditions representative of current operating conditions.

As noted previously, the SR CHEOPS Model is coded to run day-to-day operations based on general operating conditions or rules. The model follows these rules strictly, 24 hours per day and 365 days per year, similar to an automated operation. Actual Project operations generally follow the operating rules, but deviations from general operating rules sometimes occur. Therefore, the verification goal is to obtain less than a five percent difference when comparing long-term modeled results to historical generation data over the hydrologic period. In cases where the modeled results exceeded a five percent difference, potential causes for the differences were examined to determine whether the difference was due to deviations in model setup, historical deviations in operations, or discrepancies in the reconstructed hydrology data.

4.3.1 Summary of Modeled Results versus Historical Operations

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).

The SR CHEOPS Model simulation of the historical baseline scenario (A1) estimated an average annual energy output two percent higher than historical generation for the same period, as shown in Table 4-1. There are significant annual swings in the percent difference between historical and modeled operations for the 1998 through 2008 period, with the largest variations at the Duke Energy facilities (as opposed to USACE facilities).

Table 4-1. Historical Base: Generation Comparison

Year	Bad Creek	Jocassee	Keowee	Hartwell	Richard B. Russell	J. Strom Thurmond	System Total
1998	4%	12%	5%	2%	--	-4%	4%
1999	7%	52%	-20%	0%	--	3%	14%
2000	0%	47%	15%	11%	--	11%	10%
2001	15%	16%	28%	11%	--	2%	14%
2002	5%	-10%	-9%	12%	--	24%	3%
2003	-9%	-9%	28%	24%	--	9%	-2%
2004	12%	-5%	17%	2%	--	4%	6%
2005	-3%	-10%	10%	3%	--	-8%	-4%
2006	5%	1%	-13%	-6%	-4%	-13%	0%
2007	-9%	6%	43%	21%	5%	12%	-1%
2008	-14%	-46%	38%	10%	7%	15%	-16%
Period Total (1998–2008)	**0%**	**1%**	**10%**	**7%**	**2%**	**3%**	**2%**

Note: Prior to 2006, the Richard B. Russell pump units (four) were rarely operated, therefore comparisons consider 2006-2008 only.

Duke Energy facilities are operated on demand with a priority on peaking operations to optimize the value of generation based on energy pricing, whereas USACE facilities are operated on a weekly baseload schedule. The result is that the operations of Duke Energy facilities (especially pumping operations) vary greatly depending on the value of generation. For the period assessed (1998-2008), the Duke Energy system was only required to release water to stay in balance with the system as outlined in the 1968 Operating Agreement[4] regarding stored water sharing (releases) from the then planned KT Project. The USACE system was driven by a combination of the power requirements to SEPA, the system storage balance, and the minimum discharge requirements from the J. Strom Thurmond Development (HDR 2014a).

As shown in Table 4-1, there are significant swings between modeled and historical generation. There are many factors inherent in the model data and setup that can contribute to output discrepancies (i.e., deviations) when compared to historical data. In many cases, several of these factors may be involved simultaneously, which makes it difficult to isolate individual sources of difference. Four examples of potential sources of deviations from historical data are:

- **Pumping Operations –** The model follows a set of defined rules for pumping, but it is seen in the historical records that pumping operations vary greatly from year-to-year, month-to-month, and even day-to-day. This is probably the single greatest contributor to deviations in the generation comparison and is also why the goal of this summary is to compare long-term trends rather than monthly or annual values.
- **Hydrology –** The model uses reconstructed unimpaired flow data as the input for daily inflow to the system. The unimpaired hydrology was synthesized based on streamflow gage data and plant records, both of which have a certain amount of inherent error especially when multiple locations and data sources are involved. The overall hydrologic dataset appears to be a good representation of daily inflows and is acceptable for use in future water management planning.
- **Minimum Streamflow Requirements –** The model is set up to account for minimum streamflow requirements automatically. As a result, the model is proactive in automatically addressing minimum streamflow requirements rather than reactive in providing excess flow to avoid potential violations, as may occur during actual operations.

[4] The 1968 Operating Agreement was an agreement between Duke Energy, the US USACE Savannah District, and the Southeastern Power Administration (SEPA). It was superseded by the 2014 Operating Agreement between the same parties.

- **Unit Outages and Performance –** The model has been set up with post upgrade/rehabilitation unit performance information and does not take into account detailed unit outage information. For example, Units 1 through 4 at Hartwell were rehabilitated over the 11-year period of 1997 through 2007 but unit outages associated with the rehabilitation were not taken into account in the model.

In interpreting the information provided in the model operations/verification report (HDR 2014b), it is important to consider purpose of the model: to reasonably characterize operations at the generation facility under evaluation. Comparing model results with historical data confirms use of the model as a tool for simulating “real” operations. It is not possible within reasonable time and budget constraints to account for every outside influence or condition to match historical operations and hydrology.

Small changes in input data or model logic can often result in large changes in output. This is due to a number of reasons including (but not limited to) runoff characteristics, reliance on coordinated operations, and numerous/variable flow requirements. Each of these elements individually contributes to the sensitivity of the system. Combined, the sensitivity effects are multiplied. The input data and logic in the historical base scenario is an attempt to consolidate the effects of these variables to achieve an approximation of “characteristic operations.”

The sensitivity described above also means that those factors that cannot be accounted for in the model (short-term operations decisions based on pricing, demand, forecasts, etc.) as well as data that are impossible to replicate exactly (synthesized hydrology data, shutdowns due to irregular maintenance, etc.) can result in relatively large discrepancies between modeled output and historical data on a per-month/per-development basis. The factors and sensitivity warrant careful model review with awareness of the potential for outliers. The ultimate acceptance of the results should not hinge on the extremes but rather on the overall impression of consistency between modeled and historical operations.

Most importantly, model verification should be used solely to assess the relative impacts between scenarios. In other words, model verification is really the only time it is appropriate to compare model results with historical data. As previously stated, verification is intended to validate the model input data and model logic so the “Base Case” becomes the baseline for all subsequent analyses.

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.

For more information about the validation of the SR CHEOPS model, see "Operations Model Study Savannah River Basin Model Logic and Verification Report" (HDR 2014b).

4.4 Project Data

4.4.1 Bad Creek Project

The Project uses the Bad Creek Reservoir as its upper reservoir and Lake Jocassee as its lower reservoir. The approximately 300-acre upper reservoir, formed by the damming of Bad Creek and West Bad Creek, has a drainage area of approximately 1.5 square miles (sq mi). Due to the small drainage area of Bad Creek Reservoir, inflows are minimal. The Bad Creek Reservoir normal maximum reservoir elevation is 2,310 feet (ft) above mean sea level (msl)[5] with a minimum elevation of 2,150 ft msl.

The powerhouse contains four reversible motor-pump/turbine-generator units. There is no license-required operating guide curve; rather the reservoir is operated as needed for generation.

4.4.2 Jocassee Development

Lake Jocassee, which operates as the lower reservoir for the Project, was formed by impounding the Keowee River just downstream of the confluence of the Whitewater and Toxaway rivers. Lake Jocassee has a drainage area of 145 sq mi, a surface area of approximately 7,980 acres, and approximately 92 miles of shoreline at normal full pond (1,110 ft msl). Normal minimum pond elevation is 1,080 ft msl.

[5] All vertical elevations in this report are National Geodetic Vertical Datum 1929 unless noted differently.

The Jocassee Development is a pumped storage facility with four reversible motor-pump/turbine-generator units. The SR CHEOPS Model uses an end of day target elevation of 1,107 ft msl.

The Jocassee Development and the downstream Keowee Development comprise the KT Project.

4.4.3 Keowee Development

Lake Keowee is formed by two parallel watersheds connected by a 2,000-ft-long canal. The watershed draining directly into Lake Keowee is approximately 439 sq mi. The reservoir surface area is approximately 17,660 acres at the normal full pond elevation of 800 ft msl.

Keowee Hydroelectric Station contains two conventional turbine-generator units. For SR CHEOPS modeling purposes, a target curve of 798 ft msl from May 1 to October 15, which then lowers gradually to 797 ft msl on January 1 and refills gradually by May 1, has been simulated to calculate usable storage for coordination with the USACE. Based on a review of historical operations of Lake Keowee, code was added to the SR CHEOPS Model for Lake Keowee to retain water in the Jocassee-Keowee pumped storage system for pumping and generating cycles. Because of this unique requirement, the model's target curve is not followed as strictly specified under normal hydroelectric reservoir operating conditions (HDR 2014b).

Based on the additional SR CHEOPS Model control at Lake Keowee, the model will not schedule discretionary releases from Lake Keowee unless the reservoir is nearing its normal full pond elevation and available storage for capturing runoff is reduced. This additional logic for Lake Keowee was applied and evaluated through verification of the model. This additional logic is user input whereas the SR CHEOPS Model can be adjusted to evaluate operational alternatives.

4.4.4 Hartwell Development

The Keowee Development releases water into the 55,900-acre Hartwell Lake which is operated by the USACE. Hartwell Hydroelectric Station has five conventional turbine-generator units. The Hartwell Development includes 5 ft of flood control storage from an elevation of 660 to 665 ft msl, which contains approximately 293,000 acre-ft of storage. A flood surcharge zone exists from 665 to 679 ft msl. A seasonally varying guide curve provides additional flood control during the winter and early spring. The minimum pool elevation is 625 ft msl (HDR 2014b).

4.4.5 Richard B. Russell Development

The 26,650-acre Richard B. Russell Lake is impounded by the USACE's Richard B. Russell Dam 30 miles downstream of the Hartwell Dam. The powerhouse contains four conventional turbine-generator units and four motor-pump/turbine-generator units. Two small house turbine-generator units were not modeled as part of the previous SR CHEOPS Model effort.

The Richard B. Russell reservoir includes 5 ft of flood control storage from an elevation of 475 to 480 ft msl. The limited conservation storage range between reservoir elevation 470 and 475 ft msl and fluctuation caused by pumping/generating cycles necessitates a constant guide curve with no seasonal drawdown (HDR 2014b).

4.4.6 J. Strom Thurmond Development

The 71,100-acre J. Strom Thurmond Lake is impounded by the J. Strom Thurmond Dam. The dam is located 37 miles downstream of the Richard B. Russell Dam. The powerhouse contains seven conventional turbine-generator units.

The objective of flood control regulation at the J. Strom Thurmond project is to reduce flood damages to the lower Savannah River basin to the extent possible. Normal pool varies seasonally from 330 ft msl April 1 through October 15; and between October 15 and December 15, the pool is drawn down to a seasonal normal pool of 326 ft msl to allow for the statistically higher winter and spring inflows. Starting January 1, the pool is refilled to reach 330 ft msl on April 1 (HDR 2014b).

4.5 Hydrology

The hydrologic dataset, Savannah River Unimpaired Flow 1939-2008 Time Series Extension Report (ARCADIS 2010), applied in the SR CHEOPS Model was provided by ARCADIS and prepared for Duke Energy, the Savannah District of the USACE, and the Georgia Environmental Protection Division (EPD). The study performed by ARCADIS developed unimpaired incremental flow (UIF) time series data (UIF database dated September 16, 2010) for the five hydroelectric developments on the Savannah River from Lake Jocassee to J. Strom Thurmond Lake. Due to the small size of the Bad Creek watershed, HDR developed the UIF to Bad Creek as a portioned one percent of the developed Jocassee UIF. As outlined in the Savannah River

Unimpaired Flow 1939-2008 Time Series Extension Report released by ARCADIS on August 12, 2010, these data are suitable for the following purposes:

- Reservoir system operational modeling by Duke Energy and the USACE, with the USACE serving as a cooperating agency for the FERC relicensing of Duke Energy's KT Project
- Reservoir operational planning studies by the USACE
- Determination of desired flow regimes and consumptive water-use assessments for Georgia EPD

The excerpt below from Section 1 of the Savannah River Unimpaired Flow 1939-2008 Time Series Extension Report (ARCADIS 2010) defines the methods applied in the development of the UIF time series data. All time series data were supplied in the USACE'S Hydrologic Engineering Center Data Storage System (HEC-DSS) databases.

> *Incremental and cumulative UIFs are developed for the Seneca River at the Jocassee and Keowee sites from historical stream flows and reservoir releases at these locations by removing (1) effects of reservoir regulation (holdouts and releases from storage), (2) differential pre- and post-reservoir net evaporation (i.e., evaporation minus precipitation excess from the reservoir surface area), and (3) consumptive water uses within the respective local drainage areas. General assumptions and methods applicable to UIF development under this study are subsequently described as follows.*

- *The period of record (POR) for UIFs developed under this study uniformly extends from January 1939 through December 31, 2008. UIFs previously developed by Georgia EPD for 1939–2007 (Georgia EPD 2010) were recalculated.*
- *Daily incremental UIFs were developed at the following nodes within the Savannah River basin: Jocassee (Seneca River); Keowee (Seneca River); Hartwell, Richard B. Russell (U.S. Geological Survey [USGS] gage 02189000, Calhoun Falls); Bell (Broad River, USGS gage 02192000); Thurmond, Augusta (USGS gage 0219700); Burtons Ferry (USGS gage 02197500); Millhaven (Brier Creek, USGS gage 02198000); and Clyo (USGS gage 02198500).*

- *Georgia EPD has provided daily potential evapotranspiration (PET) time series data computed using the Hamon equation that extend from January 1, 1939 to December 31, 2008. These have been used in the computation of reservoir evaporation following procedures used in the development of the January 1, 1939 to December 31, 2007 UIF time series.*
- *Federal and non-federal reservoir holdouts, net evaporation, and daily inflows and outflows have been computed and applied as appropriate to UIF derivation. For reservoirs where time series data required for these calculations are not available, run-of-river operation has been assumed. Operational data were provided by Duke Energy, including Bad Creek Reservoir elevation time series data and elevation and outflow time series data for the Jocassee and Keowee projects, in addition to elevation-area-storage paired data for the Keowee and Jocassee projects.*
- *UIF data development has been primarily accomplished by filling and routing of missing 1939 to 2008 historical flow data and by adjustments for reservoir effects and water uses. Techniques may involve application of Riverside's TSTool software and USACE DSS utilities, interactively and by batch programming. All time series and paired data have been stored in HECDSS databases and map-referenced as approved by Georgia EPD. UIF development has largely relied upon time series previously developed by ARCADIS U.S., Inc. (ARCADIS) for Georgia EPD.*
- *Historical water use data, on a daily or monthly time step, have been provided by Georgia EPD in electronic form quality-controlled and suitable for UIF development. Water use data extends from 2005 to 2008.*
- *Routing techniques for observed flow filling and UIF derivation have been selected by ARCADIS for consistency with existing 1939 to 2007 Savannah UIF data previously developed for Georgia EPD.*

Additional information on the development of the UIF is available in the Savannah River Unimpaired Flow 1939-2011 Time Series Extension Report revised by ARCADIS in May 2013 (ARCADIS 2010, 2013).

During the initial stages of the model scenario development phase of the KT Project relicensing process, the OSC identified the desire to have a Savannah River Basin inflow dataset that verified well against the most severe historical drought period on record, the 2007-2008 drought. Through a review of inputs and assumptions used in the SR CHEOPS Model, the OSC concluded there was too much water accounted for in the back calculated incremental inflow time series. The OSC requested an investigation to determine the source of the apparent inconsistency in the inflow time series during 2007-2008 when comparing modeled results to historical data. ARCADIS assisted HDR with a review of the inflow time series development and documentation. The review compared the inflow time series to USACE calculated inflow series and recommended using a different combination of inflow data (from within the September 2010 HEC-DSS database) for all reservoirs with the most significant differences in the Richard B. Russell Lake. These datasets were pulled from the supplied September 2010 HEC-DSS files. The OSC approved revising the model inflow data series in the SR CHEOPS model.

The 1939 through 2008 hydrologic dataset adopted by the OSC in August 2012 was used for KT model relicensing scenario development from September 2010 through December 2012. In the fall of 2012, Duke Energy, following a recommendation from the OSC, funded an extension of the inflow dataset by three years. The inflow dataset was extended by ARCADIS using the same methodology developed to construct the original dataset expanding the period of record (POR) to 1939 through 2011. The final revised dataset was provided by ARCADIS on May 13, 2013, and extended the existing inflow hydrology files in the SR CHEOPS model as described in detail in the May 2013 Savannah River Unimpaired Flow Data Report (ARCADIS 2010, 2013).

4.6 Baseline Scenario

4.6.1 Logic

Figure 4-1 and Figure 4-2 provide an overview of the model logic in sequence.

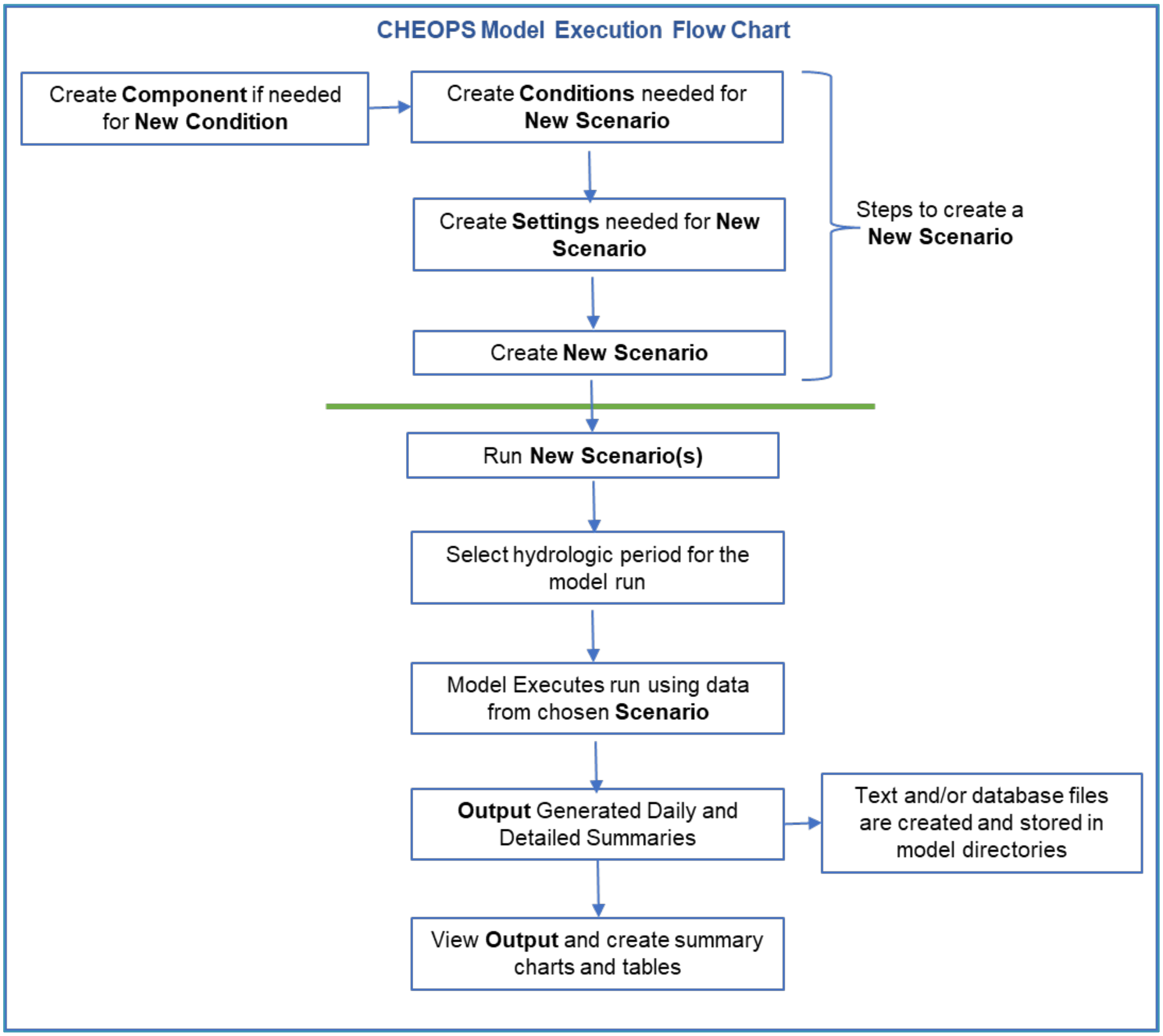

Figure 4-1. CHEOPS Model Execution Flow Chart

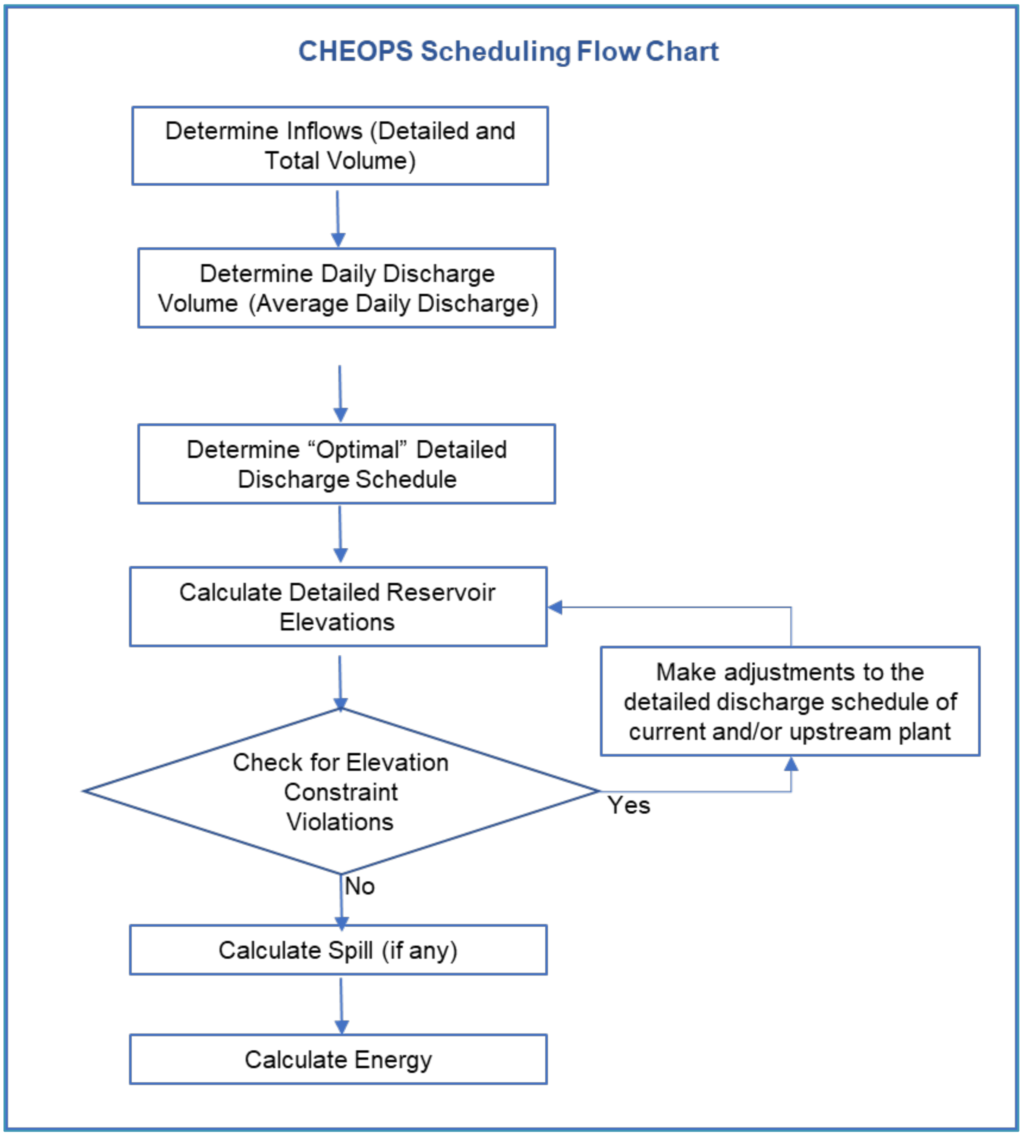

Figure 4-2. CHEOPS Scheduling Flow Chart

4.6.2 Input Data

The input data listed in the following subsections show the general operational constraints and physical parameters used in the SR CHEOPS Model to define the existing system configuration for the Baseline scenario setup. The following subsections are organized by the four components that define a CHEOPS scenario, as shown on Figure 4-3.

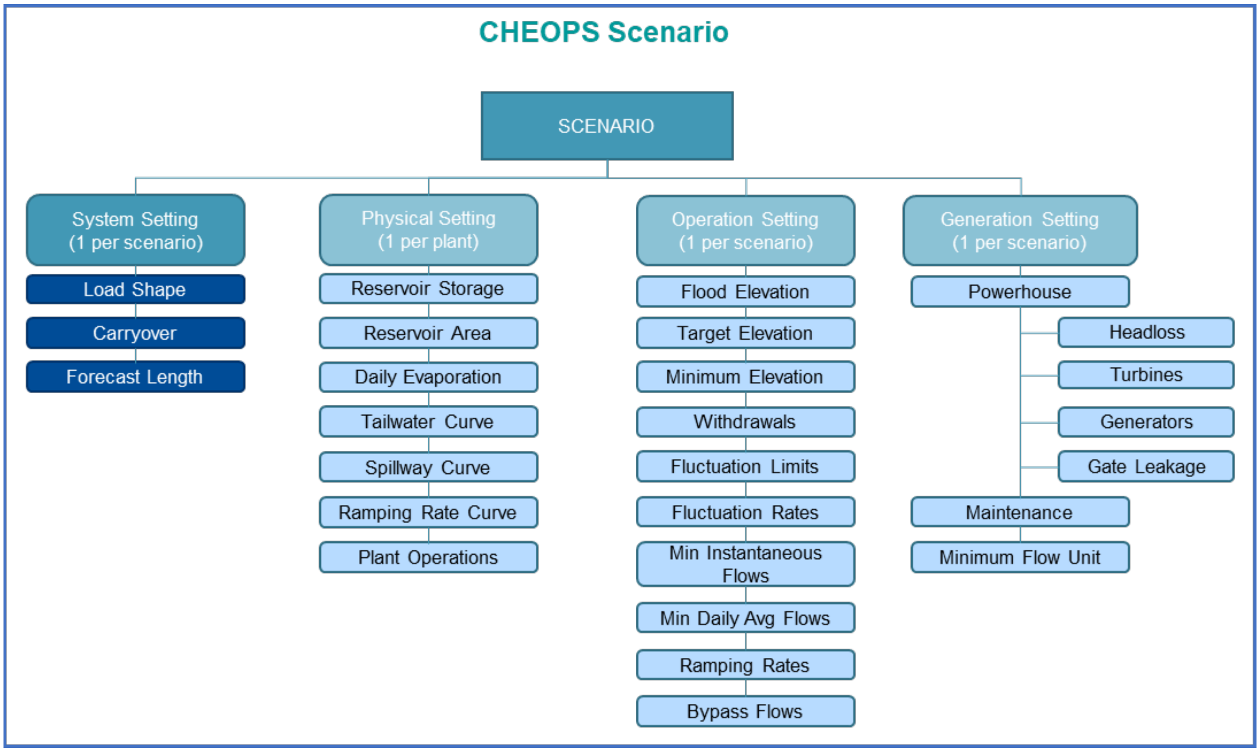

Figure 4-3. CHEOPS Scenario

4.6.3 System Data

4.6.3.1 Load Shapes and Energy Values

This section contains the load shape and energy value data common to the facilities on the Savannah River. The SR CHEOPS Model load shape defines the daily schedule, on an hourly basis, of relative power pricing and the hour durations of each price in the peak, off-peak, and shoulder periods, as presented in Table 4-2 and Table 4-3. The model uses the load shape data to schedule the release of water throughout the day, prioritizing generation during peak periods. Durations for the load shape reflect anticipated changes in operation as additional renewable generation is incorporated into Duke Energy's generation portfolio.

Table 4-2. Load Shape – Weekday Schedule

Weekday Schedule (hours/day)						
Month	**Morning Off Peak**	**Morning Secondary Peak**	**Morning Peak**	**Afternoon Secondary Peak**	**Afternoon Peak**	**Evening Secondary Peak**
January	1	5	2	10	3	3
February	1	5	2	10	4	2
March	1	5	2	11	2	3

Weekday Schedule (hours/day)						
Month	**Morning Off Peak**	**Morning Secondary Peak**	**Morning Peak**	**Afternoon Secondary Peak**	**Afternoon Peak**	**Evening Secondary Peak**
April	1	5	2	11	2	3
May	1	5	1	13	1	3
June	1	0	2	17	2	2
July	1	0	2	17	2	2
August	1	0	1	18	2	2
September	1	5	2	11	1	4
October	1	5	2	10	2	4
November	1	5	2	10	3	3
December	1	5	2	10	1	5

Table 4-3. Load Shape – Weekend Schedule

Weekend Schedule (hours/day)					
Month	**Morning Off Peak**	**Morning Peak**	**Afternoon Off Peak**	**Afternoon Peak**	**Evening Off Peak**
January	5	3	10	4	2
February	5	3	10	3	3
March	6	2	11	2	3
April	5	3	11	2	3
May	1	7	12	2	2
June	1	7	12	2	2
July	1	3	15	4	1
August	1	3	15	4	1
September	1	3	16	3	1
October	1	2	16	4	1
November	6	2	9	5	2
December	6	2	9	6	1

4.6.3.2 Carry-Over Elevations Condition

The Carry-Over Elevations Condition controls how to treat the beginning-of-year and end-of-year elevations. The model begins a run (scenario simulation) on January 1 of the start year with each reservoir at its target elevation. If the scenario is run for a multiple year period, then the model can either start subsequent years with the reservoirs at the target elevations or at the end of previous year elevations.

The Carry-Over Elevations is selected (i.e., the checkbox is checked) in this model. Therefore, the model will carry-over the end-of-year elevations to the next year, and reservoirs will start the next year at the ending elevations of the previous year.

4.6.3.3 Forecast Set-Up Condition

The Forecast Set-Up Condition requires two inputs: a number of forecast days, and an accuracy of the forecast. The number of days is how many days the model looks ahead in the inflow file to calculate how much water the system is going to receive. The model is set up to look 1 day ahead with 100 percent accuracy. Since the model has "perfect" forecasting as it looks at the actual inflow file, the accuracy setting allows the user to adjust the model's ability to forecast accurately. The accuracy setting adjusts inflow by a fixed multiple. The model looks ahead the given number of days, adds up the inflows, multiplies those inflows by the entered accuracy value, then schedules releases based on this forecasted inflow volume. If the accuracy setting is not 100 percent (1.0), then the forecasted volume is not accurate. By running the model with 90 percent (0.9) accuracy, and then running again at 110 percent (1.1) accuracy, the user can simulate operations where the operator has an ability to forecast inflows plus or minus 10 percent.

4.6.3.4 Operating Agreement (Storage Balance Operations)

This section provides details of the storage relationship between the Duke Energy and USACE facilities resulting from the development of the 2014 Operating Agreement which is implemented as part of the Baseline scenario for use during ongoing Bad Creek relicensing.

On October 1, 1968, Duke Energy's predecessor company, Duke Power Company, entered into 1968 Operating Agreement with the USACE Savannah District and SEPA regarding stored water sharing (releases) from the planned KT Project. The 1968 Operating Agreement was replaced by the 2014 Operating Agreement in conjunction with KT Relicensing.

The 2014 Operating Agreement defines balancing of the available storage in Duke Energy reservoirs (Bad Creek, Jocassee, and Keowee) with USACE available storage (Hartwell, Richard B. Russell, and J. Strom Thurmond) according to storage balance rules as outlined in the 2014 Operating Agreement. The SR CHEOPS Model incorporates the terms of the 2014 Operating Agreement through a series of programming rules where balance checks are performed on weekly basis. These rules are integral in simulating the storage relationships between the developments and significant time was spent refining these rules in the SR CHEOPS Model.

When a tandem or parallel reservoir system is defined within the SR CHEOPS Model, the model determines the priority and the amount of release to make from each reservoir to operate towards a user-defined storage balance. For every decision interval, an end-of-period storage is first estimated for each reservoir based on the sum of beginning-of-period storage and period average inflow volume, minus all potential outflow volumes. The estimated end-of-period storage for each reservoir is compared to a desired storage that is determined by using a system storage balance scheme. The priority for release is then given to the reservoir that is furthest above the desired storage. When a final release decision is made, the end-of-period storages are recomputed. Depending on other constraints or higher priority rules, system operation strives for a storage balance such that the reservoirs have either reached their guide curves or they are operating at the desired storage (percent of the active storage zone).

The storage balance operations of the system are simulated in CHEOPS using an OpenOffice-based input sheet referenced by the CHEOPS drought plan input. Each reservoir in the system from Lake Jocassee to J. Strom Thurmond Lake is simulated with a drought plan. The USACE developed and updated the DCP to help sustain the basin's water supply needs for domestic and industrial water users, navigation, and environmental protection. To decelerate the decline in reservoir elevations during the early stages of drought, the USACE reduces weekly average flow releases from the Hartwell and J. Strom Thurmond developments. Once the DCP has been activated, flows are reduced in a step-wise fashion starting with a reduction of downstream releases from J. Strom Thurmond Lake. Reservoir elevations at Lake Hartwell and J. Strom Thurmond Lake are kept in balance during both normal and drought conditions.

During 1988 drought conditions, the J. Strom Thurmond and Hartwell Lakes were almost 17 and 15 ft below the top of their conservation pools, respectively. (The conservation pool is the amount of usable storage in the reservoir.) Accordingly, during the 1988 drought period, the USACE was not able to fully meet authorized project purposes. This led the USACE to initially develop the 1989 DCP with three trigger levels (USACE 1989). In 2006, the DCP was revised to include a fourth trigger level. The 2006 DCP allows the USACE to maintain higher pools at the reservoirs without further impacts to any water intakes upstream or downstream of the dams. In

2012, the DCP flows required out of J. Strom Thurmond Lake were revised, along with the addition of an inflow trigger.

The reservoir storage at the Bad Creek Project and Richard B. Russell developments are not included in the DCP. However, for model stability purposes and implementation of the KT LIP, Bad Creek reservoir and Richard B. Russell Lake storage are included in the CHEOPS Model storage index calculations while using a rule-link but no reservoir storage adjustments are required. Each reservoir in the system is linked to its downstream reservoir (except as noted) with a system storage balance relationship. The storage balance definition defines the rate of drawdown at each reservoir in relation to the next downstream reservoir and is user definable. The application of the storage balance definition simulates the system in accordance with the 2014 Operating Agreement and the USACE DCP.

4.6.3.5 Low Inflow Protocol (LIP)

This section provides details of the SR CHEOPS Model functionality to simulate the LIP.

The LIP specifies how Duke Energy will operate the Bad Creek and KT Projects during droughts. The LIP includes five stages based on specific triggers (i.e., remaining usable storage and DP levels, stream flows, and the U.S. Drought Monitor[6]). The LIP also specifies maximum reservoir drawdowns and maximum downstream flow releases from Keowee Hydro Station based upon the specific LIP stage. It should also be noted the remaining usable storage for determination of LIP stage (only applicable at Duke Energy reservoirs) is based on normal full pond elevations.

The SR CHEOPS Model incorporates the terms of the LIP as outlined in the KT Project FERC license through a series of programming rules. The LIP functionality was added to the SR CHEOPS during KT Relicensing to enable LIP stage definitions and specify required actions for each LIP stage. Model logic measures, on the specified day, the Duke Energy usable storage based on full pond elevations and gage hydrology, then implements the LIP stage change after the appropriate delay. The LIP adds Bad Creek and Richard B. Russell reservoirs to the USACE

[6] The U.S. Drought Monitor is produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the National Oceanic and Atmospheric Administration, and the U.S. Department of Agriculture. It blends precipitation, streamflows, temperatures, evaporative demand, and other factors to interpret drought conditions.

DCP usable storage calculations, which required modifications to the USACE DCP input file. The modifications to the USACE DCP file to reflect the LIP include specifying whether to include the Bad Creek and Richard B. Russell reservoirs in the usable storage calculation, and also provided cells for inputting the elevation which is considered bottom of usable storage pool for all six reservoirs.

Additional SR CHEOPS model parameters associated with the LIP include:

- The minimum elevation for Lake Keowee is 790.0 ft msl. However, the elevation will remain above 791.5 ft msl until the Duke Energy system remaining usable storage is at or below 12 percent (see Table 4-4).
- The percentage of Duke Energy remaining usable storage at which the outflow from Lake Keowee is limited to evaporation, water use, and leakage is 12 percent.
- The LIP minimum reservoir elevations for each LIP stage as listed in Table 4-4.
- The Lake Keowee water release calculation uses 790.0 ft msl as the minimum Lake Keowee reservoir elevation for the calculation of Duke Energy remaining usable storage.
- The Jocassee minimum reservoir elevation for the calculation of Duke Energy remaining usable storage is 1,080.0 ft msl.
- Full pond at the Duke Energy reservoirs is defined as the maximum elevation in the remaining usable storage calculation.
- The volume of storage in the Bad Creek Upper Reservoir from elevation 2,310.0 ft msl to 2,150.0 ft msl is included in the calculation of Duke Energy storage balancing contribution with the USACE system.
- The volume of storage in the Richard B. Russell reservoir between elevations 475.0 ft msl and 470.0 ft msl is included in the USACE remaining usable storage balancing calculations.

The Baseline scenario references USGS gage averaging using a 4-month rolling average and LIP logic to reference “triggered” DCP level versus “in-effect” DCP level during LIP recovery. The referenced DCP level allows the LIP to change more quickly to a lower stage number during the recovery process, eliminating the 2-ft recovery delay in the USACE’s DCP.

Table 4-4. Lakes Jocassee and Keowee Low Inflow Protocol Stage Minimum Elevation

LIP Stage	Lake Jocassee Elevation (ft msl)	Lake Keowee Elevation (ft msl)
0	1,096.0	796.0
1	1,092.0	795.0
2	1,087.0	793.0
3	1,083.0	792.0
4	1,080.0	791.5*

*Note: In LIP Stage 4, the Keowee reservoir elevation will be maintained at or above 791.5 ft msl until the Duke Energy storage balance reaches 12 percent. The minimum elevation used to calculate the usable storage for storage balancing with the USACE is 790.0 ft msl.

Additionally, LIP/DCP functionality includes the following logic:

- Functionality to allow the user to limit spring lake stabilization to LIP Stage 0 (Normal).
- Functionality to allow the user to specify that the USACE and Duke Energy reservoir storage balancing logic use full pond elevation versus target elevation at Duke Energy reservoirs for calculations of usable storage.
- Functionality to fine-tune simulated Lake Keowee operations and limit discharge from Lake Keowee by allowing the user to define a percentage above the target curve (published in the 1968 Operating Agreement) for the model to attempt to maintain a Full Pool.
- Functionality to allow the user to define two Maximum Required Weekly Release volumes from Lake Keowee for LIP Stage 4. The first is based on a Duke Energy Percent Usable Storage Remaining trigger and the second is the default if less than the defined Duke Energy Percent Usable Storage Remaining.
- Functionality to allow the user to revise the LIP logic to reference “triggered” DCP level versus “In-Effect” DCP level during LIP recovery. This allows the LIP to more quickly change to a lower stage number during recovery process, eliminating the 2-foot recovery delay in DCP protocol.
- Ability to set lake level fluctuation base elevation to be set at the lowest instantaneous elevation from the day prior to the start of the lake stabilization period.

4.6.3.6 System Power

The USACE developments have a power generation requirement with SEPA to achieve a minimum generation value (HDR 2014b). The weekly generation requirement can be met by any combination of the three USACE plants, and the requirement value varies by month. The weekly targets are based on power contracts with SEPA, as listed in Table 4-5. These values are currently entered into the model in the Drought Plan input sheet.

Table 4-5. Weekly Target Generation from USACE Projects

Month	Weekly Target Generation (megawatt-hours)
January	27,233
February	26,714
March	20,669
April	18,504
May	21,948
June	25,935
July	31,195
August	32,035
September	30,685
October	27,304
November	26,284
December	27,104

4.6.4 Physical Data

4.6.4.1 Reservoir Storage Curves

The Reservoir Storage Curve is a tabulated link between the reservoir elevation and reservoir volume. The model uses this curve to calculate elevations based on inflows and model-determined releases. Figure 4-4 shows the Bad Creek reservoir storage curve based on LiDAR data collected in 2018.[7] The Lake Jocassee and Lake Keowee storage-volume relationships were based on bathymetric data collected in 2010 (Figure 4-5 and Figure 4-6) and the USACE storage-volume relationships for Hartwell, Richard B. Russell, and J. Strom Thurmond lakes (Figure 4-7 through Figure 4-9) were based on published storage-volume relationships revised based on applying regional sedimentation rates from the Savannah River basin. Sedimentation rates were converted to sediment volume using methods outlined in USACE Engineer Manual 1110-2-4000 and estimated compressed density of the sediment[8].

[7] Values for 2110 feet and lower are based on historic 1974 data.

[8] Storage volume curves for the USACE reservoirs are identical to those used during KT relicensing. No additional sedimentation was calculated.

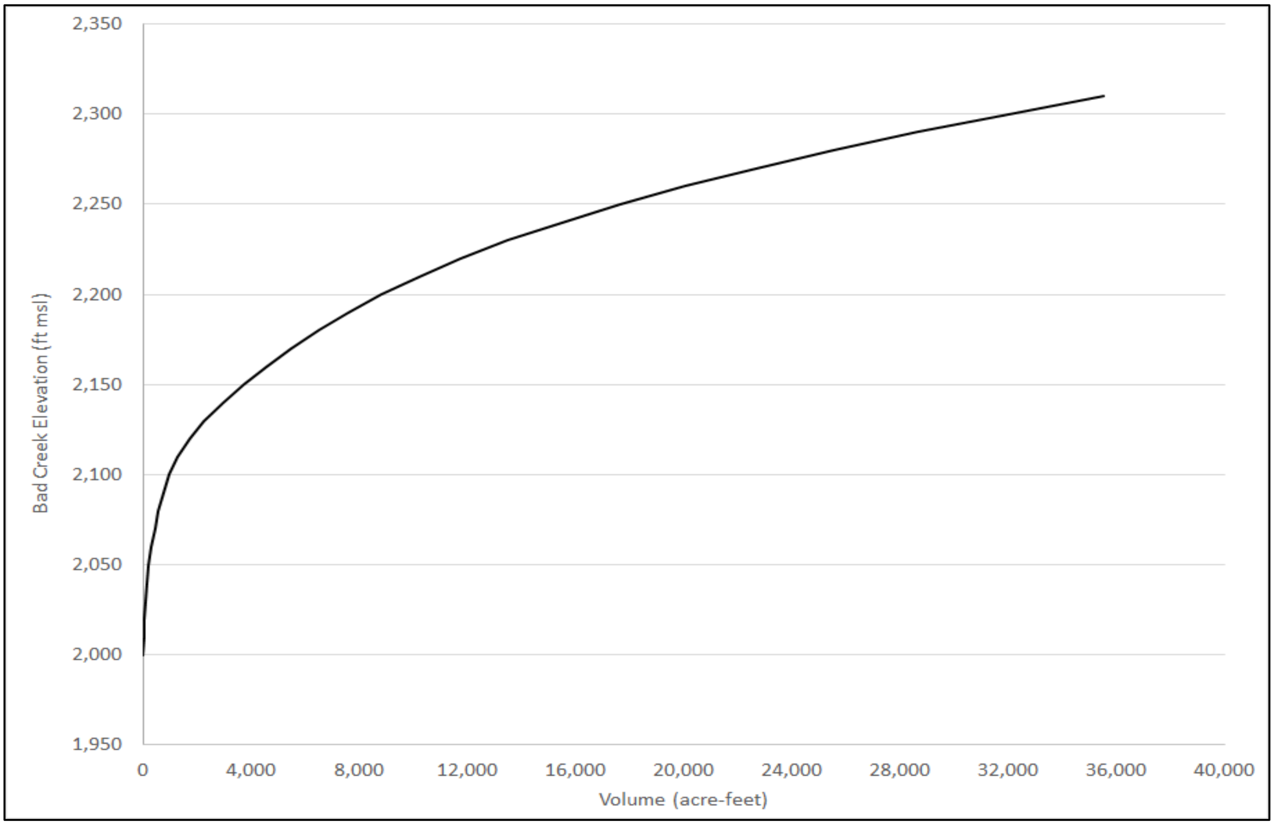

Figure 4-4. Bad Creek Reservoir Storage Volume Curve

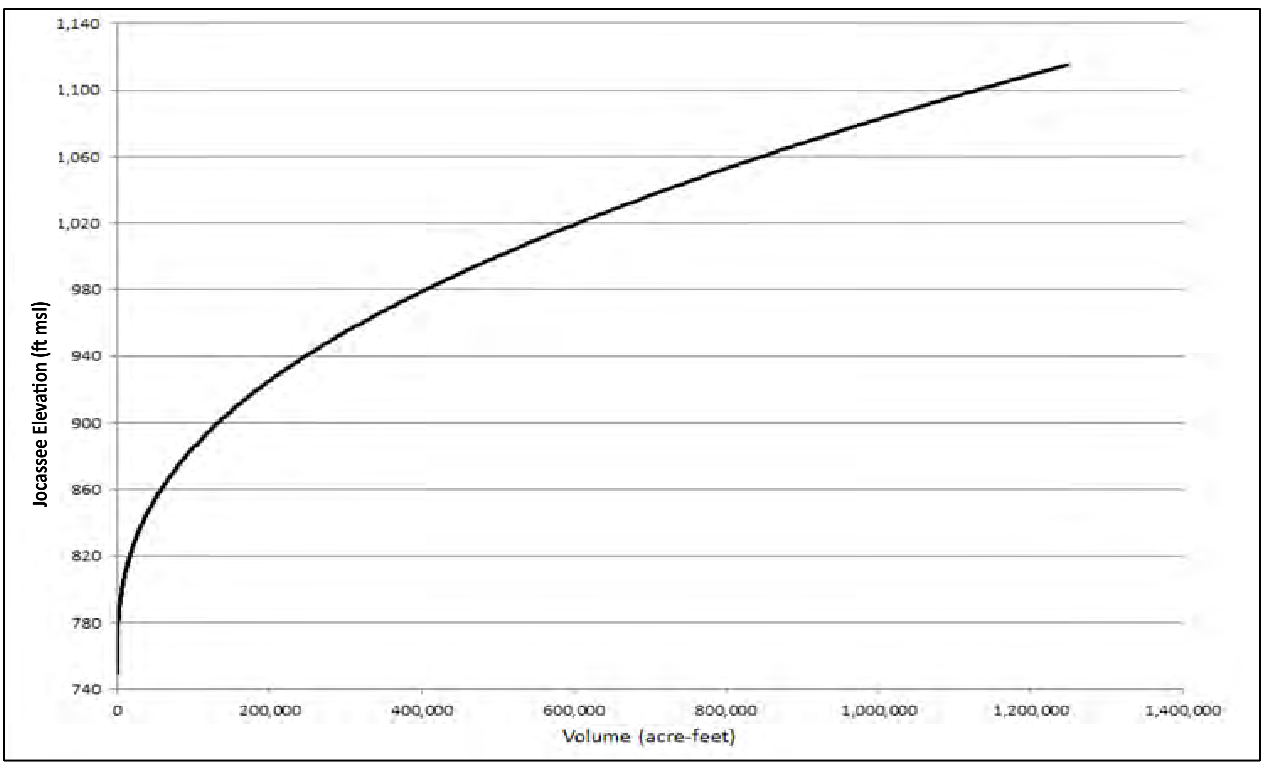

Figure 4-5. Jocassee Reservoir Storage Volume Curve

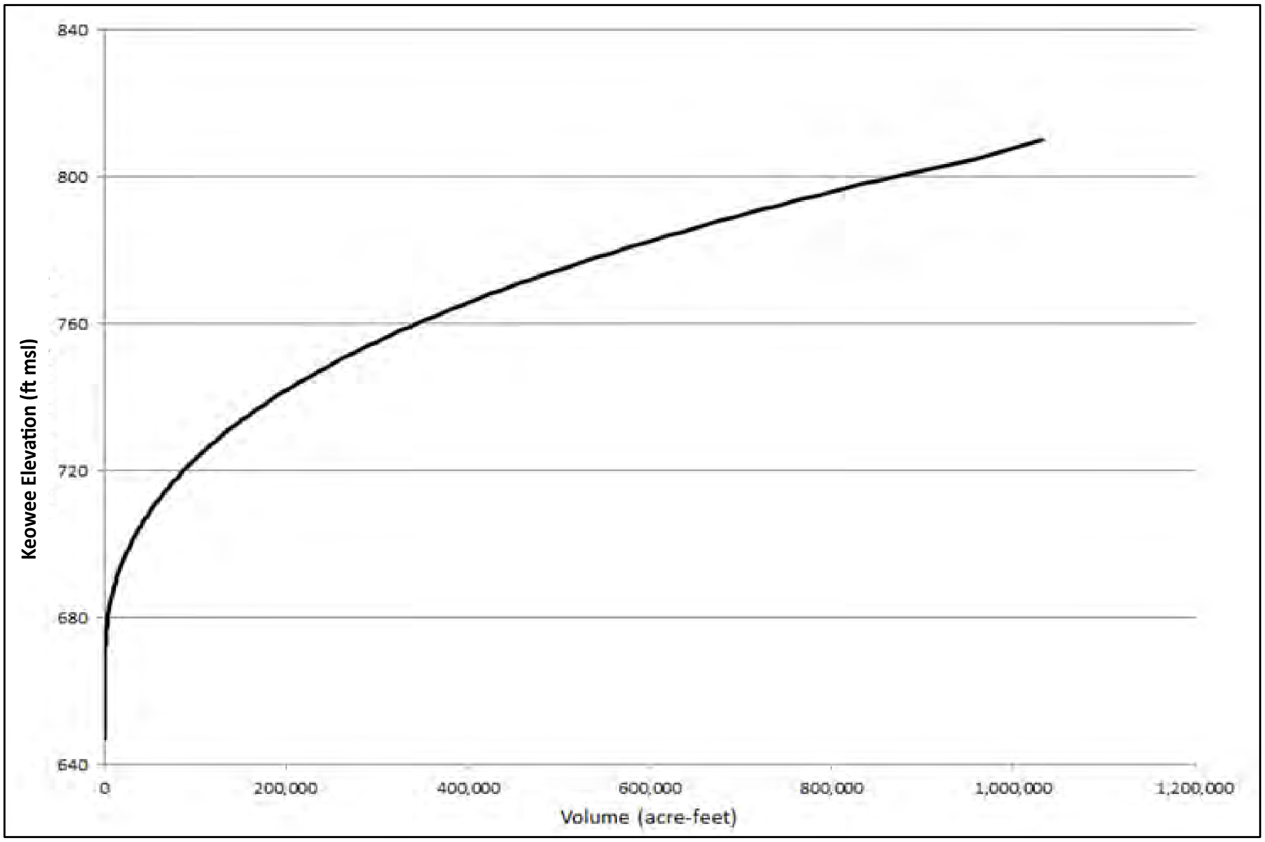

Figure 4-6. Keowee Reservoir Storage Volume Curve

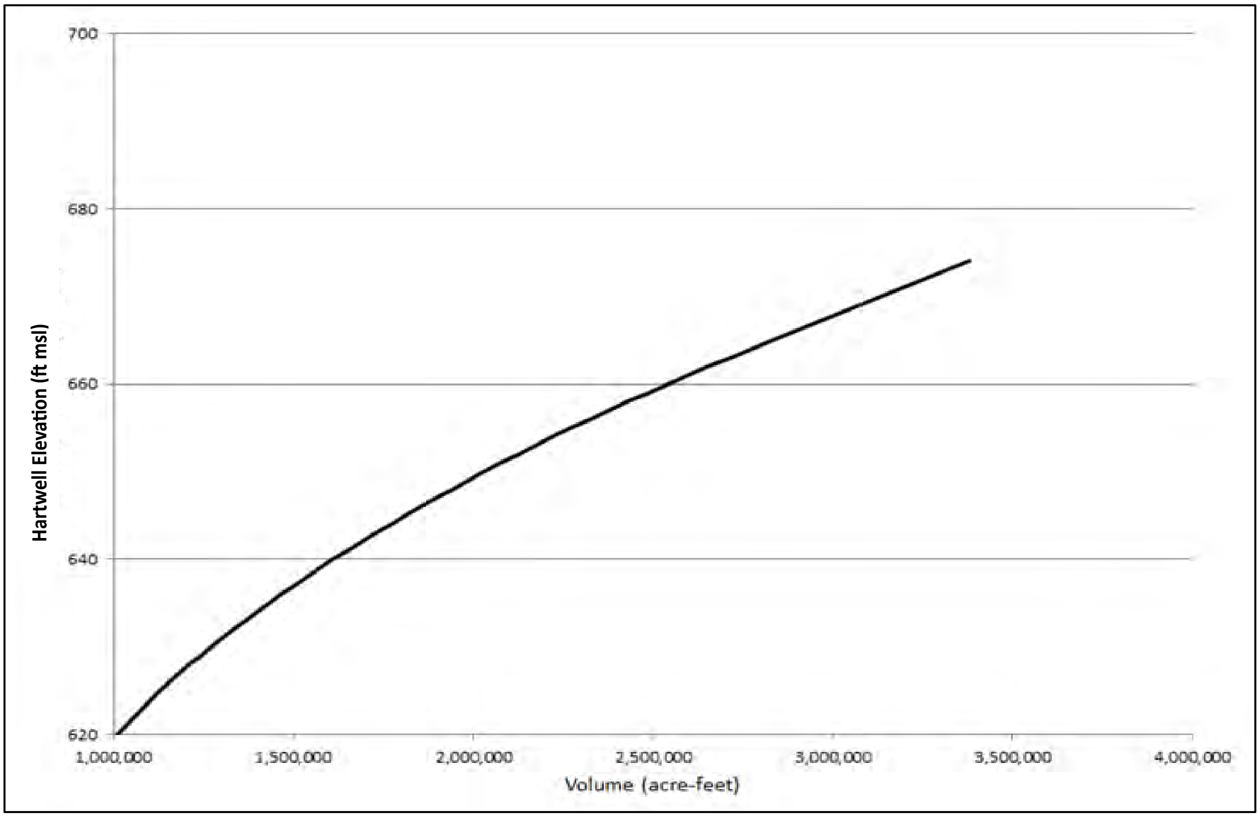

Figure 4-7. Hartwell Reservoir Storage Volume Curve

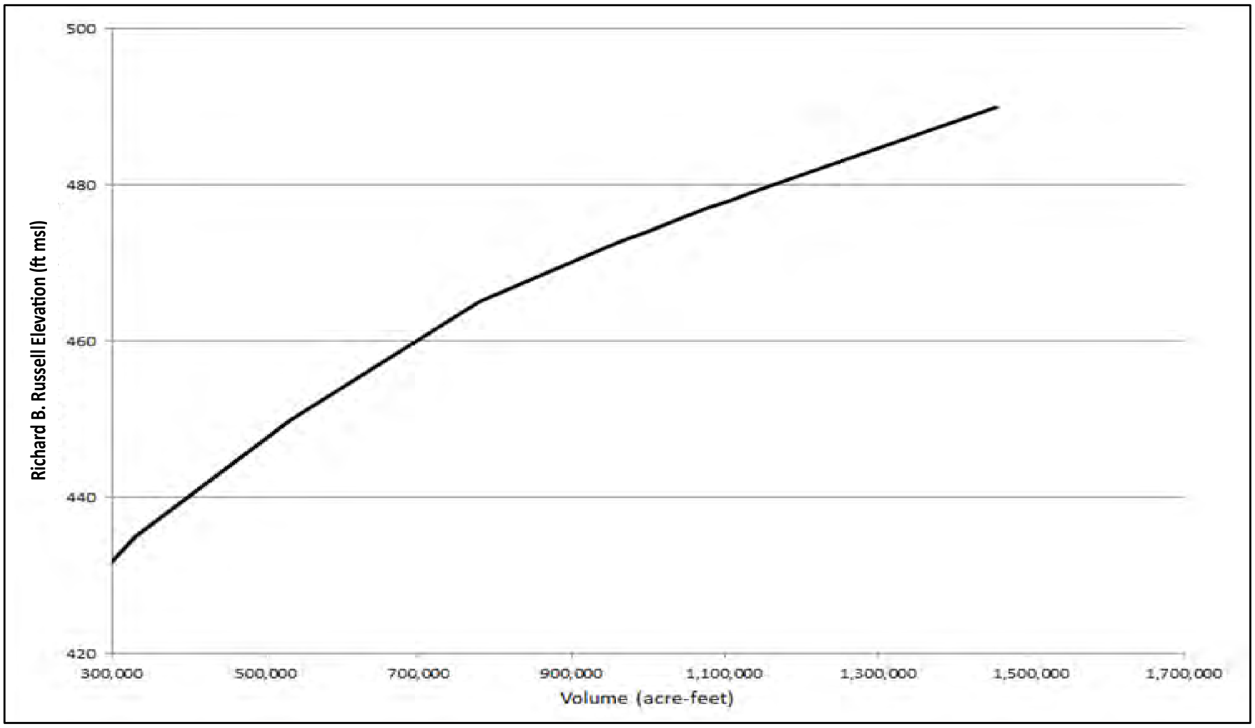

Figure 4-8. Richard B. Russell Storage Volume Curve

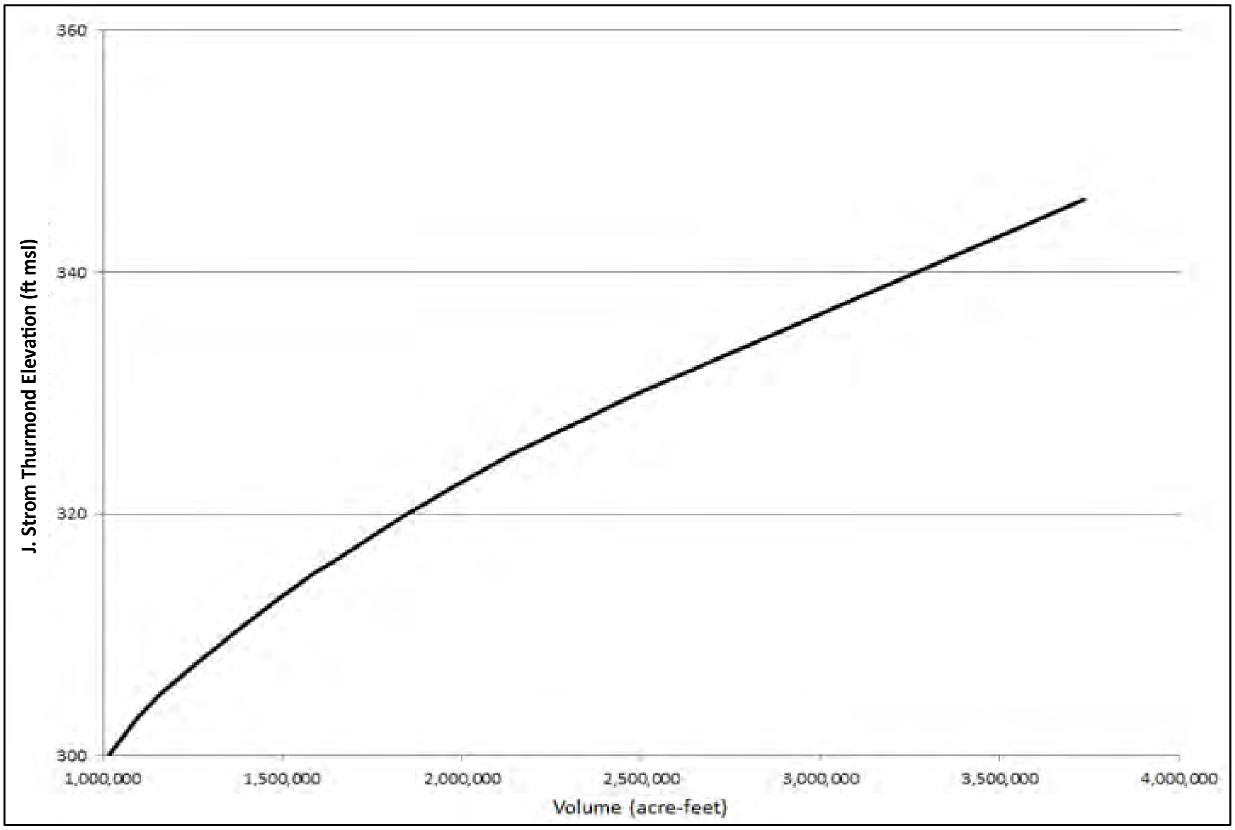

Figure 4-9. J. Strom Thurmond Reservoir Storage Volume Curve

4.6.4.2 Reservoir Area Curves

The Reservoir Area Curve is a tabulated link between the reservoir elevation and reservoir surface area. The model uses this curve to calculate the surface area and uses this data for computing evaporation losses. Figure 4-10 through Figure 4-15 show the reservoir area curves used in the model.

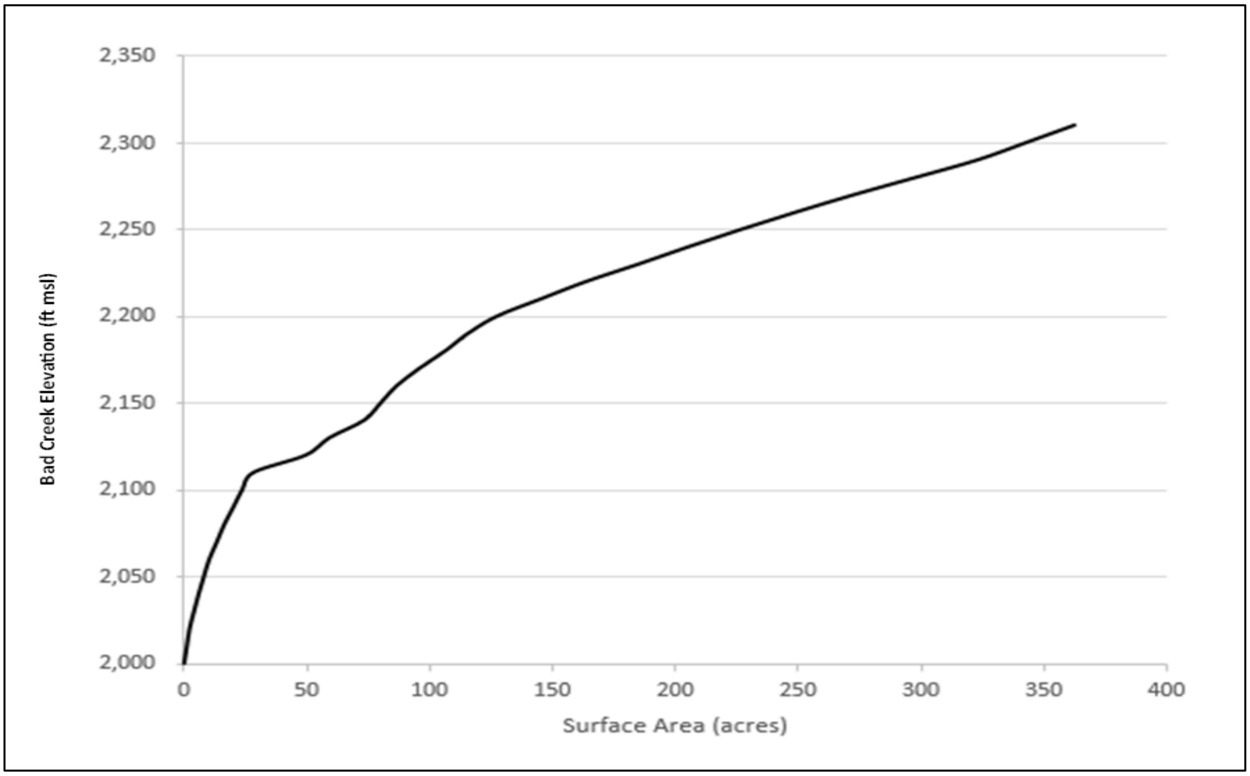

Figure 4-10. Bad Creek Reservoir Area Curve

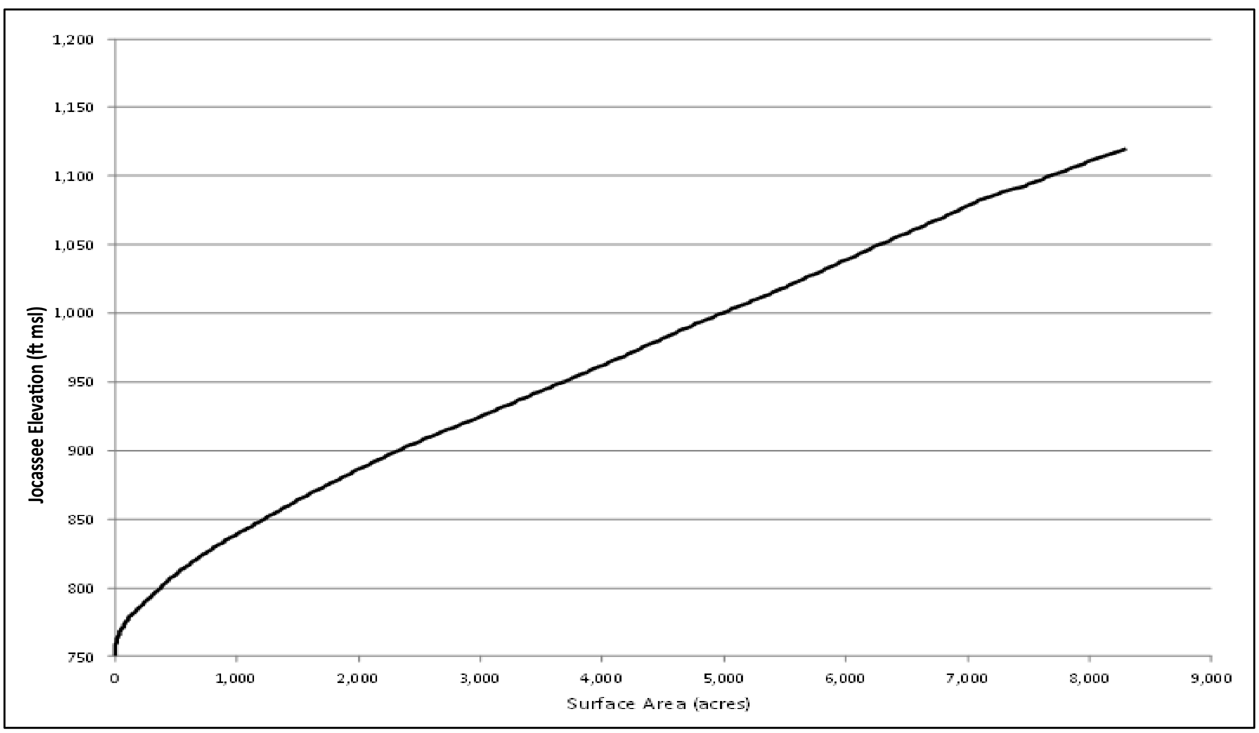

Figure 4-11. Jocassee Reservoir Area Curve

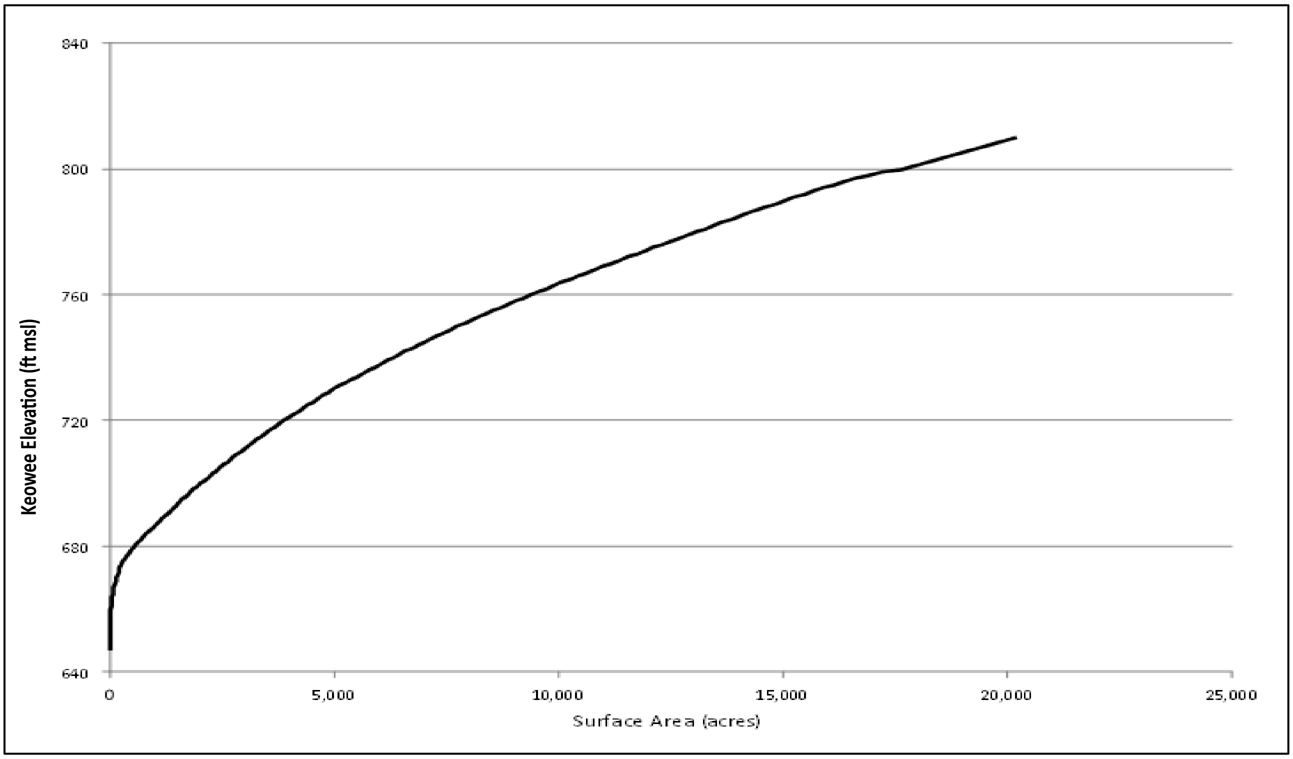

Figure 4-12. Keowee Reservoir Area Curve

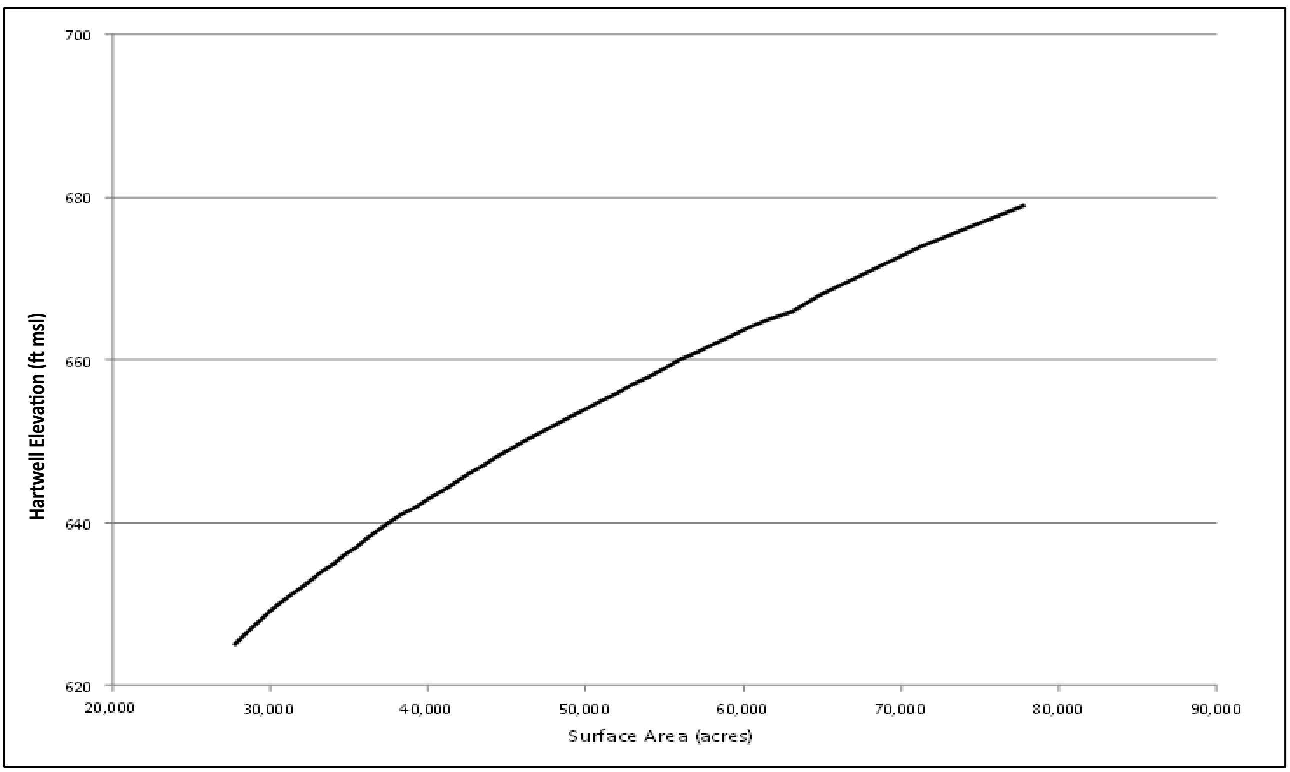

Figure 4-13. Hartwell Reservoir Area Curve

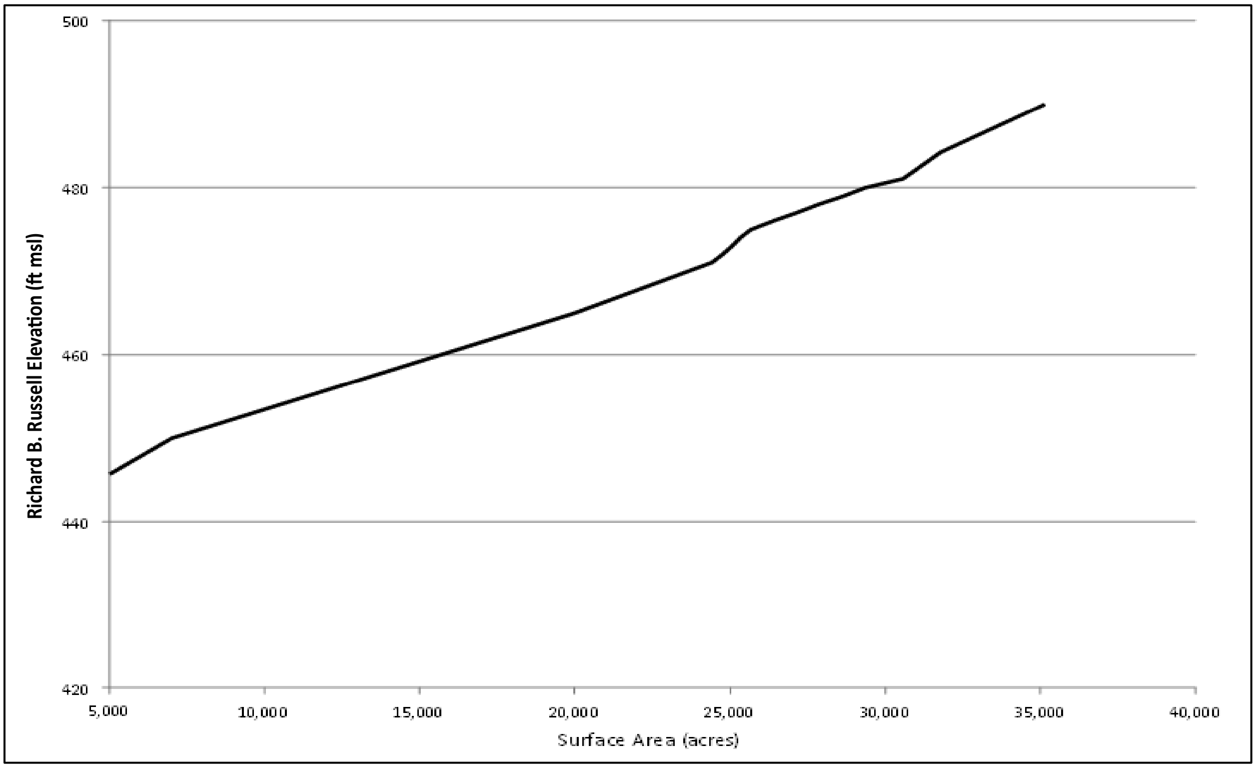

Figure 4-14. Richard B. Russell Reservoir Area Curve

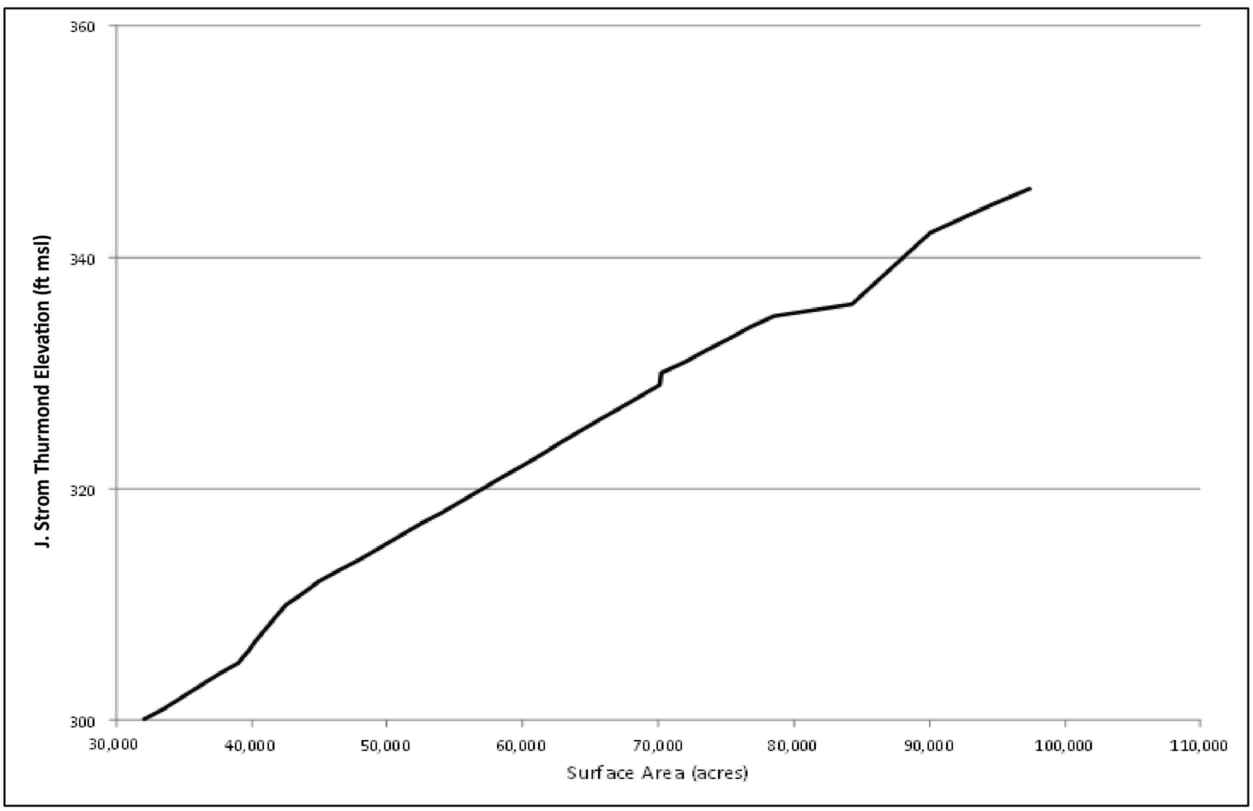

Figure 4-15. J. Strom Thurmond Reservoir Area Curve

4.6.4.3 Monthly Evaporation

Evaporation is based upon a monthly varying coefficient that defines the evaporative loss per reservoir. This evaporative loss is not strictly composed of losses due to evaporation, but rather a net change to inflows due to evaporation, direct precipitation to water surface, precipitation runoff, and changes to evapotranspiration losses. Negative values indicate a net inflow to the reservoir. Based on the median data, the precipitation inflow to the reservoir exceeds the evaporation from the reservoir. This coefficient (which is entered into the model in ft per day per acre) is multiplied by the surface area of the reservoir to compute total evaporative loss volume for the reservoir. Table 4-6 shows the SR CHEOPS Model evaporation loss coefficients for each reservoir by month. The evaporation loss coefficients reflect the monthly 2008 values published by ARCADIS in the Savannah River Basin May 13, 2013, time series release (ARCADIS 2010, 2013). The September 16, 2010 ARCADIS time series release contains the same 2008 evaporation values as provided in the May 2013 release.

Table 4-6. Evaporative Loss Coefficients

Month	Bad Creek Evaporation Loss (ft/day/acre)	Jocassee Evaporation Loss (ft/day/acre)	Keowee Evaporation Loss (ft/day/acre)	Hartwell Evaporation Loss (ft/day/acre)	Richard B. Russell Evaporation Loss (ft/day/acre)	J. Strom Thurmond Evaporation Loss (ft/day/acre)
Jan	-4.2E-03	-2.8E-03	-1.5E-03	-1.5E-03	-1.1E-03	-3.2E-03
Feb	-2.3E-03	-7.6E-04	1.0E-04	4.3E-05	-5.7E-04	-1.9E-03
Mar	-6.8E-03	-4.2E-03	6.9E-05	1.6E-05	-6.2E-05	-8.3E-05
Apr	2.5E-03	4.0E-03	4.6E-03	4.1E-03	4.1E-03	3.6E-03
May	6.1E-03	7.4E-03	6.6E-03	7.6E-03	9.6E-03	8.9E-03
Jun	1.1E-02	1.2E-02	1.3E-02	1.2E-02	1.3E-02	1.3E-02
Jul	6.3E-03	8.0E-03	9.1E-03	8.6E-03	6.5E-03	7.8E-03
Aug	-1.2E-03	1.2E-03	1.0E-03	1.9E-03	4.2E-03	3.9E-03
Sep	5.4E-03	6.4E-03	7.1E-03	7.9E-03	6.7E-03	6.4E-03
Oct	7.4E-04	1.8E-03	2.6E-03	2.1E-03	8.5E-04	7.4E-04
Nov	-1.6E-03	-6.5E-04	1.3E-04	1.3E-04	-1.1E-03	-6.4E-03
Dec	-8.8E-03	-6.6E-03	-5.8E-03	-4.9E-03	-3.0E-03	-3.4E-03

4.6.4.4 Tailwater Data

The Tailwater Curve relates the powerhouse tailwater elevation to the development’s outflow. In cases where the powerhouse releases directly into a downstream reservoir, the downstream reservoir’s elevation is used to compute tailwater elevation. The tailwater elevation is subtracted from the reservoir elevation to calculate the gross head used in determining turbine and pump-turbine hydraulic performance.

Bad Creek releases directly into Lake Jocassee, so the elevation of Jocassee is the controlling factor for Bad Creek's tailwater elevation. Likewise, the Jocassee powerhouse releases directly into Lake Keowee, so the elevation of Keowee is the controlling factor for Jocassee's tailwater elevation computation.

The Keowee powerhouse discharges into Hartwell Lake. However, due to backwater effects in the upstream lake channel, there is a difference between Hartwell Lake elevation (at Hartwell Dam) and the water surface elevation below the Keowee powerhouse when the turbines are in operation. Table 4-7 shows the Keowee Development's powerhouse tailwater curve in stage units of ft msl for various powerhouse outflows in cfs.

Table 4-7. Keowee Powerhouse Tailwater Rating Curve

Stage (ft msl)	Flow (cfs)	Stage (ft msl)	Flow (cfs)
657	0	680	39,867
660	5,042	684.8	59,879
665.1	11,345	689.9	85,879
670	16,545	695	113,612
674.9	26,000		

Similar to Bad Creek and Jocassee Hydro, the Hartwell powerhouse releases directly into Richard B. Russell Lake without backwater effects. Therefore, the Richard B. Russell Lake elevation is the control for Hartwell Hydro Station's tailwater elevation. The CHEOPS Model uses the greater of 475 ft msl or Richard B. Russell Lake water surface elevation. Reservoir elevation 475 ft msl is the minimum tailwater elevation provided by the USACE for modeling purposes.

Richard B. Russell powerhouse releases into J. Strom Thurmond Lake. The J. Strom Thurmond Lake elevation is the control for Richard B. Russell's tailwater elevation. The J. Strom Thurmond tailwater rating curve is shown in Table 4-8.

Table 4-8. J. Strom Thurmond Powerhouse Tailwater Rating Curve

Stage (ft msl)	Flow (cfs)	Stage (ft msl)	Flow (cfs)
187	0	220	280,000
190	15,000	230	440,000
200	65,000	240	640,000
210	155,000	250	870,000

4.6.4.5 Spillway Capacity

The Spillway Curve contains the data relating reservoir elevation and spillway discharge capacity. These data allow the model to determine the maximum amount of water that can be spilled at the current reservoir elevation and is the sum of all spillway conveyances with gates open to maximum setting. The CHEOPS Model allows for a simple spillway relationship of elevation and flow; therefore, all spillways, including gates, are modeled as a relationship of elevation and flow.

Spillway capacity data for the Bad Creek Project is shown in Table 4-9, derived from the Bad Creek Pumped Storage Project Supporting Technical Information Document (Duke Energy 2008). The Bad Creek emergency spillway is also known as the East Dike.

Table 4-9. Bad Creek Spillway Values

Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)
2,313.5	0	2,315	2,313
2,313.8	17	2,315.5	4,477
2,314.3	477	2,316	7,153
2,314.6	1,051		

Table 4-10 shows the maximum spillway capacity of the two-gated spillways as delineated in the Jocassee Development Supporting Technical Information Document (HDR 2010).

Table 4-10. Jocassee Total Gated Spillway Capacity Values

Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)
1,077	0	1102	34,531
1,082	2,762	1107	46,054
1,087	8,117	1112	58,671
1,092	15,374	1117	67,321
1,097	24,248	1122	74,138

Four-gated spillway capacity values for Keowee are shown in Table 4-11 as delineated in the Keowee Supporting Technical Information Document (HDR 2012a).

Table 4-11. Keowee Total Gated Spillway Capacity Values

Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)
765	0	790	63,268
770	5,505	795	82,550
775	15,851	800	102,810
780	29,399	805	123,645
785	45,393	810	144,639

The spillway capacities of the USACE projects are shown in Table 4-12 through Table 4-14. These values include original data provided by the USACE, as represented in the Savannah River ResSim Model.

Table 4-12. Hartwell Total Gated Spillway Capacity Values

Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)
630	0	657	258,924	666	416,148
635	16,800	658	274,896	667	434,184
640	52,800	659	291,288	668	452,508
645	102,000	660	308,100	669	471,120
650	160,800	661	325,320	670	489,996
653	199,248	662	342,972	671	509,160
654	213,540	663	361,032	672	528,600
655	228,252	664	379,500	673	548,316
656	243,384	665	398,400	674	568,308

Table 4-13. Richard B. Russell Total Gated Spillway Capacity Curves

Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)
436	0	473	0	482	630,000
440	0	474	0	483	650,000
450	0	475	0	484	670,000
455	0	476	0	485	690,000
460	0	477	0	486	710,000
465	0	478	0	487	725,000
470	0	479	0	488	740,000
471	0	480	593,000	489	755,000
472	0	481	620,000	490	771,000

*Spill elevation set to 475.3 ft msl and spillway capacity set to zero below 480 ft msl to support logic to prevent pumping above 475 ft msl.

Table 4-14. J. Strom Thurmond Total Gated Spillway Capacity Values

Elevation (ft msl)	Capacity (cfs)	Elevation (ft msl)	Capacity (cfs)
300	0	325	405,000
305	27,000	330	545,000
310	95,000	335	688,000
315	182,000	340	855,000
320	282,000	345	1,025,000

4.6.4.6 Plant Operation Type

The Plant Operation Type is how the CHEOPS model classifies and operates the plants. Four different components are used to describe the operation of the plants.

- **Min Powerhouse Flow –** All plants in this model have zero (0) value entered, as the turbine input curves accurately define the lowest operating flow of the units.

- **Plant Operation Type –** This condition specifies what type of scheduling logic is to be used for the plant. Options include Strictly Peaking, Non-generating, Run-of-River, and others. The plant operation types for the nodes in this model are shown below. Pumped storage plants follow pumping and discharge schedules. Strictly Peaking plants use logic to generate as much power as possible during the peak period, followed by secondary-peak and then off-peak periods. Hybrid-pumped storage plants have a pumping schedule, but schedule plant discharge using peaking plant logic.
    - Bad Creek – Pumped Storage
    - Jocassee – Hybrid-Pumped Storage
    - Keowee – Strictly Peaking
    - Hartwell – Strictly Peaking
    - Richard B. Russell – Hybrid-Pumped Storage
    - J. Strom Thurmond – Strictly Peaking
- **Delinked Owner –** This condition sets the level of water conveyance support a plant receives and provides to other plants operated by the same licensee/operator. All plants in the model have this value unchecked, meaning the plants provide supporting operation to other plants operated by the same owner.
- **Delinked System –** This condition sets the level of support a plant receives and provides to other plants operated by other licensees/operators in the modeled system. All plants in this model have this condition checked, meaning the default CHEOPS logic for support between plants is not in effect for plants operated by different operators. In this model, other methods and rules of setting the support between plants and owners are used.

4.6.5 Operational Data

4.6.5.1 Spill and Minimum Elevations

The spill or flood control elevation relates to a variety of physical situations (spillway crest, partial gate coverage, maximum normal pool, etc.), but it represents the elevation at which the model will begin to simulate spill to avoid increasing water elevation. Under a Strictly Peaking plant, when the model calculates an end-of-period elevation above the spill elevation, the model will calculate spill as well as the turbine/diversion discharge. The model's logic, under a Strictly

Peaking plant, also attempts to reduce or eliminate occurrences when the reservoir elevation exceeds the spill elevation.

The minimum elevation is the minimum allowable reservoir elevation. This elevation could be set by regulations or by a physical limit (lowest available outlet invert). Bypass flows, withdrawals, wicket gate leakage, and evaporation can draw the reservoir below this level. The model will operate to eliminate occurrences when the reservoir elevation dips below this elevation.

Table 4-15 lists the spill and minimum elevations for each development in the model.

Table 4-15. Reservoir Spill and Minimum Elevations

Development	Spill Elevation (ft msl)	Minimum Elevation (ft msl)
Bad Creek	2,310	2,150
Jocassee	1,110	1,080
Keowee	800	790
Hartwell	665	625
Richard B. Russell*	475.3	470
J. Strom Thurmond	335	312

* Richard B. Russell spill elevation set to 475.3 ft msl and spillway capacity set to zero below 480 ft msl to support logic to prevent pumping above 475 ft msl.

4.6.5.2 Target Elevations

The Target Elevation is the user-defined elevation that the model attempts to meet (targets) as the end-of-day reservoir elevation. The model straight-line interpolates between user input points to identify a target elevation for each day. The model will deviate from the target to accommodate forecasted inflows, to meet the plant's own outflow requirements or constraints, and to support downstream minimum flow requirements from the J. Strom Thurmond development.

Table 4-16 lists the guide curve elevations for the Duke Energy reservoirs (curves needed for modeling), and Table 4-17 lists the guide curves for the USACE reservoirs. Target requirements for the USACE developments were provided by the USACE with the Savannah River ResSim Model (HDR 2014b).

Table 4-16. Guide Curve Target Elevation of Duke Energy Reservoirs

Day of Year	Bad Creek Target Elevation (ft msl)	Jocassee Target Elevation (ft msl)	Keowee Target Elevation (ft msl)
Jan 1	2,280	1,107	797
May 1	2,280	1,107	798
Oct 15	2,280	1,107	798
Dec 31	2,280	1,107	797

Table 4-17. Guide Curve Target Elevations of USACE Reservoirs

Day of Year	Hartwell Target Elevation (ft msl)	Richard B. Russell Target Elevation (ft msl)	J. Strom Thurmond Target Elevation (ft msl)
Jan 1	656	475	326
Apr 1	660	475	330
Oct 15	660	475	330
Dec 15	656	475	326

4.6.5.3 Water Withdrawals

Historical water use (withdrawals and returns in cfs) were estimated as part of the Savannah River Basin September 16, 2010, UIF time series release (ARCADIS 2010, 2013). The median 2003-2008 monthly water use in cfs was modeled in the historical baseline scenario to represent historical municipal and industrial water use from each reservoir. Table 4-18 shows the historical baseline scenario modeled withdrawals and returns in cfs. The example calculation below describes the withdrawal calculation for a reservoir for a month:

$$WR_{R1,Month} = Median(WR_{Day,Year})$$

where:

$WR_{R1,Month}$ is the net withdrawal (in cfs) for the reservoir for the month

$WR_{Day,Year}$ is the withdrawal (in cfs) for the reservoir for each day of the month for each of the months of interest in the 2003 through 2008 period.

During KT relicensing, Duke Energy contracted with HDR to complete a Water Supply Study of the Savannah River Basin. This study is detailed in the *Final Keowee-Toxaway Water Supply Study Report* (HDR 2014c). The Water Supply Study provided the following data which have been adopted for the Project scenarios, including the scenarios outlined in this report:

- Water withdrawals and returns within the Savannah River Basin (Basin) that are greater than or equal to 100,000 gallons per day (HDR 2014b).
- Future projections for water withdrawals and returns within the Basin to the year 2066.

The withdrawals and returns simulated in the Water Supply Study are included in Appendix A of this report.

Table 4-18. 2003-2008 Median Monthly Water Use - Historical Baseline Scenario

Water Withdrawal (avg cfs/day)						
Day of Year	**Bad Creek**	**Jocassee**	**Keowee**	**Hartwell**	**Richard B. Russell**	**J. Strom Thurmond**
01-Jan	0.00	0.00	76.66	29.14	0.00	2.61
01-Feb	0.00	0.00	76.67	29.53	0.00	1.70
01-Mar	0.00	0.00	76.88	30.15	0.00	0.32
01-Apr	0.00	0.00	74.67	33.75	0.00	3.14
01-May	0.00	0.00	71.82	42.23	0.00	7.00
01-Jun	0.00	0.00	84.00	50.51	0.00	7.70
01-Jul	0.00	0.00	84.70	45.39	0.00	7.25
01-Aug	0.00	0.00	83.24	45.92	0.00	8.25
01-Sep	0.00	0.00	88.23	44.03	0.00	7.01
01-Oct	0.00	0.00	79.59	42.82	0.00	6.05
01-Nov	0.00	0.00	68.19	34.16	0.00	5.07
01-Dec	0.00	0.00	74.69	29.75	0.00	3.70
Water Return (avg cfs/day)						
Day of Year	**Bad Creek**	**Jocassee**	**Keowee**	**Hartwell**	**Richard B. Russell**	**J. Strom Thurmond**
01-Jan	0.00	0.00	0.00	0.00	4.75	0.00
01-Feb	0.00	0.00	0.00	0.00	5.50	0.00
01-Mar	0.00	0.00	0.00	0.00	6.37	0.00
01-Apr	0.00	0.00	0.00	0.00	3.92	0.00
01-May	0.00	0.00	0.00	0.00	1.80	0.00
01-Jun	0.00	0.00	0.00	0.00	1.26	0.00
01-Jul	0.00	0.00	0.00	0.00	1.65	0.00
01-Aug	0.00	0.00	0.00	0.00	1.10	0.00
01-Sep	0.00	0.00	0.00	0.00	0.96	0.00
01-Oct	0.00	0.00	0.00	0.00	1.88	0.00
01-Nov	0.00	0.00	0.00	0.00	2.92	0.00
01-Dec	0.00	0.00	0.00	0.00	4.60	0.00

4.6.5.4 Minimum Flows

The Hartwell, Richard B. Russell, and J. Strom Thurmond developments have fish spawning rules in the SR CHEOPS Model. The rule requires outflow to equal inflow if the reservoir is at or below target elevation during the month of April. Additionally, J. Strom Thurmond Lake has a required average daily discharge of at least 3,800 cfs year-round.

4.6.5.5 Maximum Flows

The model allows a Maximum Flow constraint to be applied either at a powerhouse or at a downstream node. This will limit operations to restrict flow to a maximum of the defined limit. The J. Strom Thurmond development has a maximum flow restriction at the downstream node in Augusta, Georgia, depending on the reservoir elevation of J. Strom Thurmond Lake. If the lake elevation is below 330 ft msl, the maximum allowable flow at Augusta is 20,000 cfs; if the reservoir elevation is greater than or equal to 330 ft msl, the maximum allowable flow is 30,000 cfs. These flow restrictions are based on goals for normal operation at the development. Under extreme flooding, these flows can be exceeded.

The Richard B. Russell development has a maximum flow constraint of 60,000 cfs, and the Hartwell development has a maximum flow constraint of 28,500 cfs.

4.6.5.6 Pump Operations

Bad Creek uses pumped storage logic and Jocassee and Richard B. Russell use hybrid-pumped storage logic. These settings require pump operations schedules. Bad Creek pump operations specify pumping and discharge schedules (specified in the tables by number of units available to operate), while Jocassee and Richard B. Russell specify pumping only. In Table 4-19 through Table 4-21, pump operations schedules are described by negative numbers. The magnitude of each negative number indicates the number of units available for pumping during a given hour. Table 4-19 includes positive numbers, which indicate discharge during a given hour. Durations for the Bad Creek and Jocassee schedules reflect anticipated changes in operation as additional renewable generation is incorporated into Duke Energy’s generation portfolio.

The model will deviate from the user-specified pumping or generating schedule when certain conditions are encountered, such as when the upper reservoir is approaching the spill elevation, the lower reservoir is approaching the minimum elevation, and when a powerhouse is undergoing maintenance. Additionally, the model will attempt to avoid operations that may empty the upper reservoir, cause spill at the downstream reservoir, or end the day significantly different from the target elevation. The model does this by evaluating the starting elevation, desired ending elevation, and user-specified pumping and generating unit-hours for the day. Using pumping and generating volume capacities at the start of the day, the model will adjust (reduce only), the number of unit-hours to balance the generation volume and pumping volume, taking into account the desired daily change in storage. For example, if a user inputs four unit hours of generation and four unit hours of pumping, the model will reduce the generation unit-hours to three so the total volume released from the upper reservoir can be made up with the four unit hours in the pump schedule.

For hybrid-pumped storage logic, the model will pump with the specified number of units during the hours specified unless the upper reservoir approaches spill elevation, the lower reservoir approaches minimum elevation, or units are in maintenance. The generation release scheduling of a hybrid-pumped storage plant occurs just as if the plant is a typical peaking plant, where outflow is determined by change in storage and inflow, which includes upstream plant discharge, upstream plant bypass flow return, upstream plant spill, incremental accretion, water withdrawal returns, and pumping operations. A powerhouse will not be scheduled to release for generation if an hour has been specified for pumping operations and pumping was actually scheduled.

Table 4-19. Bad Creek Pump Operations

Month	Day Set	Hour (number of units available per hour of the day)*																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	0	0	0	0	1	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	3	4	4	4	0	0
Feb	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	0	0	0	0	1	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	3	4	4	4	0	0
Mar	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	0	0	0	0	0	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	4	4	4	4	0	0
Apr	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	0	0	0	0	1	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	3	4	4	4	0	0
May	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	1	1	1	1	1	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	0	3	4	4	0	0
Jun	Weekday	0	2	4	0	0	0	0	-1	-2	-4	-4	-4	-4	-4	-4	-4	-2	-1	4	4	4	4	0	0
	Weekend	0	1	1	1	1	1	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	0	3	4	4	0	0
Jul	Weekday	0	2	4	0	0	0	0	-1	-2	-4	-4	-4	-4	-4	-4	-4	-2	-1	4	4	4	4	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	2	2	4	4	3	0
Aug	Weekday	0	2	4	0	0	0	0	-1	-2	-4	-4	-4	-4	-4	-4	-4	-2	-1	4	4	4	4	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	2	2	4	4	3	0
Sep	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	0	4	4	4	3	0
Oct	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-4	-4	-4	-4	-4	-4	-4	-2	0	0	4	4	4	3	0
Nov	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	0	0	0	0	0	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	2	2	4	4	4	0	0
Dec	Weekday	0	0	0	0	0	0	2	4	-2	-4	-4	-4	-4	-4	-4	-4	-2	-2	4	4	4	4	0	0
	Weekend	0	0	0	0	0	0	1	1	-2	-4	-4	-4	-4	-4	-4	-4	-2	2	2	4	4	2	2	0

*Pumping unit operations are described with negative values.

Table 4-20. Jocassee Pump Operations

Month	Day Set	Hour (number of units available per hour of the day)*																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Feb	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Mar	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Apr	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
May	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Jun	Weekday	0	0	0	0	0	0	0	-1	-4	-4	-4	-4	-4	-4	-4	-4	-2	-1	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Jul	Weekday	0	0	0	0	0	0	0	-1	-4	-4	-4	-4	-4	-4	-4	-4	-2	-1	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Aug	Weekday	0	0	0	0	0	0	0	-1	-4	-4	-4	-4	-4	-4	-4	-4	-2	-1	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Sep	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Oct	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Nov	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0
Dec	Weekday	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	-2	0	0	0	0	0	0
	Weekend	0	0	0	0	0	0	0	0	-4	-4	-4	-4	-4	-4	-4	-4	-2	0	0	0	0	0	0	0

*Pumping unit operations are described with negative values.

Table 4-21. Richard B. Rusell Pump Operations

Month	Day Set	Hour (number of units available per hour of the day)*																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Annual	Weekdays	-3	-3	-3	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Saturdays	-3	-3	-3	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sundays	-3	-3	-3	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Pumping unit operations are described with negative values.

4.6.6 Generation Data

Unit performance information was modeled based on the information available at the time of model development.

4.6.6.1 Headloss Coefficients

The CHEOPS model allows two common headloss coefficients for each plant and an individual coefficient for each unit. Headloss for each unit is calculated by multiplying the unit's common coefficient by the total flow for that common coefficient squared added to the individual coefficient multiplied by the individual unit flow squared. The formula is:

$$H_i = \left(\sum_{j=1}^{n} F_i \right)^2 h_C + F_i^2 h_i$$

Where:

H_i is the unit headloss in ft

h_c is the common coefficient for the i^{th} unit

h_i is the individual coefficient for the i^{th} unit

F_i is the flow for the i^{th} unit

j runs from 1 to n

n is the number of units that have the same common coefficient as the unit i

Table 4-22 presents the estimated headlosses for each plant as a function of flow (Q):

Table 4-22. Headloss Coefficients

Development	Common 1	Common 2	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8
Bad Creek	1.25E-07	-	-	-	-	-	-	-	-	-
Jocassee	1.41E-08	1.41E-08	6.99E-08[a]	6.99E-08[a]	6.99E-08[b]	6.99E-08[b]	-	-	-	-
Keowee	1.22E-08	-	2.33E-08[a]	2.33E-08[a]	-	-	-	-	-	-
Hartwell	-	-	3.55E-08	3.55E-08	3.55E-08	3.55E-08	-	-	-	-
Richard B. Russell	-	-	2.40E-08	2.40E-08	2.40E-08	2.40E-08	2.40E-08	2.40E-08	2.40E-08	2.40E-08
J. Strom Thurmond	-	-	1.56E-07	1.56E-07	1.56E-07	1.56E-07	1.56E-07	1.56E-07	1.56E-07	-

a) Unit headloss plus Common 1
b) Unit headloss plus Common 2

4.6.6.2 Turbine Efficiency Curves

Turbine performance is entered by plant and as flow versus efficiency at five separate net heads. The Bad Creek Powerhouse contains four reversible motor-pump/turbine-generator units with a design head of 1,115 ft msl. The modeled performance of the turbines in generation mode is presented in Table 4-23. The Jocassee powerhouse also contains four reversible motor-pump/turbine-generator units; modeled performance is presented in Table 4-24.

The Keowee powerhouse contains two similarly sized conventional turbine-generator units. The modeled performance of these turbines is presented in Table 4-25. The Hartwell powerhouse contains five conventional turbine-generator units, four of which were rehabilitated over the 11-year span of 1997 through 2007. The Richard B. Russell powerhouse contains four similarly sized conventional turbine-generator units and four reversible turbine-generator/motor-pump units. The J. Strom Thurmond powerhouse contains seven similarly sized conventional turbine-generator units. The modeled performance of the USACE turbines is presented in Table 4-26 through Table 4-29.

Table 4-23. Bad Creek Development Units 1 through 4 Turbine Efficiencies Over a Range of Net Heads

Units 1 through 4									
Net Head of 1,000 ft		Net Head of 1,050 ft		Net Head of 1,115 ft		Net Head of 1,181 ft		Net Head of 1,230 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
3,070	88.60%	3,105	89.65%	3,352	91.10%	3,458	92.10%	3,352	92.10%
3,176	89.00%	3,176	89.90%	3,529	91.65%	3,529	92.35%	3,529	92.70%
3,352	89.60%	3,352	90.55%	3,705	92.20%	3,705	92.85%	3,705	93.10%
3,529	90.25%	3,529	91.10%	3,882	92.50%	3,882	93.15%	3,882	93.30%
3,705	90.95%	3,705	91.60%	4,058	92.60%	4,058	93.15%	4,058	93.25%
3,882	91.45%	3,882	91.95%	4,164	92.50%	4,235	92.90%	4,235	93.05%
3,987	91.48%	4,058	92.10%	4,235	92.35%	4,411	92.55%	4,411	92.75%
4,058	91.40%	4,235	91.75%	4,411	92.00%	4,587	92.20%	4,587	92.45%
4,235	91.00%	4,411	91.25%	4,587	91.55%	4,764	91.80%	4,764	92.10%
4,376	90.50%	4,517	90.85%	4,729	91.15%	4,940	91.40%	4,940	91.75%

Table 4-24. Jocassee Development Units 1 through 4 Turbine Efficiencies Over a Range of Net Heads

Units 1 through 4									
Net Head of 278 ft		Net Head of 289 ft		Net Head of 301 ft		Net Head of 312 ft		Net Head of 323 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
7,140	91.17%	6,877	91.06%	6,612	90.93%	6,395	90.70%	6,213	90.18%
7,150	91.19%	6,900	91.13%	6,900	91.50%	6,700	91.47%	6,325	90.64%
7,400	91.50%	7,150	91.64%	7,200	92.25%	6,950	92.00%	6,450	91.15%
7,600	91.50%	7,400	92.00%	7,450	92.56%	7,250	92.65%	6,700	91.83%
7,800	91.40%	7,600	92.10%	7,700	92.45%	7,500	92.95%	6,950	92.43%
8,000	91.10%	7,850	91.80%	8,000	92.00%	7,800	92.70%	7,200	92.80%
8,250	90.56%	8,100	91.41%	8,250	91.60%	8,050	92.40%	7,450	93.16%
8,450	90.10%	8,350	91.00%	8,500	91.25%	8,350	92.00%	7,700	93.15%
8,650	89.45%	8,550	90.62%	8,800	90.80%	8,600	91.67%	7,950	92.82%
8,850	88.70%	8,800	90.00%	9,050	90.10%	8,638	91.60%	8,200	92.55%

Table 4-25. Keowee Development Units 1 and 2 Turbine Efficiencies Over a Range of Net Heads

Units 1 and 2									
Net Head of 90 ft		Net Head of 105 ft		Net Head of 117 ft		Net Head of 125 ft		Net Head of 140 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
5,400	54.00%	5,000	51.00%	4,900	48.00%	4,700	44.50%	4,300	43.00%
6,400	66.50%	5,500	62.00%	5,300	60.00%	5,100	55.50%	4,600	50.50%
6,900	72.00%	6,000	68.50%	5,700	66.50%	5,600	65.50%	4,900	56.00%
7,400	77.00%	6,500	74.00%	6,200	73.00%	6,100	73.00%	5,200	62.00%
7,900	81.00%	7,000	78.00%	6,700	77.50%	6,600	77.00%	5,600	68.50%
8,400	84.50%	7,500	81.00%	7,200	81.00%	7,100	81.00%	6,000	73.00%
8,900	88.50%	8,000	84.00%	7,700	84.00%	7,600	84.00%	6,400	76.50%
9,100	90.00%	8,500	88.00%	8,200	87.00%	8,100	87.00%	6,800	79.50%
9,300	91.50%	8,800	90.50%	8,700	90.50%	8,400	89.00%	7,200	82.00%
9,500	92.00%	9,000	92.00%	8,900	91.50%	8,600	90.50%	7,600	84.50%
9,700	91.00%	9,200	93.00%	9,000	92.00%	8,700	91.00%	7,800	86.00%
9,900	90.00%	9,400	93.50%	9,200	93.00%	8,800	91.50%	8,000	87.00%
10,100	88.00%	9,700	92.50%	9,500	93.50%	8,900	92.00%	8,200	88.00%
10,300	86.00%	10,000	91.00%	9,700	93.00%	9,100	93.00%	8,400	89.50%

Table 4-26. Hartwell Development Units 1 through 4 Turbine Efficiencies Over a Range of Net Heads

Units 1 through 4									
Net Head of 170 ft		Net Head of 175 ft		Net Head of 180 ft		Net Head of 185 ft		Net Head of 190 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
2,724	81.74%	2,678	80.77%	2,635	79.81%	2,596	78.82%	2,560	77.83%
2,985	83.90%	2,931	83.00%	2,881	82.09%	2,837	81.11%	2,796	80.14%
3,245	85.71%	3,185	84.83%	3,128	83.98%	3,078	83.04%	3,032	82.08%
3,504	87.28%	3,438	86.42%	3,375	85.59%	3,319	84.68%	3,269	83.71%
3,756	88.81%	3,684	87.95%	3,619	87.05%	3,560	86.10%	3,505	85.15%
4,071	90.45%	3,987	89.71%	3,911	88.92%	3,848	87.93%	3,794	86.84%
4,335	91.34%	4,233	90.87%	4,145	90.22%	4,073	89.33%	4,012	88.30%
4,601	92.09%	4,491	91.65%	4,387	91.22%	4,299	90.57%	4,230	89.62%
4,870	92.70%	4,748	92.37%	4,637	91.95%	4,540	91.38%	4,451	90.75%
5,148	93.08%	5,015	92.82%	4,887	92.60%	4,782	92.08%	4,688	91.45%
5,463	92.77%	5,289	93.08%	5,153	92.89%	5,036	92.47%	4,924	92.09%
5,823	91.76%	5,605	92.60%	5,430	92.93%	5,291	92.80%	5,168	92.51%
6,227	90.20%	5,969	91.41%	5,739	92.43%	5,569	92.68%	5,426	92.62%
6,878	86.58%	6,482	89.25%	6,204	90.66%	5,952	91.94%	5,774	92.28%

Table 4-27. Hartwell Development Unit 5 Turbine Efficiencies Over a Range of Net Heads

Unit 5									
Net Head of 170 ft		Net Head of 175 ft		Net Head of 180 ft		Net Head of 185 ft		Net Head of 190 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
2,663	79.74%	2,618	78.77%	2,576	77.81%	2,538	76.82%	2,502	75.83%
2,918	81.90%	2,865	81.00%	2,816	80.09%	2,773	79.11%	2,733	78.14%
3,172	83.71%	3,113	82.83%	3,058	81.98%	3,009	81.04%	2,964	80.08%
3,425	85.28%	3,361	84.42%	3,299	83.59%	3,244	82.68%	3,195	81.71%
3,671	86.81%	3,601	85.95%	3,538	85.05%	3,480	84.10%	3,426	83.15%
3,979	88.45%	3,897	87.71%	3,823	86.92%	3,761	85.93%	3,709	84.84%
4,237	89.34%	4,138	88.87%	4,052	88.22%	3,981	87.33%	3,922	86.30%
4,497	90.09%	4,390	89.65%	4,288	89.22%	4,202	88.57%	4,135	87.62%
4,760	90.70%	4,641	90.37%	4,533	89.95%	4,438	89.38%	4,351	88.75%
5,032	91.08%	4,902	90.82%	4,777	90.60%	4,674	90.08%	4,583	89.45%
5,340	90.77%	5,170	91.08%	5,037	90.89%	4,923	90.47%	4,813	90.09%
5,692	89.76%	5,479	90.60%	5,308	90.93%	5,172	90.80%	5,052	90.51%
6,087	88.20%	5,835	89.41%	5,610	90.43%	5,444	90.68%	5,304	90.62%
6,723	84.58%	6,336	87.25%	6,064	88.66%	5,818	89.94%	5,644	90.28%

Table 4-28. Richard B. Russell Development Units 1 through 4 Turbine Efficiencies Over a Range of Net Heads

Units 1 through 4									
Net Head of 139 ft		Net Head of 144 ft		Net Head of 151 ft		Net Head of 157 ft		Net Head of 162 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
5,100	79.80%	5,190	81.00%	5,300	82.75%	5,300	83.50%	5,300	83.80%
5,400	81.50%	5,400	82.30%	5,600	84.50%	5,445	84.30%	5,550	85.20%
5,625	82.80%	5,725	84.25%	5,850	85.75%	5,700	85.50%	5,800	86.60%
5,900	84.50%	6,000	85.90%	6,100	87.20%	6,000	87.00%	6,100	88.00%
6,125	85.60%	6,225	87.00%	6,350	88.50%	6,200	88.20%	6,250	88.80%
6,400	87.25%	6,450	88.25%	6,600	89.70%	6,480	89.50%	6,400	89.60%
6,590	88.25%	6,690	89.25%	6,850	90.90%	6,700	90.50%	6,590	90.45%
6,800	89.20%	6,900	90.00%	7,050	91.40%	6,990	91.50%	6,750	91.00%
7,000	90.10%	7,100	90.60%	7,250	91.40%	7,200	91.55%	6,900	91.40%
7,150	90.20%	7,250	90.70%	7,400	90.75%	7,350	91.40%	7,095	92.00%
7,325	89.60%	7,450	90.25%	7,575	90.00%	7,500	91.10%	7,255	91.95%
7,575	88.50%	7,680	88.75%	7,840	88.75%	7,690	90.45%	7,450	91.50%
7,800	87.50%	7,900	87.50%	8,040	87.60%	7,875	89.50%	7,500	91.35%

Table 4-29. J. Strom Thurmond Development Units 1 through 7 Turbine Efficiencies Over a Range of Net Heads

Units 1 through 7									
Net Head of 114 ft		Net Head of 123 ft		Net Head of 132 ft		Net Head of 141 ft		Net Head of 148.5 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
3,110	84.32%	3,140	83.54%	3,230	84.01%	3,450	85.79%	3,570	86.53%
3,210	84.93%	3,180	84.00%	3,310	84.68%	3,570	86.43%	3,680	87.19%
3,340	86.29%	3,310	85.07%	3,430	85.64%	3,600	87.27%	3,790	87.82%
3,490	87.05%	3,440	86.05%	3,550	86.53%	3,790	88.06%	3,900	88.41%
3,640	87.74%	3,570	86.96%	3,670	87.37%	3,900	88.81%	4,010	88.97%
3,790	88.37%	3,710	87.56%	3,790	88.15%	4,020	89.29%	4,120	89.51%
3,940	88.96%	3,840	88.36%	3,910	88.88%	4,130	89.97%	4,230	90.01%
4,090	89.50%	3,980	88.87%	4,040	89.35%	4,250	90.39%	4,340	90.49%
4,230	90.22%	4,110	89.57%	4,160	90.01%	4,370	90.80%	4,450	90.95%
4,370	90.90%	4,240	90.23%	4,280	90.63%	4,490	91.18%	4,560	91.38%
4,520	91.33%	4,380	90.65%	4,410	91.02%	4,610	91.55%	4,680	91.60%
4,670	91.66%	4,520	91.03%	4,550	91.18%	4,740	91.70%	4,810	91.62%
4,850	91.24%	4,670	91.21%	4,690	91.33%	4,830	91.73%	4,940	91.63%
5,310	89.48%	4,840	90.99%	4,840	91.29%	4,930	91.58%	5,030	91.58%
5,520	87.96%	5,150	90.19%	5,230	90.49%	5,230	91.15%	5,070	91.64%

4.6.6.3 Generator Efficiency Curve

The generator data, like the turbine data, is entered by plant and then associated with a unit. The generator performance data is a relationship of generator output versus generator efficiency. The generator condition includes a maximum generator output. This value is the maximum generator output the model will allow, assuming there is turbine capacity to meet this limit. The model will limit turbine output based on the generator maximum desired output. The generator efficiency curves for each of the units in the system are shown in Table 4-30 through Table 4-36.

Table 4-30. Bad Creek Development Units 1 through 4 Generator Efficiency Curve

Units 1 through 4			
Efficiency	Output (MW)	Efficiency	Output (MW)
97.06%	78.25	98.95%	360
97.80%	110	98.98%	400
98.37%	156.5	99.00%	420
98.76%	234.75	99.00%	440
98.91%	313	99.00%	460

Table 4-31. Jocassee Development Units 1 through 4 Generator Efficiency Curve

Units 1 through 4			
Efficiency	**Output (MW)**	**Efficiency**	**Output (MW)**
95.20%	45	98.25%	150
96.15%	60	98.40%	180
97.50%	90	98.45%	195.5
98.00%	120	98.50%	215

Table 4-32. Keowee Development Units 1 and 2 Generator Efficiency Curve

Units 1 and 2					
Efficiency	**Output (MW)**	**Efficiency**	**Output (MW)**	**Efficiency**	**Output (MW)**
89.00%	10	97.36%	42.5	98.31%	72.5
92.00%	15	97.60%	47.5	98.39%	77.5
94.00%	20	97.79%	52.5	98.44%	82.5
95.30%	25	97.95%	57.5	98.46%	87.5
96.20%	30	98.09%	62.5	98.48%	90.0
96.80%	35	98.20%	67.5	98.50%	100.6
97.20%	40				

Table 4-33. Hartwell Development Units 1 through 4 Generator Efficiency Curve

Units 1 through 4					
Efficiency	**Output (MW)**	**Efficiency**	**Output (MW)**	**Efficiency**	**Output (MW)**
89.00%	10	97.41%	39	98.24%	64
92.00%	15	97.64%	43	98.30%	68
94.00%	19	97.83%	47	98.35%	72
95.25%	23	98.00%	52	98.40%	76
96.10%	27	98.11%	56	98.45%	80
96.75%	31	98.18%	60	98.50%	85
97.11%	35				

Table 4-34. Hartwell Development Unit 5 Generator Efficiency Curve

Unit 5					
Efficiency	**Output (MW)**	**Efficiency**	**Output (MW)**	**Efficiency**	**Output (MW)**
90.04%	10	96.27%	35	97.53%	60
92.76%	15	96.57%	39	97.64%	64
93.99%	19	96.82%	43	97.75%	68
94.83%	23	97.03%	47	97.84%	72
95.44%	27	97.25%	52	97.93%	76
95.90%	31	97.40%	56	98.04%	82

Table 4-35. Richard B. Russell Development Units 1 through 4 Generator Efficiency Curve

Units 1 through 4					
Efficiency	**Output (MW)**	**Efficiency**	**Output (MW)**	**Efficiency**	**Output (MW)**
89.00%	10	97.36%	42.5	98.31%	72.5
92.00%	15	97.60%	47.5	98.39%	77.5
94.00%	20	97.79%	52.5	98.44%	82.5
95.30%	25	97.95%	57.5	98.46%	87.5
96.20%	30	98.09%	62.5	98.48%	90
96.80%	35	98.20%	67.5	98.50%	100.625
97.20%	40				

Table 4-36. J. Strom Thurmond Development Units 1 through 7 Generator Efficiency Curve

Units 1 through 7					
Efficiency	**Output (MW)**	**Efficiency**	**Output (MW)**	**Efficiency**	**Output (MW)**
94.61%	10	97.39%	30	98.33%	50
95.56%	15	97.74%	35	98.45%	55
96.32%	20	98.00%	40	98.56%	60
96.93%	25	98.19%	45		

4.6.6.4 Wicket Gate Leakage

The Wicket Gate Leakage flow is active only during times of non-generation. Thus, during periods of non-generation, this leakage flow is used to make up all or a portion of the minimum flow requirement. Wicket gate leakage is only modeled at the Jocassee and Keowee Stations, where it is 11 cfs per Jocassee unit and 25 cfs per Keowee unit for a total of 44 cfs and 50 cfs when no units are operating, respectively.

4.6.6.5 Powerhouse Weekend Operations

The Powerhouse Weekend Operations Condition permits the simulation of reduced powerhouse operations during Saturdays and/or Sundays. B ypass flow requirements are still met since bypass flows are not powerhouse dependent. Minimum instantaneous and minimum daily average flow requirements are met by bringing the powerhouse online for the required flow only. This condition removes the change-in-storage component from consideration in computing a desired daily discharge. To simulate actual usage, Saturday and Sunday powerhouse operations are minimized at the Keowee, Hartwell, and Richard B. Russell developments. During high inflow periods with little usable storage available, the model will bring the powerhouse online to generate with outflows, rather than permit spilling.

4.6.6.6 Maintenance

The Maintenance schedule provides the functionality to take a unit out of service for all or part of each year for a scenario run. There are currently no outages modeled.

4.6.6.7 Pump Efficiency

The Pump Efficiency Condition provides the functionality to enter pump efficiency information for pumped storage plants. This dataset is required for plants with plant operation type specified as pumped storage and hybrid-pumped storage. The pump efficiency information modeled for the Bad Creek, Jocassee, and Richard B. Russell developments is presented in Table 4-37 through Table 4-39.

Table 4-37. Bad Creek Pump Efficiency

Total Head (ft)	Efficiency	Power (MW)	Flow (cfs)
1,066	92.80%	405.0	4,164
1,145	93.45%	377.1	3,635
1,173	93.51%	367.3	3,458
1,201	93.43%	357.2	3,282
1,253	93.00%	338.1	2,964

Table 4-38. Jocassee Pump Efficiency

Total Head (ft)	Efficiency	Power (MW)	Flow (cfs)
286	92.45%	207.5	7,921
296	92.80%	205.3	7,601
307	93.10%	204.7	7,331
318	93.40%	201.8	7,001
328	93.50%	196.8	6,626

Table 4-39. Richard B. Russell Pump Efficiency

Total Head (ft)	Efficiency	Power (MW)	Flow (cfs)
140	91.20%	93.6	7,201
145	91.68%	93.7	6,996
150	92.10%	93.7	6,791
155	92.50%	93.4	6,581
160	92.80%	92.9	6,361

4.7 Bad Creek II Scenario

Bad Creek II scenario inputs are identical to the Baseline ("Base Case") scenario except for the following changes:

- Four additional units with the turbine efficiencies in Table 4-40, the generator efficiencies in Table 4-41, the pump efficiencies in Table 4-41, and the headlosses in Table 4-42, are available to meet energy requirements; and,
- The pump operations schedule was revised to reflect the availability of 8 units at Bad Creek due to the additional four units at Bad Creek II (Table 4-43).

Table 4-40. Bad Creek II Units 5 through 8 Turbine Efficiencies over a Range of Net Heads

Units 5 through 8									
Net Head of 1,000 ft		Net Head of 1,050 ft		Net Head of 1,150 ft		Net Head of 1,200 ft		Net Head of 1,230 ft	
Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency	Flow (cfs)	Efficiency
1,100	65.10%	1,100	68.40%	1,100	71.70%	1,100	73.10%	1,100	74.50%
1,300	71.00%	1,400	77.00%	1,400	79.00%	1,400	80.90%	1,400	82.10%
1,650	79.00%	1,650	81.80%	1,650	83.60%	1,650	85.00%	1,650	86.00%
2,000	85.00%	2,000	86.50%	2,000	87.80%	2,250	91.00%	2,000	89.50%
2,600	91.55%	2,635	92.30%	2,650	92.90%	2,750	93.80%	2,250	91.50%
3,000	94.00%	3,000	94.20%	3,000	94.50%	3,000	94.60%	2,750	94.00%
3,200	94.90%	3,200	94.70%	3,200	95.00%	3,200	94.90%	3,200	95.30%
3,450	95.30%	3,600	95.30%	3,700	95.30%	3,850	95.30%	3,875	95.30%
4,110	94.75%	4,201	94.73%	4,300	94.75%	4,450	94.75%	4,525	94.75%
4,990	92.90%	4,990	93.20%	4,990	93.50%	4,960	93.70%	4,810	94.30%

Table 4-41. Bad Creek II Units 5 through 8 Generator Efficiency Curve

Units 5 through 8			
Efficiency	Output (MW)	Efficiency	Output (MW)
94.00%	78.3	98.10%	348.5
95.00%	110	98.25%	400
96.20%	161.5	98.28%	430
97.00%	200	98.31%	464
97.40%	233	98.33%	500
97.80%	290		

Table 4-42. Bad Creek II Pump Efficiency

Total Head (ft)	Efficiency	Power (MW)	Flow (cfs)
1,058	93.60%	468.1	4,890
1,136	94.15%	467.4	4,575
1,185	94.35%	469.5	4,415
1,229	94.55%	468.8	4,265
1,244	94.60%	468.4	4,208

Table 4-43. Headloss Coefficients

Development	Common 1	Common 2	Unit 5	Unit 6	Unit 7	Unit 8
Bad Creek II	1.61E-07	1.61E-07	4.09E-07[a]	4.09E-07[b]	4.09E-07[b]	4.09E-07[b]

a) Unit headloss plus Common 1
b) Unit headloss plus Common 2

Table 4-44. Bad Creek and Bad Creek II Pump Operations

Month	Day Set	Hour (number of units available per hour of the day)*																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	4	8	8	4	0	0
	Weekend	0	0	0	0	0	2	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	4	4	8	4	0	0
Feb	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	4	8	8	4	0	0
	Weekend	0	0	0	0	0	2	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	4	4	8	4	0	0
Mar	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	4	8	8	4	0	0
	Weekend	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	6	4	8	6	0	0
Apr	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	4	8	8	4	0	0
	Weekend	0	0	0	0	0	2	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	4	4	8	4	0	0
May	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	4	4	8	8	0	0
	Weekend	0	1	1	1	1	1	1	1	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	4	3	8	4	0	0
Jun	Weekday	0	2	4	0	0	0	0	-1	-2	-2	-8	-8	-8	-4	-2	-2	-2	-1	4	4	8	6	0	0
	Weekend	0	1	1	1	1	1	1	1	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	4	3	8	4	0	0
July	Weekday	0	2	4	0	0	0	0	-1	-2	-2	-8	-8	-8	-4	-2	-2	-2	-1	4	4	8	6	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	2	6	8	4	3	0
Aug	Weekday	0	2	4	0	0	0	0	-1	-2	-2	-8	-8	-8	-4	-2	-2	-2	-1	4	4	8	6	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	2	6	8	4	3	0
Sep	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	4	8	8	4	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	2	4	6	8	3	0
Oct	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	6	8	6	4	0	0
	Weekend	0	1	1	1	0	0	0	0	-2	-2	-8	-8	-8	-4	-2	-2	-2	0	2	4	6	8	3	0
Nov	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	6	8	6	4	0	0
	Weekend	0	0	0	0	0	0	1	1	-2	-2	-8	-8	-8	-4	-2	-2	-2	2	2	6	8	6	0	0
Dec	Weekday	0	0	0	0	0	0	2	2	-2	-2	-8	-8	-8	-4	-2	-2	-2	-2	8	8	4	4	0	0
	Weekend	0	0	0	0	0	0	1	1	-2	-2	-8	-8	-8	-4	-2	-2	-2	2	2	6	8	4	2	0

*Pumping unit operations are described with negative values.

4.8 Climate Sensitivities

Two water quantity sensitivity assessments were completed for the Baseline and Bad Creek II scenarios. These sensitivity assessments were simulated to evaluate possible impacts of future temperature increases and basin inflow reduction and were developed from climate change sensitivity scenarios identified during KT relicensing (HDR 2012b).

Climate change sensitivities CC-01 and CC-02 (as explained below) represent future possible climate change conditions. These two sensitivities are a simplification of possible future decreases in available water in the basin but were agreed upon by the OSC as a method to provide stakeholders with additional information to evaluate proposed operation scenarios during KT relicensing. The POR (January 1939 through December 31, 2011) plus the two climate change sensitivities represent the three hydrologic conditions discussed in this report.

4.8.1 Low Impact of Climate Change Sensitivity (CC-01 or ccLow)

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 and was developed based on the recommended CC-01 climate change scenario. The net impact was to simulate a reduction in available water in the basin due to increased surface evaporation applied uniformly over the entire 12 months of each year simulated. The application of the surface evaporation increase to the modeled net monthly evaporation coefficient included consideration of a positive or negative coefficient due to some months historically having more precipitation than evaporation. In the case of a negative monthly net evaporation coefficient, the adjustment was applied as to always result in less water being available in that reservoir.

4.8.2 High Impact of Climate Change Sensitivity (CC-02 or ccHigh)

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 (see explanation of application of increased evaporation in Section 4.8.1). The high impact climate change sensitivity was developed based on the recommended CC-02 climate change scenario (HDR 2014b)

4.9 Performance Measures

Performance Measures (PM) provide a means for relicensing stakeholders to readily distinguish between the outcomes of different scenarios. The PMs were initially developed by the OSC during KT relicensing. The PMs were generally retained for use during Bad Creek relicensing with minor modifications.

5 Modeled Results

5.1 Scenario Results

Elevation duration plots showing the detailed elevations for each scenario, for each reservoir, and for each of the three hydrologic conditions (Normal, ccLow, and ccHigh) are provided in Figure 5-1 through Figure 5-3. Discharge duration plots from Lake Keowee (discharge from the KT Project) are provided for each scenario and hydrologic condition in Figure 5-4. Performance Measure Sheets for each of the hydrologic conditions are provided in Appendix B. All simulated results presented in this report are based on the 15-minute model output, unless stated otherwise.

5.1.1 Baseline (Current License)

The Baseline scenario simulates reservoir operations by Duke Energy based on KT license requirements, including the LIP and 2014 Operating Agreement, and current Bad Creek License requirements. As demonstrated by the model results in Table 5-1 and the reservoir elevation duration curves in Figure 5-1through Figure 5-3, minimum and maximum reservoir elevations for Bad Creek Reservoir, Lake Jocassee, and Lake Keowee meet the FERC license normal minimum and maximum reservoir elevations for both the Project as well as the KT Project under the three hydrology conditions (i.e., Normal, ccLow and ccHigh). Simulated reservoir levels for the Bad Creek Reservoir, Lake Jocassee, and Lake Keowee were generally comparable under Normal and ccLow hydrology, but additional Bad Creek Reservoir storage was accessed for a short duration with the ccHigh hydrology. Simulated reservoir elevations under all three hydrology conditions maintain reservoir elevations at Lake Keowee higher than the minimum operating levels for the existing municipal water intakes and Oconee Nuclear Station. Bad Creek and the KT Project were simulated to be in some stage of the LIP approximately 67 to 70 percent of the POR depending on the hydrology. Reservoir elevation duration curves are shown in Figure 5-1 through Figure 5-3.

Table 5-1. Minimum and Maximum Simulated Reservoir Elevations and Reservoir Operating Band for the Baseline Scenario (ft msl)

Hydrology	Bad Creek			
	Minimum	**Median**	**Maximum**	**Band (ft)**
Normal	2,246.1	2,259.5	2,280.0	33.9
ccLow	2,246.1	2,259.5	2,280.0	33.9
ccHigh	2,160.0	2,259.5	2,280.0	120.0
	Jocassee			
	Minimum	**Median**	**Maximum**	**Band (ft)**
Normal	1,084.1	1,107.0	1,110.0	25.9
ccLow	1,083.8	1,107.0	1,110.0	26.2
ccHigh	1,083.0	1,106.9	1,109.5	26.5
	Keowee			
	Minimum	**Median**	**Maximum**	**Band (ft)**
Normal	791.6	799.2	800.0	8.4
ccLow	791.6	799.2	800.0	8.4
ccHigh	792.0	799.1	800.0	8.0

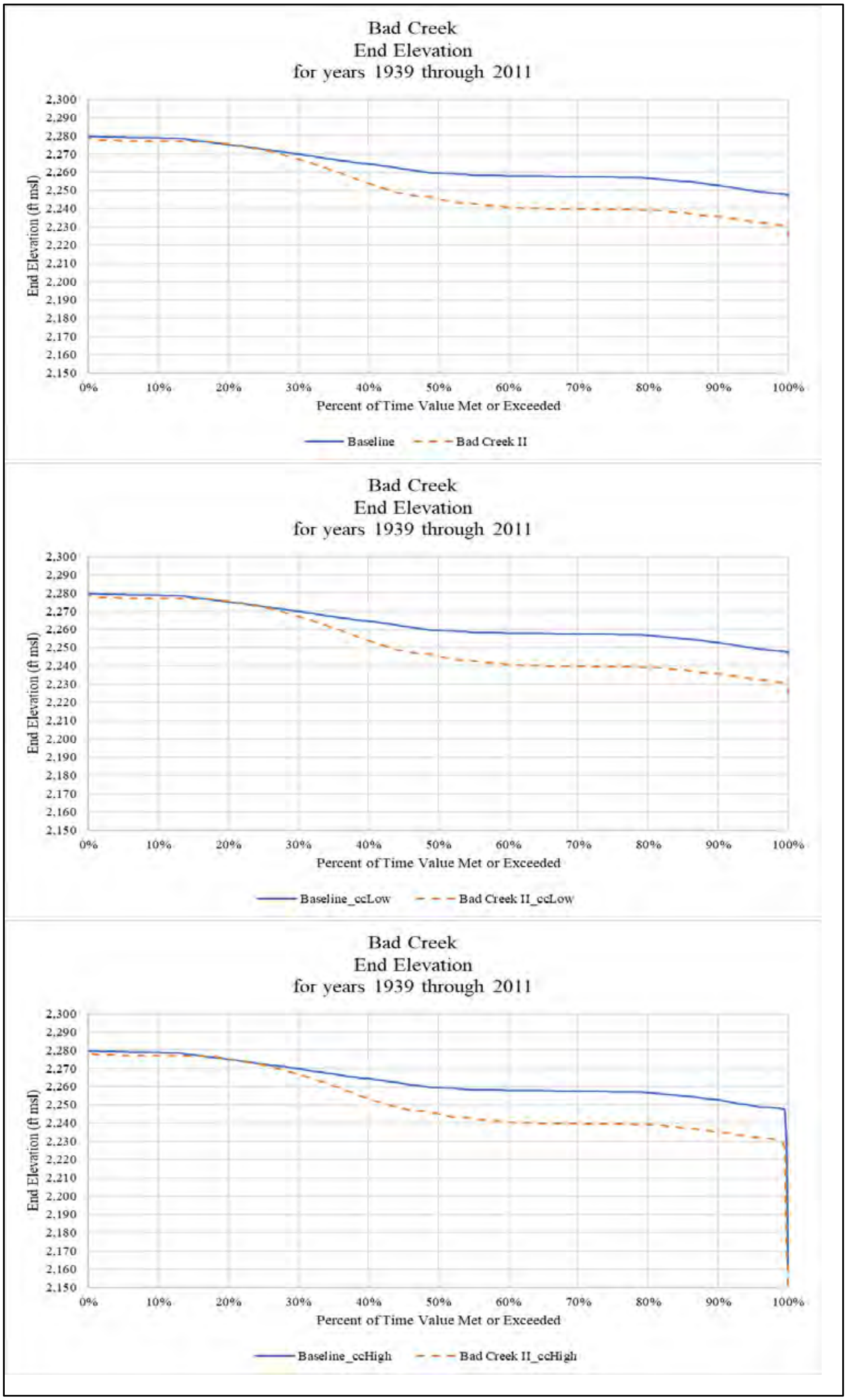

Figure 5-1. Bad Creek Simulated Reservoir Elevation Duration Curves for 1939 – 2011

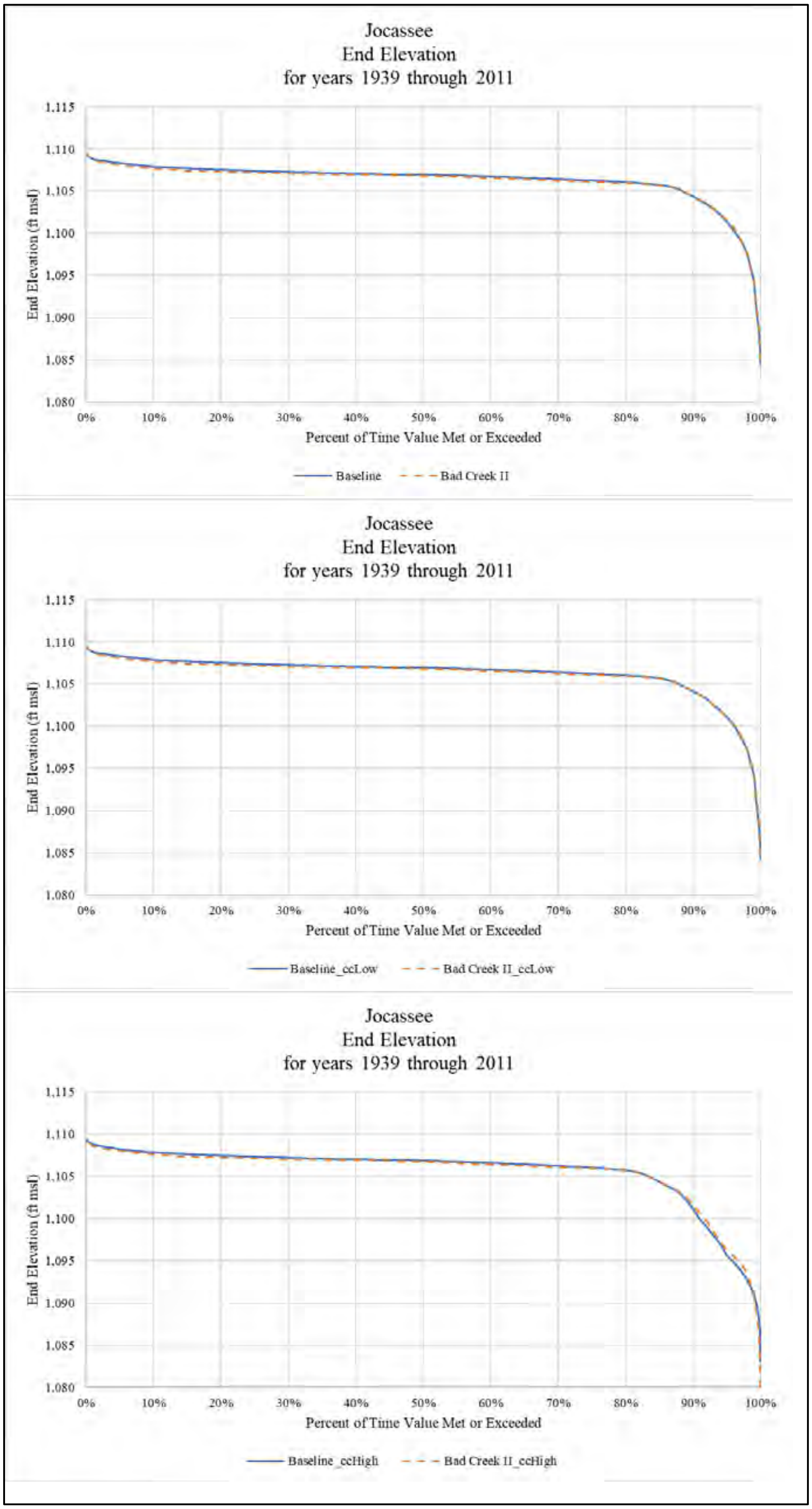

Figure 5-2. Jocassee Simulated Reservoir Elevation Duration Curves for 1939 – 2011

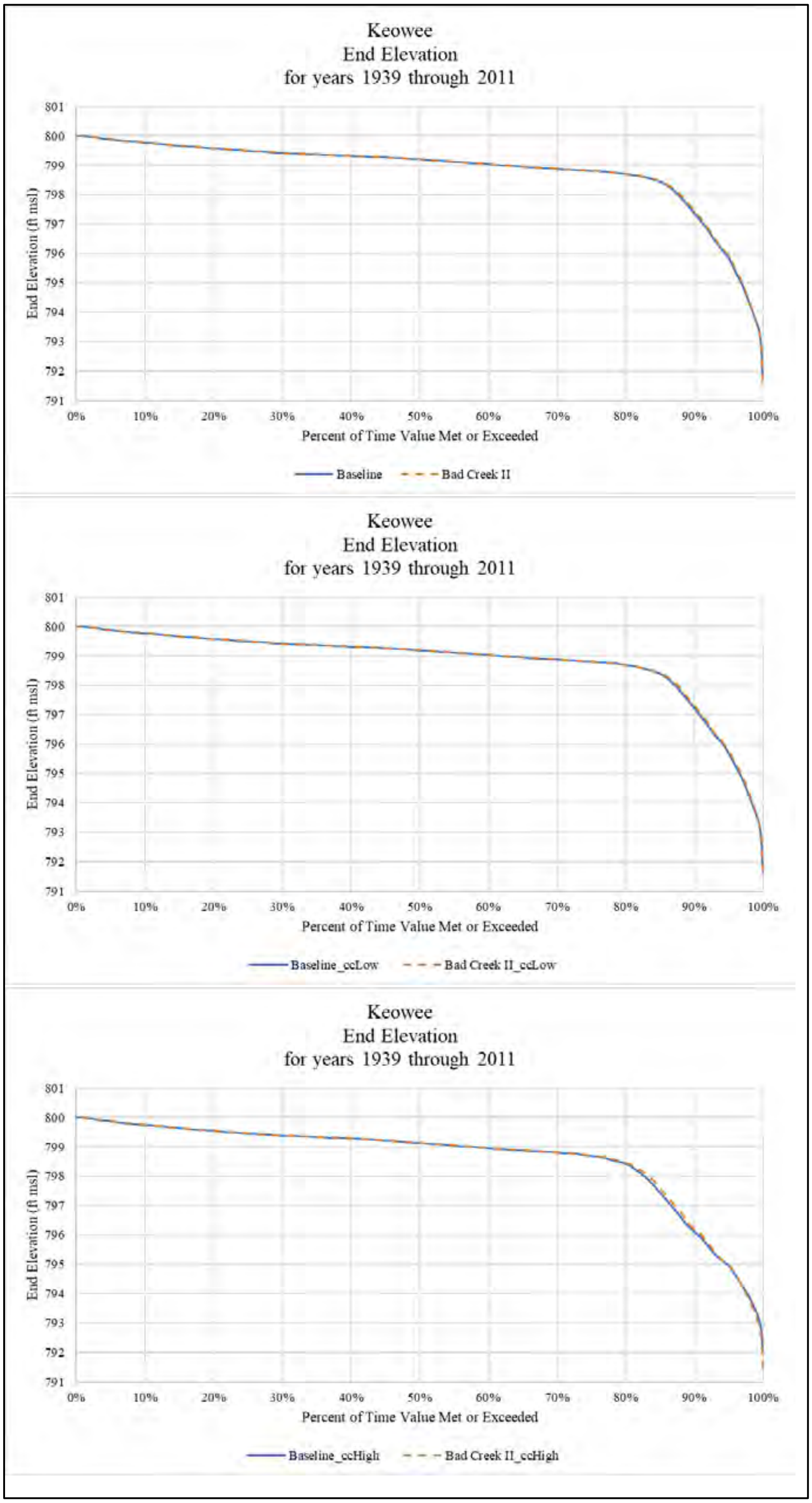

Figure 5-3. Keowee Simulated Reservoir Elevation Duration Curves for 1939 – 2011

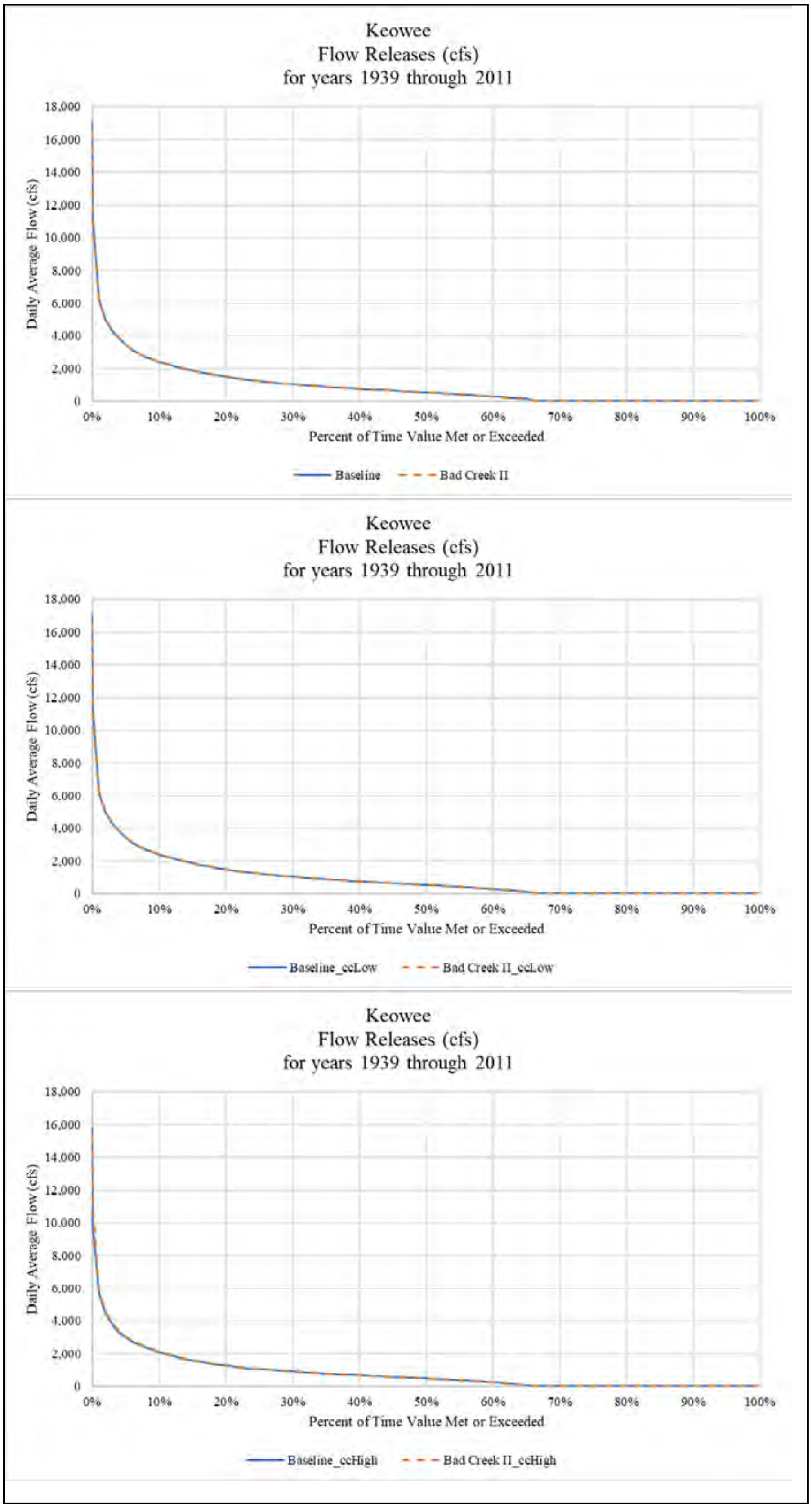

Figure 5-4. Keowee Daily Average Flow Releases for 1939 – 2011

5.1.2 Bad Creek II

The Bad Creek II scenario is identical to the Baseline scenario except for the differences described in Section 4.7. As with the Baseline Scenario, the model results in Table 5-2 and Figure 5-1 through Figure 5-3 demonstrate minimum and maximum reservoir elevations for Bad Creek Reservoir, Lake Jocassee, and Lake Keowee meet the FERC license normal minimum and maximum reservoir elevations for both the Project as well as the KT Project under the three hydrology conditions (i.e., Normal, ccLow and ccHigh).

As with the Baseline scenario, simulated reservoir levels for the Bad Creek Reservoir, Lake Jocassee, and Lake Keowee were generally comparable under Normal and ccLow hydrology, but additional Bad Creek Reservoir storage was accessed with the ccHigh hydrology. Simulated reservoir elevations under all three hydrology conditions maintain reservoir elevations at Lake Keowee higher than the minimum operating levels for the existing municipal water intakes and Oconee Nuclear Station. The Project and the KT Project were simulated to be in some stage of the LIP 81 to 87 percent of the POR, depending on hydrology.

Table 5-2. Minimum and Maximum Simulated Reservoir Elevations for the Bad Creek II Scenario (ft msl)

Hydrology	Bad Creek			
	Minimum	Median	Maximum	Band (ft)
Normal	2,224.7	2,245.6	2,280.0	55.3
ccLow	2,224.7	2,245.6	2,280.0	55.3
ccHigh	2,151.6	2,245.3	2,280.0	128.4
	Jocassee			
	Minimum	Median	Maximum	Band (ft)
Normal	1,084.5	1,106.8	1,110.0	25.5
ccLow	1,084.2	1,106.8	1,110.0	25.8
ccHigh	1,080.0	1,106.7	1,109.9	29.9
	Keowee			
	Minimum	Median	Maximum	Band (ft)
Normal	791.6	799.2	800.0	8.4
ccLow	791.7	799.2	800.0	8.3
ccHigh	791.4	799.1	800.0	8.6

6 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 KT 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 Appendix B for the Performance Measures sheets for additional information regarding the modeled outcomes for the Project and KT Project.

6.1 Project and KT Project Reservoir Levels

Model results in Table 6-1 through Table 6-3 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 hydrology, 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 (see Figure 5-2 and Figure 5-3), reservoir elevations under both scenarios are comparable. This is further demonstrated by the Performance Measures sheets in Appendix B. There are very 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 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 6-1. 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 6-2. 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**

Table 6-3. 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**

6.1.1 Lake Level Fluctuations and Shoreline Erosion

6.1.1.1 Fluctuation Rates

Model results in Table 6-4 demonstrate the maximum reservoir fluctuation over a 24-hour window during the POR for both the Baseline and Bad Creek II scenarios. Figure 6-1 through Figure 6-3 show the variation in reservoir fluctuation over the POR for Bad Creek, Jocassee, and Keowee. 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 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. See Appendix B for the Performance Measures sheets.

Table 6-4. 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**

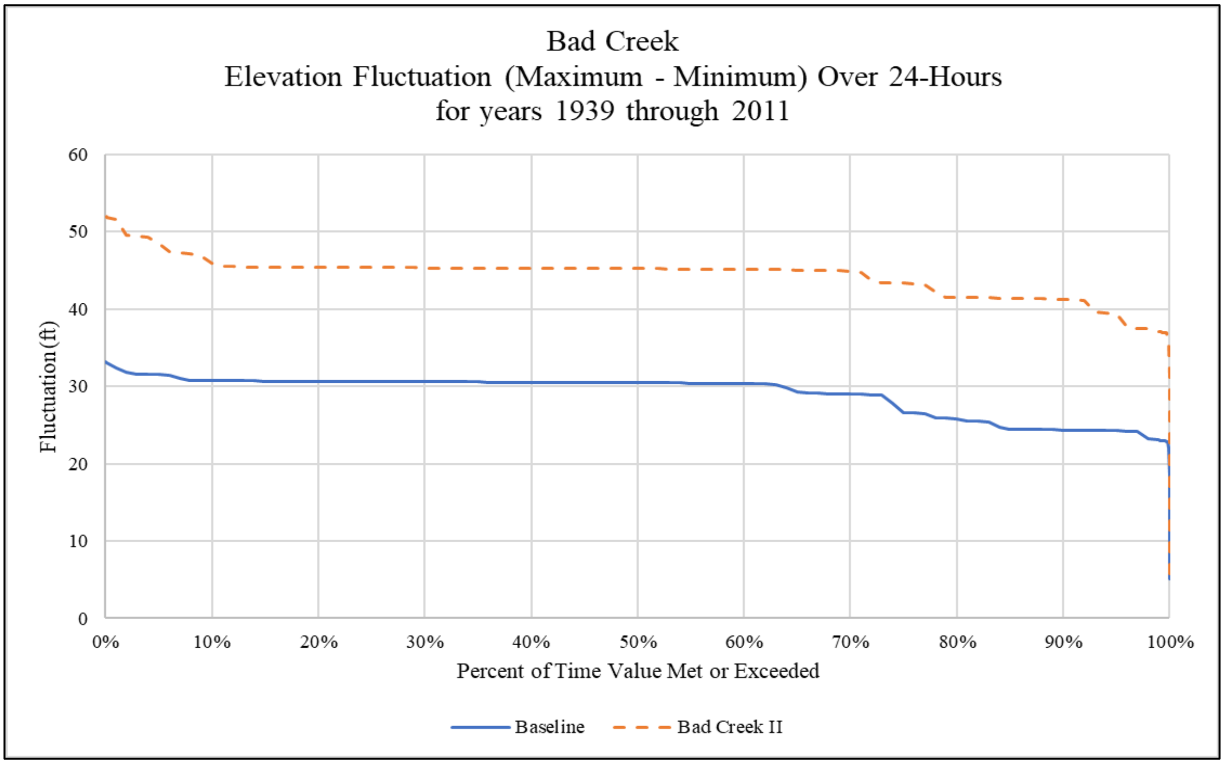

Figure 6-1. Normal Hydrology Bad Creek 24-hour Reservoir Fluctuation for 1939 – 2011

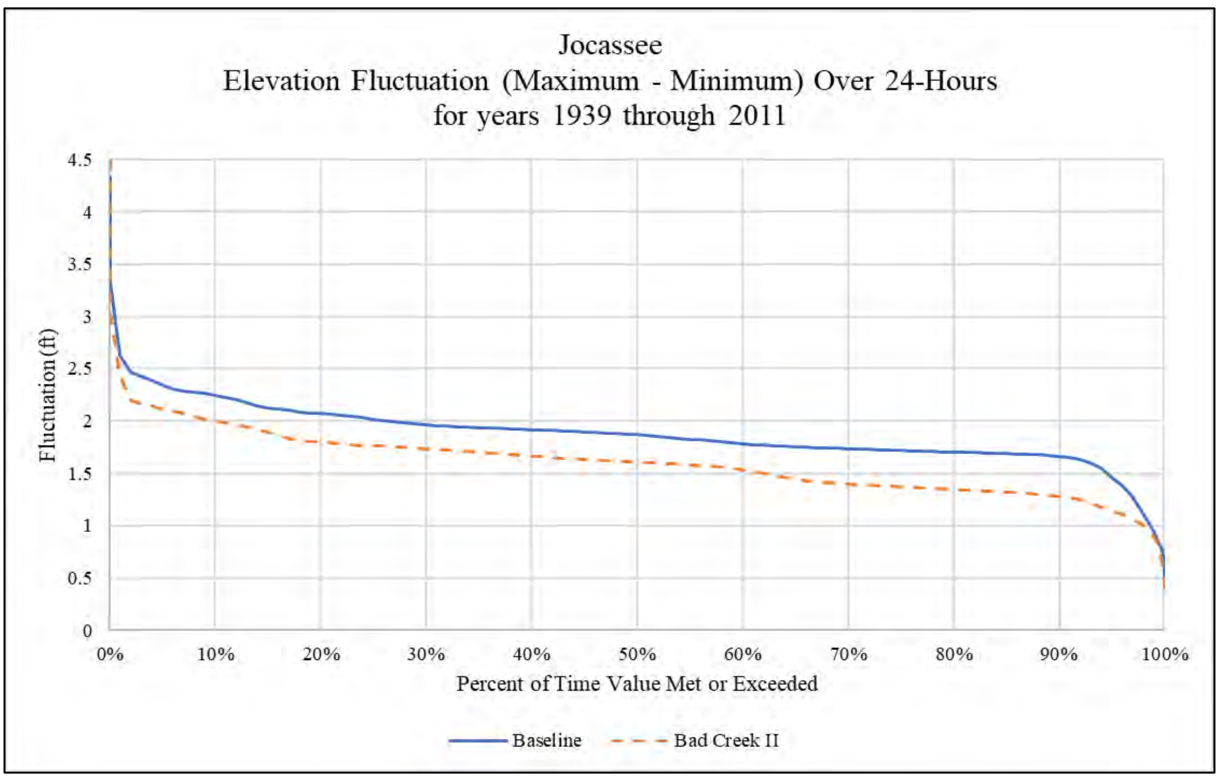

Figure 6-2. Normal Hydrology Jocassee 24-hour Reservoir Fluctuation for 1939 – 2011

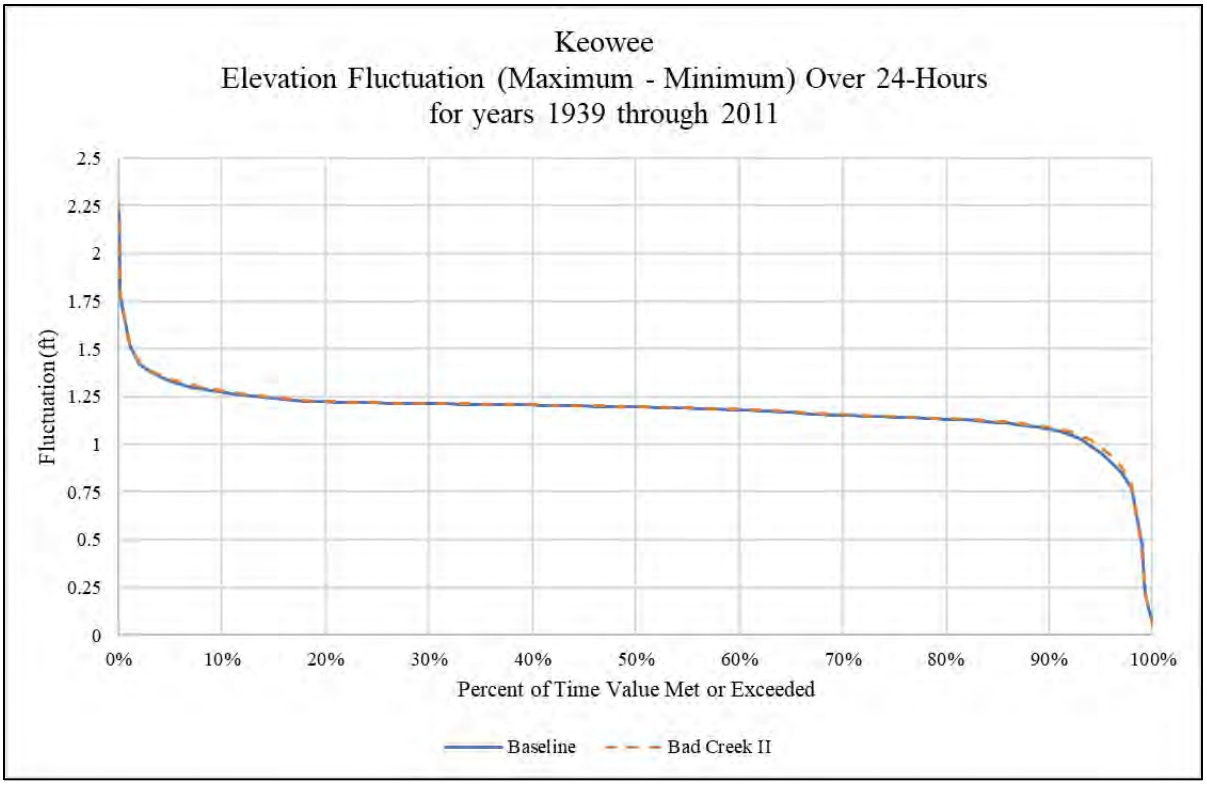

Figure 6-3. Normal Hydrology Keowee 24-hour Reservoir Fluctuation for 1939 – 2011

6.1.1.2 Whitewater River Cove Shoreline Erosion

As part of the Bad Creek II Feasibility Study authorized by Duke Energy, HDR developed a three-dimensional Computational Fluid Dynamic model 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 inlet/outlet structure and the potential associated erosion impacts to the Whitewater River cove of Lake Jocassee. The final report "Lower Reservoir CFD Flow Modeling Report" was filed with the Bad Creek RSP as Appendix I in December 2022 (HDR 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 inlet/outlet 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; detailed results are included in HDR (2022).

6.1.1.3 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 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 maintains a Shoreline Management Plan for Lakes Jocassee and

Keowee classifying the respective shorelines and denotes where environmentally important habitat exists, where existing facilities and uses occur, and where future/existing shoreline activities may be considered.

6.1.2 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 considered in the Aquatic Resources Study Report (Task 2 – Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat).

6.1.3 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 6-4. Likewise, there are a few occurrences where there is a similar shift in days from one LIP Stage to the next[9]. 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 6-4.

[9] See Performance Measures 64 through 69 in Appendix B which demonstrate the shifting of days between the earliest LIP stages.

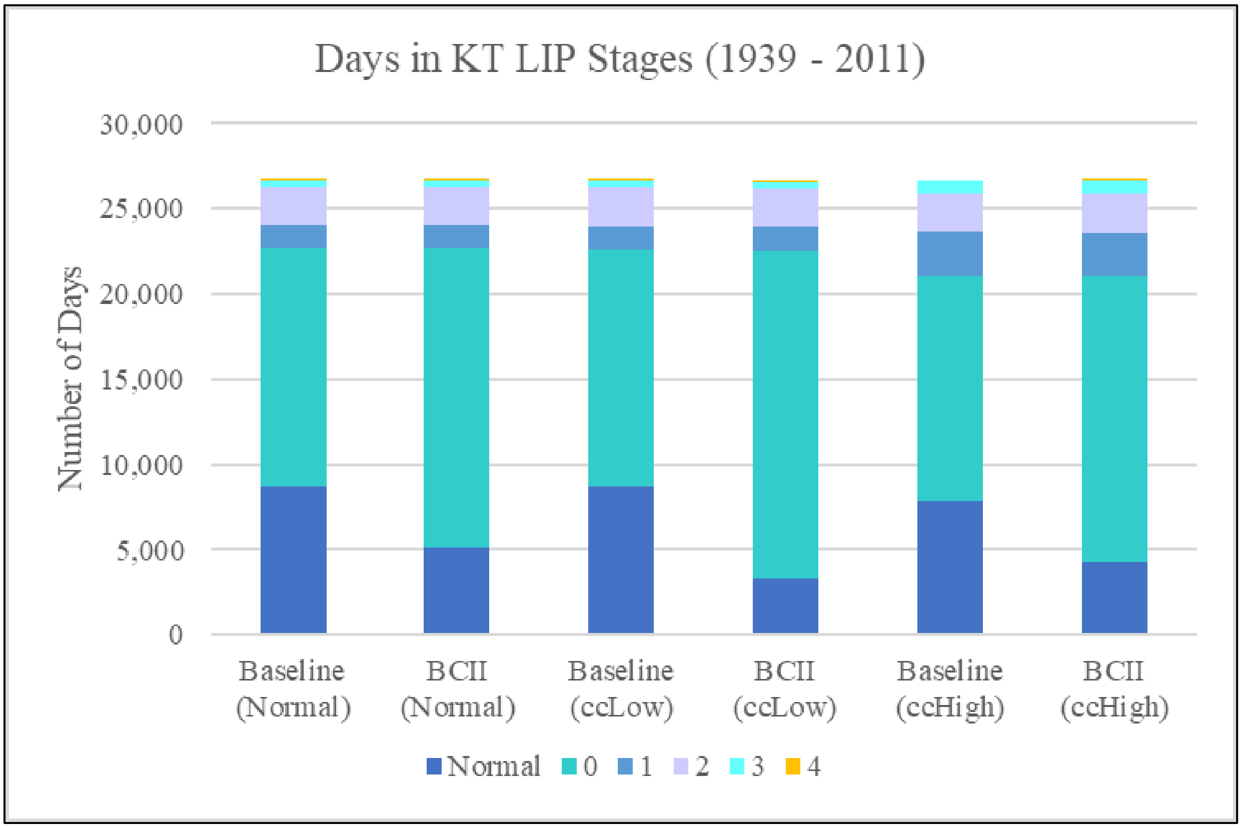

Figure 6-4. Days in KT LIP Stages for 1939 - 2011

6.2 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 KT 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 6-5, 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 6-5. Average Annual Flow Releases from the Keowee and J. Strom Thurmond Developments for the Baseline and Bad Creek II Scenarios 1939 – 2011 (cfs)

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	944	0	7,719	7,719	0
ccLow	939	939	0	7,680	7,680	0
ccHigh	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 (Figure 6-5). Given these findings, few if any effects on the USACE reservoirs are anticipated.

Figure 6-5. Keowee and J. Strom Thurmond Cumulative Release for 1939 – 2011 under Normal, ccLow, and ccHigh hydrology (total volume, thousand acre-ft [TAF])

7 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 feet or less approximately 90% of the time under the Bad Creek II scenario, but only 75% of the time under the Baseline Scenario.

- The effects of the proposed Bad Creek II on lake level fluctuations at Lake Keowee and 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 Oconee Nuclear Station.
- KT LIP Stage 0 would be triggered more frequently with Bad Creek II, but the differences in KT LIP stage frequencies generally diminish in the more advanced stages of the KT LIP.
- Proposed Bad Creek II operations have little to no modeled effects on the downstream USACE reservoirs or flow releases into the Savannah River.

8 Need for Protection, Mitigation, and Enhancement Measures to Protect Water Quality

Based on the results of CHEOPS modeling, and in consideration of results of other data collection efforts in support of KT relicensing (Duke Energy 2014), there is no need for additional PM&E measures to address reservoir elevation changes or downstream flow releases to the USACE reservoirs.

9 Variances from FERC-approved Study Plan

There were no variances from the FERC-approved RSP for this task of the Water Resources Study except for the addition of additional evaluation of the potential lake levels at the USACE reservoirs and flow releases downstream of the Project.

10 References

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Appendix A

Withdrawal and Return Estimates

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Bad Creek Withdrawals (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1940	2011	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
1941	2012	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
1942	2013	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
1943	2014	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1944	2015	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
1945	2016	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
1946	2017	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
1947	2018	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
1948	2019	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
1949	2020	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
1950	2021	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
1951	2022	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
1952	2023	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
1953	2024	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
1954	2025	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
1955	2026	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
1956	2027	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
1957	2028	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
1958	2029	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
1959	2030	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
1960	2031	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
1961	2032	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
1962	2033	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
1963	2034	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
1964	2035	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
1965	2036	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
1966	2037	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
1967	2038	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
1968	2039	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
1969	2040	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
1970	2041	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1971	2042	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
1972	2043	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
1973	2044	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
1974	2045	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
1975	2046	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
1976	2047	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
1977	2048	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
1978	2049	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
1979	2050	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
1980	2051	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
1981	2052	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
1982	2053	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
1983	2054	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
1984	2055	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
1985	2056	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
1986	2057	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
1987	2058	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
1988	2059	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1989	2060	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
1990	2061	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
1991	2062	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
1992	2063	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
1993	2064	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
1994	2065	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
1995	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
1996	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
1997	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
1998	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
1999	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2000	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2001	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2002	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2003	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2004	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2005	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2006	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2007	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2008	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2009	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2010	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2011	2066	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

Bad Creek Returns (cfs)

Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940	2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1941	2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1942	2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1943	2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1944	2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1945	2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1946	2017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1947	2018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1948	2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1949	2020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1950	2021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1951	2022	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1952	2023	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1953	2024	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1954	2025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1955	2026	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1956	2027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1957	2028	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1958	2029	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1959	2030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1960	2031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1961	2032	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1962	2033	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1963	2034	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1964	2035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1965	2036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1966	2037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1967	2038	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1968	2039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1969	2040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1970	2041	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	2042	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	2043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	2044	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	2045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	2046	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	2047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	2048	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1978	2049	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	2050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	2051	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	2052	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	2053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1983	2054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	2055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1985	2056	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	2057	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	2058	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	2059	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	2060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	2061	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	2062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	2063	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	2064	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	2065	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Jocassee Withdrawals (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22	7.22
1940	2011	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28	7.28
1941	2012	7.34	7.34	7.34	7.34	7.34	7.34	7.34	7.34	7.34	7.34	7.34	7.34
1942	2013	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40	7.40
1943	2014	7.46	7.46	7.46	7.46	7.46	7.46	7.46	7.46	7.46	7.46	7.46	7.46
1944	2015	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52	7.52
1945	2016	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58
1946	2017	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58	7.58
1947	2018	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59
1948	2019	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59	7.59
1949	2020	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
1950	2021	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
1951	2022	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60	7.60
1952	2023	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61
1953	2024	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61	7.61
1954	2025	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62
1955	2026	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62
1956	2027	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63
1957	2028	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64	7.64
1958	2029	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65
1959	2030	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65
1960	2031	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.66
1961	2032	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67	7.67
1962	2033	7.68	7.68	7.68	7.68	7.68	7.68	7.68	7.68	7.68	7.68	7.68	7.68
1963	2034	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69
1964	2035	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69	7.69
1965	2036	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70
1966	2037	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71	7.71
1967	2038	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72
1968	2039	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72	7.72
1969	2040	7.73	7.73	7.73	7.73	7.73	7.73	7.73	7.73	7.73	7.73	7.73	7.73
1970	2041	7.74	7.74	7.74	7.74	7.74	7.74	7.74	7.74	7.74	7.74	7.74	7.74
1971	2042	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75
1972	2043	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75
1973	2044	7.76	7.76	7.76	7.76	7.76	7.76	7.76	7.76	7.76	7.76	7.76	7.76
1974	2045	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77	7.77
1975	2046	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78
1976	2047	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79
1977	2048	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79	7.79
1978	2049	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80
1979	2050	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81	7.81
1980	2051	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82
1981	2052	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82	7.82
1982	2053	7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83	7.83
1983	2054	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84
1984	2055	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85
1985	2056	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86	7.86
1986	2057	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87	7.87
1987	2058	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88
1988	2059	7.89	7.89	7.89	7.89	7.89	7.89	7.89	7.89	7.89	7.89	7.89	7.89
1989	2060	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90	7.90
1990	2061	7.91	7.91	7.91	7.91	7.91	7.91	7.91	7.91	7.91	7.91	7.91	7.91
1991	2062	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92	7.92
1992	2063	7.93	7.93	7.93	7.93	7.93	7.93	7.93	7.93	7.93	7.93	7.93	7.93
1993	2064	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94	7.94
1994	2065	7.95	7.95	7.95	7.95	7.95	7.95	7.95	7.95	7.95	7.95	7.95	7.95
1995	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
1996	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
1997	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
1998	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
1999	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2000	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2001	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2002	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2003	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2004	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2005	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2006	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2007	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2008	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2009	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2010	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96
2011	2066	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96	7.96

Jocassee Returns (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940	2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1941	2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1942	2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1943	2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1944	2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1945	2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1946	2017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1947	2018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1948	2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1949	2020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1950	2021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1951	2022	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1952	2023	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1953	2024	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1954	2025	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1955	2026	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1956	2027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1957	2028	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1958	2029	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1959	2030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1960	2031	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1961	2032	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1962	2033	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1963	2034	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1964	2035	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1965	2036	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1966	2037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1967	2038	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1968	2039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1969	2040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1970	2041	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	2042	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	2043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	2044	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	2045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	2046	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	2047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	2048	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1978	2049	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	2050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	2051	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	2052	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	2053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1983	2054	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	2055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1985	2056	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	2057	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	2058	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	2059	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	2060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	2061	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	2062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	2063	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	2064	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	2065	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	2066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Keowee Withdrawals (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	94.67	93.15	91.34	98.09	101.61	117.99	116.09	113.32	109.48	98.73	89.68	94.04
1940	2011	97.13	95.57	93.73	100.72	104.41	121.23	119.24	116.39	112.45	101.41	92.13	96.55
1941	2012	99.60	97.99	96.12	103.35	107.21	124.47	122.39	119.45	115.41	104.10	94.59	99.07
1942	2013	102.06	100.41	98.50	105.99	110.01	127.72	125.53	122.52	118.37	106.79	97.05	101.58
1943	2014	104.53	102.83	100.89	108.62	112.81	130.96	128.68	125.59	121.34	109.48	99.51	104.09
1944	2015	106.99	105.25	103.28	111.26	115.61	134.20	131.83	128.66	124.30	112.17	101.96	106.61
1945	2016	109.46	107.67	105.66	113.89	118.42	137.44	134.98	131.72	127.26	114.86	104.42	109.12
1946	2017	111.32	109.48	107.46	116.02	120.85	140.21	137.63	134.30	129.73	117.13	106.53	111.13
1947	2018	113.17	111.28	109.26	118.15	123.28	142.97	140.28	136.87	132.19	119.40	108.63	113.13
1948	2019	115.03	113.08	111.06	120.28	125.71	145.74	142.93	139.44	134.66	121.67	110.74	115.14
1949	2020	116.89	114.89	112.85	122.42	128.14	148.50	145.58	142.02	137.13	123.94	112.85	117.14
1950	2021	118.74	116.69	114.65	124.55	130.57	151.27	148.23	144.59	139.59	126.21	114.95	119.15
1951	2022	120.60	118.50	116.45	126.68	133.00	154.03	150.88	147.16	142.06	128.48	117.06	121.15
1952	2023	122.46	120.30	118.25	128.81	135.43	156.80	153.53	149.74	144.52	130.75	119.17	123.16
1953	2024	124.32	122.11	120.05	130.94	137.86	159.56	156.18	152.31	146.99	133.02	121.27	125.17
1954	2025	126.17	123.91	121.85	133.07	140.29	162.33	158.82	154.88	149.46	135.29	123.38	127.17
1955	2026	128.03	125.72	123.64	135.20	142.72	165.09	161.47	157.46	151.92	137.56	125.49	129.18
1956	2027	131.45	129.08	126.95	138.77	146.44	169.42	165.72	161.60	155.92	141.16	128.76	132.59
1957	2028	134.88	132.45	130.25	142.34	150.16	173.75	169.97	165.75	159.92	144.77	132.04	136.01
1958	2029	138.30	135.82	133.55	145.91	153.89	178.07	174.22	169.89	163.93	148.38	135.31	139.43
1959	2030	141.73	139.19	136.86	149.48	157.61	182.40	178.47	174.04	167.93	151.98	138.59	142.85
1960	2031	145.16	142.55	140.16	153.05	161.33	186.73	182.72	178.19	171.93	155.59	141.86	146.26
1961	2032	148.58	145.92	143.46	156.63	165.05	191.06	186.97	182.33	175.93	159.20	145.14	149.68
1962	2033	152.01	149.29	146.77	160.20	168.78	195.38	191.22	186.48	179.93	162.80	148.41	153.10
1963	2034	155.43	152.66	150.07	163.77	172.50	199.71	195.47	190.62	183.93	166.41	151.68	156.52
1964	2035	158.86	156.02	153.37	167.34	176.22	204.04	199.72	194.77	187.94	170.02	154.96	159.93
1965	2036	162.28	159.39	156.68	170.91	179.94	208.36	203.97	198.92	191.94	173.62	158.23	163.35
1966	2037	164.12	161.18	158.47	173.05	182.40	211.17	206.63	201.49	194.41	175.90	160.35	165.37
1967	2038	165.96	162.97	160.26	175.19	184.85	213.97	209.28	204.07	196.89	178.19	162.47	167.38
1968	2039	167.81	164.76	162.05	177.33	187.30	216.77	211.94	206.64	199.36	180.47	164.58	169.39
1969	2040	169.65	166.55	163.84	179.47	189.75	219.57	214.59	209.22	201.84	182.75	166.70	171.41
1970	2041	171.49	168.34	165.63	181.61	192.20	222.37	217.25	211.79	204.31	185.03	168.82	173.42
1971	2042	173.33	170.13	167.42	183.76	194.65	225.17	219.90	214.37	206.79	187.31	170.94	175.43
1972	2043	175.17	171.92	169.21	185.90	197.10	227.97	222.56	216.94	209.26	189.59	173.05	177.45
1973	2044	177.01	173.71	171.00	188.04	199.55	230.77	225.21	219.52	211.74	191.87	175.17	179.46
1974	2045	178.85	175.50	172.79	190.18	202.00	233.57	227.87	222.10	214.21	194.15	177.29	181.47
1975	2046	180.69	177.29	174.58	192.32	204.45	236.37	230.52	224.67	216.69	196.43	179.40	183.49
1976	2047	182.49	179.03	176.33	194.41	206.85	239.11	233.11	227.19	219.10	198.66	181.47	185.45
1977	2048	184.29	180.78	178.08	196.50	209.24	241.84	235.70	229.70	221.52	200.88	183.54	187.42
1978	2049	186.09	182.53	179.83	198.59	211.63	244.57	238.30	232.21	223.93	203.11	185.60	189.38
1979	2050	187.88	184.28	181.58	200.68	214.02	247.30	240.89	234.73	226.35	205.34	187.67	191.35
1980	2051	189.68	186.02	183.32	202.77	216.41	250.03	243.48	237.24	228.77	207.56	189.73	193.31
1981	2052	191.48	187.77	185.07	204.86	218.80	252.77	246.07	239.76	231.18	209.79	191.80	195.28
1982	2053	193.28	189.52	186.82	206.95	221.20	255.50	248.66	242.27	233.60	212.01	193.87	197.24
1983	2054	195.08	191.27	188.57	209.04	223.59	258.23	251.25	244.78	236.01	214.24	195.93	199.21
1984	2055	196.88	193.02	190.32	211.13	225.98	260.96	253.84	247.30	238.43	216.47	198.00	201.17
1985	2056	198.67	194.76	192.07	213.22	228.37	263.70	256.43	249.81	240.84	218.69	200.06	203.14
1986	2057	200.72	196.75	194.05	215.59	231.09	266.80	259.38	252.67	243.59	221.22	202.41	205.37
1987	2058	202.76	198.74	196.04	217.97	233.81	269.91	262.33	255.53	246.34	223.76	204.77	207.61
1988	2059	204.81	200.73	198.03	220.35	236.53	273.02	265.28	258.39	249.09	226.29	207.12	209.84
1989	2060	206.86	202.72	200.02	222.73	239.25	276.13	268.22	261.25	251.84	228.82	209.47	212.08
1990	2061	208.90	204.70	202.01	225.11	241.97	279.24	271.17	264.11	254.58	231.35	211.82	214.31
1991	2062	210.95	206.69	204.00	227.48	244.70	282.35	274.12	266.97	257.33	233.89	214.17	216.55
1992	2063	212.99	208.68	205.99	229.86	247.42	285.46	277.07	269.83	260.08	236.42	216.52	218.79
1993	2064	215.04	210.67	207.98	232.24	250.14	288.56	280.01	272.69	262.83	238.95	218.87	221.02
1994	2065	217.08	212.66	209.97	234.62	252.86	291.67	282.96	275.55	265.58	241.49	221.22	223.26
1995	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
1996	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
1997	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
1998	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
1999	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2000	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2001	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2002	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2003	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2004	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2005	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2006	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2007	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2008	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2009	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2010	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49
2011	2066	219.13	214.65	211.96	236.99	255.58	294.78	285.91	278.41	268.32	244.02	223.57	225.49

Keowee Returns (cfs)

Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	2.71	2.21	1.82	2.28	2.24	2.70	2.44	2.51	2.61	2.22	2.03	2.43
1940	2011	2.82	2.30	1.89	2.37	2.33	2.81	2.54	2.61	2.71	2.31	2.11	2.52
1941	2012	2.93	2.38	1.96	2.46	2.42	2.91	2.63	2.71	2.81	2.40	2.19	2.62
1942	2013	3.03	2.47	2.03	2.54	2.50	3.02	2.73	2.81	2.91	2.48	2.26	2.71
1943	2014	3.14	2.55	2.09	2.63	2.59	3.12	2.82	2.91	3.02	2.57	2.34	2.81
1944	2015	3.24	2.64	2.16	2.72	2.67	3.23	2.92	3.01	3.12	2.66	2.42	2.90
1945	2016	3.35	2.73	2.23	2.80	2.76	3.33	3.01	3.11	3.22	2.74	2.50	3.00
1946	2017	3.45	2.81	2.29	2.89	2.84	3.43	3.10	3.20	3.32	2.82	2.57	3.09
1947	2018	3.55	2.89	2.36	2.97	2.92	3.53	3.19	3.30	3.42	2.91	2.64	3.18
1948	2019	3.65	2.97	2.42	3.05	3.00	3.63	3.28	3.39	3.52	2.99	2.72	3.27
1949	2020	3.75	3.05	2.49	3.14	3.09	3.73	3.37	3.49	3.62	3.07	2.79	3.36
1950	2021	3.85	3.13	2.55	3.22	3.17	3.83	3.46	3.58	3.71	3.15	2.87	3.45
1951	2022	3.95	3.21	2.62	3.30	3.25	3.93	3.55	3.67	3.81	3.24	2.94	3.54
1952	2023	4.05	3.30	2.68	3.38	3.33	4.03	3.64	3.77	3.91	3.32	3.01	3.63
1953	2024	4.16	3.38	2.75	3.47	3.41	4.13	3.73	3.86	4.01	3.40	3.09	3.72
1954	2025	4.26	3.46	2.81	3.55	3.49	4.23	3.82	3.96	4.11	3.48	3.16	3.82
1955	2026	4.36	3.54	2.87	3.63	3.58	4.33	3.91	4.05	4.20	3.57	3.23	3.91
1956	2027	4.46	3.62	2.94	3.72	3.66	4.43	4.00	4.15	4.30	3.65	3.31	4.00
1957	2028	4.56	3.70	3.00	3.80	3.74	4.53	4.09	4.24	4.40	3.73	3.38	4.09
1958	2029	4.66	3.78	3.07	3.88	3.82	4.63	4.18	4.34	4.50	3.81	3.46	4.18
1959	2030	4.76	3.86	3.13	3.96	3.90	4.73	4.27	4.43	4.60	3.90	3.53	4.27
1960	2031	4.86	3.95	3.20	4.05	3.99	4.83	4.36	4.53	4.70	3.98	3.60	4.36
1961	2032	4.96	4.03	3.26	4.13	4.07	4.93	4.45	4.62	4.79	4.06	3.68	4.45
1962	2033	5.06	4.11	3.33	4.21	4.15	5.03	4.54	4.71	4.89	4.14	3.75	4.54
1963	2034	5.16	4.19	3.39	4.30	4.23	5.13	4.63	4.81	4.99	4.23	3.83	4.63
1964	2035	5.26	4.27	3.46	4.38	4.31	5.23	4.72	4.90	5.09	4.31	3.90	4.72
1965	2036	5.36	4.35	3.52	4.46	4.39	5.33	4.81	5.00	5.19	4.39	3.97	4.81
1966	2037	5.46	4.43	3.58	4.55	4.48	5.43	4.90	5.09	5.28	4.47	4.05	4.90
1967	2038	5.56	4.52	3.65	4.63	4.56	5.53	4.99	5.19	5.38	4.56	4.12	4.99
1968	2039	5.67	4.60	3.71	4.71	4.64	5.63	5.08	5.28	5.48	4.64	4.20	5.09
1969	2040	5.77	4.68	3.78	4.79	4.72	5.73	5.17	5.38	5.58	4.72	4.27	5.18
1970	2041	5.87	4.76	3.84	4.88	4.80	5.83	5.26	5.47	5.68	4.80	4.34	5.27
1971	2042	5.97	4.84	3.91	4.96	4.88	5.93	5.35	5.56	5.78	4.88	4.42	5.36
1972	2043	6.07	4.92	3.97	5.04	4.97	6.03	5.44	5.66	5.88	4.97	4.49	5.45
1973	2044	6.17	5.01	4.03	5.13	5.05	6.13	5.53	5.75	5.97	5.05	4.56	5.54
1974	2045	6.27	5.09	4.10	5.21	5.13	6.23	5.62	5.85	6.07	5.13	4.64	5.63
1975	2046	6.38	5.17	4.16	5.29	5.21	6.33	5.71	5.94	6.17	5.21	4.71	5.72
1976	2047	6.48	5.25	4.23	5.37	5.29	6.43	5.80	6.04	6.27	5.30	4.78	5.81
1977	2048	6.58	5.33	4.29	5.46	5.37	6.53	5.89	6.13	6.36	5.38	4.86	5.90
1978	2049	6.68	5.41	4.35	5.54	5.45	6.63	5.98	6.22	6.46	5.46	4.93	5.99
1979	2050	6.77	5.49	4.42	5.62	5.53	6.72	6.07	6.31	6.56	5.54	5.00	6.08
1980	2051	6.87	5.57	4.48	5.70	5.61	6.82	6.15	6.41	6.65	5.62	5.07	6.17
1981	2052	6.97	5.65	4.54	5.78	5.69	6.92	6.24	6.50	6.75	5.70	5.15	6.26
1982	2053	7.07	5.73	4.61	5.86	5.77	7.02	6.33	6.59	6.85	5.78	5.22	6.35
1983	2054	7.17	5.81	4.67	5.94	5.85	7.12	6.42	6.69	6.94	5.86	5.29	6.44
1984	2055	7.27	5.89	4.73	6.03	5.93	7.22	6.51	6.78	7.04	5.94	5.36	6.53
1985	2056	7.37	5.97	4.79	6.11	6.01	7.32	6.60	6.87	7.14	6.02	5.44	6.62
1986	2057	7.49	6.06	4.87	6.20	6.10	7.43	6.70	6.98	7.25	6.12	5.52	6.72
1987	2058	7.60	6.15	4.94	6.29	6.19	7.54	6.80	7.08	7.36	6.21	5.60	6.82
1988	2059	7.71	6.24	5.01	6.38	6.28	7.65	6.90	7.19	7.47	6.30	5.68	6.92
1989	2060	7.82	6.33	5.08	6.48	6.38	7.76	7.00	7.29	7.57	6.39	5.76	7.03
1990	2061	7.94	6.43	5.15	6.57	6.47	7.87	7.10	7.40	7.68	6.48	5.85	7.13
1991	2062	8.05	6.52	5.22	6.66	6.56	7.98	7.20	7.50	7.79	6.57	5.93	7.23
1992	2063	8.16	6.61	5.29	6.75	6.65	8.09	7.29	7.61	7.90	6.66	6.01	7.33
1993	2064	8.27	6.70	5.37	6.85	6.74	8.20	7.39	7.71	8.01	6.76	6.09	7.43
1994	2065	8.39	6.79	5.44	6.94	6.83	8.32	7.49	7.81	8.12	6.85	6.17	7.53
1995	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
1996	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
1997	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
1998	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
1999	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2000	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2001	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2002	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2003	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2004	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2005	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2006	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2007	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2008	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2009	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2010	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63
2011	2066	8.50	6.88	5.51	7.03	6.92	8.43	7.59	7.92	8.23	6.94	6.26	7.63

Hartwell Withdrawals (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	52.40	55.65	55.48	58.80	63.36	67.38	67.47	67.72	65.47	61.21	60.35	55.05
1940	2011	55.18	58.90	58.74	62.35	67.24	71.59	71.71	71.96	69.51	64.87	64.15	58.24
1941	2012	57.96	62.15	62.01	65.90	71.13	75.81	75.95	76.19	73.56	68.53	67.94	61.42
1942	2013	60.74	65.40	65.27	69.45	75.01	80.03	80.18	80.42	77.61	72.19	71.73	64.60
1943	2014	63.51	68.65	68.54	73.00	78.89	84.24	84.42	84.66	81.66	75.84	75.52	67.79
1944	2015	66.29	71.90	71.80	76.55	82.77	88.46	88.66	88.89	85.71	79.50	79.31	70.97
1945	2016	69.07	75.15	75.07	80.10	86.66	92.68	92.90	93.12	89.76	83.16	83.10	74.15
1946	2017	70.05	76.28	76.20	81.33	88.00	94.13	94.36	94.58	91.15	84.43	84.41	75.27
1947	2018	71.03	77.41	77.33	82.57	89.34	95.59	95.81	96.03	92.54	85.70	85.71	76.39
1948	2019	72.01	78.54	78.46	83.80	90.68	97.05	97.27	97.49	93.93	86.96	87.02	77.51
1949	2020	72.98	79.68	79.59	85.03	92.03	98.51	98.73	98.94	95.32	88.23	88.33	78.62
1950	2021	73.96	80.81	80.72	86.26	93.37	99.97	100.19	100.40	96.71	89.50	89.63	79.74
1951	2022	74.94	81.94	81.85	87.49	94.71	101.43	101.65	101.85	98.10	90.77	90.94	80.86
1952	2023	75.92	83.07	82.99	88.72	96.05	102.88	103.11	103.31	99.50	92.04	92.25	81.98
1953	2024	76.90	84.20	84.12	89.96	97.40	104.34	104.57	104.76	100.89	93.31	93.55	83.10
1954	2025	77.88	85.34	85.25	91.19	98.74	105.80	106.03	106.22	102.28	94.58	94.86	84.21
1955	2026	78.86	86.47	86.38	92.42	100.08	107.26	107.49	107.67	103.67	95.84	96.17	85.33
1956	2027	80.98	88.67	88.58	94.68	102.41	109.65	109.89	110.08	106.03	98.13	98.45	87.52
1957	2028	83.10	90.87	90.79	96.93	104.73	112.05	112.29	112.48	108.40	100.42	100.74	89.70
1958	2029	85.22	93.08	92.99	99.19	107.06	114.44	114.69	114.89	110.76	102.71	103.03	91.88
1959	2030	87.35	95.28	95.19	101.45	109.39	116.84	117.09	117.29	113.12	105.00	105.32	94.07
1960	2031	89.47	97.48	97.40	103.71	111.72	119.24	119.49	119.69	115.49	107.28	107.61	96.25
1961	2032	91.59	99.68	99.60	105.96	114.04	121.63	121.89	122.10	117.85	109.57	109.90	98.44
1962	2033	93.71	101.88	101.80	108.22	116.37	124.03	124.29	124.50	120.22	111.86	112.18	100.62
1963	2034	95.84	104.09	104.01	110.48	118.70	126.42	126.69	126.91	122.58	114.15	114.47	102.80
1964	2035	97.96	106.29	106.21	112.73	121.02	128.82	129.10	129.31	124.94	116.43	116.76	104.99
1965	2036	100.08	108.49	108.41	114.99	123.35	131.21	131.50	131.71	127.31	118.72	119.05	107.17
1966	2037	100.86	109.35	109.28	115.92	124.36	132.30	132.60	132.81	128.36	119.68	120.01	108.02
1967	2038	101.64	110.22	110.14	116.85	125.38	133.40	133.69	133.91	129.41	120.65	120.97	108.86
1968	2039	102.42	111.08	111.00	117.78	126.39	134.49	134.79	135.01	130.46	121.61	121.94	109.71
1969	2040	103.20	111.95	111.86	118.71	127.40	135.58	135.89	136.11	131.52	122.57	122.90	110.56
1970	2041	103.98	112.81	112.73	119.64	128.42	136.68	136.99	137.21	132.57	123.54	123.86	111.40
1971	2042	104.76	113.68	113.59	120.57	129.43	137.77	138.09	138.31	133.62	124.50	124.83	112.25
1972	2043	105.54	114.54	114.45	121.50	130.44	138.86	139.19	139.41	134.68	125.46	125.79	113.10
1973	2044	106.32	115.41	115.31	122.43	131.46	139.96	140.29	140.51	135.73	126.43	126.75	113.94
1974	2045	107.10	116.27	116.18	123.36	132.47	141.05	141.39	141.61	136.78	127.39	127.71	114.79
1975	2046	107.88	117.14	117.04	124.28	133.48	142.15	142.48	142.71	137.83	128.36	128.68	115.64
1976	2047	108.69	118.02	117.92	125.23	134.51	143.26	143.60	143.83	138.90	129.34	129.65	116.50
1977	2048	109.50	118.90	118.80	126.18	135.55	144.37	144.72	144.95	139.98	130.32	130.62	117.37
1978	2049	110.30	119.79	119.69	127.13	136.58	145.48	145.84	146.07	141.05	131.30	131.60	118.24
1979	2050	111.11	120.67	120.57	128.07	137.61	146.59	146.95	147.19	142.12	132.29	132.57	119.10
1980	2051	111.92	121.56	121.45	129.02	138.64	147.70	148.07	148.31	143.19	133.27	133.54	119.97
1981	2052	112.73	122.44	122.33	129.97	139.67	148.82	149.19	149.42	144.26	134.25	134.51	120.83
1982	2053	113.53	123.33	123.21	130.92	140.71	149.93	150.30	150.54	145.33	135.23	135.49	121.70
1983	2054	114.34	124.21	124.09	131.86	141.74	151.04	151.42	151.66	146.40	136.22	136.46	122.57
1984	2055	115.15	125.09	124.98	132.81	142.77	152.15	152.54	152.78	147.47	137.20	137.43	123.43
1985	2056	115.95	125.98	125.86	133.76	143.80	153.26	153.65	153.90	148.54	138.18	138.41	124.30
1986	2057	116.84	126.95	126.83	134.80	144.94	154.49	154.88	155.13	149.72	139.26	139.47	125.25
1987	2058	117.73	127.93	127.80	135.84	146.07	155.71	156.11	156.36	150.90	140.34	140.54	126.20
1988	2059	118.62	128.90	128.77	136.88	147.20	156.93	157.33	157.59	152.07	141.42	141.61	127.16
1989	2060	119.51	129.87	129.74	137.92	148.34	158.15	158.56	158.82	153.25	142.50	142.68	128.11
1990	2061	120.40	130.84	130.71	138.96	149.47	159.37	159.79	160.05	154.43	143.59	143.75	129.06
1991	2062	121.29	131.82	131.68	140.01	150.61	160.59	161.02	161.28	155.60	144.67	144.81	130.01
1992	2063	122.18	132.79	132.65	141.05	151.74	161.81	162.24	162.50	156.78	145.75	145.88	130.97
1993	2064	123.07	133.76	133.62	142.09	152.87	163.04	163.47	163.73	157.96	146.83	146.95	131.92
1994	2065	123.96	134.74	134.59	143.13	154.01	164.26	164.70	164.96	159.13	147.91	148.02	132.87
1995	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
1996	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
1997	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
1998	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
1999	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2000	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2001	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2002	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2003	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2004	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2005	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2006	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2007	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2008	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2009	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2010	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82
2011	2066	124.85	135.71	135.56	144.17	155.14	165.48	165.92	166.19	160.31	148.99	149.08	133.82

Hartwell Returns (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	23.61	23.87	23.07	22.94	23.81	22.56	21.85	22.66	23.65	23.28	24.21	25.57
1940	2011	23.84	24.11	23.31	23.16	24.01	22.75	22.04	22.85	23.87	23.48	24.41	25.79
1941	2012	24.07	24.35	23.54	23.38	24.20	22.94	22.23	23.05	24.09	23.68	24.61	26.01
1942	2013	24.30	24.59	23.78	23.60	24.39	23.12	22.42	23.24	24.30	23.88	24.82	26.23
1943	2014	24.53	24.83	24.02	23.82	24.59	23.31	22.61	23.44	24.52	24.08	25.02	26.45
1944	2015	24.76	25.07	24.26	24.04	24.78	23.50	22.80	23.64	24.73	24.28	25.22	26.66
1945	2016	25.00	25.31	24.49	24.26	24.98	23.69	22.98	23.83	24.95	24.49	25.42	26.88
1946	2017	25.18	25.50	24.68	24.43	25.14	23.84	23.15	24.00	25.13	24.65	25.59	27.06
1947	2018	25.36	25.69	24.87	24.61	25.30	24.00	23.31	24.17	25.31	24.82	25.76	27.25
1948	2019	25.55	25.88	25.06	24.78	25.46	24.16	23.47	24.33	25.49	24.99	25.93	27.43
1949	2020	25.73	26.07	25.25	24.96	25.63	24.32	23.64	24.50	25.67	25.16	26.10	27.61
1950	2021	25.91	26.26	25.44	25.14	25.79	24.48	23.80	24.67	25.85	25.33	26.27	27.79
1951	2022	26.10	26.44	25.63	25.31	25.95	24.63	23.96	24.83	26.04	25.50	26.44	27.97
1952	2023	26.28	26.63	25.82	25.49	26.11	24.79	24.13	25.00	26.22	25.67	26.61	28.15
1953	2024	26.46	26.82	26.01	25.66	26.28	24.95	24.29	25.17	26.40	25.84	26.78	28.33
1954	2025	26.65	27.01	26.20	25.84	26.44	25.11	24.45	25.34	26.58	26.01	26.95	28.52
1955	2026	26.83	27.20	26.39	26.02	26.60	25.26	24.62	25.50	26.76	26.17	27.12	28.70
1956	2027	27.01	27.38	26.57	26.19	26.76	25.43	24.78	25.67	26.94	26.34	27.29	28.87
1957	2028	27.19	27.57	26.76	26.37	26.93	25.59	24.94	25.84	27.13	26.51	27.46	29.05
1958	2029	27.37	27.76	26.95	26.55	27.09	25.75	25.10	26.01	27.31	26.68	27.63	29.22
1959	2030	27.55	27.95	27.14	26.73	27.26	25.92	25.27	26.17	27.49	26.85	27.80	29.40
1960	2031	27.73	28.13	27.32	26.91	27.42	26.08	25.43	26.34	27.67	27.02	27.97	29.58
1961	2032	27.91	28.32	27.51	27.08	27.58	26.24	25.59	26.51	27.85	27.19	28.14	29.75
1962	2033	28.09	28.51	27.70	27.26	27.75	26.41	25.75	26.68	28.03	27.36	28.31	29.93
1963	2034	28.27	28.70	27.89	27.44	27.91	26.57	25.91	26.84	28.22	27.53	28.48	30.10
1964	2035	28.44	28.88	28.08	27.62	28.07	26.73	26.08	27.01	28.40	27.70	28.65	30.28
1965	2036	28.62	29.07	28.26	27.79	28.24	26.89	26.24	27.18	28.58	27.87	28.82	30.46
1966	2037	28.76	29.21	28.40	27.93	28.36	27.04	26.36	27.31	28.72	28.00	28.95	30.58
1967	2038	28.89	29.36	28.55	28.07	28.49	27.18	26.48	27.44	28.85	28.13	29.08	30.70
1968	2039	29.02	29.50	28.69	28.22	28.62	27.32	26.61	27.57	28.99	28.26	29.21	30.83
1969	2040	29.15	29.64	28.83	28.36	28.75	27.46	26.73	27.70	29.13	28.39	29.34	30.95
1970	2041	29.28	29.79	28.97	28.50	28.88	27.61	26.85	27.83	29.27	28.52	29.47	31.07
1971	2042	29.41	29.93	29.11	28.64	29.01	27.75	26.97	27.96	29.41	28.65	29.60	31.20
1972	2043	29.54	30.07	29.26	28.78	29.14	27.89	27.09	28.09	29.54	28.78	29.73	31.32
1973	2044	29.67	30.21	29.40	28.92	29.26	28.03	27.22	28.21	29.68	28.92	29.86	31.45
1974	2045	29.80	30.36	29.54	29.06	29.39	28.18	27.34	28.34	29.82	29.05	29.99	31.57
1975	2046	29.93	30.50	29.68	29.20	29.52	28.32	27.46	28.47	29.96	29.18	30.12	31.69
1976	2047	30.19	30.77	29.95	29.45	29.76	28.56	27.69	28.72	30.22	29.42	30.36	31.94
1977	2048	30.45	31.04	30.22	29.71	30.00	28.79	27.93	28.96	30.48	29.66	30.61	32.19
1978	2049	30.71	31.31	30.49	29.97	30.23	29.03	28.16	29.20	30.74	29.91	30.85	32.44
1979	2050	30.96	31.58	30.76	30.23	30.47	29.27	28.39	29.44	31.00	30.15	31.10	32.69
1980	2051	31.22	31.85	31.03	30.48	30.71	29.50	28.63	29.68	31.26	30.40	31.34	32.94
1981	2052	31.48	32.12	31.29	30.74	30.94	29.74	28.86	29.92	31.52	30.64	31.59	33.20
1982	2053	31.74	32.38	31.56	31.00	31.18	29.98	29.09	30.17	31.78	30.88	31.83	33.45
1983	2054	32.00	32.65	31.83	31.25	31.42	30.21	29.33	30.41	32.04	31.13	32.08	33.70
1984	2055	32.25	32.92	32.10	31.51	31.65	30.45	29.56	30.65	32.30	31.37	32.32	33.95
1985	2056	32.51	33.19	32.37	31.77	31.89	30.69	29.79	30.89	32.56	31.62	32.57	34.20
1986	2057	32.82	33.52	32.69	32.07	32.17	30.97	30.07	31.18	32.87	31.90	32.86	34.50
1987	2058	33.13	33.84	33.01	32.38	32.46	31.26	30.35	31.47	33.18	32.19	33.15	34.79
1988	2059	33.44	34.16	33.34	32.69	32.74	31.55	30.63	31.76	33.49	32.48	33.45	35.09
1989	2060	33.75	34.48	33.66	33.00	33.03	31.83	30.91	32.05	33.80	32.77	33.74	35.39
1990	2061	34.06	34.81	33.98	33.30	33.31	32.12	31.19	32.34	34.11	33.06	34.03	35.69
1991	2062	34.36	35.13	34.30	33.61	33.60	32.40	31.47	32.63	34.41	33.35	34.33	35.99
1992	2063	34.67	35.45	34.62	33.92	33.88	32.69	31.75	32.92	34.72	33.64	34.62	36.29
1993	2064	34.98	35.77	34.94	34.23	34.17	32.97	32.03	33.20	35.03	33.93	34.91	36.59
1994	2065	35.29	36.09	35.27	34.54	34.45	33.26	32.31	33.49	35.34	34.22	35.20	36.89
1995	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
1996	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
1997	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
1998	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
1999	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2000	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2001	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2002	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2003	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2004	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2005	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2006	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2007	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2008	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2009	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2010	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18
2011	2066	35.60	36.42	35.59	34.84	34.74	33.55	32.59	33.78	35.65	34.51	35.50	37.18

Richard B. Russell Withdrawals (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	8.59	8.43	9.03	9.72	10.38	11.73	11.57	12.23	11.56	10.32	9.48	8.81
1940	2011	8.67	8.51	9.11	9.80	10.46	11.82	11.65	12.31	11.64	10.40	9.56	8.89
1941	2012	8.75	8.59	9.19	9.88	10.54	11.90	11.74	12.39	11.72	10.48	9.63	8.97
1942	2013	8.83	8.67	9.27	9.96	10.62	11.98	11.82	12.48	11.80	10.56	9.71	9.05
1943	2014	8.91	8.75	9.35	10.04	10.70	12.06	11.90	12.56	11.88	10.64	9.79	9.12
1944	2015	8.99	8.82	9.43	10.12	10.78	12.14	11.98	12.64	11.96	10.72	9.87	9.20
1945	2016	9.07	8.90	9.51	10.20	10.86	12.23	12.06	12.72	12.04	10.80	9.95	9.28
1946	2017	10.62	10.46	11.06	11.75	12.42	13.79	13.62	14.29	13.60	12.36	11.50	10.83
1947	2018	12.17	12.01	12.61	13.31	13.98	15.35	15.18	15.85	15.17	13.92	13.06	12.38
1948	2019	13.73	13.56	14.17	14.87	15.54	16.92	16.75	17.42	16.73	15.47	14.61	13.93
1949	2020	15.28	15.12	15.72	16.42	17.10	18.48	18.31	18.98	18.29	17.03	16.17	15.49
1950	2021	16.84	16.67	17.28	17.98	18.66	20.04	19.87	20.55	19.85	18.59	17.72	17.04
1951	2022	18.39	18.22	18.83	19.54	20.22	21.61	21.43	22.11	21.41	20.15	19.27	18.59
1952	2023	19.94	19.78	20.39	21.09	21.78	23.17	22.99	23.68	22.97	21.71	20.83	20.14
1953	2024	21.50	21.33	21.94	22.65	23.34	24.73	24.55	25.24	24.54	23.27	22.38	21.69
1954	2025	23.05	22.89	23.50	24.21	24.90	26.30	26.12	26.81	26.10	24.83	23.94	23.24
1955	2026	24.61	24.44	25.05	25.76	26.45	27.86	27.68	28.37	27.66	26.38	25.49	24.79
1956	2027	24.65	24.48	25.10	25.81	26.50	27.91	27.72	28.42	27.71	26.43	25.53	24.83
1957	2028	24.69	24.52	25.14	25.85	26.55	27.96	27.77	28.47	27.75	26.47	25.58	24.87
1958	2029	24.73	24.57	25.18	25.89	26.59	28.01	27.82	28.52	27.80	26.52	25.62	24.91
1959	2030	24.78	24.61	25.23	25.94	26.64	28.06	27.87	28.57	27.85	26.56	25.66	24.95
1960	2031	24.82	24.65	25.27	25.98	26.68	28.11	27.91	28.62	27.90	26.61	25.70	24.99
1961	2032	24.86	24.69	25.31	26.03	26.73	28.15	27.96	28.67	27.94	26.65	25.74	25.03
1962	2033	24.90	24.73	25.36	26.07	26.78	28.20	28.01	28.72	27.99	26.70	25.78	25.07
1963	2034	24.94	24.78	25.40	26.11	26.82	28.25	28.06	28.77	28.04	26.74	25.83	25.11
1964	2035	24.99	24.82	25.44	26.16	26.87	28.30	28.10	28.82	28.08	26.79	25.87	25.15
1965	2036	25.03	24.86	25.49	26.20	26.91	28.35	28.15	28.87	28.13	26.83	25.91	25.19
1966	2037	25.07	24.90	25.53	26.25	26.96	28.40	28.20	28.92	28.18	26.88	25.95	25.24
1967	2038	25.12	24.95	25.57	26.29	27.01	28.45	28.25	28.97	28.23	26.93	26.00	25.28
1968	2039	25.16	24.99	25.62	26.34	27.06	28.50	28.30	29.02	28.28	26.97	26.04	25.32
1969	2040	25.20	25.03	25.66	26.38	27.10	28.55	28.35	29.07	28.33	27.02	26.08	25.36
1970	2041	25.25	25.08	25.71	26.43	27.15	28.60	28.39	29.12	28.38	27.07	26.13	25.40
1971	2042	25.29	25.12	25.75	26.47	27.20	28.65	28.44	29.18	28.42	27.11	26.17	25.44
1972	2043	25.33	25.17	25.80	26.52	27.25	28.70	28.49	29.23	28.47	27.16	26.21	25.48
1973	2044	25.38	25.21	25.84	26.56	27.29	28.75	28.54	29.28	28.52	27.21	26.26	25.53
1974	2045	25.42	25.25	25.89	26.61	27.34	28.80	28.59	29.33	28.57	27.25	26.30	25.57
1975	2046	25.47	25.30	25.93	26.65	27.39	28.85	28.64	29.38	28.62	27.30	26.34	25.61
1976	2047	27.01	26.84	27.48	28.20	28.94	30.41	30.19	30.94	30.17	28.85	27.89	27.15
1977	2048	28.56	28.39	29.03	29.75	30.49	31.97	31.75	32.50	31.73	30.40	29.44	28.70
1978	2049	30.11	29.94	30.58	31.30	32.05	33.52	33.30	34.05	33.28	31.96	30.99	30.25
1979	2050	31.66	31.49	32.13	32.86	33.60	35.08	34.86	35.61	34.84	33.51	32.54	31.79
1980	2051	33.21	33.04	33.68	34.41	35.15	36.64	36.41	37.17	36.39	35.06	34.09	33.34
1981	2052	34.76	34.59	35.23	35.96	36.71	38.19	37.97	38.72	37.95	36.61	35.63	34.89
1982	2053	36.31	36.14	36.78	37.51	38.26	39.75	39.52	40.28	39.50	38.16	37.18	36.43
1983	2054	37.86	37.69	38.33	39.06	39.81	41.31	41.08	41.84	41.06	39.72	38.73	37.98
1984	2055	39.41	39.24	39.88	40.61	41.37	42.86	42.63	43.40	42.61	41.27	40.28	39.52
1985	2056	40.96	40.78	41.43	42.16	42.92	44.42	44.19	44.95	44.17	42.82	41.83	41.07
1986	2057	41.01	40.84	41.48	42.21	42.97	44.48	44.24	45.01	44.22	42.87	41.88	41.12
1987	2058	41.06	40.89	41.53	42.27	43.03	44.54	44.30	45.07	44.28	42.93	41.93	41.17
1988	2059	41.11	40.94	41.59	42.32	43.09	44.60	44.36	45.13	44.34	42.98	41.98	41.21
1989	2060	41.16	40.99	41.64	42.37	43.14	44.66	44.41	45.19	44.39	43.04	42.03	41.26
1990	2061	41.21	41.04	41.69	42.42	43.20	44.71	44.47	45.25	44.45	43.09	42.08	41.31
1991	2062	41.26	41.09	41.74	42.48	43.25	44.77	44.53	45.31	44.51	43.14	42.13	41.36
1992	2063	41.31	41.14	41.80	42.53	43.31	44.83	44.59	45.37	44.56	43.20	42.18	41.41
1993	2064	41.37	41.19	41.85	42.58	43.36	44.89	44.64	45.43	44.62	43.25	42.23	41.46
1994	2065	41.42	41.25	41.90	42.64	43.42	44.95	44.70	45.49	44.68	43.31	42.28	41.50
1995	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
1996	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
1997	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
1998	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
1999	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2000	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2001	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2002	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2003	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2004	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2005	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2006	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2007	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2008	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2009	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2010	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55
2011	2066	41.47	41.30	41.95	42.69	43.47	45.01	44.76	45.55	44.73	43.36	42.33	41.55

Richard B. Russell Returns (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	16.23	16.17	18.81	16.91	15.13	14.69	14.95	15.09	14.99	14.40	14.07	16.24
1940	2011	16.45	16.40	19.08	17.14	15.34	14.89	15.15	15.28	15.19	14.59	14.26	16.47
1941	2012	16.67	16.62	19.35	17.37	15.54	15.10	15.36	15.48	15.39	14.78	14.46	16.69
1942	2013	16.89	16.84	19.62	17.60	15.74	15.31	15.57	15.67	15.59	14.97	14.65	16.92
1943	2014	17.12	17.06	19.89	17.83	15.95	15.52	15.78	15.87	15.79	15.16	14.84	17.15
1944	2015	17.34	17.29	20.16	18.06	16.15	15.72	15.98	16.06	16.00	15.34	15.04	17.38
1945	2016	17.56	17.51	20.43	18.29	16.36	15.93	16.19	16.25	16.20	15.53	15.23	17.61
1946	2017	17.82	17.76	20.74	18.55	16.59	16.17	16.43	16.47	16.43	15.75	15.45	17.87
1947	2018	18.07	18.02	21.06	18.82	16.82	16.41	16.67	16.70	16.65	15.97	15.68	18.13
1948	2019	18.33	18.28	21.37	19.09	17.05	16.64	16.91	16.92	16.88	16.19	15.90	18.40
1949	2020	18.59	18.54	21.68	19.35	17.29	16.88	17.14	17.14	17.11	16.41	16.12	18.66
1950	2021	18.85	18.79	21.99	19.62	17.52	17.12	17.38	17.37	17.34	16.63	16.35	18.93
1951	2022	19.11	19.05	22.30	19.88	17.75	17.36	17.62	17.59	17.57	16.85	16.57	19.19
1952	2023	19.36	19.31	22.61	20.15	17.98	17.60	17.86	17.81	17.80	17.07	16.79	19.45
1953	2024	19.62	19.57	22.92	20.41	18.22	17.83	18.10	18.03	18.03	17.28	17.02	19.72
1954	2025	19.88	19.82	23.23	20.68	18.45	18.07	18.33	18.26	18.26	17.50	17.24	19.98
1955	2026	20.14	20.08	23.54	20.95	18.68	18.31	18.57	18.48	18.49	17.72	17.46	20.25
1956	2027	20.38	20.32	23.83	21.19	18.90	18.53	18.79	18.69	18.70	17.93	17.67	20.49
1957	2028	20.62	20.56	24.12	21.44	19.12	18.75	19.01	18.90	18.92	18.13	17.88	20.74
1958	2029	20.87	20.80	24.41	21.69	19.33	18.98	19.24	19.11	19.13	18.34	18.09	20.99
1959	2030	21.11	21.05	24.70	21.93	19.55	19.20	19.46	19.32	19.35	18.54	18.30	21.24
1960	2031	21.35	21.29	24.98	22.18	19.76	19.42	19.68	19.52	19.56	18.74	18.51	21.48
1961	2032	21.59	21.53	25.27	22.43	19.98	19.64	19.90	19.73	19.78	18.95	18.72	21.73
1962	2033	21.84	21.77	25.56	22.68	20.20	19.86	20.12	19.94	19.99	19.15	18.93	21.98
1963	2034	22.08	22.01	25.85	22.92	20.41	20.09	20.34	20.15	20.21	19.36	19.14	22.23
1964	2035	22.32	22.25	26.14	23.17	20.63	20.31	20.56	20.36	20.42	19.56	19.35	22.47
1965	2036	22.56	22.50	26.43	23.42	20.85	20.53	20.79	20.57	20.64	19.77	19.56	22.72
1966	2037	22.84	22.77	26.76	23.70	21.09	20.78	21.04	20.81	20.88	20.00	19.80	23.01
1967	2038	23.13	23.05	27.09	23.98	21.34	21.04	21.29	21.05	21.13	20.24	20.04	23.29
1968	2039	23.41	23.33	27.42	24.26	21.59	21.29	21.55	21.29	21.38	20.47	20.29	23.57
1969	2040	23.69	23.61	27.75	24.55	21.83	21.55	21.80	21.53	21.62	20.71	20.53	23.86
1970	2041	23.97	23.89	28.08	24.83	22.08	21.80	22.05	21.77	21.87	20.94	20.77	24.14
1971	2042	24.25	24.17	28.41	25.11	22.33	22.06	22.30	22.01	22.11	21.18	21.01	24.43
1972	2043	24.53	24.44	28.74	25.39	22.58	22.31	22.56	22.25	22.36	21.41	21.25	24.71
1973	2044	24.81	24.72	29.07	25.68	22.82	22.56	22.81	22.49	22.61	21.65	21.49	25.00
1974	2045	25.09	25.00	29.40	25.96	23.07	22.82	23.06	22.73	22.85	21.88	21.74	25.28
1975	2046	25.37	25.28	29.72	26.24	23.32	23.07	23.32	22.97	23.10	22.12	21.98	25.56
1976	2047	25.63	25.54	30.02	26.49	23.54	23.30	23.54	23.19	23.33	22.33	22.20	25.83
1977	2048	25.89	25.79	30.32	26.75	23.76	23.53	23.77	23.41	23.55	22.55	22.42	26.09
1978	2049	26.15	26.05	30.62	27.00	23.99	23.76	24.00	23.63	23.78	22.76	22.65	26.35
1979	2050	26.41	26.31	30.91	27.26	24.21	24.00	24.23	23.85	24.00	22.98	22.87	26.61
1980	2051	26.67	26.56	31.21	27.51	24.43	24.23	24.46	24.07	24.23	23.19	23.09	26.87
1981	2052	26.93	26.82	31.51	27.77	24.65	24.46	24.68	24.29	24.45	23.40	23.31	27.13
1982	2053	27.19	27.08	31.80	28.02	24.87	24.69	24.91	24.51	24.68	23.62	23.54	27.39
1983	2054	27.45	27.33	32.10	28.28	25.10	24.92	25.14	24.73	24.90	23.83	23.76	27.65
1984	2055	27.71	27.59	32.40	28.53	25.32	25.15	25.37	24.95	25.13	24.05	23.98	27.91
1985	2056	27.97	27.84	32.69	28.79	25.54	25.38	25.60	25.17	25.35	24.26	24.20	28.17
1986	2057	28.27	28.14	33.03	29.08	25.80	25.65	25.86	25.43	25.61	24.51	24.46	28.48
1987	2058	28.58	28.44	33.38	29.37	26.05	25.92	26.12	25.69	25.87	24.76	24.73	28.78
1988	2059	28.88	28.74	33.72	29.67	26.31	26.19	26.38	25.95	26.14	25.01	24.99	29.09
1989	2060	29.19	29.04	34.06	29.96	26.57	26.45	26.65	26.20	26.40	25.26	25.25	29.39
1990	2061	29.49	29.34	34.40	30.26	26.82	26.72	26.91	26.46	26.66	25.51	25.51	29.69
1991	2062	29.80	29.64	34.74	30.55	27.08	26.99	27.17	26.72	26.92	25.76	25.77	30.00
1992	2063	30.11	29.94	35.09	30.84	27.34	27.26	27.44	26.97	27.18	26.00	26.03	30.30
1993	2064	30.41	30.24	35.43	31.14	27.59	27.53	27.70	27.23	27.45	26.25	26.29	30.61
1994	2065	30.72	30.54	35.77	31.43	27.85	27.79	27.96	27.49	27.71	26.50	26.55	30.91
1995	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
1996	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
1997	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
1998	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
1999	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2000	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2001	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2002	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2003	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2004	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2005	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2006	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2007	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2008	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2009	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2010	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22
2011	2066	31.02	30.84	36.11	31.72	28.10	28.06	28.22	27.75	27.97	26.75	26.81	31.22

J. Strom Thurmond Withdrawals (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	31.25	31.40	31.88	33.11	35.66	37.83	38.64	37.99	36.19	34.07	32.94	31.97
1940	2011	31.52	31.68	32.19	33.44	36.05	38.26	39.09	38.43	36.58	34.41	33.26	32.27
1941	2012	31.80	31.96	32.49	33.77	36.43	38.69	39.55	38.86	36.98	34.76	33.57	32.56
1942	2013	32.07	32.25	32.80	34.09	36.82	39.13	40.00	39.30	37.37	35.11	33.89	32.86
1943	2014	32.35	32.53	33.10	34.42	37.21	39.56	40.45	39.74	37.77	35.45	34.21	33.15
1944	2015	32.62	32.82	33.40	34.75	37.60	39.99	40.91	40.18	38.17	35.80	34.53	33.44
1945	2016	32.90	33.10	33.71	35.08	37.99	40.42	41.36	40.61	38.56	36.14	34.84	33.74
1946	2017	34.64	34.86	35.49	36.89	39.87	42.35	43.32	42.55	40.45	37.97	36.64	35.51
1947	2018	36.39	36.61	37.27	38.70	41.75	44.28	45.28	44.49	42.34	39.80	38.44	37.28
1948	2019	38.14	38.37	39.05	40.51	43.63	46.21	47.23	46.43	44.23	41.63	40.24	39.05
1949	2020	39.88	40.13	40.83	42.31	45.51	48.14	49.19	48.37	46.12	43.47	42.04	40.82
1950	2021	41.63	41.89	42.61	44.12	47.39	50.07	51.15	50.31	48.01	45.30	43.83	42.59
1951	2022	43.38	43.65	44.39	45.93	49.27	52.00	53.11	52.25	49.90	47.13	45.63	44.36
1952	2023	45.12	45.40	46.18	47.74	51.15	53.93	55.07	54.19	51.78	48.96	47.43	46.13
1953	2024	46.87	47.16	47.96	49.55	53.03	55.87	57.02	56.13	53.67	50.79	49.23	47.91
1954	2025	48.62	48.92	49.74	51.36	54.91	57.80	58.98	58.07	55.56	52.62	51.03	49.68
1955	2026	50.36	50.68	51.52	53.17	56.79	59.73	60.94	60.01	57.45	54.45	52.82	51.45
1956	2027	50.66	50.99	51.86	53.55	57.25	60.25	61.50	60.54	57.93	54.85	53.19	51.77
1957	2028	50.96	51.30	52.21	53.92	57.72	60.78	62.06	61.08	58.40	55.25	53.55	52.10
1958	2029	51.25	51.61	52.55	54.30	58.18	61.30	62.61	61.61	58.87	55.65	53.91	52.43
1959	2030	51.55	51.93	52.89	54.67	58.64	61.83	63.17	62.15	59.35	56.06	54.27	52.76
1960	2031	51.85	52.24	53.23	55.05	59.11	62.35	63.73	62.69	59.82	56.46	54.63	53.08
1961	2032	52.15	52.55	53.57	55.43	59.57	62.87	64.29	63.22	60.29	56.86	54.99	53.41
1962	2033	52.44	52.86	53.92	55.80	60.04	63.40	64.85	63.76	60.77	57.26	55.35	53.74
1963	2034	52.74	53.17	54.26	56.18	60.50	63.92	65.41	64.29	61.24	57.66	55.71	54.07
1964	2035	53.04	53.49	54.60	56.55	60.96	64.45	65.96	64.83	61.72	58.06	56.07	54.39
1965	2036	53.34	53.80	54.94	56.93	61.43	64.97	66.52	65.36	62.19	58.47	56.43	54.72
1966	2037	53.70	54.17	55.36	57.39	61.99	65.61	67.21	66.02	62.77	58.95	56.87	55.12
1967	2038	54.05	54.55	55.77	57.84	62.56	66.25	67.89	66.67	63.34	59.44	57.31	55.51
1968	2039	54.41	54.93	56.19	58.30	63.12	66.90	68.57	67.33	63.92	59.93	57.75	55.91
1969	2040	54.77	55.31	56.60	58.75	63.69	67.54	69.26	67.98	64.50	60.42	58.18	56.30
1970	2041	55.13	55.68	57.02	59.21	64.25	68.18	69.94	68.64	65.08	60.90	58.62	56.70
1971	2042	55.49	56.06	57.43	59.67	64.81	68.82	70.62	69.29	65.65	61.39	59.06	57.10
1972	2043	55.85	56.44	57.85	60.12	65.38	69.46	71.31	69.95	66.23	61.88	59.50	57.49
1973	2044	56.21	56.81	58.26	60.58	65.94	70.10	71.99	70.60	66.81	62.37	59.93	57.89
1974	2045	56.56	57.19	58.68	61.04	66.51	70.74	72.67	71.26	67.39	62.85	60.37	58.29
1975	2046	56.92	57.57	59.10	61.49	67.07	71.38	73.36	71.91	67.96	63.34	60.81	58.68
1976	2047	58.85	59.52	61.10	63.54	69.26	73.66	75.69	74.21	70.16	65.43	62.84	60.66
1977	2048	60.79	61.48	63.10	65.60	71.45	75.94	78.02	76.51	72.37	67.52	64.87	62.64
1978	2049	62.72	63.43	65.10	67.65	73.63	78.22	80.35	78.80	74.57	69.61	66.90	64.62
1979	2050	64.65	65.39	67.11	69.70	75.82	80.50	82.68	81.10	76.77	71.71	68.93	66.59
1980	2051	66.58	67.34	69.11	71.75	78.01	82.78	85.02	83.40	78.97	73.80	70.96	68.57
1981	2052	68.51	69.30	71.11	73.81	80.19	85.06	87.35	85.70	81.17	75.89	72.99	70.55
1982	2053	70.44	71.25	73.12	75.86	82.38	87.34	89.68	87.99	83.37	77.98	75.02	72.53
1983	2054	72.38	73.21	75.12	77.91	84.57	89.62	92.01	90.29	85.58	80.07	77.05	74.51
1984	2055	74.31	75.16	77.12	79.96	86.75	91.90	94.35	92.59	87.78	82.16	79.07	76.49
1985	2056	76.24	77.12	79.13	82.02	88.94	94.18	96.68	94.88	89.98	84.25	81.10	78.46
1986	2057	76.76	77.67	79.74	82.69	89.78	95.13	97.70	95.86	90.84	84.97	81.75	79.04
1987	2058	77.28	78.22	80.35	83.36	90.62	96.08	98.71	96.83	91.69	85.69	82.39	79.62
1988	2059	77.81	78.77	80.96	84.04	91.46	97.04	99.73	97.81	92.55	86.41	83.03	80.20
1989	2060	78.33	79.33	81.58	84.71	92.29	97.99	100.75	98.78	93.41	87.13	83.68	80.78
1990	2061	78.85	79.88	82.19	85.38	93.13	98.94	101.77	99.76	94.26	87.85	84.32	81.36
1991	2062	79.37	80.43	82.80	86.06	93.97	99.89	102.78	100.73	95.12	88.57	84.96	81.94
1992	2063	79.90	80.98	83.41	86.73	94.81	100.85	103.80	101.71	95.98	89.29	85.61	82.52
1993	2064	80.42	81.53	84.03	87.40	95.65	101.80	104.82	102.68	96.83	90.01	86.25	83.10
1994	2065	80.94	82.09	84.64	88.07	96.49	102.75	105.84	103.65	97.69	90.73	86.89	83.68
1995	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
1996	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
1997	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
1998	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
1999	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2000	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2001	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2002	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2003	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2004	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2005	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2006	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2007	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2008	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2009	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2010	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26
2011	2066	81.46	82.64	85.25	88.75	97.33	103.70	106.86	104.63	98.55	91.45	87.54	84.26

J. Strom Thurmond Returns (cfs)													
Hydrology Year	Projection Year	January	February	March	April	May	June	July	August	September	October	November	December
1939	2010	7.37	7.46	9.68	7.98	6.29	7.99	7.28	6.67	6.66	6.94	6.09	6.74
1940	2011	7.40	7.50	9.72	8.02	6.32	8.02	7.32	6.71	6.70	6.98	6.13	6.77
1941	2012	7.44	7.54	9.76	8.06	6.36	8.06	7.36	6.75	6.74	7.02	6.17	6.81
1942	2013	7.47	7.59	9.80	8.10	6.39	8.10	7.40	6.79	6.78	7.06	6.21	6.85
1943	2014	7.51	7.63	9.84	8.14	6.42	8.14	7.44	6.82	6.82	7.10	6.25	6.88
1944	2015	7.54	7.67	9.89	8.18	6.46	8.17	7.48	6.86	6.86	7.13	6.29	6.92
1945	2016	7.58	7.71	9.93	8.22	6.49	8.21	7.52	6.90	6.90	7.17	6.33	6.96
1946	2017	7.63	7.77	9.99	8.27	6.54	8.26	7.57	6.95	6.96	7.23	6.39	7.01
1947	2018	7.68	7.83	10.04	8.32	6.59	8.31	7.62	7.00	7.01	7.28	6.44	7.06
1948	2019	7.73	7.88	10.10	8.38	6.63	8.36	7.67	7.06	7.06	7.33	6.50	7.11
1949	2020	7.78	7.94	10.16	8.43	6.68	8.41	7.72	7.11	7.11	7.38	6.55	7.16
1950	2021	7.83	8.00	10.22	8.48	6.72	8.46	7.78	7.16	7.16	7.44	6.60	7.21
1951	2022	7.88	8.05	10.27	8.53	6.77	8.52	7.83	7.21	7.21	7.49	6.66	7.26
1952	2023	7.93	8.11	10.33	8.59	6.82	8.57	7.88	7.26	7.26	7.54	6.71	7.31
1953	2024	7.98	8.17	10.39	8.64	6.86	8.62	7.93	7.31	7.31	7.59	6.77	7.36
1954	2025	8.03	8.22	10.45	8.69	6.91	8.67	7.98	7.37	7.36	7.64	6.82	7.41
1955	2026	8.08	8.28	10.50	8.74	6.96	8.72	8.03	7.42	7.41	7.70	6.88	7.46
1956	2027	8.15	8.36	10.58	8.82	7.02	8.79	8.11	7.49	7.48	7.77	6.95	7.53
1957	2028	8.22	8.43	10.66	8.89	7.09	8.86	8.18	7.56	7.55	7.84	7.02	7.60
1958	2029	8.29	8.51	10.74	8.96	7.15	8.93	8.25	7.63	7.62	7.91	7.10	7.67
1959	2030	8.36	8.59	10.82	9.04	7.22	9.00	8.32	7.70	7.70	7.98	7.17	7.74
1960	2031	8.43	8.67	10.91	9.11	7.29	9.07	8.39	7.77	7.77	8.05	7.25	7.81
1961	2032	8.50	8.75	10.99	9.18	7.35	9.14	8.46	7.84	7.84	8.13	7.32	7.88
1962	2033	8.57	8.83	11.07	9.26	7.42	9.21	8.53	7.91	7.91	8.20	7.40	7.95
1963	2034	8.64	8.90	11.15	9.33	7.48	9.28	8.60	7.98	7.98	8.27	7.47	8.02
1964	2035	8.71	8.98	11.23	9.40	7.55	9.35	8.67	8.05	8.05	8.34	7.54	8.09
1965	2036	8.78	9.06	11.31	9.48	7.61	9.42	8.75	8.13	8.12	8.41	7.62	8.17
1966	2037	8.84	9.13	11.37	9.54	7.67	9.48	8.81	8.19	8.18	8.48	7.68	8.23
1967	2038	8.89	9.19	11.44	9.60	7.73	9.54	8.87	8.25	8.24	8.54	7.75	8.28
1968	2039	8.95	9.26	11.51	9.66	7.78	9.61	8.93	8.31	8.30	8.60	7.82	8.34
1969	2040	9.01	9.32	11.58	9.73	7.84	9.67	8.99	8.37	8.36	8.67	7.88	8.40
1970	2041	9.07	9.39	11.65	9.79	7.89	9.73	9.05	8.44	8.43	8.73	7.95	8.46
1971	2042	9.12	9.46	11.71	9.85	7.95	9.79	9.11	8.50	8.49	8.79	8.01	8.52
1972	2043	9.18	9.52	11.78	9.91	8.00	9.85	9.17	8.56	8.55	8.85	8.08	8.58
1973	2044	9.24	9.59	11.85	9.98	8.06	9.91	9.24	8.62	8.61	8.92	8.15	8.64
1974	2045	9.30	9.65	11.92	10.04	8.11	9.97	9.30	8.69	8.67	8.98	8.21	8.70
1975	2046	9.35	9.72	11.98	10.10	8.17	10.03	9.36	8.75	8.74	9.04	8.28	8.76
1976	2047	9.43	9.80	12.07	10.18	8.24	10.10	9.43	8.82	8.81	9.12	8.36	8.83
1977	2048	9.50	9.88	12.15	10.25	8.31	10.18	9.51	8.90	8.89	9.20	8.44	8.91
1978	2049	9.57	9.96	12.23	10.33	8.37	10.25	9.58	8.97	8.96	9.27	8.52	8.98
1979	2050	9.64	10.04	12.31	10.40	8.44	10.32	9.66	9.05	9.04	9.35	8.60	9.05
1980	2051	9.71	10.12	12.40	10.48	8.51	10.40	9.73	9.13	9.11	9.43	8.68	9.13
1981	2052	9.78	10.20	12.48	10.56	8.58	10.47	9.81	9.20	9.19	9.50	8.76	9.20
1982	2053	9.85	10.29	12.56	10.63	8.65	10.54	9.88	9.28	9.26	9.58	8.83	9.27
1983	2054	9.92	10.37	12.65	10.71	8.71	10.62	9.96	9.35	9.34	9.66	8.91	9.34
1984	2055	9.99	10.45	12.73	10.78	8.78	10.69	10.03	9.43	9.41	9.73	8.99	9.42
1985	2056	10.06	10.53	12.81	10.86	8.85	10.77	10.11	9.50	9.49	9.81	9.07	9.49
1986	2057	10.16	10.63	12.92	10.96	8.94	10.86	10.20	9.60	9.59	9.91	9.18	9.59
1987	2058	10.25	10.74	13.03	11.06	9.03	10.96	10.30	9.70	9.68	10.01	9.28	9.68
1988	2059	10.34	10.85	13.14	11.16	9.12	11.06	10.40	9.80	9.78	10.11	9.38	9.78
1989	2060	10.44	10.95	13.25	11.26	9.21	11.15	10.50	9.89	9.88	10.21	9.49	9.87
1990	2061	10.53	11.06	13.36	11.36	9.29	11.25	10.59	9.99	9.97	10.31	9.59	9.97
1991	2062	10.63	11.16	13.47	11.46	9.38	11.35	10.69	10.09	10.07	10.41	9.70	10.07
1992	2063	10.72	11.27	13.58	11.56	9.47	11.44	10.79	10.19	10.17	10.51	9.80	10.16
1993	2064	10.81	11.37	13.68	11.66	9.56	11.54	10.89	10.29	10.27	10.60	9.90	10.26
1994	2065	10.91	11.48	13.79	11.76	9.65	11.64	10.99	10.38	10.36	10.70	10.01	10.36
1995	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
1996	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
1997	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
1998	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
1999	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2000	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2001	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2002	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2003	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2004	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2005	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2006	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2007	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2008	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2009	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2010	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45
2011	2066	11.00	11.59	13.90	11.86	9.74	11.73	11.08	10.48	10.46	10.80	10.11	10.45

Appendix B

Performance Measures Sheets

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Bad Creek Relicensing / Savannah River CHEOPS Model Performance Measures Sheet

Measure Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)	Baseline	Bad Creek II
	Lake Jocassee					(1939-2011)	(1939-2011)
	Elevation - Storage Availability						
1	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 1,108 ft AMSL on May 1	1-May	1-May	5	0	0
	Elevation - Recreation						
2	Minimize restricted recreation	Number of years where cove access (reservoir level below 1,090 ft AMSL) is restricted for more than 25 days (Note 3)	1-Jan	31-Dec	2	2	2
3		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) during higher use months in any calendar year (Note 3)	1-Mar	31-Oct	5	43	43
4		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) in any calendar year (Note 3)	1-Jan	31-Dec	5	104	104
5	Minimize restricted boat launching	Number of years where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months for more than 25 days (Note 4)	1-Mar	31-Oct	2	0	0
6		Greatest number of days where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months in any calendar year (Note 4)	1-Mar	31-Oct	5	0	0
7	Minimize effects on recreational boating	Number of days where reservoir level changes more than 1.0 ft in one hour	1-Jan	31-Dec	10	0	0
	Elevation - Natural Resources						
8	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	0%	0%
13	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	56%	82%
18	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	0%	3%
21	Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	79%	99%
24	Minimize entrainment due to Bad Creek operations	Percent of days average reservoir level at or below 1,096 ft AMSL (Note 6)	1-Jan	31-Dec	5%	1%	1%
25		Percent of days average reservoir level below 1,096 ft AMSL (Note 6)	1-Dec	31-Mar	5%	2%	2%
26	Maximize littoral habitat during growing season	Percent of days average reservoir level above 1,107 ft AMSL (Note 7)	1-Apr	30-Sep	5%	46%	42%
27		Percent of days average reservoir level above 1,105 ft AMSL (Note 7)	1-Apr	30-Sep	5%	91%	91%
28	Maximize littoral habitat during spawning season	Percent of days average reservoir level above 1,107 ft AMSL (Note 7)	1-Apr	31-May	5%	20%	16%
29		Percent of days average reservoir level above 1,105 ft AMSL (Note 7)	1-Apr	31-May	5%	92%	92%
	Pumped Storage						
30	Minimize days below lake levels that impact Bad Creek operations	Number of days reservoir level below 1,099 ft AMSL (Note 8)	1-Jan	31-Dec	227	846	804
31	Minimize days below lake levels that impact Jocassee operations	Number of days reservoir level below 1,090 ft AMSL (Note 8)	1-Jan	31-Dec	14	147	139
32	Minimize days below lake levels that impact Bad Creek efficiency	Number of days reservoir level below 1,081 ft AMSL (Note 9)	1-Jan	31-Dec	12	0	0
	Lake Keowee						
	Elevation - Storage Availability						
33	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 798 ft AMSL on May 1	1-May	1-May	5	69	69
	Elevation - Aesthetics						
34	Maximize lake levels	Percent of time reservoir level at or above 797 ft AMSL	1-Jan	31-Dec	20%	91%	92%
35		Percent of time reservoir level at or above 795 ft AMSL	1-Jan	31-Dec	10%	97%	97%
36	Minimize significant drawdown of lake level	Number of days reservoir level below 796 ft AMSL	1-Jan	31-Dec	5	1,670	1,608
	Elevation - Recreation						
37	Minimize restricted recreation	Number of years where cove access (reservoir level below 792 ft AMSL) is restricted for more than 25 days (Note 10)	1-Jan	31-Dec	2	1	1
38		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) during higher use months in any calendar year (Note 10)	1-Mar	31-Oct	5	1	1
39		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) in any calendar year (Note 10)	1-Jan	31-Dec	5	41	41
40	Minimize restricted lake boat launching	Number of years where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months for more than 25 days (Note 11)	1-Mar	31-Oct	2	0	0
41		Greatest number of days where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months in any calendar year (Note 11)	1-Mar	31-Oct	5	0	0
42	Maximize boat dock usage	Percent of time reservoir level is at or above level where 85% of docks are usable (796.25 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 12)	1-Mar	31-Oct	5%	94%	94%
43		Percent of time reservoir level is at or above level where 70% of docks are usable (793.5 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 12)	1-Mar	31-Oct	5%	99%	99%

Bad Creek Relicensing / Savannah River CHEOPS Model Performance Measures Sheet

Measure Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)	Baseline	Bad Creek II
	Elevation - Natural Resources						
44	Minimize number of days water level is below toe of riprap	Number of days reservoir level below 794 ft AMSL (Note 13)	1-Jan	31-Dec	250	565	551
45	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
46		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
47		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
48	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
49		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
50		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
51	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
52		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
53		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 14)	15-May	15-Jul	5%	97%	97%
54	Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
55		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
56		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 14)	15-May	15-Jul	5%	97%	97%
57	Maximize littoral habitat during growing season	Percent of days average reservoir level above 798 ft AMSL (Note 15)	1-Apr	30-Sep	5%	89%	89%
58		Percent of days average reservoir level above 797 ft AMSL (Note 15)	1-Apr	30-Sep	5%	93%	93%
59	Maximize littoral habitat during spawning season	Percent of days average reservoir level above 798 ft AMSL (Note 15)	1-Apr	31-May	5%	94%	95%
60		Percent of days average reservoir level above 797 ft AMSL (Note 15)	1-Apr	31-May	5%	97%	97%
	Elevation - Water Supply						
61	Minimize days of restricted operation at lake-located intakes	Number of days reservoir level below critical level (775 ft AMSL) for shallowest public water supply intake operation (Note 16)	1-Jan	31-Dec	1	0	0
62		Number of days reservoir level below critical level (789.5 ft AMSL) for shallowest thermal power station operation (Note 17)	1-Jan	31-Dec	1	0	0
63		Number of days reservoir level below critical level (787.9 ft AMSL) for Keowee dam to supply backup power to ONS (Note 18)	1-Jan	31-Dec	1	0	0
	Duke Energy Hydropower & Water Quantity Management						
64	Keowee-Toxaway Low Inflow Protocol (LIP) Stage	Number of days in LIP Stage Normal (Note 19)	1-Jan	31-Dec		8,728	5,102
65		Number of days in LIP Stage 0	1-Jan	31-Dec		13,972	17,584
66		Number of days in LIP Stage 1	1-Jan	31-Dec		1,351	1,351
67		Number of days in LIP Stage 2	1-Jan	31-Dec		2,185	2,199
68		Number of days in LIP Stage 3	1-Jan	31-Dec		378	378
69		Number of days in LIP Stage 4	1-Jan	31-Dec		49	49

	Background	Performance Measure has improved vs. the Baseline Scenario
	Background	Performance Measure has declined vs. the Baseline Scenario
	White Background	There is no significant difference between the scenario and the Baseline Scenario by definition of MISC

Notes	
1	For criterion that measure on an hourly or daily basis, unless stated otherwise:
	a. If an hourly criteria occurs during the average of four contiguous 15-minute periods, then it counts as 1 hour.
	b. If a daily criterion occurs for 5 contiguous 1-hour periods, then it counts as 1 day.
	Also, daytime flows are assumed to be flows provided between 7:00 am and 7:00 pm. To the extent possible, each criterion is defined in terms of percents and averages/yr so that the same criterion is useful
2	MISC = Minimum Increment of Significant Change. The MISC has the same units (i.e., days, days/yr, percent, etc.) as does the criterion on that same row of the spreadsheet. If the output of two scenarios for a
	a. As a general rule, MISC numbers are set at 10% of the possible total for that criterion considering the Start/Stop dates.
	b. MISC numbers for criteria that have the most adverse outcomes if reached are typically set at less than 10% of the possible total for that criterion.
	c. Adjustments to the MISC numbers (up or down) have also been made depending on the desires of the stakeholders that primarily have the interests that are being measured by a particular criterion.
3	Jocassee restricted recreation elevation 1,090 ft AMSL provided by Chris Starker (Upstate Forever) and confirmed by Devils Fork State Park Staff.
4	Jocassee elevation 1,077 ft AMSL is the lowest boat ramp elevation with an additional 3 ft added for boat access. Boat ramp elevations provided by Duke Energy.
5	This criterion evaluates a day as 24 contiguous hours, not as specified in Note 1.
6	Jocassee entrainment elevation (1,096 ft AMSL) provided by Bill Marshall of SCDNR.
7	Jocassee fish habitat elevations provided by Bill Marshall of SCDNR.
8	Jocassee elevation 1,099 ft AMSL is the elevation at which an MOU between Duke Energy and SCDNR requires Duke Energy to implement operational changes at Bad Creek. Jocassee elevation 1,090 ft AMSL is
9	Jocassee elevation 1,081 ft AMSL provided by Duke Energy based on impact to pumping equipment.
10	Keowee restricted recreation elevation of 792 ft AMSL provided by James McRacken (HDR) and Scott Fletcher (Duke Energy).
11	Keowee elevation 790 ft AMSL is based on the lowest boat ramp elevation of 787 ft AMSL plus 3 ft for boat access (provided by Duke Energy).
12	Percent of time is measured as the percent of 15-minute time steps at or above threshold elevation during period starting 07:00 am and period ending 7:00 pm.
13	Toe of Keowee reservoir riprap elevation 794 ft AMSL provided by Duke Energy.
14	This criterion evaluates a day as 24 contiguous hours, not as specified in Note 1.
15	Keowee fish habitat elevations provided by Bill Marshall of SCDNR.
16	Keowee elevation 775 ft AMSL was the minimum level permitted in the previous KT FERC License, and the Keowee water supply intakes present during KT relicensing were confirmed to operate at this
17	For this measure a -0.5 ft buffer was added to filter out model excursions below the Keowee reservoir elevation limit of 790.0 ft AMSL. No counts will be displayed for reservoir levels between 789.5 ft AMSL and 790.0 ft AMSL for this measure.
18	Keowee elevation 787.9 ft AMSL is the critical elevation for Keowee to provide backup power to ONS elevation provided by Duke Energy.
19	There are 26,663 days in the POR.

Bad Creek Relicensing /Savannah River CHEOPS Model Performance Measures Sheet

Measure Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)	Baseline_ccLow	Bad Creek II_ccLow
	Lake Jocassee					(1939-2011)	(1939-2011)
	Elevation - Storage Availability						
1	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 1,108 ft AMSL on May 1	1-May	1-May	5	0	0
	Elevation - Recreation						
2	Minimize restricted recreation	Number of years where cove access (reservoir level below 1,090 ft AMSL) is restricted for more than 25 days (Note 3)	1-Jan	31-Dec	2	2	1
3		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) during higher use months in any calendar year (Note 3)	1-Mar	31-Oct	5	53	47
4		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) in any calendar year (Note 3)	1-Jan	31-Dec	5	114	108
5	Minimize restricted boat launching	Number of years where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months for more than 25 days (Note 4)	1-Mar	31-Oct	2	0	0
6		Greatest number of days where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months in any calendar year (Note 4)	1-Mar	31-Oct	5	0	0
7	Minimize effects on recreational boating	Number of days where reservoir level changes more than 1.0 ft in one hour	1-Jan	31-Dec	10	0	0
	Elevation - Natural Resources						
8	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	31-May	5%	67%	100%
9		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 5)	1-Apr	31-May	5%	33%	97%
10		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 5)	1-Apr	31-May	5%	21%	86%
11		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 30 consecutive days at least once (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	0%	0%
13	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	99%	100%
16		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 30 consecutive days at least once (Note 5)	1-Apr	31-May	5%	93%	93%
17		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 45 consecutive days at least once (Note 5)	1-Apr	31-May	5%	55%	82%
18	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	5%	41%	100%
19		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 5)	15-May	15-Jul	5%	14%	86%
20		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 5)	15-May	15-Jul	5%	0%	1%
21	Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	78%	96%
24	Minimize entrainment due to Bad Creek operations	Percent of days average reservoir level at or below 1,096 ft AMSL (Note 6)	1-Jan	31-Dec	5%	1%	1%
25		Percent of days average reservoir level below 1,096 ft AMSL (Note 6)	1-Dec	31-Mar	5%	2%	2%
26	Maximize littoral habitat during growing season	Percent of days average reservoir level above 1,107 ft AMSL (Note 7)	1-Apr	30-Sep	5%	46%	42%
27		Percent of days average reservoir level above 1,105 ft AMSL (Note 7)	1-Apr	30-Sep	5%	91%	91%
28	Maximize littoral habitat during spawning season	Percent of days average reservoir level above 1,107 ft AMSL (Note 7)	1-Apr	31-May	5%	20%	16%
29		Percent of days average reservoir level above 1,105 ft AMSL (Note 7)	1-Apr	31-May	5%	91%	91%
	Pumped Storage						
30	Minimize days below lake levels that impact Bad Creek operations	Number of days reservoir level below 1,099 ft AMSL (Note 8)	1-Jan	31-Dec	227	907	884
31	Minimize days below lake levels that impact Jocassee operations	Number of days reservoir level below 1,090 ft AMSL (Note 8)	1-Jan	31-Dec	14	156	128
32	Minimize days below lake levels that impact Bad Creek efficiency	Number of days reservoir level below 1,081 ft AMSL (Note 9)	1-Jan	31-Dec	12	0	0
	Lake Keowee						
	Elevation - Storage Availability						
33	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 798 ft AMSL on May 1	1-May	1-May	5	69	69
	Elevation - Aesthetics						
34	Maximize lake levels	Percent of time reservoir level at or above 797 ft AMSL	1-Jan	31-Dec	20%	91%	91%
35		Percent of time reservoir level at or above 795 ft AMSL	1-Jan	31-Dec	10%	97%	97%
36	Minimize significant drawdown of lake level	Number of days reservoir level below 796 ft AMSL	1-Jan	31-Dec	5	1,782	1,731
	Elevation - Recreation						
37	Minimize restricted recreation	Number of years where cove access (reservoir level below 792 ft AMSL) is restricted for more than 25 days (Note 10)	1-Jan	31-Dec	2	1	1
38		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) during higher use months in any calendar year (Note 10)	1-Mar	31-Oct	5	1	1
39		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) in any calendar year (Note 10)	1-Jan	31-Dec	5	41	35
40	Minimize restricted lake boat launching	Number of years where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months for more than 25 days (Note 11)	1-Mar	31-Oct	2	0	0
41		Greatest number of days where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months in any calendar year (Note 11)	1-Mar	31-Oct	5	0	0
42	Maximize boat dock usage	Percent of time reservoir level is at or above level where 85% of docks are usable (796.25 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 12)	1-Mar	31-Oct	5%	93%	94%
43		Percent of time reservoir level is at or above level where 70% of docks are usable (793.5 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 12)	1-Mar	31-Oct	5%	99%	99%

Bad Creek Relicensing /Savannah River CHEOPS Model Performance Measures Sheet

Measure Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)	Baseline_ccLow	Bad Creek II_ccLow
	Elevation - Natural Resources						
44	Minimize number of days water level is below toe of riprap	Number of days reservoir level below 794 ft AMSL (Note 13)	1-Jan	31-Dec	250	619	580
45	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
46		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
47		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
48	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
49		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
50		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
51	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
52		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
53		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 14)	15-May	15-Jul	5%	99%	99%
54	Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
55		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
56		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 14)	15-May	15-Jul	5%	99%	99%
57	Maximize littoral habitat during growing season	Percent of days average reservoir level above 798 ft AMSL (Note 15)	1-Apr	30-Sep	5%	89%	89%
58		Percent of days average reservoir level above 797 ft AMSL (Note 15)	1-Apr	30-Sep	5%	92%	93%
59	Maximize littoral habitat during spawning season	Percent of days average reservoir level above 798 ft AMSL (Note 15)	1-Apr	31-May	5%	94%	94%
60		Percent of days average reservoir level above 797 ft AMSL (Note 15)	1-Apr	31-May	5%	97%	97%
	Elevation - Water Supply						
61	Minimize days of restricted operation at lake-located intakes	Number of days reservoir level below critical level (775 ft AMSL) for shallowest public water supply intake operation (Note 16)	1-Jan	31-Dec	1	0	0
62		Number of days reservoir level below critical level (789.5 ft AMSL) for shallowest thermal power station operation (Note 17)	1-Jan	31-Dec	1	0	0
63		Number of days reservoir level below critical level (787.9 ft AMSL) for Keowee dam to supply backup power to ONS (Note 18)	1-Jan	31-Dec	1	0	0
	Duke Energy Hydropower & Water Quantity Management						
64	Keowee-Toxaway Low Inflow Protocol (LIP) Stage	Number of days in LIP Stage Normal (Note 19)	1-Jan	31-Dec		8,707	3,366
65		Number of days in LIP Stage 0	1-Jan	31-Dec		13,860	19,187
66		Number of days in LIP Stage 1	1-Jan	31-Dec		1,421	1,435
67		Number of days in LIP Stage 2	1-Jan	31-Dec		2,241	2,227
68		Number of days in LIP Stage 3	1-Jan	31-Dec		385	399
69		Number of days in LIP Stage 4	1-Jan	31-Dec		49	49

	Background	Performance Measure has improved vs. the Baseline Scenario
	Background	Performance Measure has declined vs. the Baseline Scenario
	White Background	There is no significant difference between the scenario and the Baseline Scenario by definition of MISC

Notes	
1	For criterion that measure on an hourly or daily basis, unless stated otherwise:
	a. If an hourly criteria occurs during the average of four contiguous 15-minute periods, then it counts as 1 hour.
	b. If a daily criterion occurs for 5 contiguous 1-hour periods, then it counts as 1 day.
	Also, daytime flows are assumed to be flows provided between 7:00 am and 7:00 pm. To the extent possible, each criterion is defined in terms of percents and averages/yr so that the same criterion is useful regardless of the
2	MISC = Minimum Increment of Significant Change. The MISC has the same units (i.e., days, days/yr, percent, etc.) as does the criterion on that same row of the spreadsheet. If the output of two scenarios for a particular
	a. As a general rule, MISC numbers are set at 10% of the possible total for that criterion considering the Start/Stop dates.
	b. MISC numbers for criteria that have the most adverse outcomes if reached are typically set at less than 10% of the possible total for that criterion.
	c. Adjustments to the MISC numbers (up or down) have also been made depending on the desires of the stakeholders that primarily have the interests that are being measured by a particular criterion.
3	Jocassee restricted recreation elevation 1,090 ft AMSL provided by Chris Starker (Upstate Forever) and confirmed by Devils Fork State Park Staff.
4	Jocassee elevation 1,077 ft AMSL is the lowest boat ramp elevation with an additional 3 ft added for boat access. Boat ramp elevations provided by Duke Energy.
5	This criterion evaluates a day as 24 contiguous hours, not as specified in Note 1.
6	Jocassee entrainment elevation (1,096 ft AMSL) provided by Bill Marshall of SCDNR.
7	Jocassee fish habitat elevations provided by Bill Marshall of SCDNR.
8	Jocassee elevation 1,099 ft AMSL is the elevation at which an MOU between Duke Energy and SCDNR requires Duke Energy to implement operational changes at Bad Creek. Jocassee elevation 1,090 ft AMSL is the elevation at
9	Jocassee elevation 1,081 ft AMSL provided by Duke Energy based on impact to pumping equipment.
10	Keowee restricted recreation elevation of 792 ft AMSL provided by James McRacken (HDR) and Scott Fletcher (Duke Energy).
11	Keowee elevation 790 ft AMSL is based on the lowest boat ramp elevation of 787 ft AMSL plus 3 ft for boat access (provided by Duke Energy).
12	Percent of time is measured as the percent of 15-minute time steps at or above threshold elevation during period starting 07:00 am and period ending 7:00 pm.
13	Toe of Keowee reservoir riprap elevation 794 ft AMSL provided by Duke Energy.
14	This criterion evaluates a day as 24 contiguous hours, not as specified in Note 1.
15	Keowee fish habitat elevations provided by Bill Marshall of SCDNR.
16	Keowee elevation 775 ft AMSL was the minimum level permitted in the previous KT FERC License, and the Keowee water supply intakes present during KT relicensing were confirmed to operate at this reservoir level.
17	For this measure a -0.5 ft buffer was added to filter out model excursions below the Keowee reservoir elevation limit of 790.0 ft AMSL. No counts will be displayed for reservoir levels between 789.5 ft AMSL and 790.0 ft AMSL for this measure.
18	Keowee elevation 787.9 ft AMSL is the critical elevation for Keowee to provide backup power to ONS elevation provided by Duke Energy.
19	There are 26,663 days in the POR.

Bad Creek Relicensing / Savannah River CHEOPS Model Performance Measures Sheet

Measure Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)	Baseline_ccHigh	Bad Creek II_ccHigh
	Lake Jocassee					(1939-2011)	(1939-2011)
	Elevation - Storage Availability						
1	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 1,108 ft AMSL on May 1	1-May	1-May	5	0	0
	Elevation - Recreation						
2	Minimize restricted recreation	Number of years where cove access (reservoir level below 1,090 ft AMSL) is restricted for more than 25 days (Note 3)	1-Jan	31-Dec	2	3	2
3		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) during higher use months in any calendar year (Note 3)	1-Mar	31-Oct	5	86	85
4		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) in any calendar year (Note 3)	1-Jan	31-Dec	5	128	131
5	Minimize restricted boat launching	Number of years where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months for more than 25 days (Note 4)	1-Mar	31-Oct	2	0	0
6		Greatest number of days where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months in any calendar year (Note 4)	1-Mar	31-Oct	5	0	0
7	Minimize effects on recreational boating	Number of days where reservoir level changes more than 1.0 ft in one hour	1-Jan	31-Dec	10	0	0
	Elevation - Natural Resources						
8	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	31-May	5%	73%	100%
9		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 5)	1-Apr	31-May	5%	40%	95%
10		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 5)	1-Apr	31-May	5%	23%	86%
11		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 30 consecutive days at least once (Note 5)	1-Apr	31-May	5%	1%	63%
12		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 45 consecutive days at least once (Note 5)	1-Apr	31-May	5%	0%	0%
13	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	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 (Note 5)	1-Apr	31-May	5%	99%	100%
16		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 30 consecutive days at least once (Note 5)	1-Apr	31-May	5%	92%	92%
17		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 45 consecutive days at least once (Note 5)	1-Apr	31-May	5%	56%	79%
18	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	5%	55%	100%
19		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 5)	15-May	15-Jul	5%	19%	85%
20		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 5)	15-May	15-Jul	5%	3%	3%
21	Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	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 (Note 5)	15-May	15-Jul	5%	82%	96%
24	Minimize entrainment due to Bad Creek operations	Percent of days average reservoir level at or below 1,096 ft AMSL (Note 6)	1-Jan	31-Dec	5%	5%	5%
25		Percent of days average reservoir level below 1,096 ft AMSL (Note 6)	1-Dec	31-Mar	5%	6%	6%
26	Maximize littoral habitat during growing season	Percent of days average reservoir level above 1,107 ft AMSL (Note 7)	1-Apr	30-Sep	5%	43%	38%
27		Percent of days average reservoir level above 1,105 ft AMSL (Note 7)	1-Apr	30-Sep	5%	87%	87%
28	Maximize littoral habitat during spawning season	Percent of days average reservoir level above 1,107 ft AMSL (Note 7)	1-Apr	31-May	5%	19%	14%
29		Percent of days average reservoir level above 1,105 ft AMSL (Note 7)	1-Apr	31-May	5%	90%	90%
	Pumped Storage						
30	Minimize days below lake levels that impact Bad Creek operations	Number of days reservoir level below 1,099 ft AMSL (Note 8)	1-Jan	31-Dec	227	2,272	2,086
31	Minimize days below lake levels that impact Jocassee operations	Number of days reservoir level below 1,090 ft AMSL (Note 8)	1-Jan	31-Dec	14	224	246
32	Minimize days below lake levels that impact Bad Creek efficiency	Number of days reservoir level below 1,081 ft AMSL (Note 9)	1-Jan	31-Dec	12	0	10
	Lake Keowee						
	Elevation - Storage Availability						
33	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 798 ft AMSL on May 1	1-May	1-May	5	67	67
	Elevation - Aesthetics						
34	Maximize lake levels	Percent of time reservoir level at or above 797 ft AMSL	1-Jan	31-Dec	20%	87%	87%
35		Percent of time reservoir level at or above 795 ft AMSL	1-Jan	31-Dec	10%	95%	95%
36	Minimize significant drawdown of lake level	Number of days reservoir level below 796 ft AMSL	1-Jan	31-Dec	5	2,886	2,761
	Elevation - Recreation						
37	Minimize restricted recreation	Number of years where cove access (reservoir level below 792 ft AMSL) is restricted for more than 25 days (Note 10)	1-Jan	31-Dec	2	0	0
38		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) during higher use months in any calendar year (Note 10)	1-Mar	31-Oct	5	0	14
39		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) in any calendar year (Note 10)	1-Jan	31-Dec	5	0	23
40	Minimize restricted lake boat launching	Number of years where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months for more than 25 days (Note 11)	1-Mar	31-Oct	2	0	0
41		Greatest number of days where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months in any calendar year (Note 11)	1-Mar	31-Oct	5	0	0
42	Maximize boat dock usage	Percent of time reservoir level is at or above level where 85% of docks are usable (796.25 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 12)	1-Mar	31-Oct	5%	90%	90%
43		Percent of time reservoir level is at or above level where 70% of docks are usable (793.5 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 12)	1-Mar	31-Oct	5%	99%	99%

Bad Creek Relicensing / Savannah River CHEOPS Model Performance Measures Sheet

Measure Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)	Baseline_ccHigh	Bad Creek II_ccHigh
	Elevation - Natural Resources						
44	Minimize number of days water level is below toe of riprap	Number of days reservoir level below 794 ft AMSL (Note 13)	1-Jan	31-Dec	250	869	858
45	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
46		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
47		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
48	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
49		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
50		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 14)	15-Mar	31-May	5%	100%	100%
51	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
52		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
53		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 14)	15-May	15-Jul	5%	99%	99%
54	Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
55		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 14)	15-May	15-Jul	5%	100%	100%
56		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 14)	15-May	15-Jul	5%	99%	99%
57	Maximize littoral habitat during growing season	Percent of days average reservoir level above 798 ft AMSL (Note 15)	1-Apr	30-Sep	5%	84%	84%
58		Percent of days average reservoir level above 797 ft AMSL (Note 15)	1-Apr	30-Sep	5%	88%	88%
59	Maximize littoral habitat during spawning season	Percent of days average reservoir level above 798 ft AMSL (Note 15)	1-Apr	31-May	5%	90%	91%
60		Percent of days average reservoir level above 797 ft AMSL (Note 15)	1-Apr	31-May	5%	92%	93%
	Elevation - Water Supply						
61	Minimize days of restricted operation at lake-located intakes	Number of days reservoir level below critical level (775 ft AMSL) for shallowest public water supply intake operation (Note 16)	1-Jan	31-Dec	1	0	0
62		Number of days reservoir level below critical level (789.5 ft AMSL) for shallowest thermal power station operation (Note 17)	1-Jan	31-Dec	1	0	0
63		Number of days reservoir level below critical level (787.9 ft AMSL) for Keowee dam to supply backup power to ONS (Note 18)	1-Jan	31-Dec	1	0	0
	Duke Energy Hydropower & Water Quantity Management						
64	Keowee-Toxaway Low Inflow Protocol (LIP) Stage	Number of days in LIP Stage Normal (Note 19)	1-Jan	31-Dec		7,860	4,276
65		Number of days in LIP Stage 0	1-Jan	31-Dec		13,160	16,793
66		Number of days in LIP Stage 1	1-Jan	31-Dec		2,625	2,527
67		Number of days in LIP Stage 2	1-Jan	31-Dec		2,213	2,304
68		Number of days in LIP Stage 3	1-Jan	31-Dec		805	728
69		Number of days in LIP Stage 4	1-Jan	31-Dec		0	35

	Background	Performance Measure has improved vs. the Baseline Scenario
	Background	Performance Measure has declined vs. the Baseline Scenario
	White Background	There is no significant difference between the scenario and the Baseline Scenario by definition of MISC

Notes	
1	For criterion that measure on an hourly or daily basis, unless stated otherwise:
	a. If an hourly criteria occurs during the average of four contiguous 15-minute periods, then it counts as 1 hour.
	b. If a daily criterion occurs for 5 contiguous 1-hour periods, then it counts as 1 day.
	Also, daytime flows are assumed to be flows provided between 7:00 am and 7:00 pm. To the extent possible, each criterion is defined in terms of percents and averages/yr so that the same criterion is useful regardless of the length
2	MISC = Minimum Increment of Significant Change. The MISC has the same units (i.e., days, days/yr, percent, etc.) as does the criterion on that same row of the spreadsheet. If the output of two scenarios for a particular criterion
	a. As a general rule, MISC numbers are set at 10% of the possible total for that criterion considering the Start/Stop dates.
	b. MISC numbers for criteria that have the most adverse outcomes if reached are typically set at less than 10% of the possible total for that criterion.
	c. Adjustments to the MISC numbers (up or down) have also been made depending on the desires of the stakeholders that primarily have the interests that are being measured by a particular criterion.
3	Jocassee restricted recreation elevation 1,090 ft AMSL provided by Chris Starker (Upstate Forever) and confirmed by Devils Fork State Park Staff.
4	Jocassee elevation 1,077 ft AMSL is the lowest boat ramp elevation with an additional 3 ft added for boat access. Boat ramp elevations provided by Duke Energy.
5	This criterion evaluates a day as 24 contiguous hours, not as specified in Note 1.
6	Jocassee entrainment elevation (1,096 ft AMSL) provided by Bill Marshall of SCDNR.
7	Jocassee fish habitat elevations provided by Bill Marshall of SCDNR.
8	Jocassee elevation 1,099 ft AMSL is the elevation at which an MOU between Duke Energy and SCDNR requires Duke Energy to implement operational changes at Bad Creek. Jocassee elevation 1,090 ft AMSL is the elevation at
9	Jocassee elevation 1,081 ft AMSL provided by Duke Energy based on impact to pumping equipment.
10	Keowee restricted recreation elevation of 792 ft AMSL provided by James McRacken (HDR) and Scott Fletcher (Duke Energy).
11	Keowee elevation 790 ft AMSL is based on the lowest boat ramp elevation of 787 ft AMSL plus 3 ft for boat access (provided by Duke Energy).
12	Percent of time is measured as the percent of 15-minute time steps at or above threshold elevation during period starting 07:00 am and period ending 7:00 pm.
13	Toe of Keowee reservoir riprap elevation 794 ft AMSL provided by Duke Energy.
14	This criterion evaluates a day as 24 contiguous hours, not as specified in Note 1.
15	Keowee fish habitat elevations provided by Bill Marshall of SCDNR.
16	Keowee elevation 775 ft AMSL was the minimum level permitted in the previous KT FERC License, and the Keowee water supply intakes present during KT relicensing were confirmed to operate at this reservoir level.
17	For this measure a -0.5 ft buffer was added to filter out model excursions below the Keowee reservoir elevation limit of 790.0 ft AMSL. No counts will be displayed for reservoir levels between 789.5 ft AMSL and 790.0 ft AMSL for this measure.
18	Keowee elevation 787.9 ft AMSL is the critical elevation for Keowee to provide backup power to ONS elevation provided by Duke Energy.
19	There are 26,663 days in the POR.

Attachment B: Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat

(Final Report)

EFFECTS OF BAD CREEK II COMPLEX AND EXPANDED WEIR ON AQUATIC HABITAT

FINAL REPORT

AQUATIC RESOURCES STUDY

Bad Creek Pumped Storage Project
FERC Project No. 2740

Oconee County, South Carolina

June 3, 2024

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EFFECTS OF BAD CREEK II COMPLEX AND EXPANDED WEIR ON AQUATIC HABITAT FINAL REPORT
BAD CREEK PUMPED STORAGE PROJECT
FERC PROJECT NO. 2740
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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
ANOVA	analysis of variance
Bad Creek (or Project)	Bad Creek Pumped Storage Project
Bad Creek II Complex	Bad Creek II Power Complex
CFR	Code of Federal Regulations
CFD	Computational Fluid Dynamics
CHEOPS	Computer Hydro-Electric Operations and Planning Software™
DO	dissolved oxygen
Duke Energy	Duke Energy Carolinas, LLC
Eq.	equation
FERC or Commission	Federal Energy Regulatory Commission
ft	feet
ft msl	feet above mean sea level
KT Project	Keowee-Toxaway Hydroelectric Project
m	meters
mg/L	milligrams per liter
MISC	minimum increment of significant change
RSP	Revised Study Plan
SCDNR	South Carolina Department of Natural Resources
SD	standard deviation
Tukey HSD	Tukey’s Honestly Significant Difference

1 Project Introduction and Background

Duke Energy Carolinas, LLC (Duke Energy) is the owner and operator of the 1,400-megawatt Bad Creek Pumped Storage Project (Project) (FERC Project No. 2740) located in Oconee County, South Carolina, approximately eight miles north of Salem. The Project utilizes the Bad Creek Reservoir as the upper reservoir (Upper Reservoir) and Lake Jocassee, which is licensed as part of the Keowee-Toxaway (KT) Hydroelectric Project (FERC Project No. 2503), as the lower reservoir.

The existing (original) license for the Project was issued by the Federal Energy Regulatory Commission (FERC or Commission) for a 50-year term, with an effective date of August 1, 1977, and expiration date of July 31, 2027. The license has been subsequently and substantively amended, with the most recent amendment on August 6, 2018, for authorization to upgrade and rehabilitate the four pump-turbines in the powerhouse and increase the Authorized Installed and Maximum Hydraulic capacities for the Project.[1] Duke Energy is pursuing a new license for the Project pursuant to the Commission's Integrated Licensing Process, as described at 18 Code of Federal Regulations (CFR) Part 5.

In accordance with 18 CFR §5.11 of the Commission's regulations, Duke Energy developed a Revised Study Plan (RSP) for the Project and proposed six studies for Project relicensing. The RSP was filed with the Commission and made available to stakeholders on December 5, 2022. FERC issued the Study Plan Determination on January 4, 2023, which included modifications to one of the six proposed studies (Recreational Resources Study).

This report includes the methods and results from Task 2 (Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat) of the Bad Creek Aquatic Resources Study. The Aquatic Resources Study is ongoing in support of preparing an application for a new license for the Project in accordance with 18 CFR §5.15, as provided in the RSP.

[1] *Duke Energy Carolinas LLC, 164 FERC ¶ 62,066 (2018)*

1.1 Project Nexus

Duke Energy is proposing the development of a second powerhouse as part of the new license for the Project. The Bad Creek II Power Complex (Bad Creek II Complex) would consist of a new upper reservoir inlet/outlet structure, water conveyance system, underground powerhouse, and lower reservoir inlet/outlet structure. Operation of the Bad Creek II Complex would more than double the existing flow to Lake Jocassee during generation as compared to the existing Project, which has the potential to affect reservoir dynamics.

As part of the original Project design, a submerged weir was constructed approximately 1,800 feet (ft) downstream of the Project's inlet/outlet structure to dissipate energy from generation flows and minimize the effects of Project operations on natural lake stratification by preventing the mixing of warmer water from the discharge with the cooler water in Lake Jocassee. The weir functions as a fish protection mechanism for Lake Jocassee's trout fishery, which relies on suitable pelagic habitat with cool water and high dissolved oxygen (DO). This habitat can become limited during summer months, particularly following warmer winters which limit lake turnover and thus replenishment of oxygenated water at lower reservoir elevations. As part of the Bad Creek II Complex construction, the submerged weir is proposed to be expanded in the downstream direction with approximately 1.3 million cubic yards of spoil material from the underground tunnel excavation and new inlet/outlet structure construction.

The Aquatic Resources Task 2 Study evaluates how the addition of Bad Creek II Complex operations and expanded submerged weir may affect pelagic trout habitat in Lake Jocassee and alter conditions within the littoral zone[2] due to changes in water discharge and surface water elevation.

[2] The littoral zone is the nearshore habitat where solar radiation penetrates through the water column all the way to the lake bottom in sufficient levels to support photosynthesis (Seekell et al. 2021).

2 Goals and Objectives

Tasks for the Bad Creek Aquatic Resources Study used standard methodologies consistent with the scope and level of effort described in the RSP. The goal of the Aquatic Resources study is to evaluate potential impacts to aquatic life populations, communities, and habitats, due to the construction and operation of the proposed Bad Creek II Complex.

This report was developed in support of Task 2 of the Aquatic Resources Study (Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat). The main objective of this task is to assess changes to pelagic and littoral aquatic habitat in Lake Jocassee resulting from the proposed additional operations from a second powerhouse and expanded submerged weir. This objective was met through the evaluation of model results developed for the Water Resources Study, including:

1) The Computational Fluid Dynamics (CFD) model developed for the Water Resources Study (Task 3); results from the CFD model were used to evaluate potential effects, if any, on pelagic trout habitat due to water column mixing in Lake Jocassee and if the addition of Bad Creek II operations and expanded weir could impact habitat; and

2) The Computer Hydro-Electric Operations and Planning Software™ (CHEOPS) model (updated in collaboration with the Bad Creek Water Resources Resource Committee); results from the CHEOPS model informed effects on littoral habitat in Lake Jocassee associated with water exchange rates, magnitude, and duration of operations between the Project and Bad Creek II Complex, and the Jocassee Pumped Storage Station.

3 Study Area

The study area includes Lake Jocassee. Specifically, the study evaluates the pelagic area downstream of the expanded weir in Whitewater River cove and the lake-wide littoral zone (Figure 3-1).

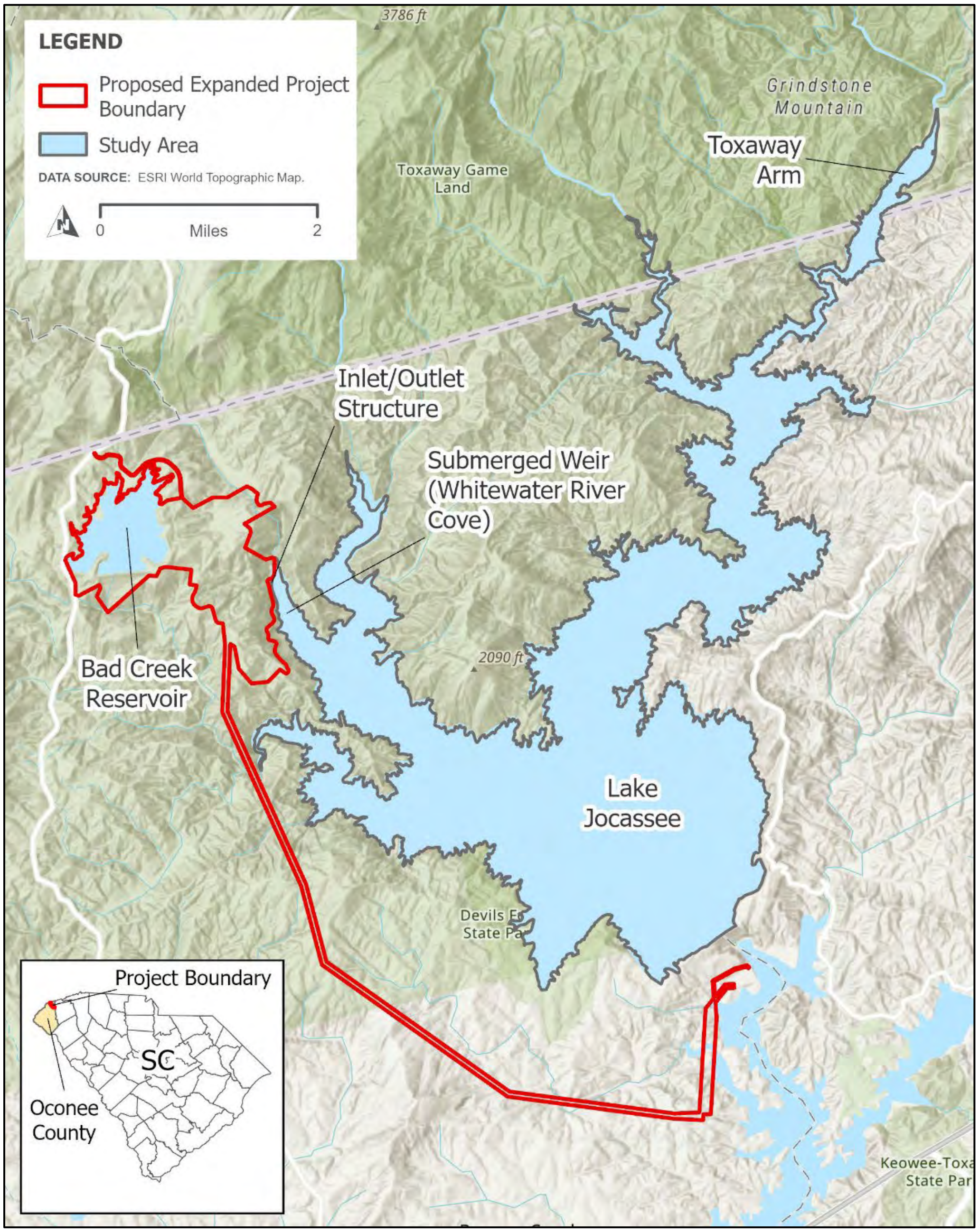

Figure 3-1. Aquatic Resources Study Task 2 Study Area

4 Methods

4.1 Pelagic Trout Habitat Assessment

As one of the few reservoirs in South Carolina containing both a year-round warmwater and coldwater fishery, the state prioritizes Lake Jocassee as a trout fishery by implementing a stocking program and regular monitoring of the trout and forage fish community. To assess how the addition of Bad Creek II Complex may affect trout in Lake Jocassee, specific water quality parameters and CFD modeling results were evaluated for potential disruptions to late summer pelagic trout habitat.

4.1.1 Pelagic Trout Habitat Monitoring Review

In support of the fishery and originally as part of the 10-year work plans under the Memorandum of Understanding developed in 1996 with the South Carolina Department of Natural Resources (SCDNR)[3], Duke Energy monitors Lake Jocassee's pelagic trout habitat as indicated by specific thermal and DO criteria (see Duke Energy [2022] for a summary of the 10-year work plans to date and the KT Project Relicensing Agreement). Pelagic trout habitat is defined as water with temperatures ≤ 20.0 degrees Celsius (°C) and DO concentrations ≥ 5.0 milligrams per liter (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). Lake Jocassee is a monomictic lake which experiences thermal stratification during the summer and mixing during the winter. Thermal stratification occurs from late spring to late fall when the uppermost layer of the water column (epilimnion) warms from solar radiation, resulting in a less-dense layer of water atop a more dense, cooler bottom layer (hypolimnion). The transition between these layers is the thermocline, or metalimnion, which exhibits a rapid change in temperature and functions as a barrier between the two layers, thereby preventing mixing. In late fall as ambient

[3] Included in the KT Project Relicensing Agreement and New License issued by FERC in 2016 for the KT Project.

air temperatures decline and solar radiation is reduced, the epilimnion becomes cooler and more dense, sinking in the water column and resulting in a mixing, or turnover, of the water column.

4.1.2 CFD Model Results Review

A CFD model was developed using FLOW-3D (Flow Science 2023) to evaluate flow patterns and the potential for vertical mixing in the Whitewater River cove downstream of the submerged weir. Results of the CFD study (HDR 2023) were filed with the Initial Study Report on January 4, 2024 as Appendix A, Attachment 3 (*Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse Final Report;* HDR 2023). For details on modeling approach, geometry, resolution, boundary conditions, simulations, limitations, and assumptions, refer to HDR (2023).

For the current task, results of the CFD model 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 (HDR 2023), 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.

4.2 Littoral Habitat Assessment

Operation of the Bad Creek II Complex will influence water surface elevations in Lake Jocassee and may affect littoral zone habitat in the lake. 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).

4.2.1 CHEOPS Model Results Review

The CHEOPS model is designed to evaluate the effects of operational changes and physical modifications at multi-development hydroelectric projects. The CHEOPS model used for the Project includes six hydroelectric facilities within the Savannah River Basin and was originally developed in support of the KT Project relicensing. For use during current Bad Creek relicensing, the model was updated to incorporate changes since KT Project relicensing as well as proposed operations of the Bad Creek II Complex.

Performance measures (a statistical summary of model output) related to a variety of different stakeholder interests were developed in consultation with relicensing stakeholders in 2023. Performance measures related to frequency of water surface fluctuations and water surface elevations in the littoral zone for Lake Jocassee were evaluated for this study (Table 4-1).

Stable water surface elevations are important for species that use the littoral zone for spawning, including black basses (*Micropterus* spp.), sunfishes (*Lepomis* spp.), Threadfin Shad (*Dorosoma petenense*), and landlocked Blueback Herring (*Alosa aestivalis*) (Stuber et al. 1982a, 1982b; Edwards et al. 1983; Aho et al. 1986; Rhode 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 was run for two scenarios using a hydrologic data set from 1939 to 2011: Baseline (Duke Energy operations based on Project and KT Project license requirements) and Bad Creek II (Baseline scenario with the four additional Bad Creek II Complex units). Additional information on the development of the CHEOPS model and results is available in the *Water Exchange Rates and Lake Jocassee Reservoir Levels Report* (HDR 2024).

Table 4-1. Summary of CHEOPS Performance Measures Related to Littoral Habitat

Performance Measures	Measure Number	Criterion	Start Date	End Date	MISC[1]
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[2]	1-Apr	31-May	5%
	9	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once[2]	1-Apr	31-May	5%
	10	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once[2]	1-Apr	31-May	5%
	11	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 30 consecutive days at least once[2]	1-Apr	31-May	5%
	12	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 45 consecutive days at least once[2]	1-Apr	31-May	5%
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[2]	1-Apr	31-May	5%
	14	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once[2]	1-Apr	31-May	5%
	15	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once[2]	1-Apr	31-May	5%
	16	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 30 consecutive days at least once[2]	1-Apr	31-May	5%
	17	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 45 consecutive days at least once[2]	1-Apr	31-May	5%
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[2]	15-May	15-Jul	5%
	19	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once[2]	15-May	15-Jul	5%
	20	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once[2]	15-May	15-Jul	5%
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[2]	15-May	15-Jul	5%
	22	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once[2]	15-May	15-Jul	5%

Performance Measures	Measure Number	Criterion	Start Date	End Date	MISC[1]
	23	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once[2]	15-May	15-Jul	5%
Maximize littoral habitat during growing season	26	Percent of days average reservoir level above 1,107 ft msl[3]	1-Apr	30-Sep	5%
	27	Percent of days average reservoir level above 1,105 ft msl [3]	1-Apr	30-Sep	5%
Maximize littoral habitat during spawning season	28	Percent of days average reservoir level above 1,107 ft msl[3]	1-Apr	31-May	5%
	29	Percent of days average reservoir level above 1,105 ft msl[3]	1-Apr	31-May	5%
Minimize days below lake levels that impact Bad Creek efficiency	32	Number of days reservoir level below 1,081 ft msl[4]	1-Jan	31-Dec	12

[1]MISC = minimum increment of significant change. The MISC is the same units (i.e., days, days/year, percent, etc.) as the criterion. If the output of two scenarios for a particular criterion differs by less than or equal to the MISC, then there is no significant difference between those two scenarios.
[2]This criterion evaluates a day as 24 contiguous hours.
[3]Jocassee fish habitat elevations provided by Bill Marshall of SCDNR during the KT Project relicensing. Elevations in ft above mean sea level (ft msl).
[4]Jocassee elevation 1,081 ft msl provided by Duke Energy based on impact to pumping equipment.

4.2.2 Quantification of the Littoral Zone

4.2.2.1 Secchi Depth Data and Processing

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 in Lake Jocassee by recording depth to the nearest 0.1 meter (m) as an average of two readings: when the disk disappeared from view and when it reappeared during raising (Duke Energy Field Procedure ESFP-SW-0503, Rev1). A map of Lake Jocassee Secchi Disk sampling locations is shown on Figure 4-1.

The dataset consisted of 1,182 samples with Secchi depth (meters), location sampled, and sampling date spanning from 2003 to 2015 (Duke Energy 2024). Based on variability of Secchi depth observed through preliminary descriptive statistics, it was hypothesized that Secchi depths closer to tributary inputs (i.e., coves) were not as deep compared to those in open water areas due to increased turbidity from tributaries. Increased precipitation related to seasonal changes could also result in changes in water clarity throughout the year. Therefore, analysis of variance (ANOVA) was used to determine if Secchi depth varied by sampling region (two regions: cove or open water [Figure 4-1]) or season (four seasons: March-May = spring, June-August = summer, September-November = fall, and December-February = winter) in factorial design (Secchi Depth ~ Sampling Region * Season). Factorial design was chosen *a priori* because it was believed that lake region and season could influence Secchi depth, simultaneously. Tukey's Honestly Significant Difference (Tukey HSD) test was used for post-hoc analysis of specific comparisons, mainly, lake region (cove or open water) comparison for each season (e.g., cove-spring: open water-spring).

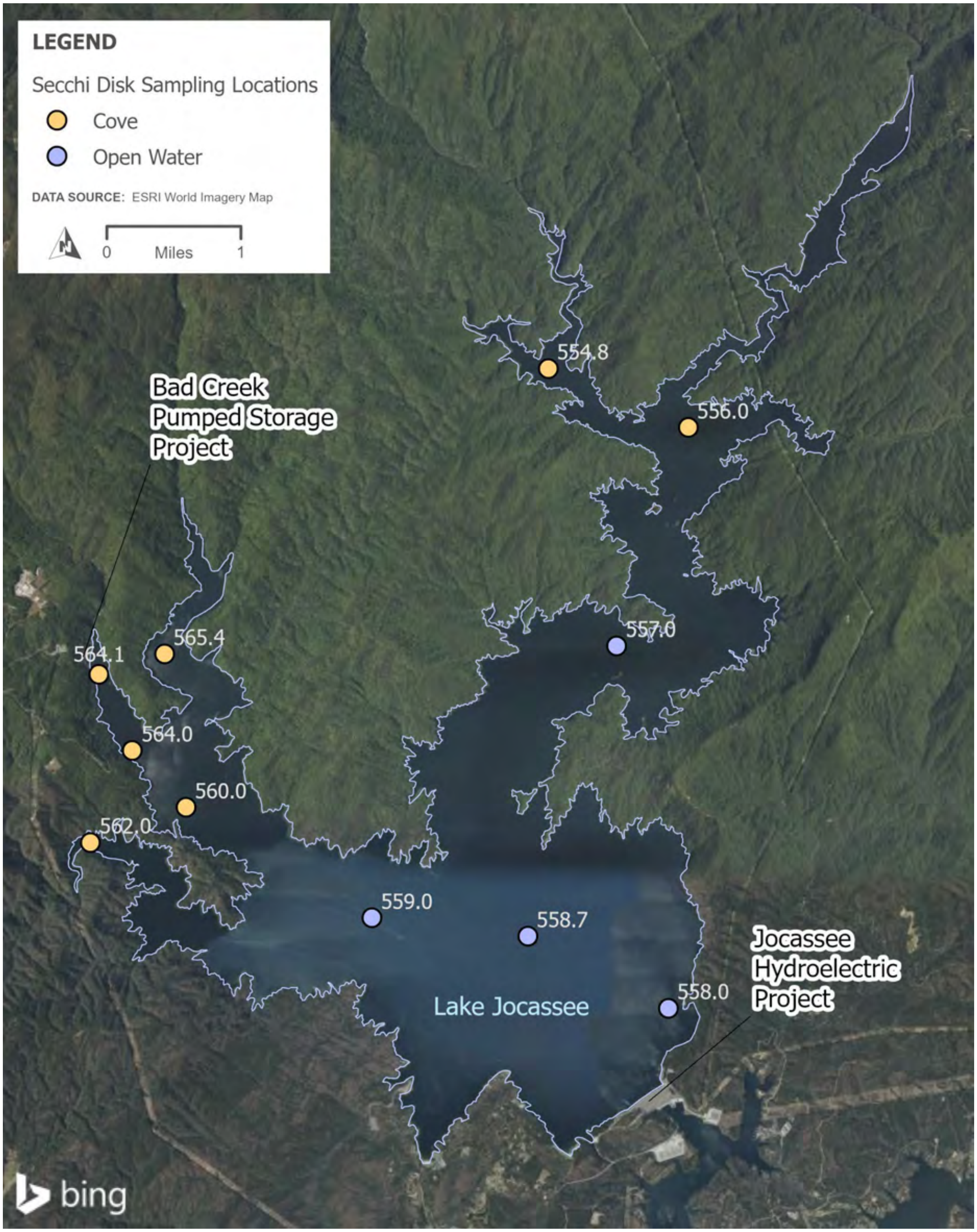

Figure 4-1. Secchi Depth Sampling Locations

4.2.2.2 Littoral Zone Depth and Extent

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), or 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) (Equation [Eq.] 1). Light at any given depth can be calculated from Eq. 2 and rearranged to find the depth of the euphotic zone using Eq. 3 and 4 (Lee and Rast 1997).

(Eq. 1) $$\eta = \frac{1.7}{Secchi}$$

(Eq. 2) $$I_z = I_o e^{-\eta z}$$

(Eq. 3) $$z = \frac{\ln(I_o) - \ln\,(I_z)}{\eta}$$

(Eq. 4) $$z = \frac{4.605}{\eta}$$

Where:

η	vertical absorption coefficient
Secchi	Secchi disk depth in m
z	depth
I_z	incident radiation at depth z
I_o	incident radiation at depth 0

The extent, or spatial area, of the littoral zone was estimated using the calculated littoral zone depth for cove and open water regions (Sections 4.2.2.1 and 4.2.2.2), existing bathymetry data, and pre-defined water surface elevations. The bathymetry data for Lake Jocassee were collected as part of the KT Project relicensing in May and June 2010 (HDR 2010).

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 4-2.

Table 4-2. 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.

5 Results

5.1 Pelagic Trout Habitat Assessment

5.1.1 Pelagic Trout Habitat Monitoring

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 (Figure 5-1).

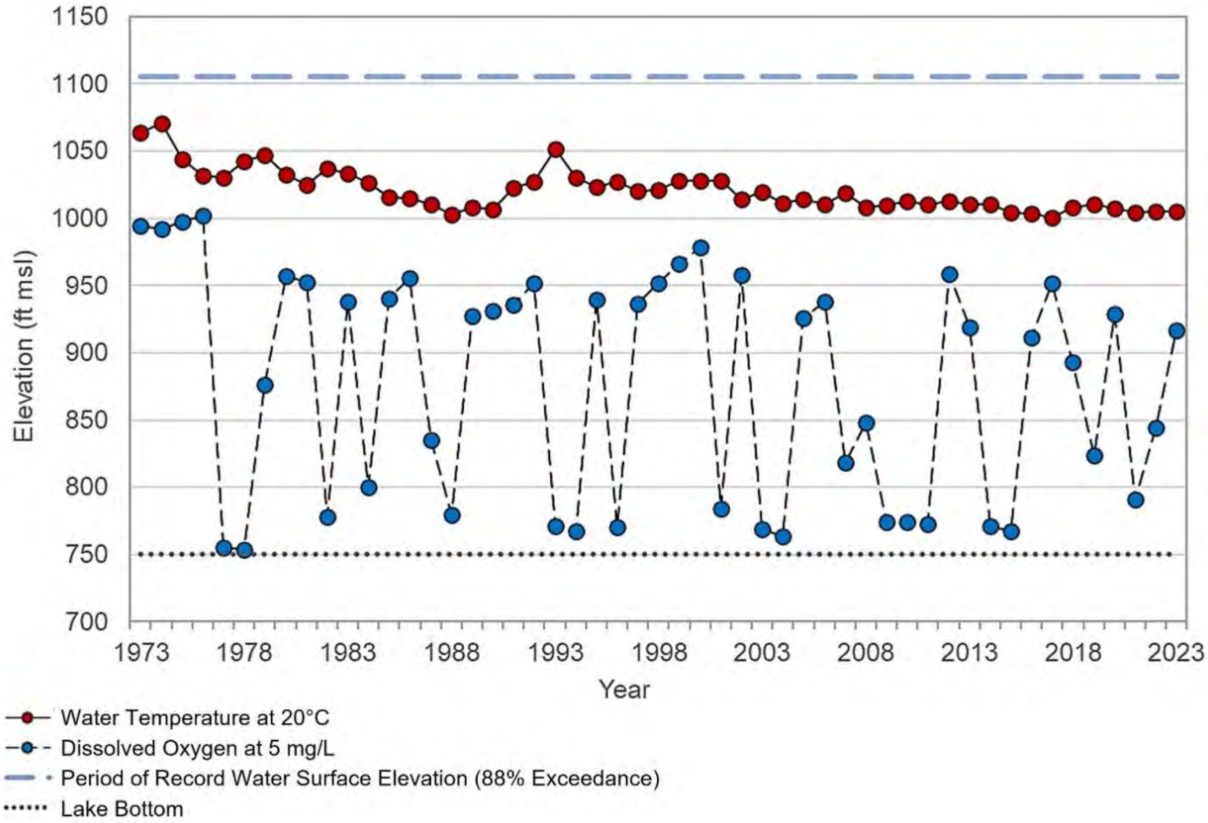

Figure 5-1. Pelagic Trout Habitat Thresholds from 1973-2023

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 5-2). Water quality parameters for trout habitat are measured at the deepest part of the lake at location 558.0 (Figure 4-1), 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.

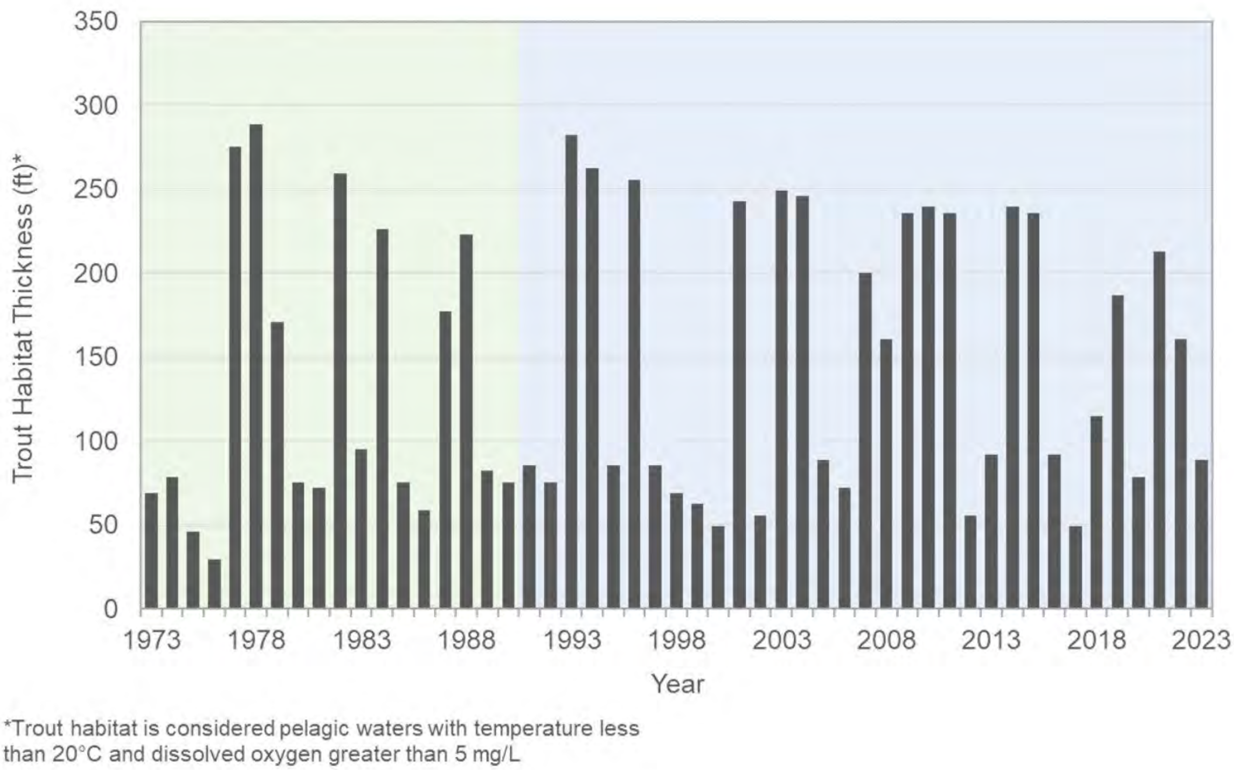

Figure 5-2. Measured or Predicted Pelagic Trout Habitat Thickness from 1973-2023; green and blue shaded areas represent time prior to and following commencement of Project operations (1991)

A study completed by Foris (2014) depicted the seasonal pelagic trout habitat distribution from just upstream of the submerged weir (Station 564.1, see Figure 4-1) to Jocassee Dam using water quality data collected during 2013. The study also evaluated pelagic trout habitat in the Toxaway River arm. Contour plots from this study showed the seasonal restriction of pelagic trout habitat across the lake due to summer thermal stratification (Attachment A). More importantly, the Foris (2014) study showed that effects from Project operations were limited to the area upstream of the submerged weir (Attachment A, Figures 2 and 3). Pelagic trout habitat downstream of the weir and within Whitewater River cove, as indicated by data collected at sampling location 564.0 (see Figure 4-1), was approximately 29.5 ft "thick" in October 2013 (the most restricted month due to natural seasonal stratification). Although more limited than the deepest part of the lake (location 558.0 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.

5.1.2 CFD Model Results

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. Water quality profile data (current and historic) support CFD model results; results from field monitoring as well as CFD modeling indicate the water column is completely mixed (i.e., no natural stratification) near the inlet/outlet structure upstream of the weir; however, just downstream of the weir, stratification is comparable to rest of the waterbody, indicating the weir is functioning as intended and mixing is largely confined to the Whitewater River cove upstream of the weir.

5.1.2.1 Maximum Generation, Maximum Elevation Scenario

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 (Attachment B, Figures 1 and 2). The effect of added generation from the additional powerhouse did not extend beyond the Whitewater River cove. Water column mixing effects were observed immediately downstream of the weir, but do not extend more than approximately 1,050 ft from the weir (Attachment B, Figure 3) which is approximately halfway from the weir to sampling location 564.0.[4]

5.1.2.2 Maximum Generation, Minimum Elevation Scenario

As expected, velocity effects over the weir increase under the minimum elevation (i.e., maximum drawdown), however effects were again limited to the Whitewater River cove (Attachment B, Figures 4 and 5). Water column mixing effects were confined to the area immediately downstream of the weir, extending approximately 450 ft downstream. (Attachment B, Figure 6).

[4] The entire length of the Whitewater River cove of Lake Jocassee is approximately 5,700 ft.

5.1.3 Findings

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. Historical trout habitat monitoring conducted by Foris (2014) showed consistent (year-round) suitable trout habitat present at location 564.0, which is approximately 2,500 ft downstream 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. CFD modeling showed no substantial difference in downstream effects between the existing weir and the expanded weir (HDR 2023).

Impacts to pelagic trout habitat resulting from increased vertical mixing due to operations from the Bad Creek II Complex are not expected based on historical lake dynamics, trout habitat monitoring, and hydraulic modeling.

5.2 Littoral Habitat Assessment

5.2.1 CHEOPS Model Results

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 (HDR 2024). 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 5-1). The operation of Bad Creek II Complex 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 (HDR 2024) (Figure 5-3).

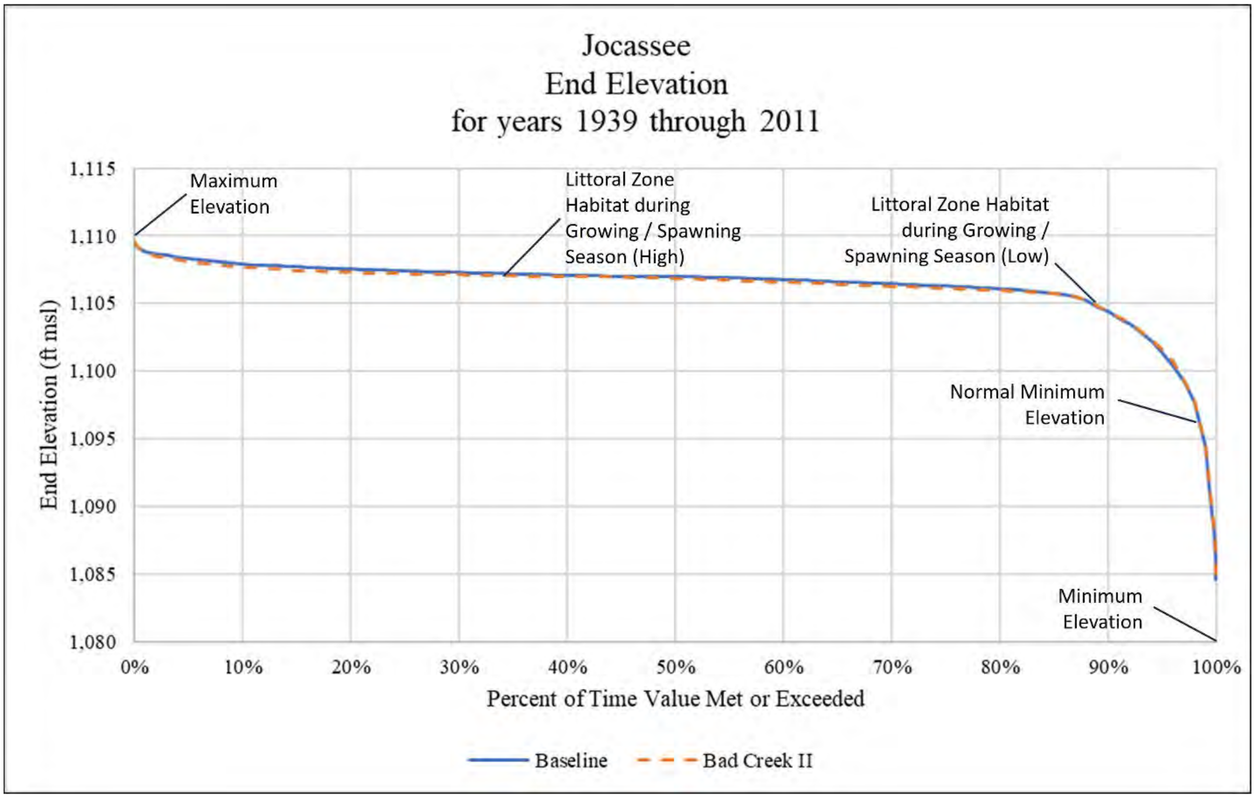

Figure 5-3. Normal Hydrology Jocassee 24-hour Reservoir Fluctuation for 1939-2011 (HDR 2024)

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 (Table 5-1).

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 5-1. 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%

Performance Measures	Measure Number	Criterion	Scenario	
			Baseline	Bad Creek II
	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%
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

Background (green)	Performance measure has improved vs. the Baseline scenario
Background (orange)	Performance measure has declined vs. the Baseline scenario
Background	There is no significant difference between the scenarios by definition of MISC (see Table 4-1)

5.2.2 Quantification of the Littoral Zone

5.2.2.1 Secchi Depth Analysis

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 5-4). 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 in the water column in cove regions compared to open water areas across all seasons (Figure 5-4).

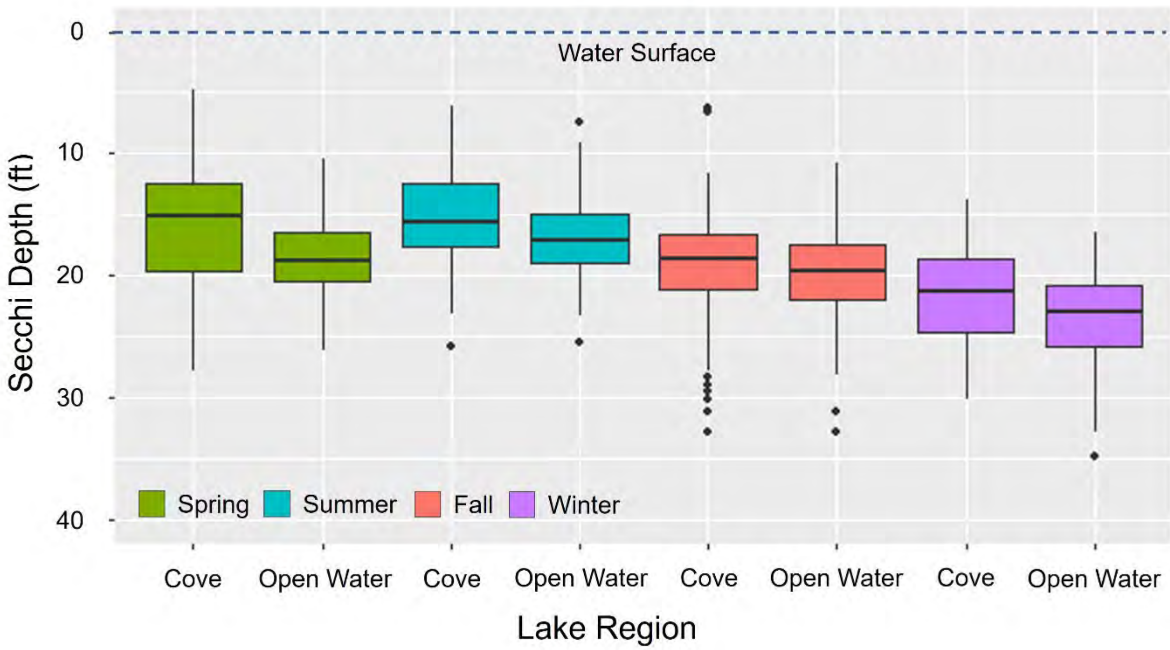

Figure 5-4. Box Plot of Secchi Depth Data (Duke Energy 2024) for Cove and Open Water Locations

The ANOVA model showed both sample location (open water or cove) and season (spring, summer, fall, winter) significantly influenced Secchi depth (ANOVA, $p < 0.0001$). However, the two-way interaction was also significant, indicating that both factors 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 4-2). 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.

5.2.2.2 Littoral Zone Estimate

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 4-2 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 5-2 and bathymetry data.

Table 5-2. 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 (see Table 4-1).
[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 elevation (1,110 ft msl) (Table 5-3). 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 (Attachment C, pages 1-4).

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 (Attachment C, pages 5-8) 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 5-3).

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 5-3. 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

5.2.3 Findings

The CHEOPS model results indicate the addition of the Bad Creek II Complex 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 Complex operations as indicated by the performance measures.

The maximum drawdown scenario inherently 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 (HDR 2024). 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.

6 Conclusions

In coordination with the SCDNR and in accordance with the KT Project Relicensing Agreement, Duke Energy has conducted pelagic trout habitat monitoring in Lake Jocassee since 1973. If trout habitat is projected to be less than 32.8 ft (10 m) thick by September, potential adjustments to hydropower operations at Jocassee Pumped Storage Station are made in consultation with the SCDNR. The lowest projected trout habitat since the Project's operations started in 1991 was 49.2 ft in the year 2000 and 2017, well above the threshold for consultation.

Pelagic trout habitat in Lake Jocassee was not substantially different before or after the development and operation of the Project. Based on historic spatial temperature and DO dynamics of Lake Jocassee and hydraulic modeling to predict flow velocity and water column mixing, no impacts to pelagic trout habitat are expected as a result of Bad Creek II Complex operations.

Littoral habitat in Lake Jocassee under Bad Creek II Complex operations is expected to remain the same or improve as compared to Baseline conditions. Increased generation and pumping rates with the addition of Bad Creek II Complex (and coupled with increased Jocassee Pumped Storage Station operations which act to offset Bad Creek II Complex 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 addition of the Bad Creek II Complex.

7 Variances from FERC-approved Study Plan

There were no variances from the FERC-approved study plan.

8 Germane Correspondence and Consultation

Consultation documentation for the Aquatic Resources Study will be included in the USR.

9 References

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Attachment A

Attachment A – Pelagic Trout Habitat Figures (Foris 2014)

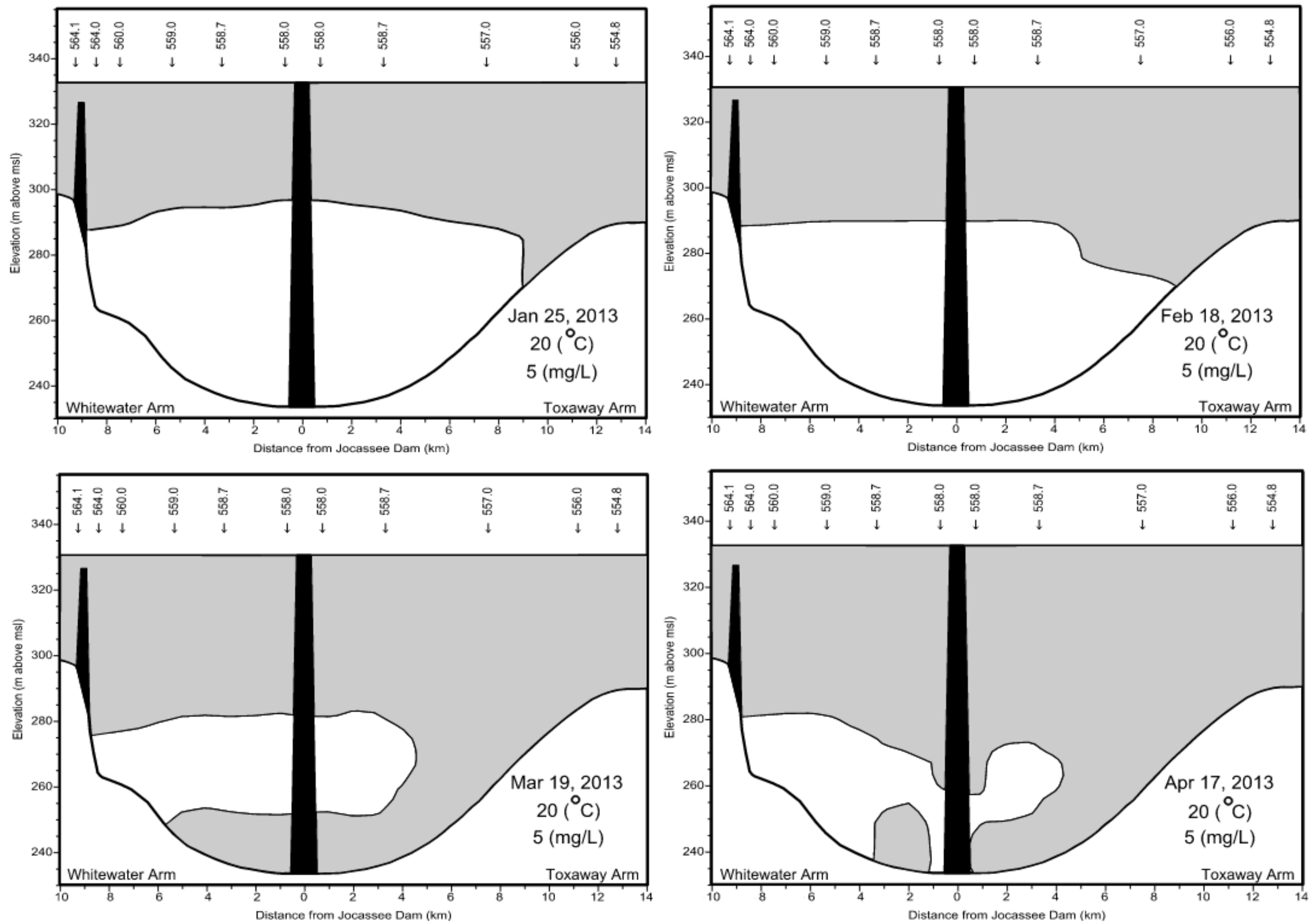

Figure 1. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, January – April 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from Jocassee Dam is the submerged weir in Whitewater River cove.

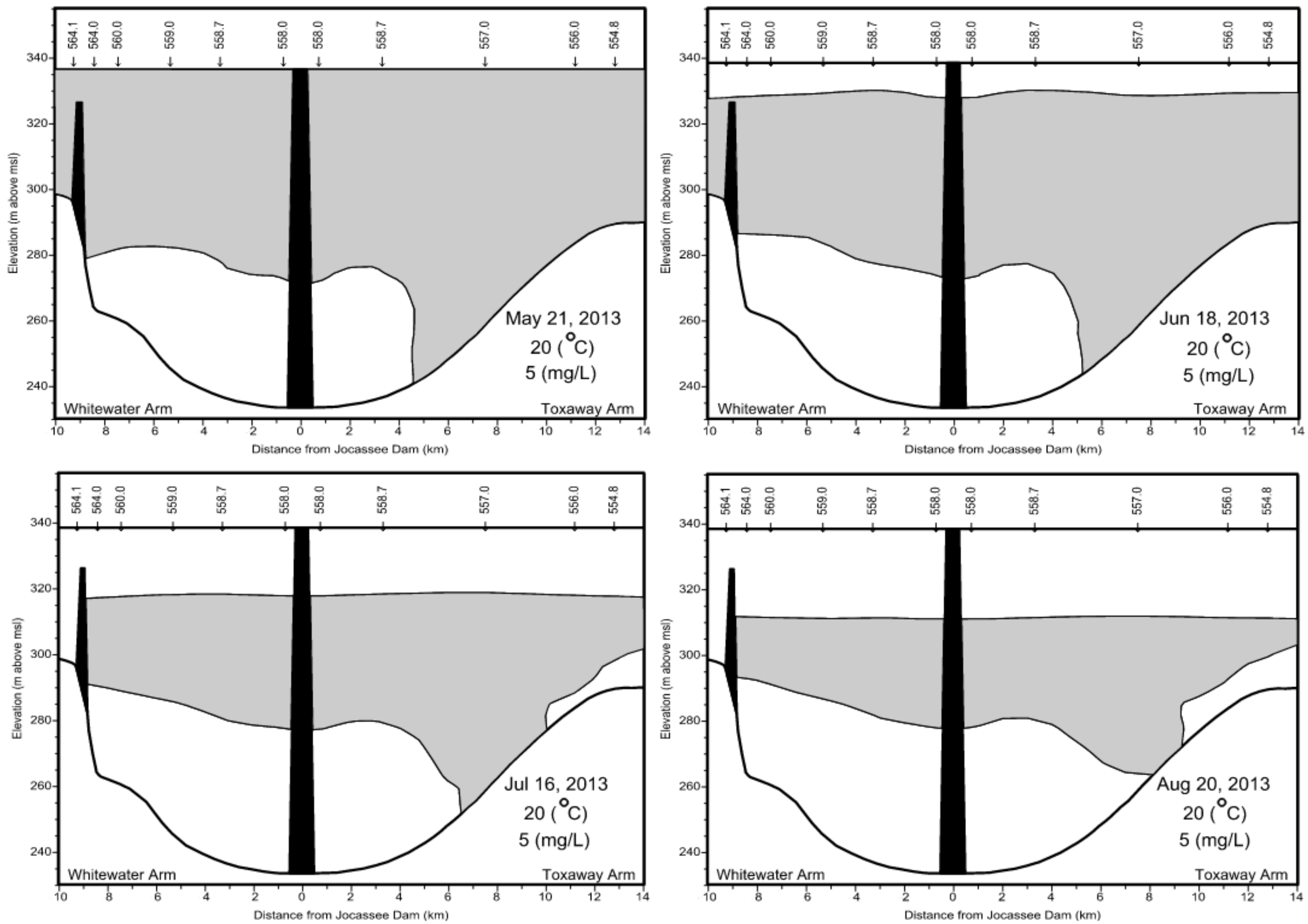

Figure 2. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, May – August 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from Jocassee Dam is the submerged weir in Whitewater River cove.

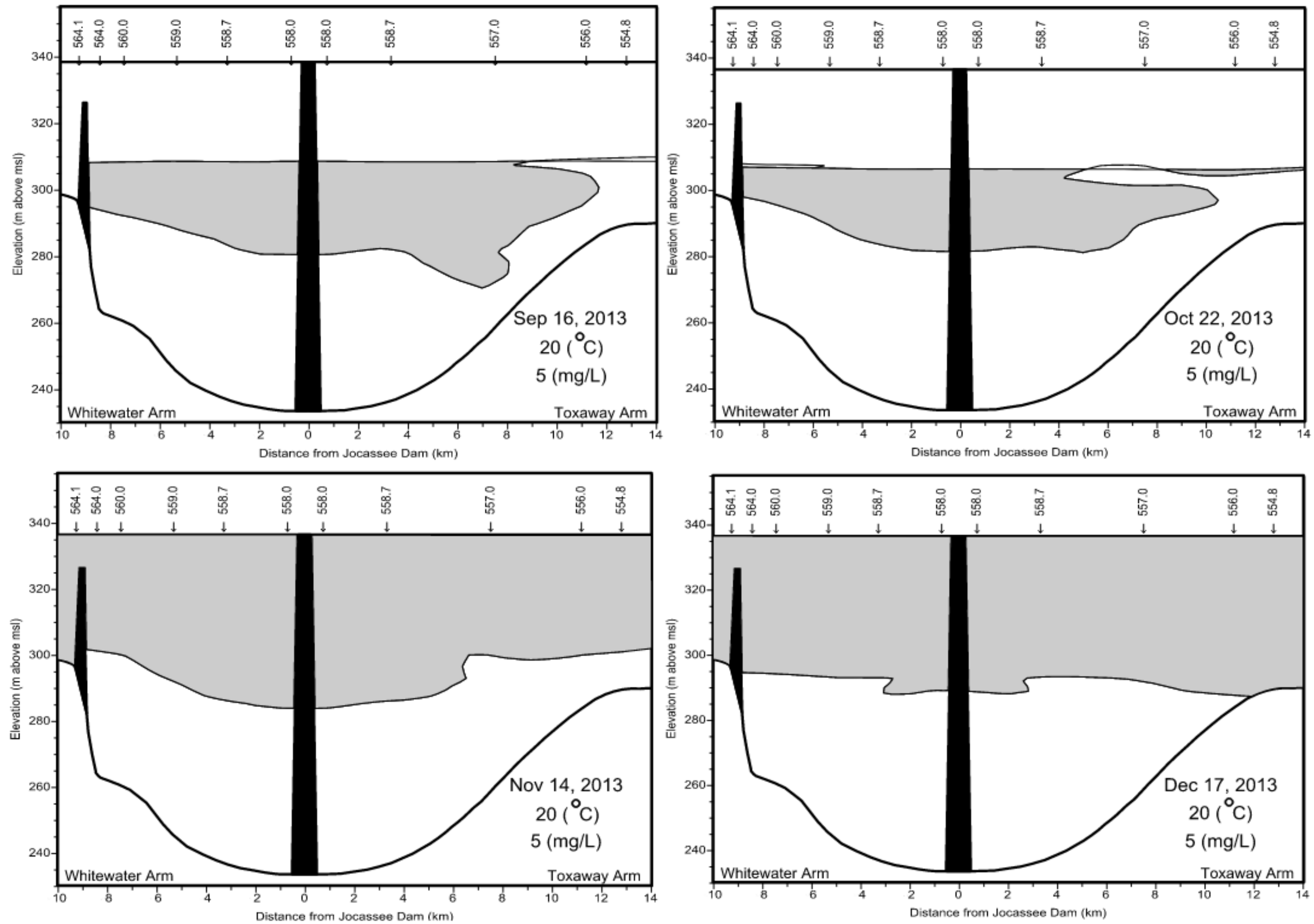

Figure 3. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, September – December 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from Jocassee Dam is the submerged weir in Whitewater River cove.

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Attachment B

Attachment B – CFD Modeling Figures

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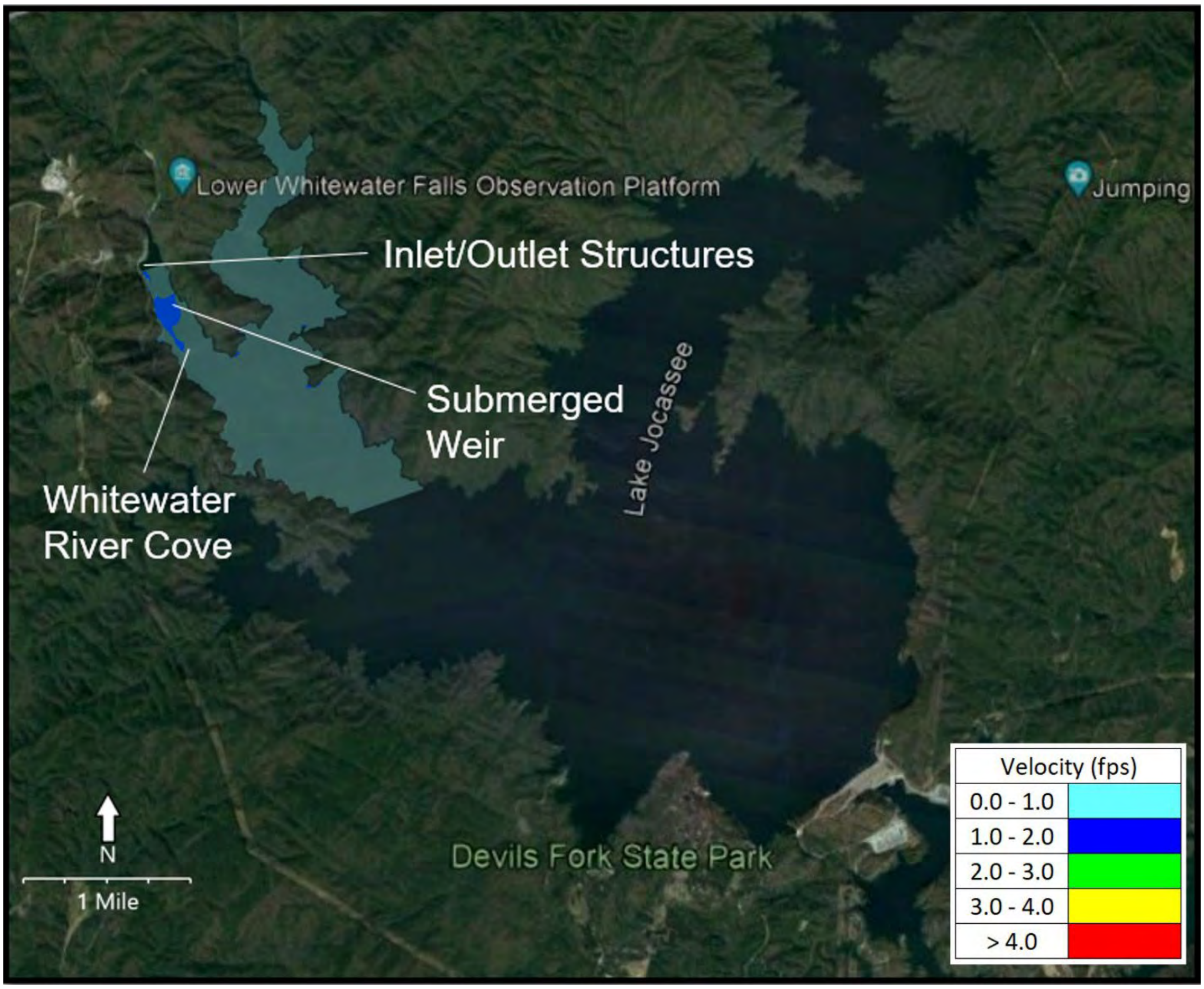


Figure 1. Proposed Generation with Expanded Weir at Full Pond (1,110 ft msl) – Velocity Contours (HDR 2023)

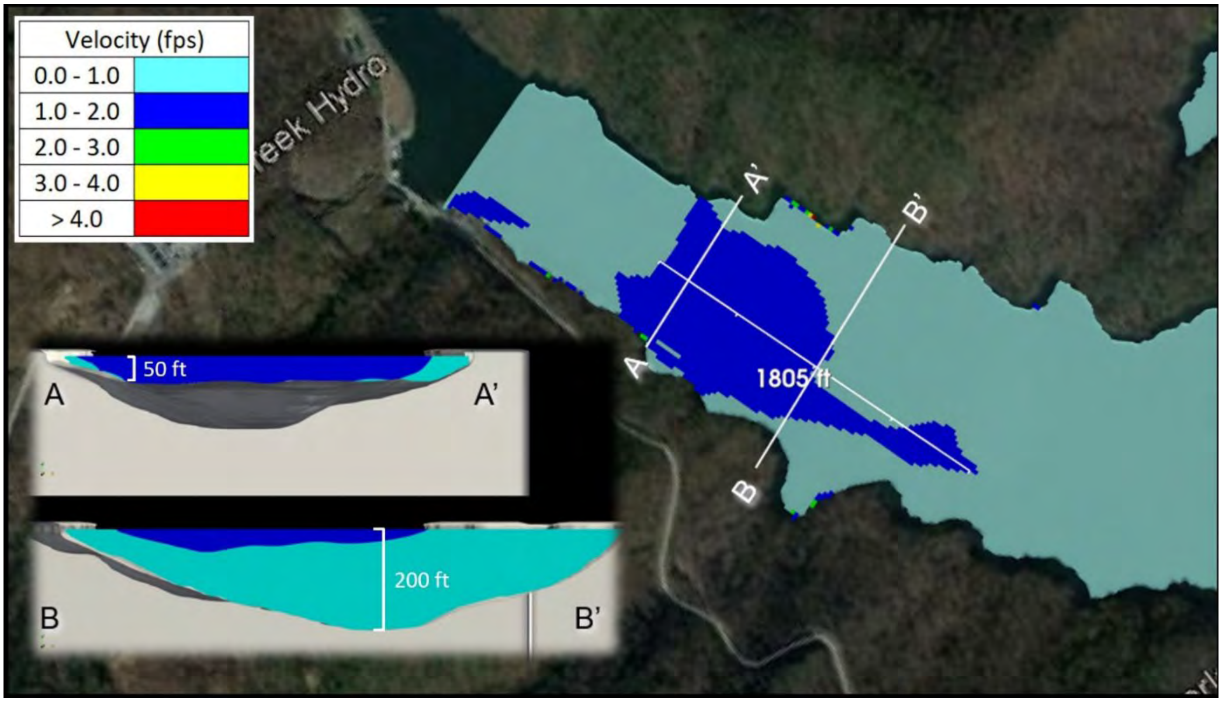


Figure 2. Proposed Generation (Expanded Weir) at Full Pond (1,110 ft msl) – Velocity Contours in Submerged Weir Vicinity (Flow is Left to Right) (HDR 2023)

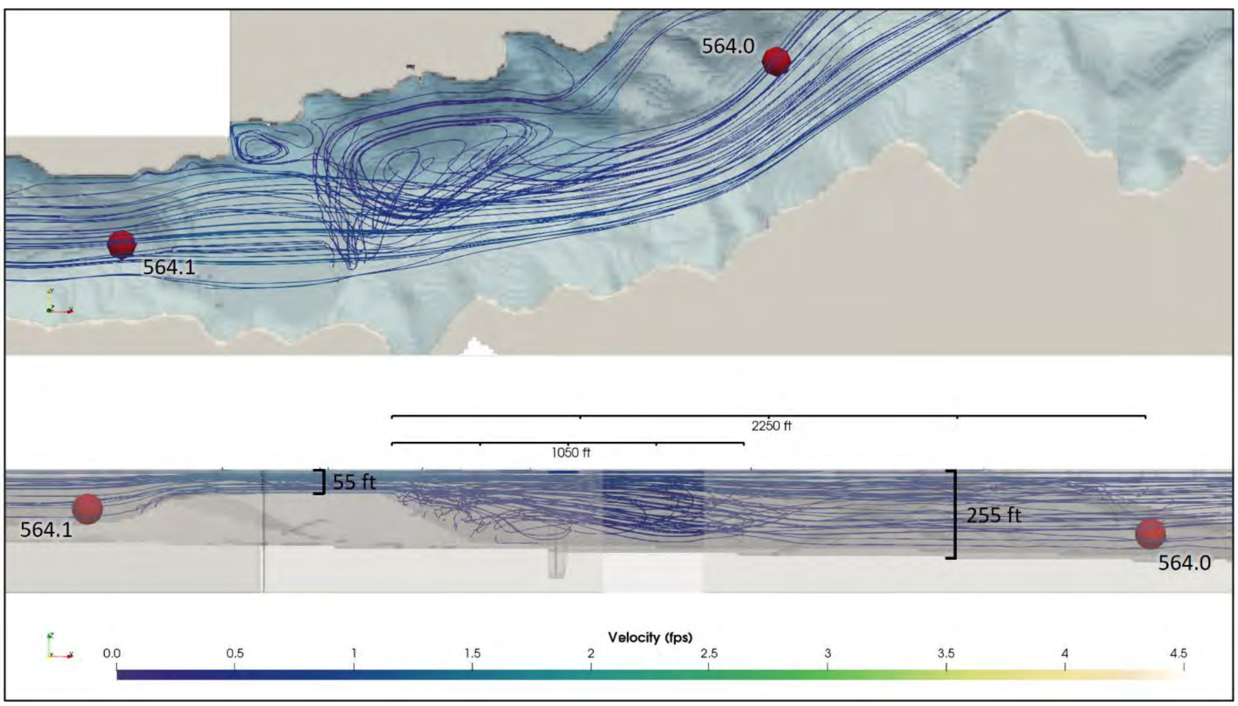


Figure 3. Proposed Generation (Expanded Weir) at Full Pond (1,110 ft msl) – Whitewater River Cove Streamlines (flow is left to right, red circles represent water quality sampling locations) (HDR 2023)

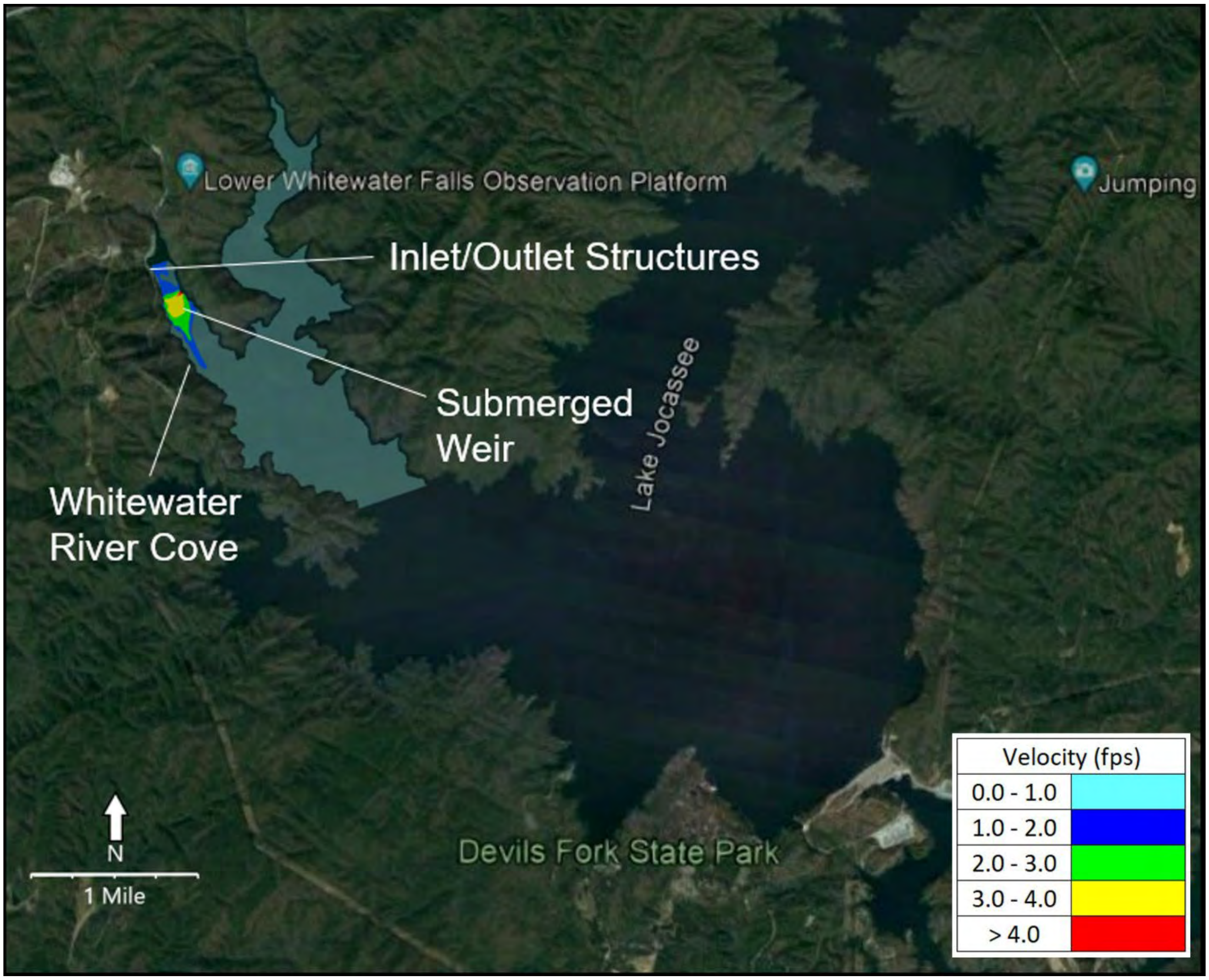


Figure 4. Proposed Generation with Expanded Weir at Maximum Drawdown (1,080 ft msl – Velocity Contours (HDR 2023)

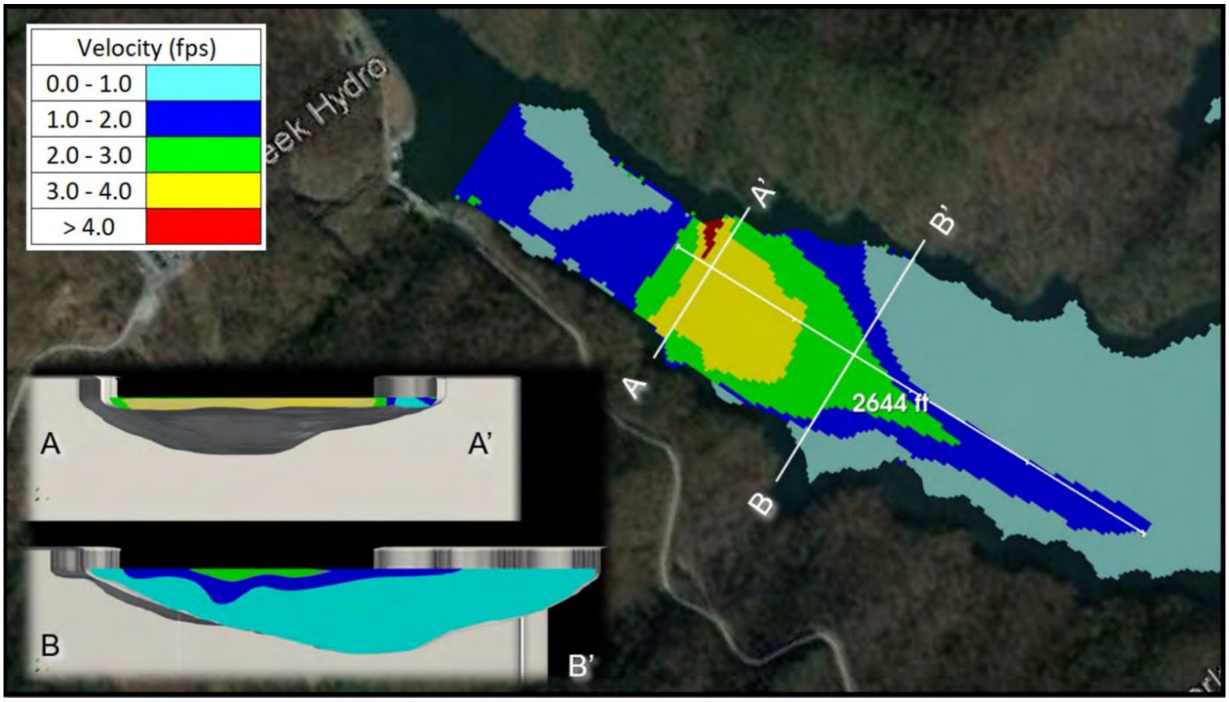


Figure 5. Proposed Generation (Expanded Weir) at Maximum Drawdown (1,080 ft msl) – Velocity Contours in Submerged Weir Vicinity (Flow is Left to Right) (HDR 2023)

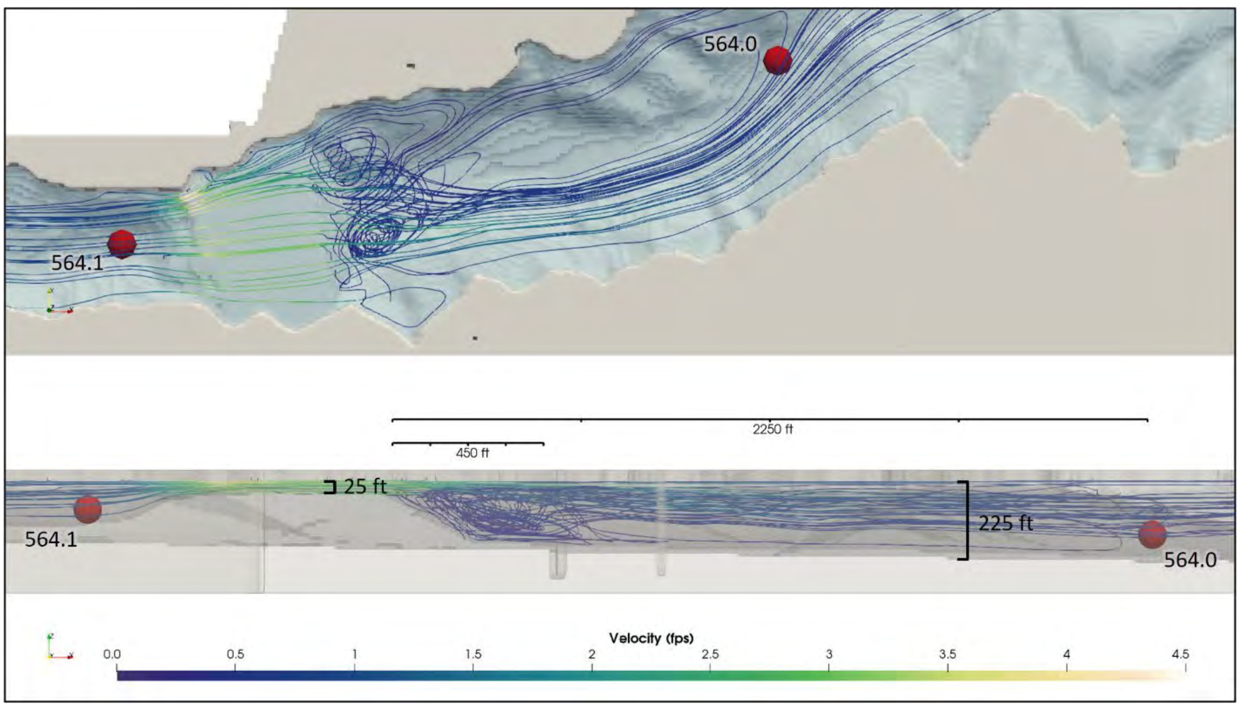
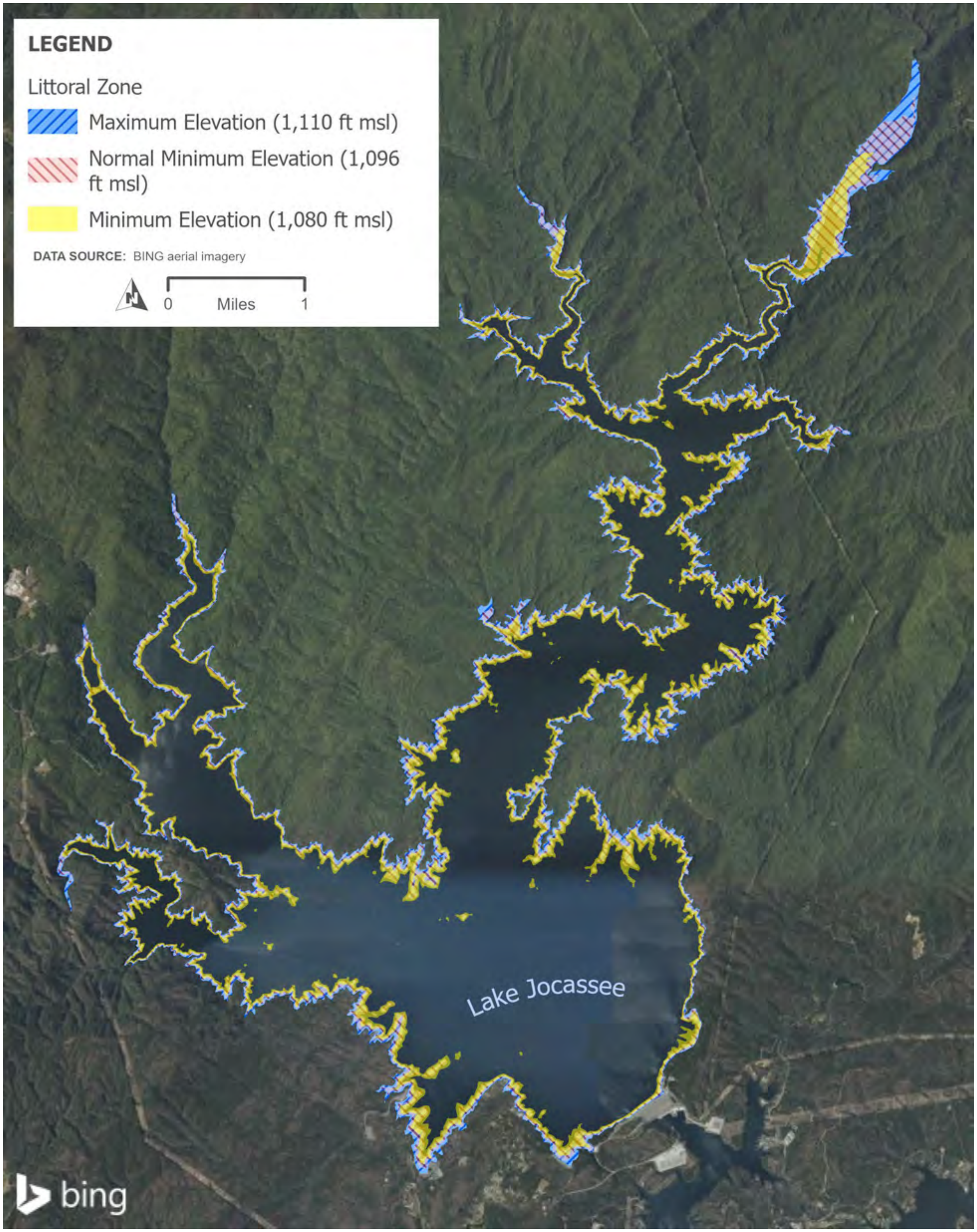


Figure 6. Proposed Generation (Expanded Weir) at Maximum Drawdown (1,080 ft msl) – Whitewater River Cove Streamlines (flow is left to right, red circles represent water quality sampling locations) (HDR 2023)

Attachment C

Attachment C – Littoral Habitat Figures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Normal Minimum Elevation (1,096 ft msl)
Minimum Elevation (1,080 ft msl)
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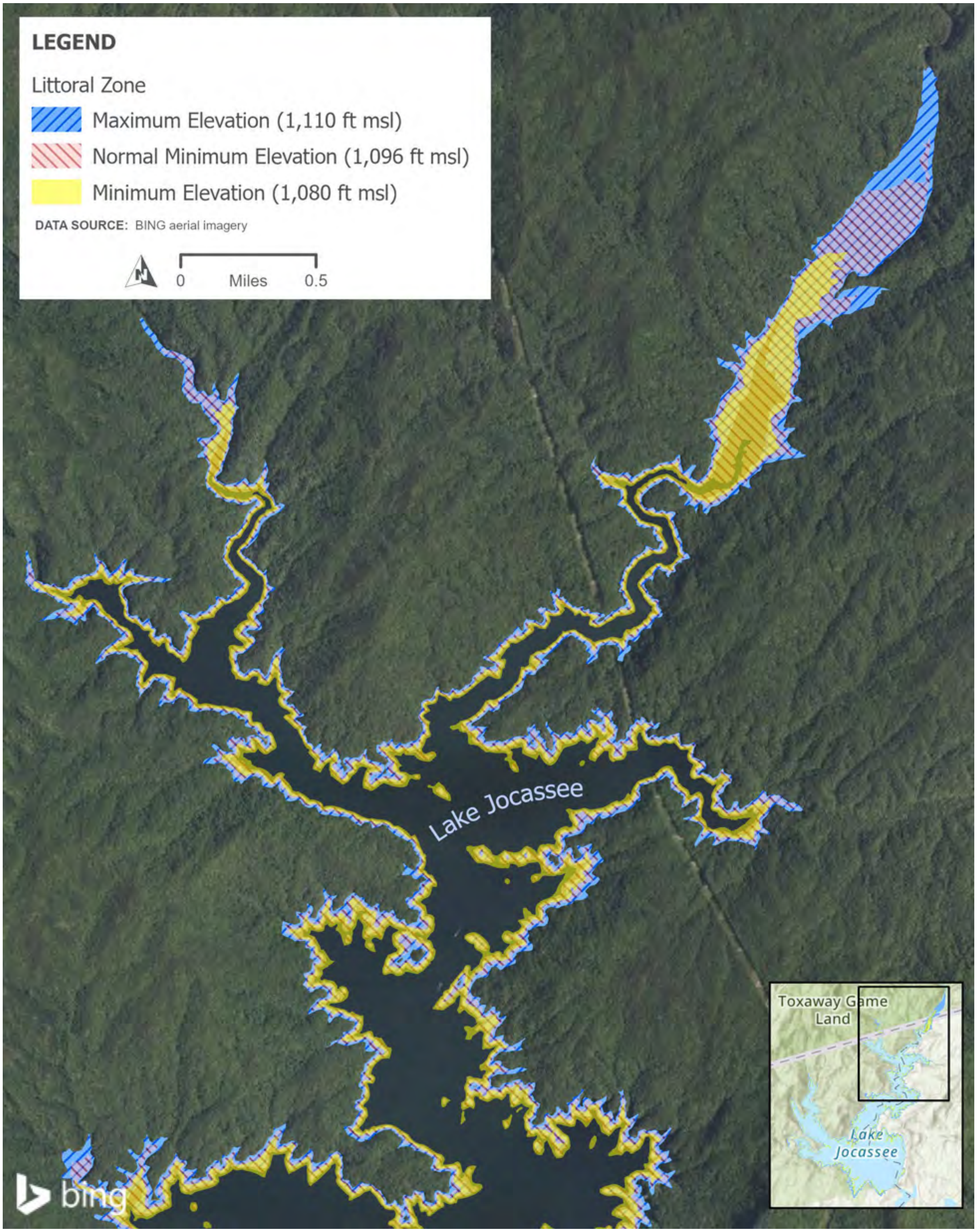
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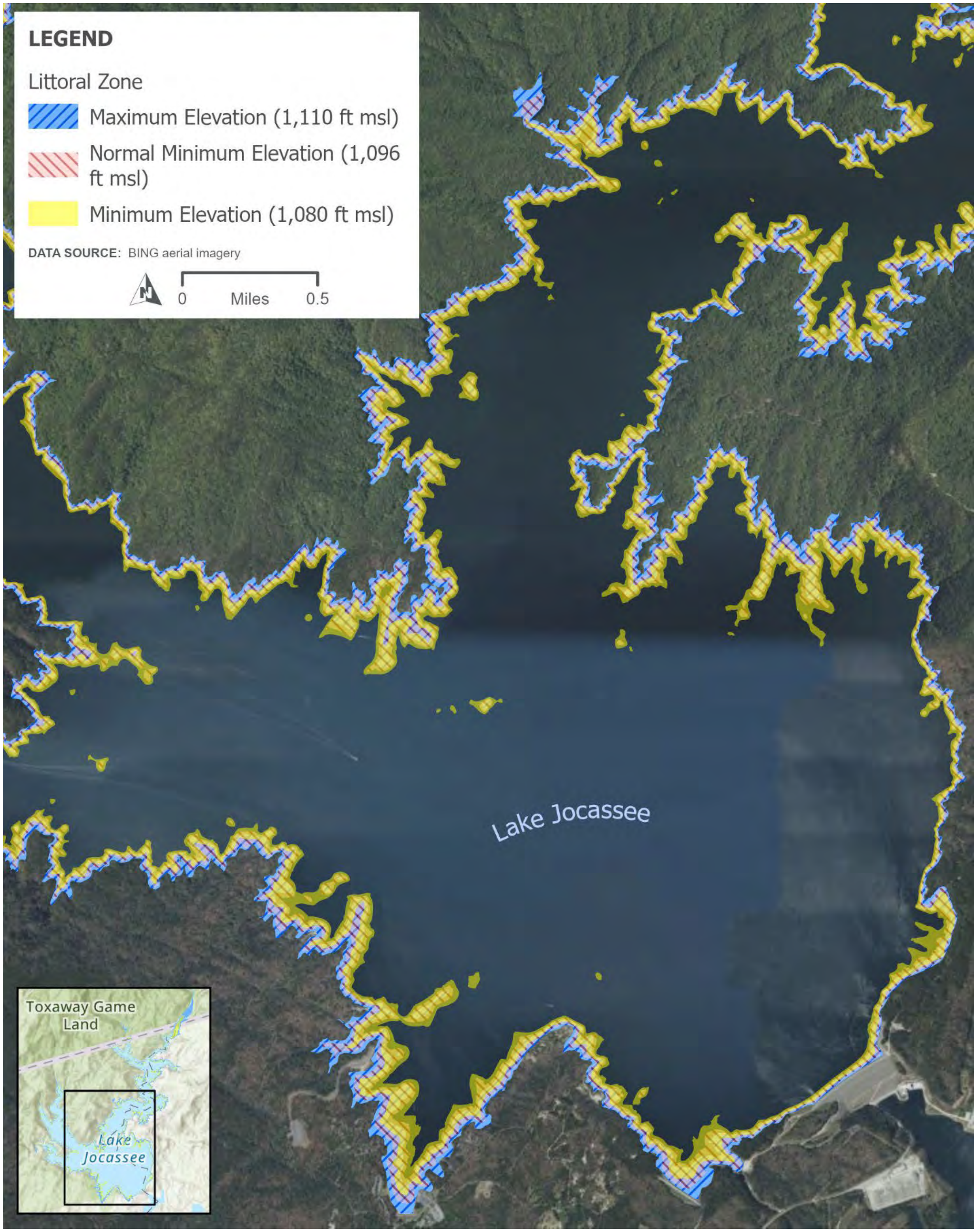
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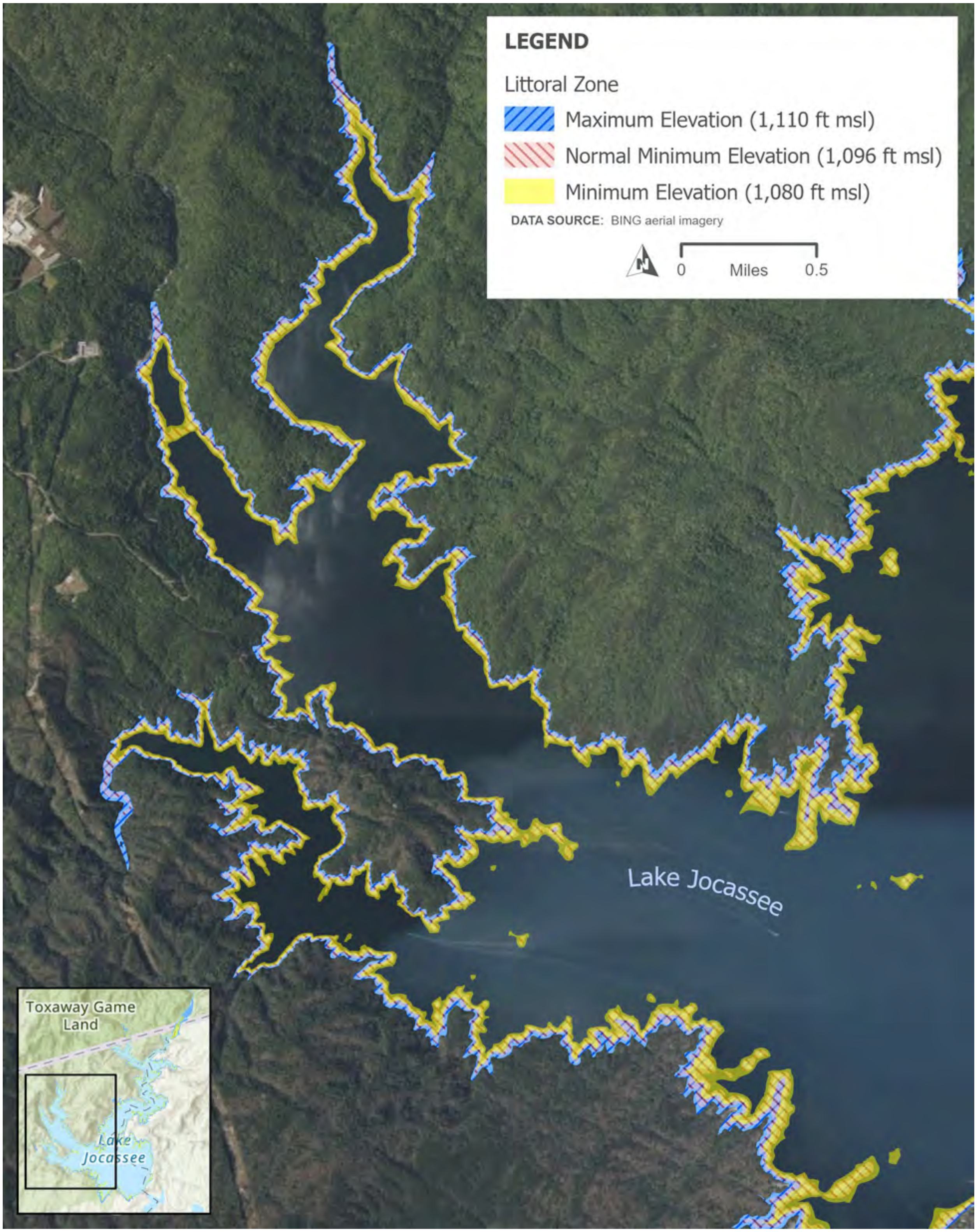
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Normal Minimum Elevation (1,096 ft msl)
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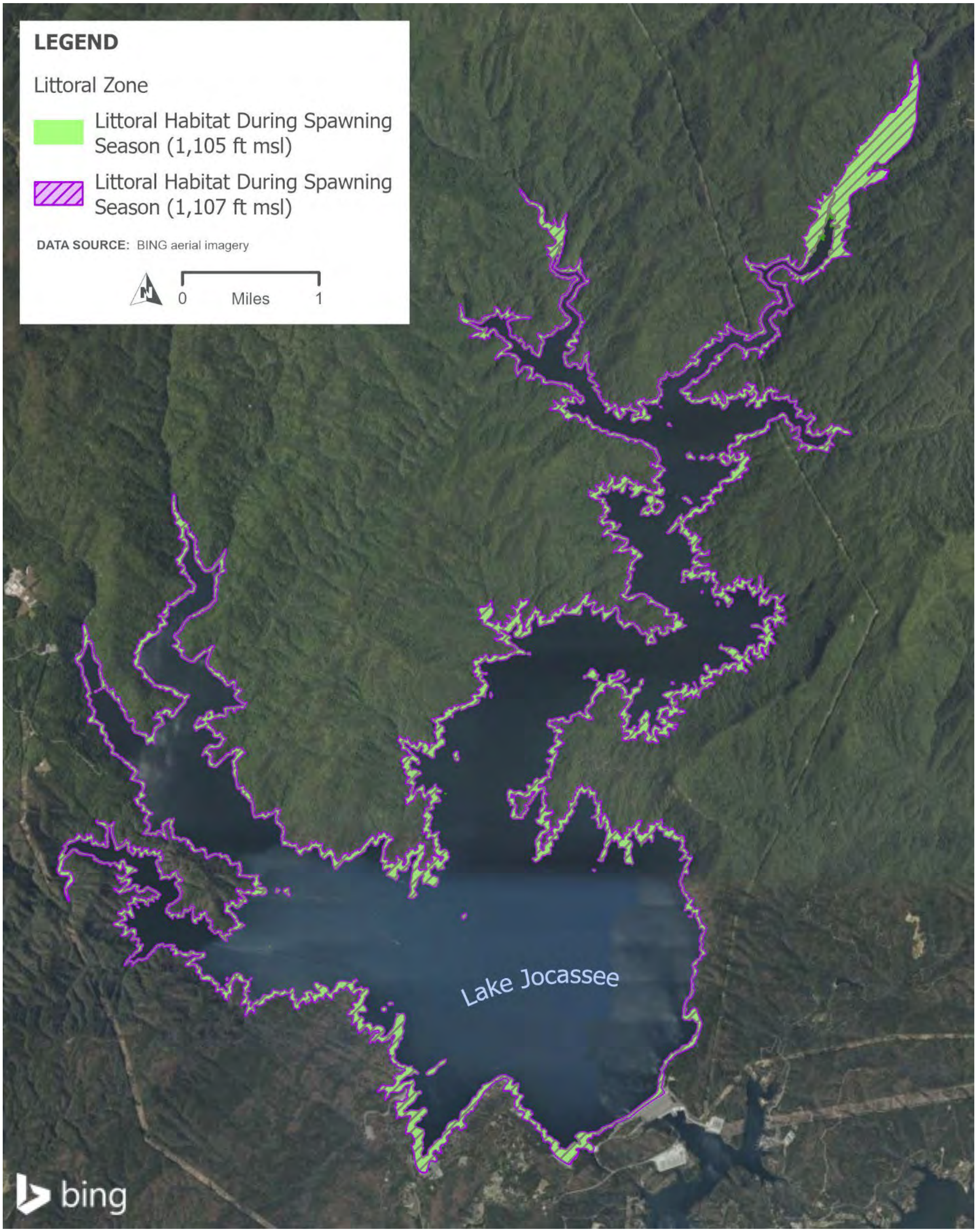
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Littoral Habitat During Spawning Season (1,107 ft msl)
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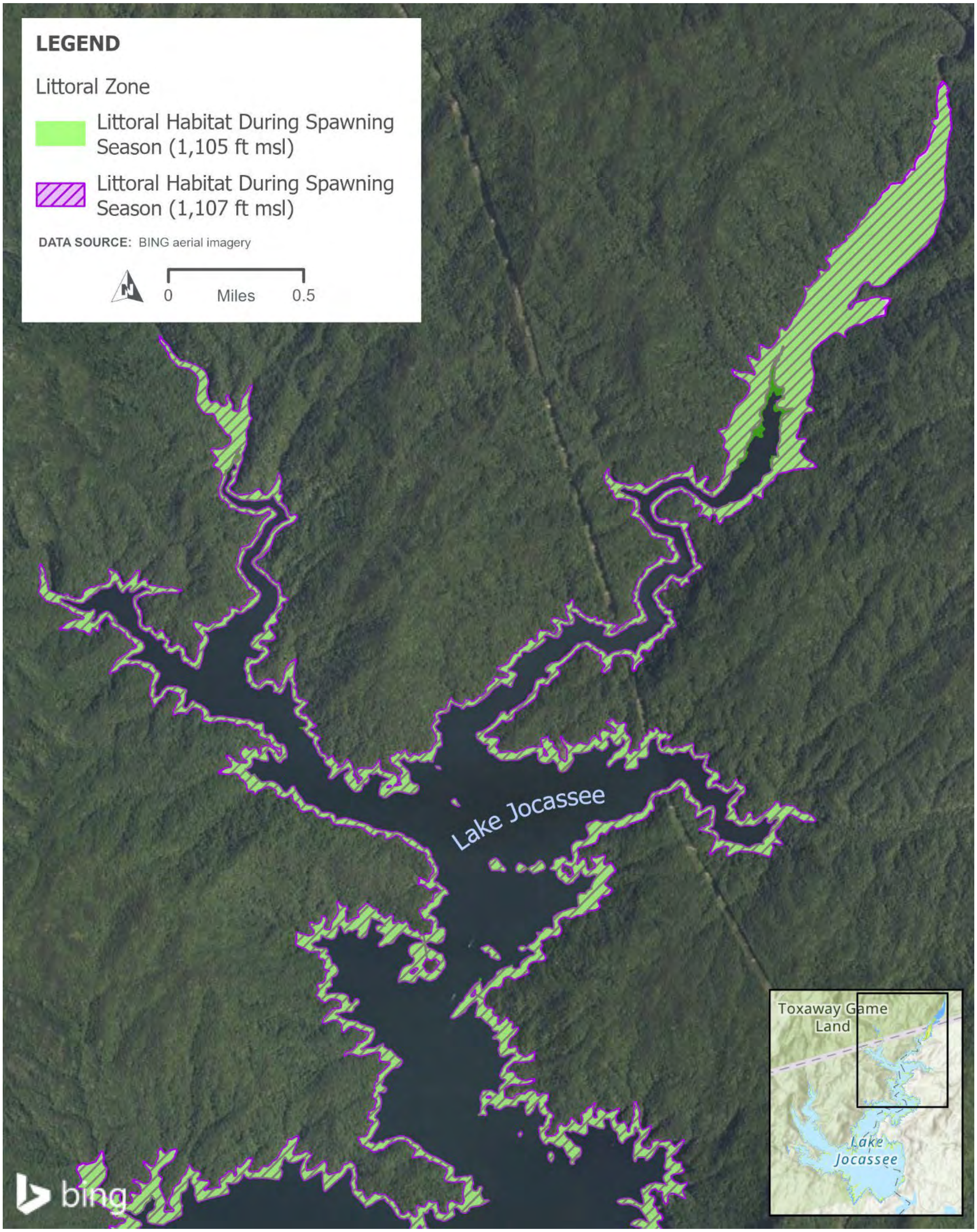
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Littoral Zone
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Littoral Habitat During Spawning Season (1,107 ft msl)
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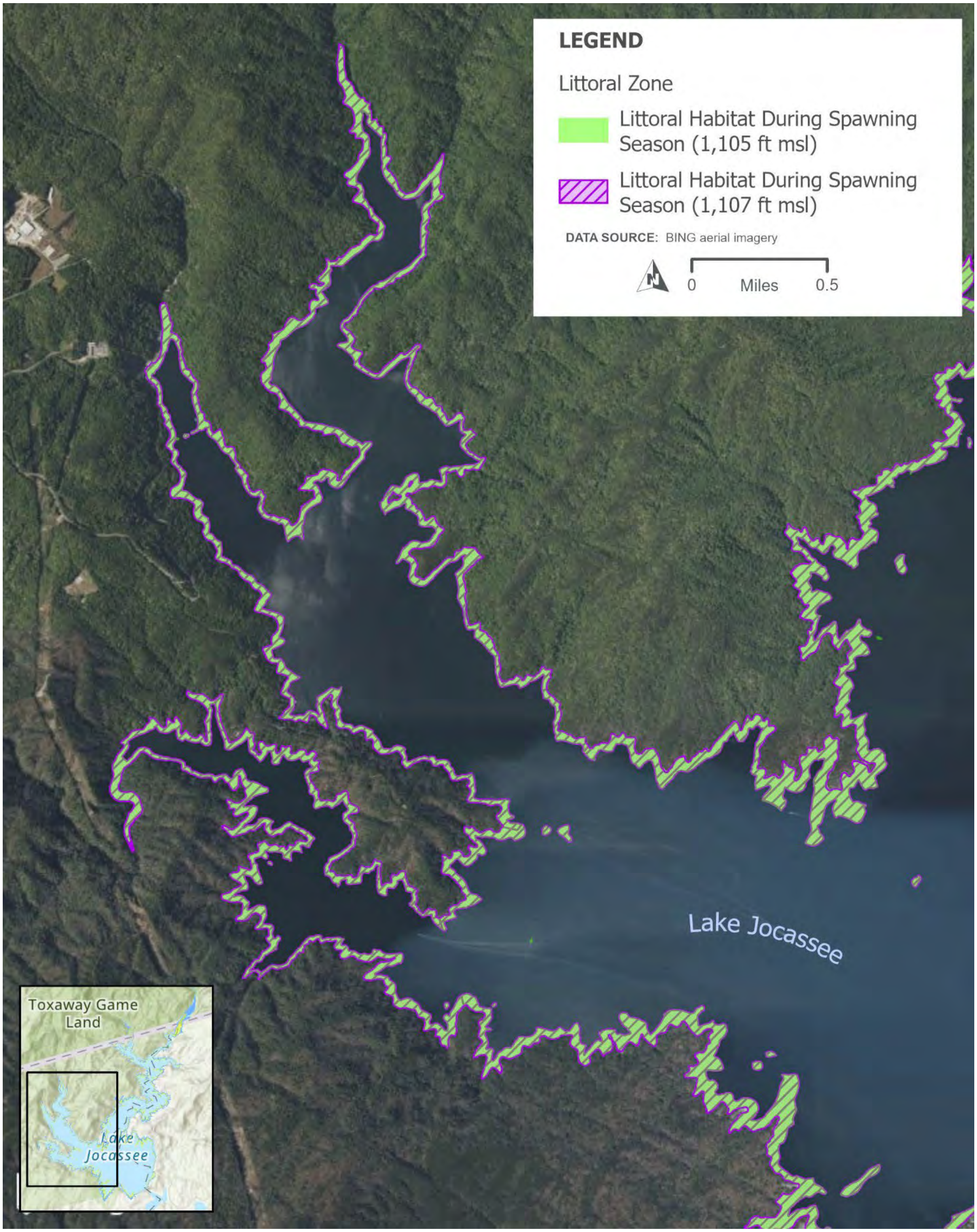
LEGEND
Littoral Zone
Littoral Habitat During Spawning Season (1,105 ft msl)
Littoral Habitat During Spawning Season (1,107 ft msl)
DATA SOURCE: BING aerial imagery
0
Miles
0.5
Lake Jocassee
Toxaway Game Land
Lake Jocassee

Attachment C: Visual Resources Study Report

(Final Report)

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VISUAL RESOURCES STUDY
FINAL REPORT

Bad Creek Pumped Storage Project
FERC Project No. 2740

June 26, 2024

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VISUAL RESOURCES STUDY FINAL REPORT
BAD CREEK PUMPED STORAGE PROJECT
FERC PROJECT NO. 2740

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ACRONYMS AND ABBREVIATIONS

ANSI	American National Standards Institute
Bad Creek (or Project)	Bad Creek Pumped Storage Project
Bad Creek II Complex or Bad Creek II	Bad Creek II Power Complex
CFR	Code of Federal Regulations
Comprehensive Plan	Oconee County 2020 Comprehensive Plan
DarkSky	DarkSky International
DEM	Digital elevation model
Duke Energy or Licensee	Duke Energy Carolinas, LLC
ft	foot/feet
ft msl	ft above mean sea level
EA	Environmental Assessment
EIS	Environmental Impact Statement
FERC or Commission	Federal Energy Regulatory Commission
GIS	Geographic Information System
HDR	HDR Engineering, Inc.
IESNA	Illumination Engineering Society of North America
K	Kelvin
Kimley-Horn	Kimley-Horn and Associates, Inc.
KT Project	Keowee-Toxaway Hydroelectric Project
kV	kilovolt
LED	light-emitting diode
PM&E	protection, mitigation, and enhancement
mm	millimeter
NEPA	National Environmental Policy Act
RC	Visual Resources Resource Committee
ROW	right-of-way
SCDNR	South Carolina Department of Natural Resources
SMP	Shoreline Management Plan
SMS	Scenery Management System
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VIA	Visual Impact Analysis

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1 Project Introduction and Background

Duke Energy Carolinas, LLC (Duke Energy or Licensee) is the owner and operator of the 1,400-megawatt Bad Creek Pumped Storage Project (Project) (FERC Project No. 2740) located in Oconee County, South Carolina, approximately eight miles north of Salem. The Project utilizes the Bad Creek Reservoir as the upper reservoir and Lake Jocassee, which is licensed as part of the Keowee-Toxaway (KT) Hydroelectric Project (FERC Project No. 2503), as the lower reservoir.

The existing (original) license for the Project was issued by the Federal Energy Regulatory Commission (FERC or Commission) for a 50-year term, with an effective date of August 1, 1977, and expiration date of July 31, 2027. The license has been subsequently and substantively amended, with the most recent amendment on August 6, 2018 for authorization to upgrade and rehabilitate the four pump-turbines in the powerhouse and increase the Authorized Installed and Maximum Hydraulic capacities for the Project.[1] Duke Energy is pursuing a new license for the Project pursuant to the Commission's Integrated Licensing Process, as described at 18 Code of Federal Regulations (CFR) Part 5.

In accordance with 18 CFR §5.11 of the Commission's regulations, Duke Energy developed a Revised Study Plan for the Project and proposed six studies for Project relicensing. The Revised Study Plan was filed with the Commission and made available to stakeholders on December 5, 2022. FERC issued the Study Plan Determination on January 4, 2023, which approved the Visual Resources Study as proposed.

2 Visual Resources Study

The Commission issued Scoping Document 2 on August 5, 2022, which identified environmental resource issues related to scenery and visual resources to be analyzed in the National Environmental Policy Act (NEPA) document developed for Project relicensing. The NEPA document will evaluate both the effects of the Project as well as the potential effects of the expanded Bad Creek II Complex (Bad Creek II Complex or Bad Creek II) construction,

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[1] Duke Energy Carolinas LLC, 164 FERC ¶ 62,066 (2018)

operation (including the presence of Project facilities), and maintenance activities on scenery and visual resources.

The FERC-approved Visual Resources Study includes the nine study tasks listed below.

- Task 1 – Existing Landscape Description
- Task 2 – Seen Area Analysis
- Task 3 – Field Investigation
- Task 4 – Key Views Selection
- Task 5 – Existing Visual quality Assessment
- Task 6 – Visual Analysis
- Task 7 – Visual Management Consistency Review
- Task 8 – Mitigation Assessment
- Task 9 – Conceptual Design of Bad Creek II Complex

3 Study Goals and Objectives

While specific requirements related to visual resource protection are not explicitly outlined by federal, state, or local agencies in the Project area, it is evident a high value is placed on preserving the natural beauty and ecological importance of the Lake Jocassee area. These agencies will continue to be informed and involved during the FERC and NEPA processes. The NEPA process requires evaluation of the potential effects on historic properties, scenic resources, and the scenic experiences of people who view the landscape. This evaluation includes a comprehensive Visual Impact Analysis (VIA). The VIA examines impacts on places and considers impacts on the people at those places and on the broader landscape. The VIA process includes the following steps.

- The VIA process starts with the identification of key viewpoints. These are locations from which the proposed project would be visible and could potentially alter the existing landscape. These viewpoints could include residential areas, public parks, historic sites, or any other locations that are frequented by the public.

- The existing visual conditions of these viewpoints are documented. This involves capturing photographs and noting the characteristics of the landscape, including landforms, water bodies, vegetation, and man-made structures.

- Visual simulations are created to show how the proposed project would alter the existing landscape. These simulations need to accurately depict the scale and appearance of the proposed project within the existing landscape.
- The simulations are evaluated to determine the level of visual impact. This evaluation considers factors such as the contrast of the project with the existing landscape, the number of people who would view the project, and the duration and frequency of the views.
- The results of the VIA are compiled into the NEPA document, either an Environmental Impact Statement (EIS) or Environmental Assessment (EA). The EIS/EA is a public document that provides full disclosure of the environmental impacts of a proposed project, including its visual impacts.

The VIA process is crucial in ensuring that the aesthetic and scenic values of the environment are considered in decision-making processes. It helps to identify potential visual impacts early in the project planning process, allowing for design modifications that can minimize these impacts.

Avoidance and mitigation measures are integral parts of the NEPA process. These measures aim to minimize or eliminate the potential adverse visual impacts of a proposed project. This could involve modifying the project design, implementing landscape treatments, or other strategies to reduce visual contrast and preserve the existing visual character of the landscape.

Conduct of this Visual Resources Study is consistent with NEPA requirements. Duke Energy's study employs standard methodologies consistent with the scope and level of effort of visual resources evaluations conducted at other FERC-licensed hydropower projects. This study is intended to provide sufficient information to support an analysis of the potential Project-related effects on visual resources, as well as potential effects or impacts due to the construction and operation of the proposed Bad Creek II Complex. The main objectives of this study are as follows:

- Describe the key scenic characteristics of the existing landscape within the study area and surrounding lands expected to potentially be within visual range of Project facilities.
- Identify areas within the existing landscape from which the existing and proposed Project facilities are or would potentially be visible.

- Identify existing Project operations and maintenance activities that affect visual characteristics.
- Evaluate expected effects of construction and operation of the Bad Creek II Complex on visual resources and proposed protection, mitigation, and enhancement (PM&E) measures.

This Visual Resources Study provides information to support the pursuit of the New License for the Project; data collected will be used to support Project feasibility and design and to assess potential effects of the proposed Project on scenery and visual resources. Due to the remote location of the dams and upper reservoir, underground location of the powerhouse, surrounding mountainous terrain, and heavily forested nature of the Project vicinity, there are limited public and (non-Duke Energy) private access areas providing views of Project facilities.

No adverse additional effects to scenery and visual resources are expected to result from the continued operation of the Project over the New License term, and no practical or necessary PM&E measures have been previously identified or proposed for existing Project structures. Therefore, this study is focused on visual effects from the potential construction and operation of Bad Creek II. These effects could include:

- land clearing and grading activities;
- creation of new upland spoil areas;
- temporary, localized turbidity impacts in the Whitewater River cove (also called Whitewater River arm);
- construction traffic; and,
- temporary construction facilities and the presence of heavy construction equipment.

The scenery in the immediate vicinity of the Project shown on Figure 3-1 would be permanently altered through the addition of Bad Creek II structures and spoil areas, though these features will be similar in appearance and adjacent to existing Project structures. The proposed expanded Project Boundary (Project area) is shown on Figure 3-1; however, the study area for the Visual Resources Study is not constrained to the expanded Project Boundary and includes lands within an approximately four mile radius of Bad Creek II features.

Existing Project Location and Proposed Expanded Project Boundary

4 Background and Existing Information

The Project is located entirely on Duke Energy-owned property except for a portion of the existing primary transmission line corridor that is currently maintained under a property easement. 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 inlet/outlet 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.

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. The scenic conditions within the vicinity of the Project have been a consideration for Duke Energy since development of energy projects on the Keowee-Toxaway river system in the 1970s, and this commitment continues today. 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.

Visual elements associated with the existing Project include the upper reservoir, the main dam, the west dam, the east dike, the equipment building, access roads, lower reservoir inlet/outlet structure and powerhouse portal area, transformer yard, switchyard (adjacent to equipment building), and primary transmission line extending from the Project transformer yard to a grid intertie station at the Jocassee Station.

During a 2013 Recreation Use and Needs Study at the KT Project (Duke Energy 2014), one third of the people surveyed stated nothing detracts from the scenic quality of Lake Jocassee. Almost half of Lake Jocassee respondents listed low-water levels as the main detraction to visual resources while in a 2007 Recreation Use and Needs Study only 36 percent of respondents listed low-water levels as a detraction. No respondents listed “development” as detracting from scenic and visual qualities of the area (Duke Energy 2014).

The KT Project Shoreline Management Plan (SMP) has provisions limiting the ability of lake neighbors to remove shoreline vegetation within the FERC Project Boundary along Lake Jocassee with the intention to provide a natural looking shoreline buffer. Additionally, following the relicensing of the KT Project, normal minimum lake elevations were increased, a new drought protocol (Low Inflow Protocol) was put in place, and a 2014 Operating Agreement with the U. S. Army Corps of Engineers was put in place. Each of these contribute to reducing the frequency and magnitude of exposed Jocassee shorelines, improving the visual appearance for visitors.

The natural and aesthetic character of Lake Jocassee, the Foothills Trail, Whitewater Falls, and non-developed, forested areas surrounding the Project contribute to the recreational and cultural value of the Project vicinity, within the Blue Ridge Mountains in the Upstate of South Carolina. The existing Project facilities have been in place since Project construction was completed in the early 1990s, and the Project has actively operated since that time.

The construction of Bad Creek II would include a new underground powerhouse and associated structures as well as a new inlet/outlet structure adjacent to the existing structure in Lake Jocassee. Similar to the existing lower reservoir inlet/outlet structure, following completion of construction, the new inlet/outlet structure would be viewable by the public via boat (primarily from the Whitewater River cove). With the construction of Bad Creek II, the visual landscape would be altered during and after construction.

5 Methods

Study objectives are to provide information needed to determine the potential direct, indirect, and/or cumulative effects of proposed Project facilities on scenic and visual resources. The results of this study, in conjunction with existing information, will be used to inform analysis in and recommendations for the New License application regarding potential Project effects on visual resources and potential PM&E measures to be included in the New License.

This study was conducted in consultation with the Recreational and Visual Resources Resource Committee (RC)[2] and state and federal resource agencies. Appendix A includes meeting summaries and stakeholder consultation associated with the Visual Resources Study.

[2] Recreational and Visual Resources RC participants include the following organizations: Advocates for Quality Development; Foothills Trail Conservancy; Friends of Lake Keowee Society (FOLKS); South Carolina Department of Natural Resources (SCDNR); South Carolina Department of Parks and Recreation; Upstate Forever.

5.1 Task 1 – Existing Landscape Description

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 U.S. Geological Survey (USGS) topographic maps and the Multi-Resolution Land Characteristics Consortium National Land Cover Database (2021); federal, state, and local government planning documents that include information on scenic and visual resource conditions; and photographs and aerial/satellite imagery (Google Earth 2022). 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.

5.2 Task 2 – Seen Area Analysis

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 inlet/outlet 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 (GIS) tools for calculating viewsheds based on a digital elevation model (DEM) and a set of observer points. The model analysis used the observer dataset and a DEM raster dataset to analyze which cells can be seen by the observer and which cannot, typically because a landform feature blocks the sight line.

Kimley-Horn and Associates, Inc. (Kimley-Horn) performed the seen area analysis using the Viewshed Analysis Spatial Analyst Tool in ESRI ArcGIS Pro software. The data utilized to perform the analysis were USGS DEM data, which are bare earth data that do not account for trees, buildings, or other surface objects. This represents line-of-sight conditions based only on topography. Because the Project area is predominantly forested, the bare earth seen area analysis results are a conservative representation of potential visibility. The seen area analysis also did not account for the effects of atmospheric conditions such as humidity, cloud cover, or fog. The effects of revegetation of spoil areas and the potential temporary access road (i.e., Fisher Knob Access Road) were also not incorporated in the analyses. Because the site design for Bad Creek II has not yet been finalized, conservative assumptions were used when conducting the seen area analysis as described below:

- **Transformer Yard Design:** The proposed transformer yard was modeled as a solid block.
- **Spoil Areas:** Where side slopes for potential spoil area were not available, the spoil areas were modeled as straight-sided features.
- **Primary Transmission Line Towers:** For purposes of the seen area analysis, Duke Energy assumed a transmission tower would be constructed parallel to each existing primary transmission line transmission tower.
- **Temporary Fisher Knob Access Road:** When the seen area analysis was run, two potential routes for the temporary access road were under consideration. While one of the routes has now been eliminated, both routes are reflected in the analysis.

The analysis was run from the perspective of Bad Creek II features looking out over the landscape. These results can be used inversely to identify points in the landscape with direct views of project features.

Observer points refer to the locations from which the analysis of the observed area is conducted. They were selected based on the shape, type, and proposed top elevation of proposed features to be analyzed. Points features were used for the proposed towers; corners were used for rectilinear pad features such as the switchyard and the transformer yard. Lines features were used when analyzing features of greater complexity such as the proposed access road, spoil areas, and upper contours of inlet/outlet structures. The analysis then calculated the area that can be seen from observer points, displaying visible/not visible of the tip elevation as a single color. One feature, like a transformer pad or a proposed road, had multiple observer points used to mark the corners of the pad or the centerline of the road. For these features, the viewshed output displays a gradient of color representing the lowest number of observer points to highest number visible in the surrounding landscape.

The general process for the analysis followed the following sequence: USGS 1/3 arc-second (10-meter) DEM data were downloaded for the study area. DEM tiles were merged using the Mosaic to new Raster tool. Then the data were converted from meters to feet using the Spatial Analyst Math tool using the projection North American Datum of 1983 State Plane South Carolina State Plane coordinates system (U.S. Feet). HDR Engineering, Inc. (HDR) provided contour/elevation data for proposed Bad Creek II features. Point or line observer features for each element were imported into ESRI ArcGIS from AutoCAD at the associated X-Y coordinates and assigned proposed Z-values (elevations). The ESRI ArcGIS Pro Viewshed Spatial analyst tool was used to run the analysis and the viewshed output symbology was adjusted to display color where observer points can be seen and no color where the observer points cannot be seen.

The final seen area maps in Section 6.2 show a color gradation, with darker color indicating more observation points of the feature are visible. Areas of the landscape with a color, even pale, indicate at least a portion of the project feature is visible.

5.3 Task 3 – Field Investigation

This task involved a field investigation of the potential Key Views identified during Task 4 as described in Section 5.4 below. Photographs and field records were logged and organized immediately following the field investigation (Appendix B).

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
- Conditions – atmospheric conditions[3], field notes

This field investigation was conducted on December 11, 2023, during leaf-off conditions.

5.4 Task 4 – Key Views Selection

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.

Based on the results of the seen area analysis developed for Task 2, travel routes, and potential viewer characteristics, HDR and Kimley-Horn identified 11 potential Key Views. The RC evaluated these sites during its July 27, 2023, RC meeting and selected six for field investigation[4].

Based on RC requests to evaluate the potential effects of additional lighting associated with Bad Creek II, Duke Energy used a similar process to identify potential locations for lighting visualizations in consultation with the RC[5].

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[3] Humidity and windspeed were obtained from Lake Jocassee Station Greer, SC undefined | Weather Underground (wunderground.com). Accessed on February7, 2024.

[4] See Appendix A for a summary of the July 27, 2023, meeting discussion.

[5] See Appendix A for the October 11, 2023, email requesting RC input regarding potential locations for nighttime views.

Following acquisition of the photographs at the potential daytime Key views, the RC met on January 11, 2024, to finalize the Key Views[6]. (See Appendix B for all the views reviewed by the RC.)

5.5 Task 5 – Existing Visual Quality Assessment

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 U.S. Forest Service (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 took into account a wide variety of landscape characteristics, such as:

- Slope
- Vegetative cover type, pattern, height, and distribution
- Water
- Color, texture, line
- Effects of adjacent scenery
- Cultural modifications

Distance zones are used to describe how viewers see the landscape. The SMS identifies four distance zones:

- Immediate foreground (0 to 300 feet);
- Foreground (300 feet to 0.5 mile);
- Middle ground (0.5 mile to 4 miles); and
- Background (4 miles to the horizon).

Immediate foreground and foreground views tend to highlight details ranging from individual leaves to individual trees. The middle ground "is usually the predominant distance zone at which

[6] See Appendix A for a summary of the January 11, 2024, RC meeting to select the Key Views.

National Forest landscapes are seen, except for regions of…tall, dense vegetation." In the background, "texture has disappeared, and color has flattened, but large patterns of vegetation or rock are still distinguishable" (USDA 1995).

Scenic classes, as defined in the SMS, recognize the idea that all National Forests have "value" as scenery (USDA 1995). The classes, which range from 1 (most valuable scenery) to 7 (least valuable scenery) can be used to consistently evaluate the scenic value and relative scenic importance of a particular area. They are used in forest planning to compare values of scenery with other types of resources. The higher the scenic value (i.e., Scenic Classes 1 and 2), the more important it is to maintain.

Scenic Integrity Objectives range from very high to very low and express the desired future aesthetic condition of a forest. Scenic Integrity Objectives descriptions, as defined below, generally express a comparison to existing or preferred conditions (USDA 1995):

- **Very High**: "landscapes where the valued landscape character 'is' intact with only minute if any deviations."
- **High**: "landscapes where the valued landscape character 'appears' intact. Deviations may be present but must repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such scale that they are not evident."
- **Moderate**: "landscapes where the valued landscape character 'appears slightly altered.' Noticeable deviations must remain visually subordinate to the landscape character being viewed."
- **Low**: "landscapes where the valued landscape character 'appears moderately altered' Deviations begin to dominate the valued landscape character being viewed but they borrow valued attributes such as size, shape, edge effect and pattern of natural openings, vegetative type changes or architectural styles outside the landscape being viewed."
- **Very Low**: "landscapes where the valued landscape character 'appears heavily altered.' Deviations may strongly dominate the valued landscape character."

5.6 Task 6 – Visual Analysis

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 Complex, and the expected viewer response to those changes.

HDR developed visual simulations of Bad Creek II features that were 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 (3D) model of the proposed project-build scenario was integrated with the existing conditions photography. Using project design and location specific information, HDR built a 3D model 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 inlet/outlet 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. (See Appendix C for annotated visualizations.)

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 Complex.

5.7 Task 7 – Visual Management Consistency Review

This task involved review of the consistency of the proposed Bad Creek II Complex 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.

5.8 Task 8 – Mitigation Assessment

This task involved identification and assessment of potential mitigation measures that would address the scenic and visual effects of the Bad Creek II Complex 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.

5.9 Task 9 – Conceptual Design of Bad Creek II Complex

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.

The following assumptions were used to develop the proposed conceptual design rendering:

- **Spoils areas**: Duke Energy has identified 13[7] potential spoil area locations for permanent storage of excavated materials (earth and rock) but does not plan to use them all. Eleven of the potential locations are in upland areas while the other two are in the upper and lower reservoirs. To provide a conservative (i.e., most impactful) representation of potential effects associated with spoil areas, all upland spoil areas were incorporated in the rendering using the crest or peak elevations in Table 5-1.

  Duke Energy will revegetate spoil areas at the completion of construction. Therefore, the appearance of these areas will change over time as vegetation grows and develops. However, for purposes of developing the conceptual site layout, Duke Energy has based the rendering on projected appearance approximately five years after construction and revegetation is complete.

[7] Two spoils areas, A and H, would be located within reservoirs and would not be visible.

Table 5-1. Spoil Area Crest / Peak Elevations

Spoil Area	Elevation (ft msl)
B	1,826.0
C	1,874.0
D	1,885.0
E	2,240.0
F	2,000.0
G	2,270.0
I	2,338.0
J	1,930.0
K	2,436.0
L	2,348.0
M	1,885.0

Ft msl – feet above mean sea level

- **Primary transmission line right-of-way (ROW) width:** The proposed transmission line would adjoin the existing primary transmission line that ties into the Jocassee switchyard. A portion of the existing primary transmission line ROW is occupied by a single 525-kilovolt (kV) line while the southern portion of the ROW is occupied by a 525-kV and 100-kV line. The amount of additional ROW width that would be needed is anticipated to be 180 ft or 145 ft, depending on the number of lines present, as shown on Figure 5-1.

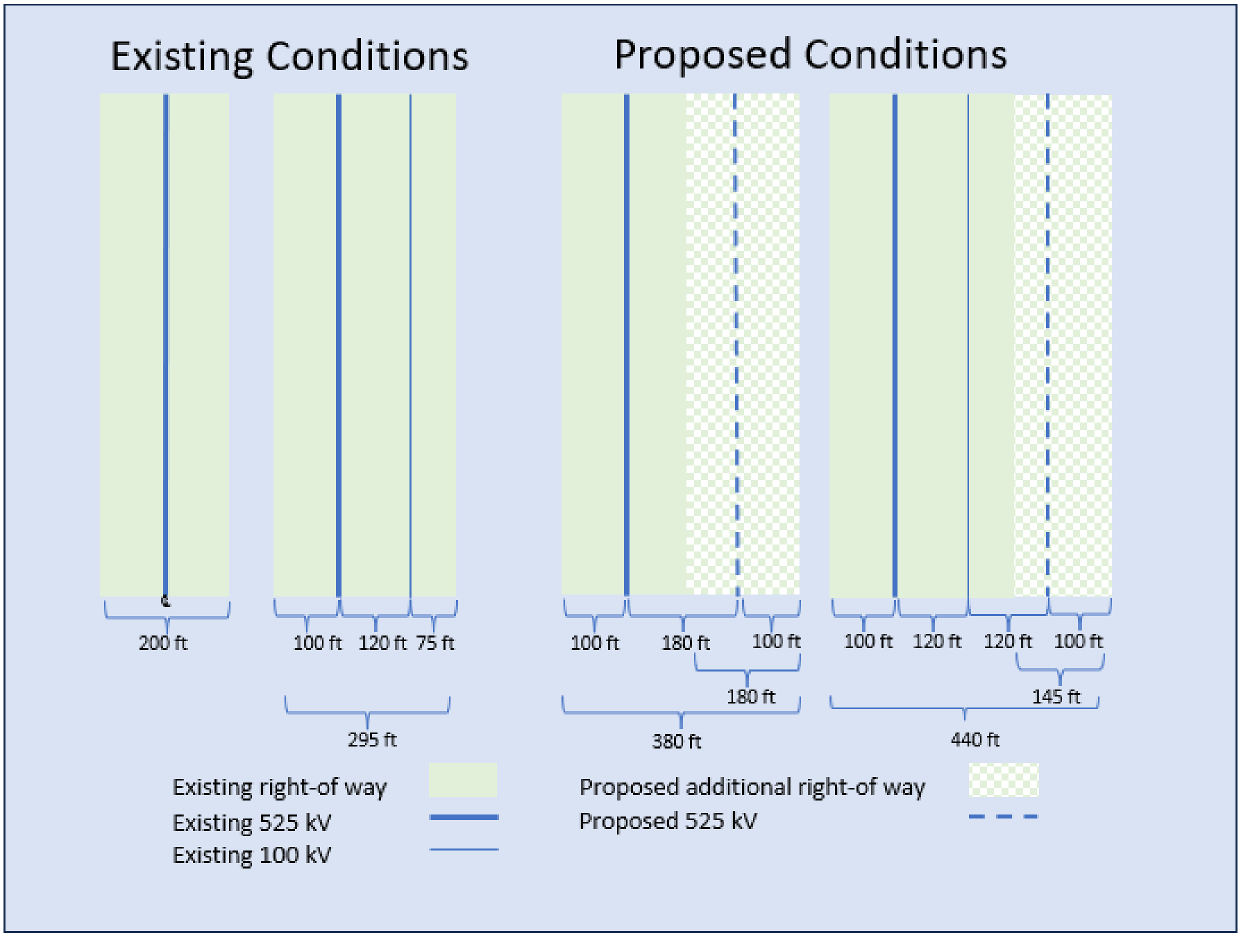

Figure 5-1. Additional Right-of-Way Widths Associated with the Bad Creek II Transmission Line

6 Study Results

6.1 Task 1 – Existing Landscape Description

6.1.1 Introduction

The existing landscape description provides existing available information in the study area to characterize the existing landscape within the proposed Bad Creek II area and the scenic quality of the surrounding landscape. This review establishes a baseline for existing conditions and character that proposed changes can be evaluated against. The management plans of landscape level scenic resources near the Project area are also reviewed, characterizing Project operations and vegetation management that may impact visual resources within the study area. The character of the existing landscape is described using the fundamental visual elements of form, line, color, texture, and pattern.

The Project is situated within the Blue Ridge Mountains in the Upstate of South Carolina (Figure 6-1). The existing landscape and scenic attributes in the vicinity are dominated by rolling hills, forests, stream corridors, steep slopes, waterfalls, rock outcrops, and mountain ridges. The areas surrounding the Project area are primarily undeveloped forest land managed by the USFS and the SCDNR. Although there is some residential and recreational development around Lake Jocassee, the shoreline is mostly forested with a mixture of pines and hardwoods. The area is characterized by ridges and narrow stream valleys, many with numerous waterfalls, which drain into Lake Jocassee. Surrounding protected lands include the Sumter National Forest, Nantahala and Pisgah National Forests, and the Jocassee Gorges. The area overall can be characterized as scenic mountain wilderness and is aesthetically appealing.

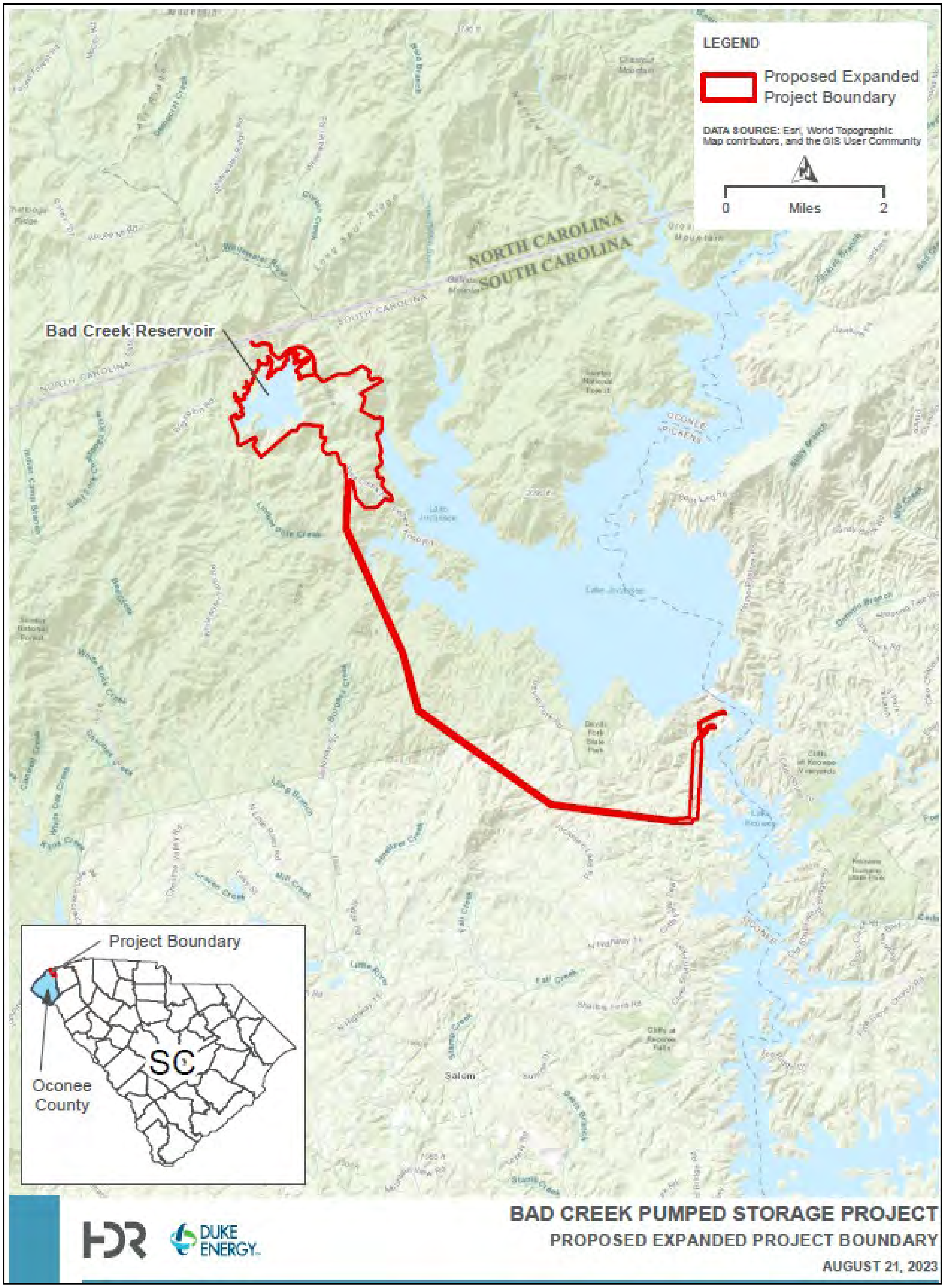

Figure 6-1. Bad Creek Project and Vicinity

6.1.2 Elements of the Existing Landscape

6.1.2.1 Project Terrain

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. The region includes diverse topography, rugged mountainous terrain, and rolling hills typical of Transylvania County, NC and Pickens and Oconee counties, SC. 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 msl. The area includes watersheds of Lake Jocassee, and the Blue Ridge Mountains, Brevard Fault Zone, and Chauga belt geological regions. Topographic features in the area have been formed over millions of years by tectonic forces, erosion, and weathering. The physiography of the area comprises a series of mountain valleys flanked by steep mountain ridges.

6.1.2.2 Elevation

The Project sits on an elevated ridge system which surrounds the Bad Creek Reservoir at an elevation of approximately 2,400 feet ft msl. Elevations surrounding the site range from 800 ft to over 3,900 ft with Flat Mountain (3,929 ft) being the highest point in the area. Higher elevations (1,500 - 3,900 ft) are typical of areas north of the site and are characterized by several mountains within the Blue Ridge Mountain Range. The tallest peak in South Carolina, Sassafras Mountain (3,554 ft), is 14 miles east of the Project. Mountains, ridges, and knolls to the north and west of the site feature higher elevations than the site topography. These include Flat Mountain (3,929 ft), Round Mountain (3,690 ft), and Grassy Knob (3,411 ft) to the north, Persimmon Mountain (3,060 ft) to the west, and Limber Pole Mountain (2,000 ft) to the south. Landforms and elevations to the south and east of the reservoir are characterized by ridge and valley systems associated with watersheds draining into Lake Jocassee and the Keowee River valley. This includes Whitewater Mountain (2,276 ft), Gallbuster Mountain (2,123 ft), and Musterground Mountain (2,319 ft).

Each of the higher elevation points noted above offers potential sightlines towards proposed Bad Creek II features.

Lower elevations are to the south and east of Bad Creek Reservoir and are associated with the watersheds and hydrological and geological features of the many watersheds draining to Lake Jocassee and Lake Keowee. These include Hester Mountain (1,565 ft), Fisher Knob (1,515 ft), and Double Spring Mountain (2,056 ft) to the southeast. McKinney's Mountain (1,938 ft) and Tater Hill (1,666 ft) lie south of the site. This area includes gentler topography encompassing large areas of hills, valleys, and Lake Jocassee, and the topography of these areas is contrasted by the surrounding ridges, knolls, and mountainous topography.

6.1.2.3 Landforms

As mentioned above, landforms are diverse and are characterized by the underlying geology of the region and the various natural forces acting on it. They are classified into three orders by scale. First order landforms include continents and ocean. Second order landforms are significant large-scale masses formed through tectonic action. Within the study area, second order landforms include steep mountain terrain, peaks, ridges, hills, plateaus, and plains. Third order landforms and topographic features are created through weathering, erosion, and deposition. Within the study area, these include escarpments, gorges, and other features unique to the region.

6.1.2.4 Slopes

The geology and hydrology of the region includes floodplains, hills, steep ridges, and cliffs with slopes ranging from 0 to over 100 percent[8] , with sheer cliffs. Approximately 36 percent of the study area has slopes from 50-83 percent, indicative of the differentially weathered character of the mountainous terrain and escarpments. Approximately 43 percent of the area's slopes range from 25-50 percent, often associated with the foothills and drainages of the steeper and eroding topography. The remaining slopes, approximately 21 percent, have 0-10 percent slope and are associated with the floodplains and transition slopes of lowlands, as well as plateaus and gentle knolls of intermediate elevations.

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[8] A slope percent of 100% corresponds to a 45° angle.

6.1.2.5 Water Features

The Project region includes the Savannah River Basin and its many drainages which provide the physical framework for the waterbodies that are defined by them. Waterbodies and features in the area include streams, creeks, falls, rivers, lakes, ponds, and reservoirs. They are defined by the interactions of water and erosion on the landforms and geology of the area which are defined by the elevational transition of the Blue Ridge Mountain region to the piedmont region of the Carolinas and the Jocassee escarpment. The Project complex is primarily in the Whitewater River subbasin, but the Project primary transmission line extends into the Upper Little River-Lake Keowee and the Cane Creek-Lake Keowee subbasins.

Lake Jocassee and, to a lesser extent the Whitewater River, dominate the water-based visual resources at the Project. Lake Jocassee is fed by several cold-water rivers which result in cool and clear water throughout the year. Primary inflows to Lake Jocassee include Whitewater River, Thompson River, Horsepasture River, and Toxaway River. Lake Jocassee is an approximately 7,980-acre, 300-ft-deep reservoir impounded in 1973.

The Whitewater River and its upper and lower falls are dramatic and are a regional recreation destination for hikers and other recreationists. The Upper Whitewater Falls is the highest waterfall east of the Rockies and drops 411 ft. The Lower Whitewater Falls drops another 200 ft across the escarpment. Numerous other waterfalls can be found in the area including falls that flow directly into Lake Jocassee.

6.1.2.6 Water Quality

Water quality in the Jocassee watershed is high to excellent due to the forested, undeveloped nature of the watershed; many streams that flow directly into the lake are headwater streams that drain pristine areas (Duke Energy 2022). Many of the streams and tributaries include healthy populations of aquatic invertebrates and fish that are sensitive to watershed and soil disturbances (i.e., increased sediments in the streams) and their presence is indicative of healthy waters supportive of critical habitat. Under the authority of the South Carolina Pollution Control Act, the SC Department of Health and Environmental Control 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 uses are indicative of the desired water quality needed to support designated uses.

Duke Energy has monitored water quality conditions in Lake Jocassee in some capacity since its formation. The South Carolina Department of Health and Environmental Control 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). Lake Jocassee is one of only a few reservoirs in South Carolina that possesses the necessary aquatic habitat (water temperatures and dissolved oxygen) to support both a warmwater and a coldwater (salmonid [trout]) fishery year-round (USACE 2014).

6.1.2.7 Landcover

The Project region includes the diverse land cover typologies and plant communities defined by the area's elevation, slopes, soils, hydrology, and human activity. The area is dominated by mixed forest, deciduous forest, evergreen forest, and open water bodies. Secondary land cover types include pasture, crop land, barren, and developed land. Higher percentages of complete forest cover of various types exist farther beyond Lake Jocassee's immediate vicinity, while areas around the lake tend to have more developed and or barren cover due to development activities associated with parks, residential development, and infrastructure. Land coverage according to the 2021 National Land Cover Database within the study area (excluding the transmission line area) is dominated by forest cover (56%) and water bodies (22%). Pasture, crop land, scrub, and herbaceous cover entails approximately 15 percent of the study area with the remaining 6.6 percent is generally developed or barren land. Beyond the Project area, forest cover dominates at over 84 percent with open water accounting for another 8 percent and developed space for just less than 4 percent.

The study area includes diverse tree species and forest types. The area was intensively logged in the past. This has resulted in a mosaic pattern of three predominant forest types (oak-hickory forest, mixed pine-hardwood stand, and naturally occurring stands of white pine) broken by the occasional patch of developed or bare land. Despite past logging and disturbances, old-growth patches of hemlock, white pine, and yellow poplar trees remain. Most of the current stands of forest include middle to late successional forest types. These yield a mix of canopy species approaching 100 ft in height. The variety of semi-mature and mature vegetation serves to shade riparian habitats, stabilize steep slopes, and provides buffers that obscure sight lines.

6.1.2.8 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). The structure of the Blue Ridge province is controlled by major thrust faults, folding, and faulting (Hatcher 1978a; Clendenin and Garihan 2007a, 2007b).

Sassafras Mountain and the Blue Ridge Escarpment lie within the inner Piedmont belt. It is believed that this highly eroded thrust sheet was attached to the North American plate during the Taconic orogeny. Colliding tectonic plates during the Acadian and the Alleghanian orogenies created pressure and heat which turned sedimentary and igneous rocks into the schists, gneiss, and metagranites that are commonly seen in the area. Faulting and uplifting during the Mesozoic period and Oligocene to the Miocene periods created the area’s many gorges and waterfalls as well as vistas including Jumping Off Rock and Sassafras Mountain and gorges harboring waterfalls and cascades such as Laurel Fork Falls, Whitewater Falls, and Eastatoe Gorge.

The Project vicinity is considered to have low to moderate seismic risk, with no known Quaternary/active faults (USGS 2014a, 2014b, 2018).

6.1.2.9 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.

The soils of the Project vicinity are diverse. 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.

The geology, and soils of the area combined with mild temperatures and a high average annual rainfall supports a unique diversity of flora and fauna as well as habitats for endemic rare and endangered species.

6.1.2.10 Cultural Features

Much of the Project vicinity is a rural and scenic setting. There is abundant land set aside for conservation open space, national forests, wilderness areas, and wildlife management areas. The region is marketed as a mountain wilderness tourist destination, known for mountain views, waterfalls and creeks, and rare plant communities. There is very little human development in the area, with limited residential development and water access points along the shores of Lake Jocassee. The most visually impactful human development in the area are the existing Project and its primary transmission line as well as the homes within the Fisher Knob community along the western shoreline of the Whitewater River cove.

6.1.2.11 Infrastructure

6.1.2.11.1 Roads

The local area surrounding the Project has few roads, in part because of the mountainous terrain and the remote nature. South Carolina state routes 107 and 130 run north-south, 4 and 2 miles west of Lake Jocassee, respectively; SC Highway 178 runs north-south 7 miles east of Lake Jocassee, and Route 11 runs east-west 2 miles south of Lake Jocassee. In North Carolina, highway 64 runs east-west. There are several small secondary roads in the area that provide access to residential areas and parks, but much of the area does not have roads. The roads are all two-lane routes.

The Oscar Wigington Scenic Byway is a 20-mile designated section of SC 107 and SC 281 running from the North Carolina border through Sumter National Forest, with the Oscar Wigington Overlook on SC 413 offering views of Lake Jocassee and the Blue Ridge Mountains.

6.1.2.11.2 Utilities

The Project is the most visually apparent utility in the area. Visible features include the upper reservoir, lower reservoir inlet/outlet structure, transformer yard, switchyard, ancillary buildings, parking lots, dams, access roads, and graded and revegetated spoil areas. The total area of land associated with the existing Project, excluding utility corridors and open water, is approximately 200 acres.

Jocassee Pumped Storage Station is at the southern end of Lake Jocassee. Other than the dam itself, the spillway, and intake structure, most facility features are on the downstream side of the dam, visually shielded from boaters at Lake Jocassee.

The Project primary transmission line extends approximately 9.25 miles from the existing Project switchyard south and east to the Jocassee Pumped Storage Station on the southern end of Lake Jocassee. As discussed in Section 5.9, the primary transmission line corridor ranges from approximately 200 to 300 ft wide and serves a 525kV line on towers that are approximately 130 ft tall. The corridor cuts through mixed hardwood and pine forests on mountainous terrain. The towers are often located on high elevation points spanning ravines to reduce environmental effects of corridor maintenance.

6.1.2.11.3 Development

There is limited human development in the area around the Project. There are lakeshore residences with docks around Lake Jocassee as well as public boat launch points at Devils Fork State Park on the southwest shore of Lake Jocassee. The area to the south of Lake Jocassee near Jocassee Dam has additional residential and mixed development with additional land clearing.

6.1.2.12 Recreation

6.1.2.12.1 Parks and Conservation Areas

The Project area has numerous parks and other conservation open space areas as shown in Figure 6-2. These include Sumter National Forest in South Carolina, Nantahala National Forest in North

Carolina, the Toxaway Game Lands, Gorges State Park, Devils Fork State Park, and Keowee-Toxaway State Park. These resources provide numerous recreational opportunities.

The Jim Timmerman Natural Jocassee Gorges Natural Area (Jocassee Gorges) encompasses a large conservation open space area along the northern and eastern shores of Lake Jocassee. Jocassee Gorges is approximately 43,500 acres and is a Wildlife Management Area operated by SCDNR. Jocassee Gorges is a remote recreation destination with waterfalls, backcountry hiking and camping opportunities, fishing access, scenic driving routes, and overlooks.

The 600-acre Devils Fork State Park is located near Jocassee Pumped Storage Station and offers public boat ramps and canoe/kayak launches, as well as camping and cabin rental.

Lake Jocassee (Figure 6-3) itself is a recreational destination that offers boating and other aquatic recreational opportunities for lakeside residents and area visitors. Fishing, boating, kayaking, water skiing, scuba diving, and other water-based activities are available.

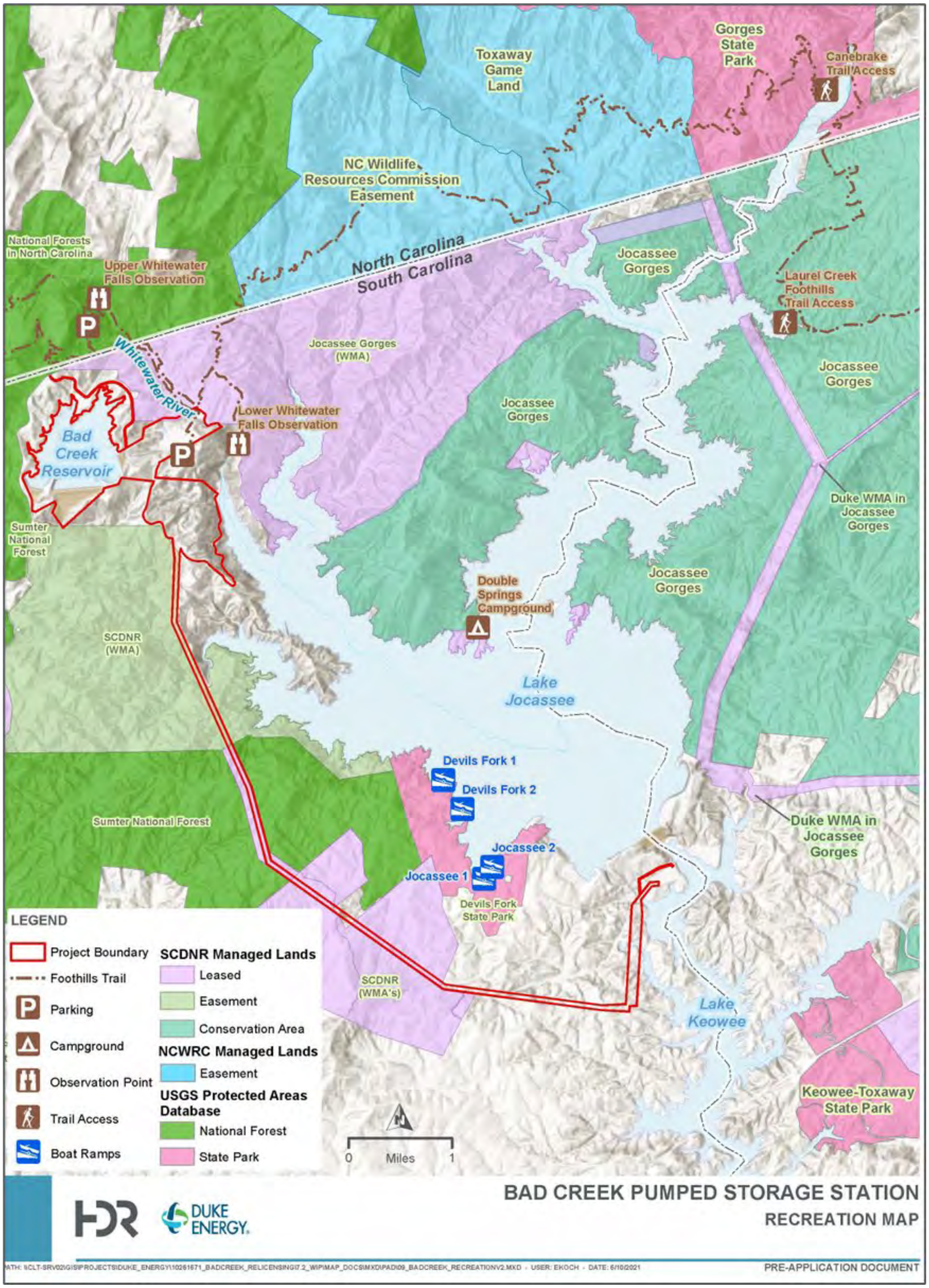


Figure 6-2. Recreational Resources near the Project

Figure 6-3. Lake Jocassee Looking South (Whitewater River cove right side of photo)

6.1.2.12.2 Recreational Sites

Recreational sites near the Project include hiking trails, waterfalls, and scenic overlooks. The Whitewater River has two destination waterfalls. The trailhead for the Lower Whitewater Falls is adjacent to the Project office complex. The two-mile trail continues to an observation deck on the eastern bank of the gorge, offering views of the falls (Figure 6-4). A half-mile upstream in North Carolina is Whitewater Falls, the highest waterfall east of the Rockies (USFS 2023b). Whitewater Falls is in the Nantahala National Forest and the section of the river from the state line upstream was designated as a newly eligible Wild & Scenic River in the 2023 Nantahala Pisgah National Forest Land Management Plan.

Figure 6-4. Lower Whitewater Falls as viewed from the Lower Whitewater Falls Overlook

Hikers can access both falls via the Foothills Trail, a designated national recreation trail. Located in Upstate South Carolina and Western North Carolina, the trail is 77 miles long. The trail is popular with backpackers as well as day hikers. The trail passes west of the Project through Sumter National Forest, crosses the North Carolina border into Nantahala National Forest, dips back into South Carolina to follow the Whitewater River before turning north again into North Carolina, ultimately ending at Table Rock State Park, South Carolina. The trailhead and parking lot for the Lower Whitewater Falls is an access point for the Foothills Trail.

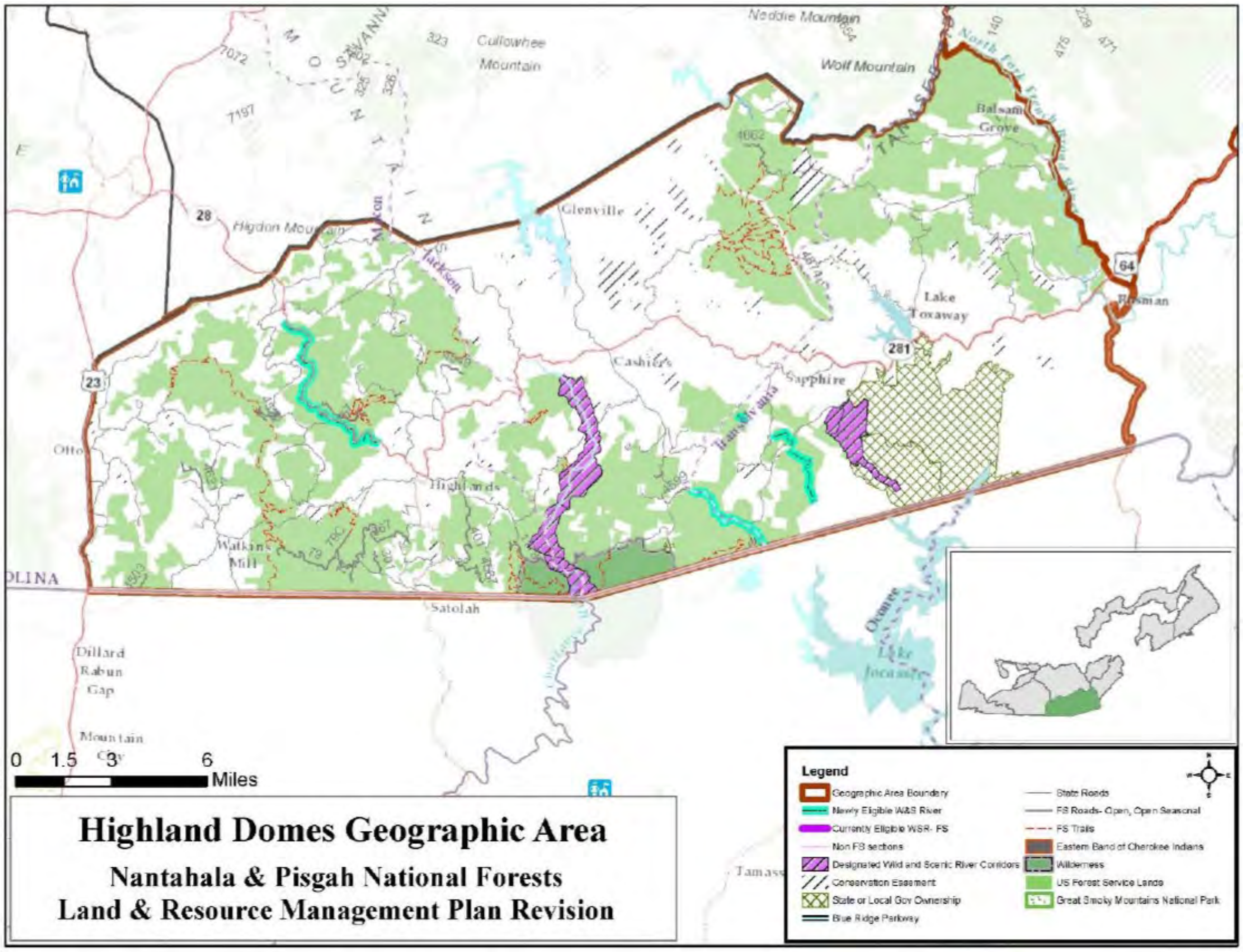
Duke Energy provides a visitor overlook and pullover on Bad Creek Road approximately 0.8 miles south of the existing lower reservoir inlet/outlet. The overlook provides over 180-degree views north, east, and south across Lake Jocassee and the Blue Ridge Mountains beyond. The pull off includes a dedication monument by Duke Energy to the workers who developed the Project and a selfie frame.

6.1.3 Existing Management Plans

6.1.3.1 Nantahala and Pisgah National Forests

The Nantahala and Pisgah National Forests (Forests) are in western North Carolina. The Forests are managed under one plan[9], though tracts remain designated as Nantahala or Pisgah National Forests (USFS 2023a). The Nantahala National Forest, totaling approximately 531,000 acres, is clustered in the southwest corner of the state, bordering South Carolina, Georgia, and Tennessee. The Pisgah National Forest, approximately 513,000 acres, has tracts near the South Carolina border and along the Tennessee border. No portion of the Pisgah National Forest adjoins the Project. The Forests are subdivided into geographic areas that share a distinctive landscape. The Highland Domes geographic area borders South Carolina, adjacent to Lake Jocassee and the Project (Figure 6-5).

[9] Available online at https://www.fs.usda.gov/main/nfsnc/landmanagement/planning.

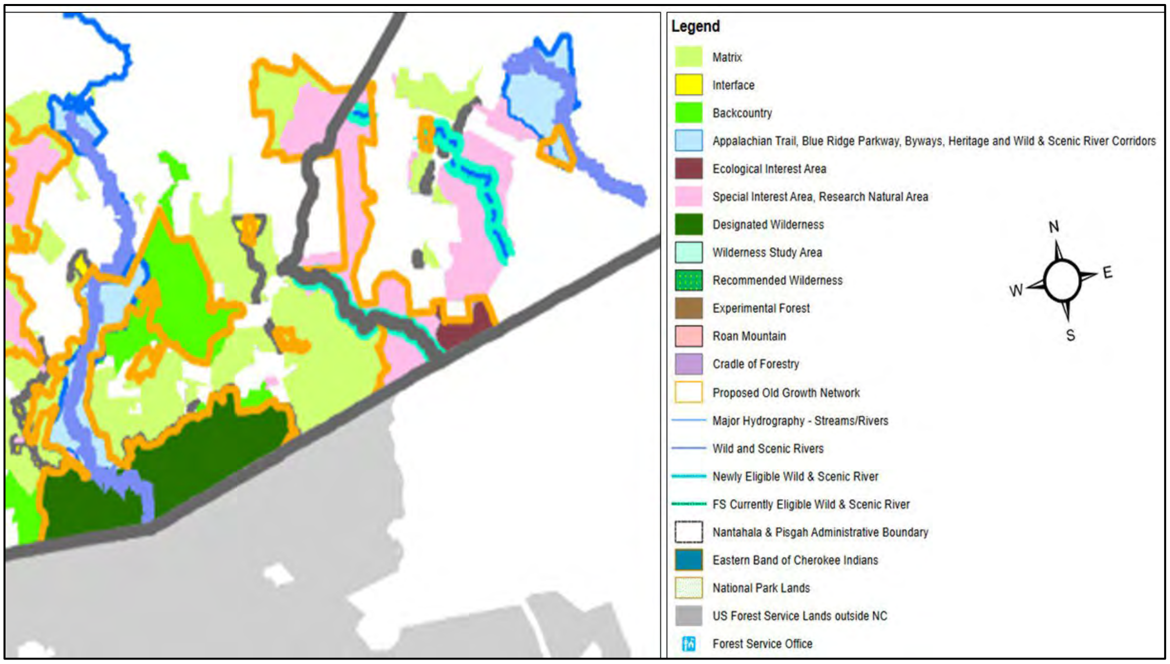


Source: Nantahala and Pisgah National Forests Land Management Plan (USFS 2023a)

Figure 6-5. The Highland Domes Geographic Area of the Nantahala National Forest

6.1.3.1.1 Resource Management

The Nantahala and Pisgah National Forests Land Management Plan (USFS 2023a) defines and identifies management areas, areas with related characteristics that lead to defined patterns of development and resource management. Five management areas in the Nantahala National Forest are near the Project: Matrix, Ecological Interest Area, Special Interest Area, Designated Wilderness, and Newly Eligible Wild & Scenic River. A separate overlay identifies Proposed Old Growth Networks, which in this area of the Forests, includes the Ecological Interest and Special Interest areas around Whitewater River and the Ellicott Rock Wilderness Area (see Figure 6-6 and Figure 6-7). Following is a description of each type of management areas and key management standards that would affect viewsheds and viewshed development (USFS 2023a).



Source: USFS 2023a

Figure 6-6. Management Areas of Nantahala and Pisgah National Forests adjacent to Project Area

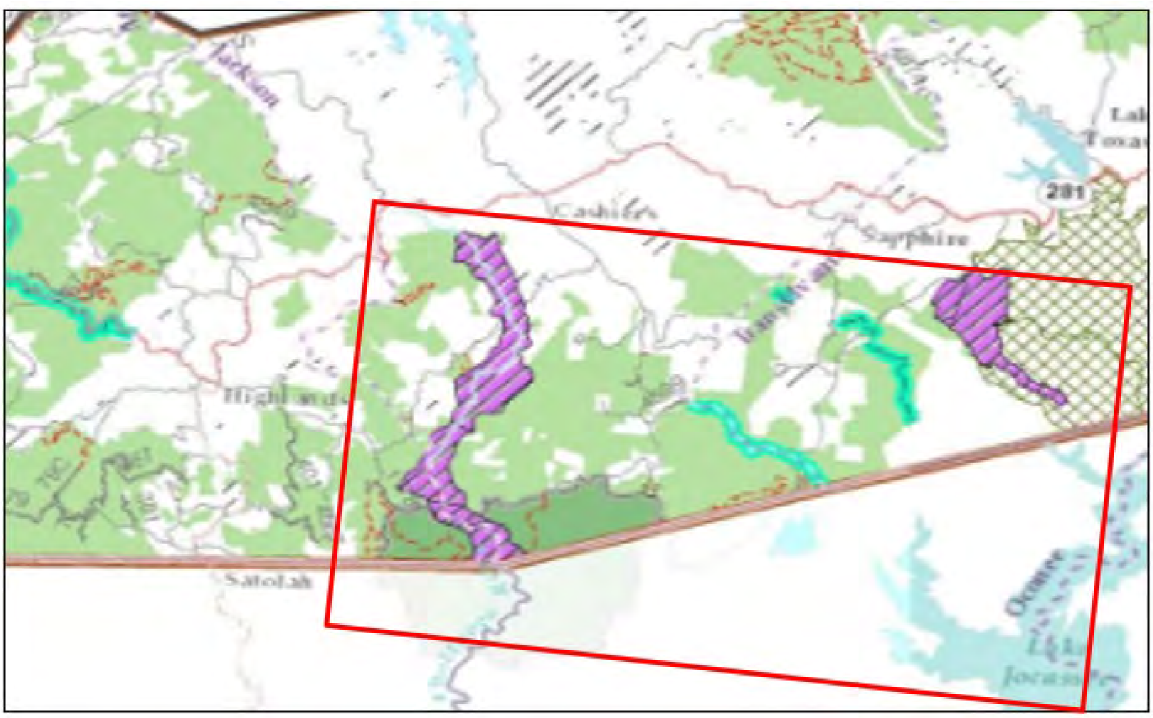


Figure 6-7. Locator Map of the Management Areas shown on Figure 6-6

- **Matrix:** Matrix designated areas include diverse vegetation, and are managed to meet the objectives of restoration, wildlife habitat, and sustainable flow of wood products. Desired scenic character in Matrix management areas is natural appearing or pastoral in semi-primitive motorized recreation settings, and rural forested, pastoral, or cultural/historic in roaded-natural or rural settings. The desired scenic integrity objective ranges from High to Low, depending on the inventoried scenic class. Timber production is allowed.
- **Ecological Interest Area:** These areas are managed to improve ecological species composition. The desired scenic character is natural evolving to natural-appearing in semi-primitive recreation settings, and rural forested, pastoral, or cultural/historic in roaded-natural settings. The desired scenic integrity objective ranges from high to low, depending on the scenic class. These areas are unsuitable for timber production, and timber harvest is allowed only to restore species composition.
- **Special Interest Area:** These areas are the most exceptional ecological communities that serve as core areas for conservation, and these areas are managed to support and enhance the communities and the scenic character of the area. The desired scenic integrity objective ranges from high to low, depending on the inventories scenic class. These areas are unsuitable for timber production, and timber harvest is allowed only to restore desired community composition.
- **Designated Wilderness:** Wilderness is managed to perpetuate or enhance the natural and undeveloped character of the area while providing opportunities for recreation. The desired scenic integrity objective is very high. The sites are managed with little to no human development, including roads or developed recreational or commercial features. These areas are unsuitable for timber production. Ellicott Rock Wilderness is the designated wilderness area within the study area. Ellicott Rock Wilderness is an 8,300-acre designated area encompassing three states, North Carolina, South Carolina, and Georgia. North Carolina contains the largest portion, 3,400 acres. For more information on Ellicott Rock Wilderness Area, refer to the Sumpter National Forest description below (Section 6.1.3.4).
- **Eligible Wild and Scenic River:** The Whitewater River is identified as having outstanding scenery, recreation, geology, and ecology/botanical value, and is

recommended for inclusion as a wild and scenic river from the North Carolina – South Carolina line upstream 3.6 miles (Figure 6-8). As an eligible wild and scenic river, as designated in the 2023 Nantahala and Pisgah National Forest Land Management Plan (USFS 2023a), it should be managed to maintain those elements. The desired scenic integrity objective is high. No management activities that may reduce the scenic resources of the river may be conducted within 0.25-mile on either side of the river segment. Silviculture can be performed as long as there is no substantial adverse effect.

Silviculture and timber production has been identified as a high priority in the current Management Plan, increasing annual timber production from 650 acres annually to 1,200 acres in the short term and 3,200 acres annually in the long term. Approximately 44% of the Forests are open to timber production, including steep slopes and backcountry areas, which would require new access roads. A timber sales plan has not yet been published but timbering activities may occur in the timeframe of the management plan (2023-2063) in those management areas that allow timber production.

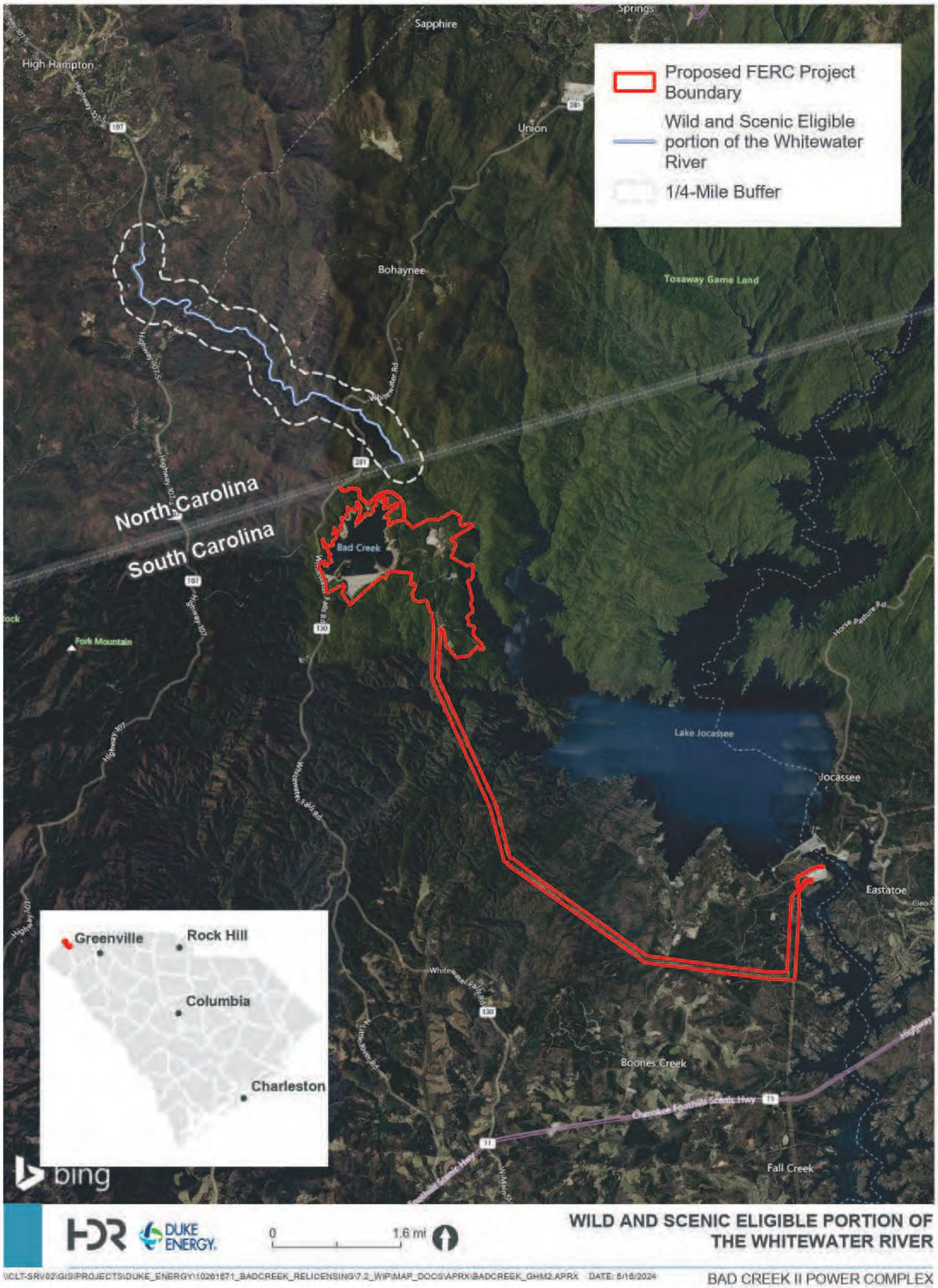


Figure 6-8. Wild and Scenic River Eligible Section of the Whitewater River in Nantahala Nation with 0.25-mile buffer

6.1.3.1.2 Summary of Potential Viewshed Effect

The management of the Nantahala and Pisgah National Forests near the Project includes areas to be managed consistent with the current land cover condition and development and areas open to timber production, which would affect the viewshed. National Forests are protected from sale, so the Forests will remain as conservation open space into perpetuity. There are no Forest regulations that impose viewshed requirements on the surrounding area.

6.1.3.2 Sumter National Forest

Sumter National Forest consists of three non-contiguous ranger districts in South Carolina. The Andrew Pickens Ranger District is in the western edge of the state in Oconee County on more than 85,000 acres near the Project as shown on Figure 6-9.

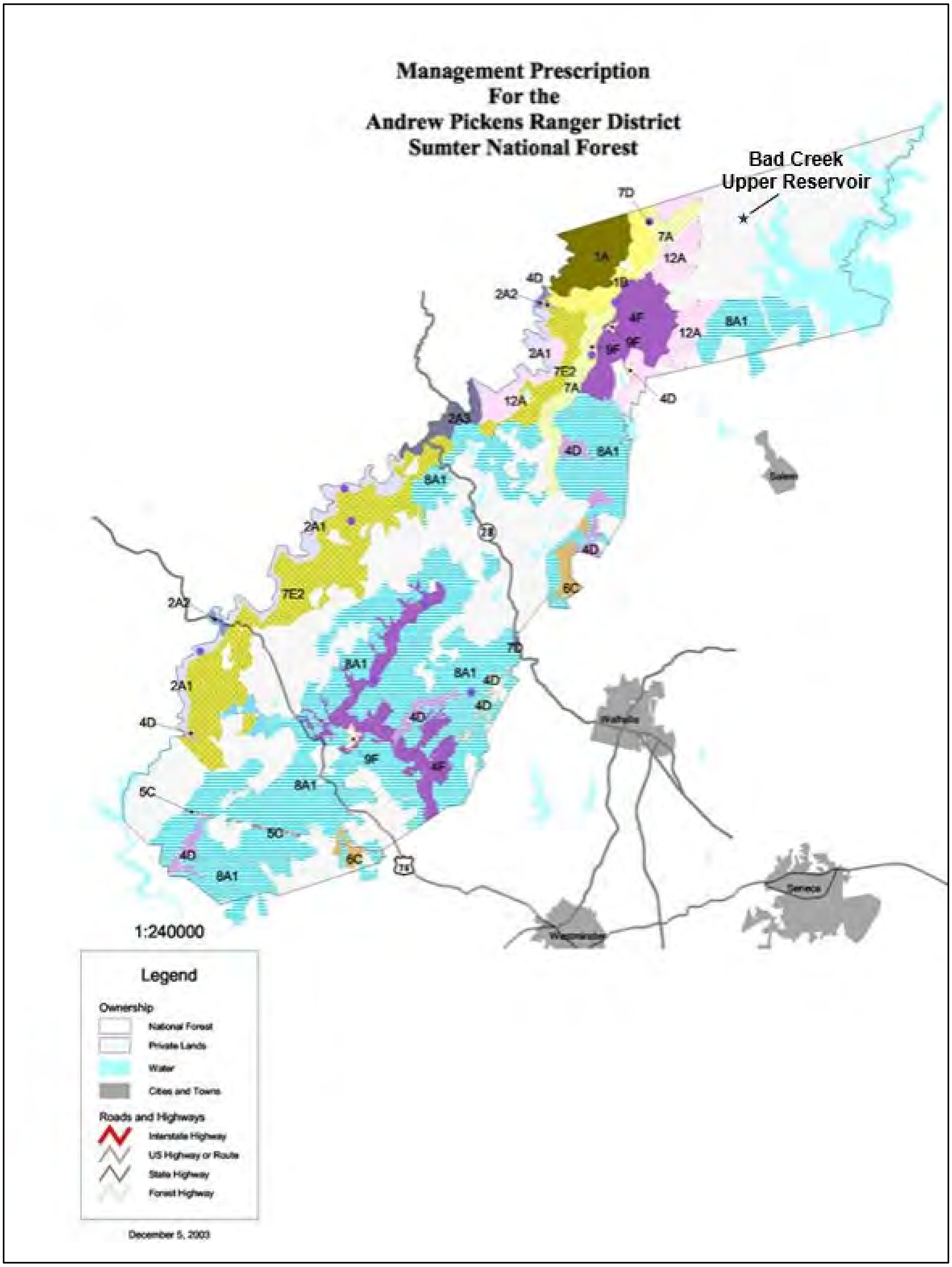


Image source: USFS 2004

Figure 6-9. Management Strategy Areas of Sumter National Forest in Oconee County, South Carolina

6.1.3.2.1 Resource Management

The management of the district emphasizes habitat restoration and enhancement for a diverse range of wildlife and plant species, with emphasis on rare, threatened, endangered, and sensitive species. There were seven tracts of timber sales in the Andrew Pickens Ranger District in FY 2020-2022, but they were all in southern half of the district, and not near the Project area.

The Revised Land and Resource Management Plan Sumter National Forest (USFS 2004) identifies areas within the national forest for different management strategies[10]. The following is a summary of strategy areas near the Project and key management standards that would affect viewsheds and viewshed development.

- **1A – Designated Wilderness Area:** Very high scenic integrity objective, no new utility corridors or community sites, no mining leases permitted, unsuitable for timber production.
- 1**B – Recommended Wilderness Study Area:** Very high scenic integrity objective, no new utility corridors or community sites, no mining leases permitted, unsuitable for timber production.
- **4F – Scenic Area:** Very high or high scenic integrity objective, no surface mining leases, unsuitable for timber production.
- **7A – Scenic Byway Corridor:** includes the area visible during leaf-off season for up to ½ mile from either side of the road, management is focused on outstanding scenery, high scenic integrity objective, no surface mining leases, unsuitable for timber production.
- **7D – Concentrated Recreation Zone:** variety of recreational development including high-density, high to moderate scenic integrity objective, no surface mining leases, unsuitable for timber production.

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[10] The Sumter Forest Land and Resource Management Plan is available online at https://www.fs.usda.gov/detailfull/scnfs/landmanagement/planning/?cid=stelprdb5261413.

- **8A1 – Mix of Successional Forest Habitats:** managed for mast production and habitat and vegetative diversity, high to low scenic integrity objective, mining leases are possible, suitable for timber production.
- **9F – Rare Communities:** Very high to moderate scenic integrity objective, no mining leases permitted, unsuitable for timber production.
- **12A – Remote Backcountry, Few Open Roads:** High scenic integrity objective, no surface mining leases, unsuitable for timber production.

Ellicott Rock Wilderness Area

Ellicott Rock Wilderness is an 8,300-acre wilderness area west of the Project site. It spans three states and three forests: North Carolina (Nantahala National Forest), South Carolina (Sumter National Forest), and Georgia (Chattahoochee National Forest) (Figure 6-10). Approximately 2,855 acres of the wilderness are within Sumter National Forest in South Carolina. The Ellicott Rock Wilderness Area is designated 1A on the Andrew Pickens Ranger District management prescription map (USFS 2023c).

Federally designated wilderness areas have different management goals than other federally managed lands, that are more restrictive of human impact. The intent for a wilderness area is to be protected and managed to maintain a “wilderness character” free of permanent improvements and the sights and sounds of modern human occupation. Commercial activities, including timber harvesting, motorized access, roads, structures, and facilities are prohibited in wilderness areas.

The management standards for Ellicott Rock Wilderness in Sumter National Forest include that the scenic integrity objective is very high for all inventoried scenic classes, no new utility corridors or communication sites will be authorized, no new roads shall be built, and the lands are unsuitable for timber production.

The Sumter National Forest Management Plan identifies a 1,982-acre area directly east of Ellicott Rock Wilderness as a recommended wilderness study area. (Designated as area 1B on the management prescription map). This area is managed to protect wilderness characteristics pending legislation as to their characteristics.

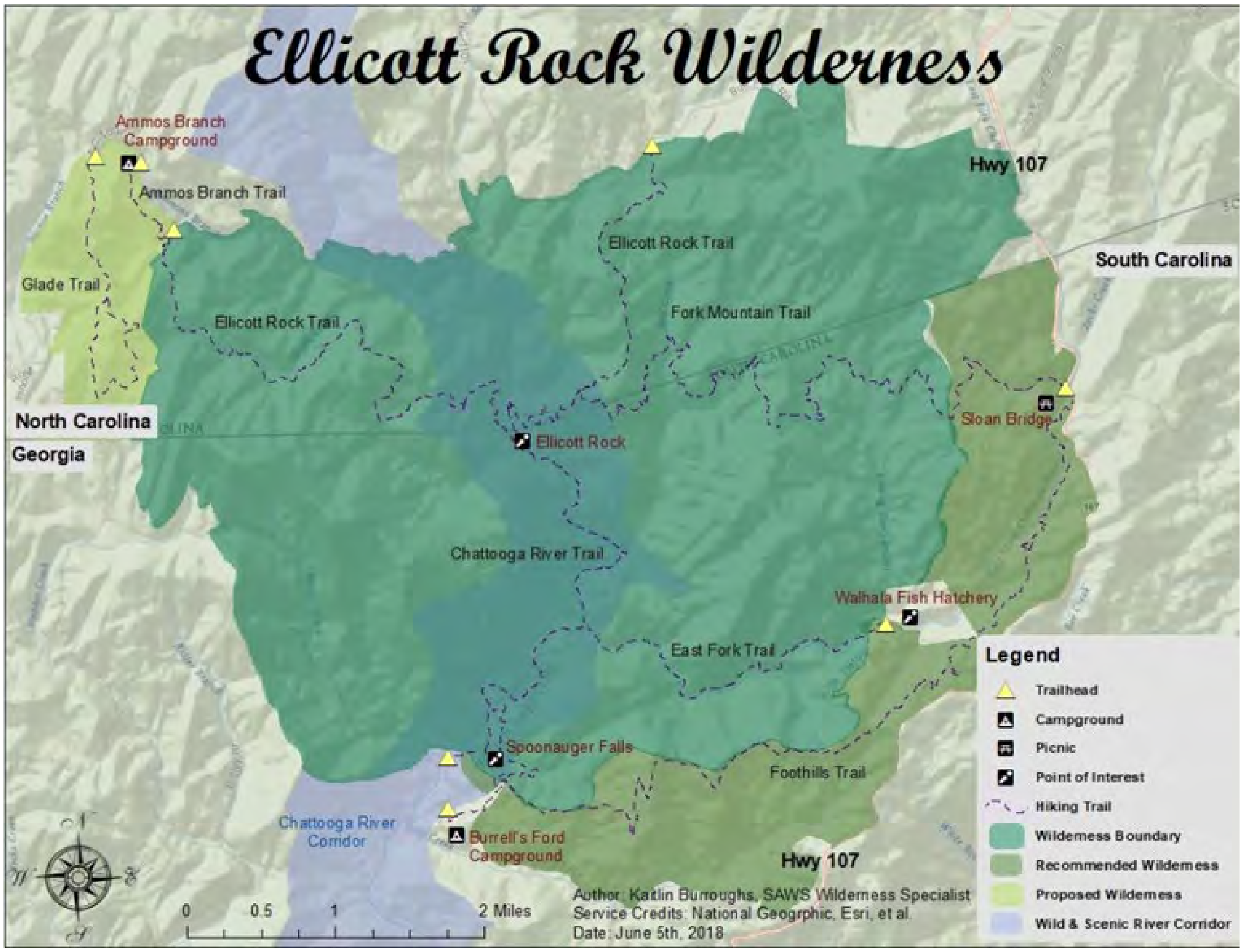


Image source: USFS

Figure 6-10. Map of Ellicott Rock Wilderness Area in North Carolina, South Carolina, and Georgia

6.1.3.2.2 Summary of Potential Viewshed Effect

The management of the Sumter National Forest near the Project area by and large protects the viewshed in its current condition, by limiting timber production, surface mining operations, or intensive development. One section of the National Forest adjacent to Devils Fork State Park and bisected by the Duke Energy utility corridor is managed for timber production. This area may be logged at some point, affecting the views in the area. However, this management strategy is in alignment with widening of the primary transmission line corridor as would be needed for Bad Creek II, offsetting potential effects of the widening project. National Forests are protected from sale, so Sumter National Forest will remain as conservation open space in perpetuity. There are no regulations of the Forest that impose viewshed requirements on the surrounding area.

6.1.3.3 Jim Timmerman Natural Resources Area at Jocassee Gorges

The Jim Timmerman Natural Jocassee Gorges Natural Area (Jocassee Gorges) is approximately 43,500 acres in size and is a series of properties east and north of Lake Jocassee in South Carolina (Figure 6-11). The land is primarily managed as a Wildlife Management Area by SCDNR. SCDNR owns most of this land and activities are governed by a management plan and regulations developed, in large part, in response to public input. Duke Energy, the former owner of much of the Jocassee Gorges, has retained ownership of some of the lands, but has granted a conservation easement to SCDNR. Public access to the Duke Energy lands is allowed.

6.1.3.3.1 Resource Management

"A Resource Management Plan for the Jocassee Gorges Property" was prepared by SCDNR in 1998 (SCDNR 1998)[11]. The plan identifies the most important consideration in the management of Jocassee Gorges is to maintain the natural character of the area. The secondary objective is to provide public recreation compatible with the area's natural character. Recreational activities provided for in the plan include hunting, fishing, hiking, and horseback riding. The management plan also recognizes that Jocassee Gorges provides tremendous opportunity for scientific study and education.

The size of this tract and its position among other public properties with substantial stands of hardwood and pine-hardwood forest contribute to its significant scenic and recreational attributes. A forest management plan has been developed for the property, with the purpose of improving wildlife and plant habitat and diversity. Some areas of the site may be considered for timber harvest, related to enhancement of habitat, biodiversity, and forest health, but timber harvest will not be relied upon as a major funding source. Managed burns are also part of the forest management plan.

[11] The plan is available online at https://www.dnr.sc.gov/land/publications/jocplan.html.

Image source: SCDNR 1998.

Figure 6-11. Map of Jocassee Gorges with visitor attractions

6.1.3.3.2 Summary of Potential Viewshed Effect

Jocassee Gorges is being managed as a natural scenic area, preserving the existing forest habitat and views into perpetuity. Though there may be small development or forest management activities that would affect the view of or within the property, those activities would have minimal effect on the near- and long-term views. There are many trails, overlooks, and camping opportunities within the site, drawing visitors from the state and the larger region to the Lake Jocassee region. There are no regulations of Jocassee Gorges that impose viewshed requirements on the surrounding area.

6.1.3.4 Oconee County Comprehensive Plan

Oconee County's 2020 Comprehensive Plan (Oconee County 2020; Comprehensive Plan) was developed to guide growth and development decisions[12]. It lays out guiding principles for coordinated long-term planning around all aspects of the development of unincorporated areas in

[12] Oconee County's Comprehensive Plan and associated documents are available online at https://oconeesc.com/planning-and-zoning-home/comprehensive-plan.

Oconee County including the Project site. The current Comprehensive Plan was approved on March 3, 2020. It establishes guidelines for a ten-year period with a state-required update at five years. The Comprehensive Plan includes the following components:

- Goals, objectives, and strategies
- Future use land map
- Implementation Plan

6.1.3.4.1 Resource Management

The Comprehensive Plan lays forth guiding principles related to all aspects of future development of Oconee County. Topics include transportation, education, housing, economic development, tourism, land use planning, recreation, natural resource protection, and viewshed protection.

Specific guidance related to visual resources are addressed in the Natural Resources Element of the Comprehensive Plan. Goals, objectives, and strategies related specifically to the protection of visual resources include are identified in Goal 6.2. (Preserve, protect, and enhance Oconee County's land resources):

- **Objective 6.2.1. Promote partnerships and voluntary conservation easements to preserve significant lands, habitats, and scenic areas under development pressure.**
  - Strategy 6.2.1.1. Support existing land conservation organizations in their efforts to preserve and protect rural lands, sensitive areas, and significant natural resources and transfer of development rights and conservation easements to protect rural lands, sensitive areas, and significant natural resources.
  - Strategy 6.2.1.2. Provide appropriate assistance from County departments and agencies in efforts to identify and preserve significant lands, and scenic areas.

- **Objective 6.2.2. Manage natural assets to ensure natural resources enhance the quality of life for residents and visitors and increase economic opportunities.**
  - Strategy 6.2.2.1. Protect and preserve natural resources for recreational use and develop new opportunities for recreational access.
  - Strategy 6.2.2.2. Work with public conservation partners to identify additional significant natural resources including viewsheds and habitats that warrant protection.

- **Objective 6.2.4. Continue to promote reasonable access to Oconee County's public natural amenities for residents and visitors.**

- Strategy 6.2.4.1. Encourage compatible land use adjacent to National and State Forests, wildlife management area, and County, State and municipal parks to protect such lands from incompatible uses.
- Strategy 6.2.4.3. Encourage and support efforts by public and private organizations to provide public access when conserving open space, natural areas and scenic vistas in Oconee County.

Comprehensive Plan objectives are supported by the Oconee County Zoning Ordinance which addresses visual resources through the Lake Overlay District, lighting requirements for commercial and industrial facilities, and development restrictions based on Existing and Future Land Use Classifications as summarized further below. However, as set forth in Section 38-9.5 (4), "*Notwithstanding any other provision herein to the contrary, proposed utility generation facilities and structures needed by regional and local utility providers in the production, transmission, and distribution of electricity, natural gas, water, or sewer services, as well as any facility or structure necessary to comply with any federal or state license requirements, related to such production, transmission, and distribution, shall be permitted by right in any district and shall be exempt from any standard set forth in this chapter*" (Oconee County 2024).

Lake Overlay District

Oconee County created the Lake Overlay District as an amendment to the Zoning Ordinance in 2012 to, among other purposes, maintain natural beauty and ensure the enjoyment of Lake Jocassee and Lake Keowee by residents. The Lake Overlay District established a natural vegetative buffer of 25 ft as measured from the Lake Jocassee full pond elevation (1,110 ft msl). Within the buffer, no trees larger than six-inch caliber can be removed unless certified to be a hazard, and new manicured lawns or managed spaces cannot be established. No development activity or soil disturbance can occur in buffer areas, with buffer protection required during construction or development. The preservation of existing natural vegetation is encouraged.

Existing Land Use and Future Land Use Maps

The Existing Land Use and Future Land Use Maps must be viewed together to understand their application to allowable activities. When developing the Comprehensive Plan, Oconee County inventoried and mapped existing land uses. The Project site was classified as Utility and Agricultural/Forest use in the Existing Land Use Map (Figure 6-11). Utility lands are used by electricity, natural gas, water, sewer, and communications providers. The Project site was classified as Rural/Agricultural in the Future Land Use Map (Figure 6-12) which allows for a mix of uses so long as new uses do not negatively impact existing land uses.

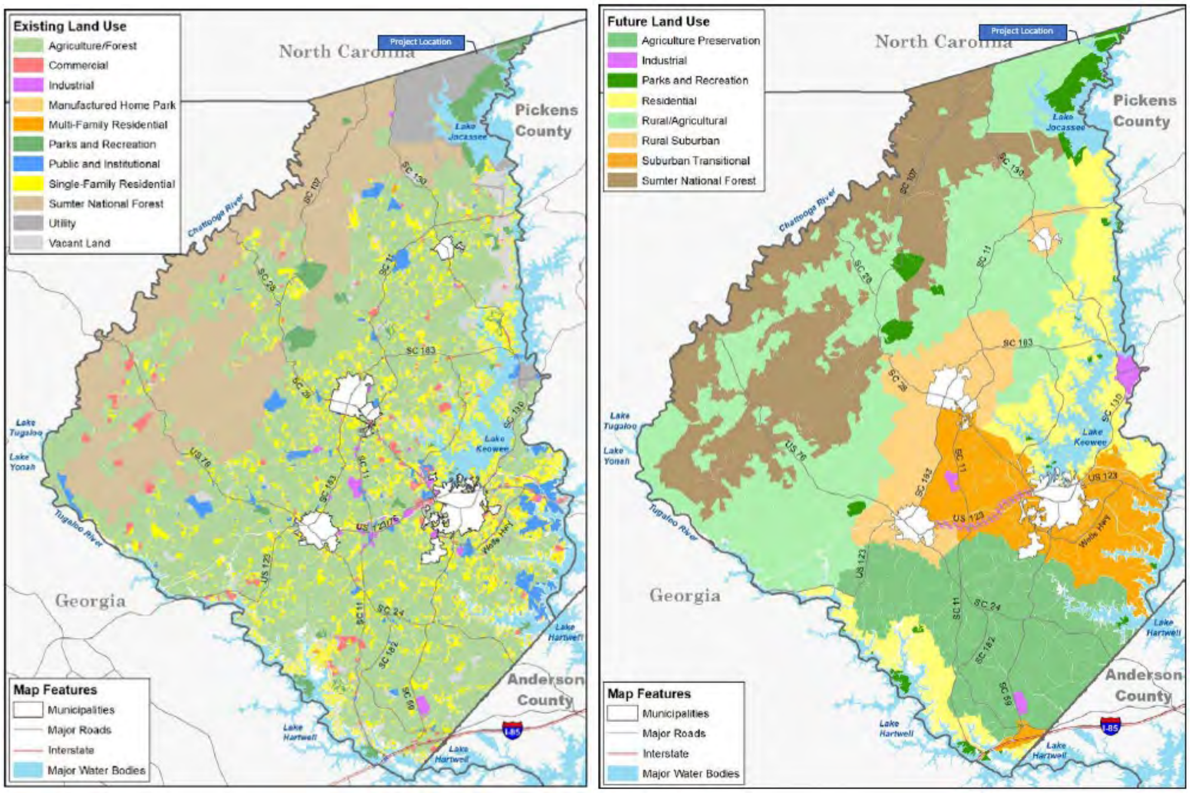


Image source: Oconee County 2020

Figure 6-12. Existing (left) and Future (right) Land Use Classification Maps

Lighting Standards

Oconee County's lighting standards are set forth in the Oconee County Code of Ordinances Chapter 38, Appendix A. The purpose of the Lighting Standards is to, "assure that adequate exterior lighting is provided to facilitate crime prevention, security, and safe passage, and that exterior lights be shielded to reduce the impact of lighting on neighboring uses, potential safety hazards to the traveling public, and the effect on viewsheds and nightscapes." Consistent with this purpose, the County requires project developers to obtain approval of lighting plans for projects that include the installation of outdoor lighting fixtures. Lighting plans must include the location, type, and height of luminaries including both building and ground-mounted fixtures; and, a description of the luminaries, including lamps, poles or other supports and shielding devices including the angle of light emission. Exterior lighting must be shielded to avoid illuminating the night sky. On-site lighting may be used to provide safety and security on pedestrian walkways, at building entrances, areas between buildings, and in parking areas. Blinking and flashing lights are prohibited unless the lights are required as a safety feature (Oconee County 2024).

6.1.3.4.2 Summary of Potential Viewshed Effect

The Comprehensive Plan recognizes that the Project is an area with high scenic quality and that efforts should be made to ensure Bad Creek II Project features are compatible with existing land uses and protect scenic vistas to the extent practicable. The Project is consistent with both Existing Land Use and future Land Use Classifications. Bad Creek II is exempt from the requirements for the Lake Overlay District and Lighting Standards established in Chapter 38 of the Oconee County Code of Ordinances. In summary, the regulations in the Oconee County Comprehensive Plan impose restrictions on the area that protect the viewshed in day and night conditions, but these requirements to not applicable to the existing Project or Bad Creek II.

6.1.3.5 KT Shoreline Management Plan

Duke Energy's KT Shoreline Management Plan (SMP) is a comprehensive management tool for managing requests from lake neighbors for shoreline activities within the KT Project Boundary at Lake Keowee and Lake Jocassee in a manner consistent with KT Project purposes. The SMP identifies the types of activities that are allowed along the shoreline based on Shoreline Classification and includes Shoreline Management Guidelines (SMG) establishing the requirements for lake neighbors seeking approval for such activities The KT SMP was initially developed by Duke Energy in the mid-1980s and most recently updated during the relicensing of the KT Project (Duke Energy 2014).

6.1.3.5.1 Resource Management

The KT SMP includes two categories of shoreline classifications: environmental classifications and existing and future use classifications. SMP Shoreline Classifications at Lake Jocassee, their definitions, and allowable shoreline uses are summarized below. Notably, the KT SMP limits residential development to only a few shoreline areas at Lake Jocassee; marinas and other intensive types of shoreline uses are not allowed. The remaining shoreline classifications allow for public recreation, public infrastructure, and hydroelectric project operations.

- Environmental Classifications

- Environmental Areas: Undeveloped, vegetated areas or cove heads with a stream confluence. While many wildlife species use Environmental areas, the primary importance of these areas is to provide spawning, rearing, and nursery habitat for fish and rearing, nursery, and adult habitat for amphibians, reptiles, and birds. No vegetation removal, construction, excavation, or shoreline stabilization is permitted.
- Integrated Management Zones: Undeveloped Project lands and waters important from a scenic, environmental, or cultural standpoint, but the protection of these important values does not necessarily preclude Project or non-Project construction and use; development impacts are avoided or minimized and may require mitigation measures.
- Natural Areas, Natural Isolated Berm: Areas with characteristics that make most development undesirable, such as shallow water, isolated berms, significant cultural resources or significant terrestrial habitat areas; no vegetation removal, construction, or excavation is permitted.

- Existing and Future Use Classifications
  - Integrated Management Zones Developed: Developed Project lands and waters important from a scenic, environmental, or cultural standpoint, but the protection of these important values does not preclude Project or non-Project construction and use; future development impacts are avoided or minimized and may require mitigation measures.
  - Project Operations: Project lands and waters associated with hydroelectric power production including but not limited to dams, dikes, powerhouses, and other hydroelectric plant properties. At Lake Jocassee, this includes shoreline associated with both the Project as well as Jocassee Pumped Storage Station.
  - Public Infrastructure: Existing non-recreational public facilities (e.g., utility line corridors) that support regional needs.
  - Public Recreation (existing and future): Existing or future facilities supporting various public recreational amenities including Project Access Areas and state,

district, county, and city parks and public recreation lands adjoining the Project Boundary.

- Residential (existing and future): Existing or future private facilities for Project-front landowners, none of which can be multi-family dwellings, including, among other things, piers, boathouses, boat shelters, boat docks, floats, and existing boat ramps for individual residences.

In addition to shoreline classifications, the KT SMP restricts adjacent landowners from most vegetation management activities within the FERC Project Boundary. This will limit the effect of future residential development activities on the shoreline buffer at Lake Jocassee.

6.1.3.5.2 Summary of Potential Viewshed Effect

Allowable shoreline uses at Lake Jocassee are limited with only a few areas of the lake available for additional residential development. In addition, any such additional development will be limited with respect to ability to remove shoreline buffer vegetation. This will ensure a continued shoreline buffer around Lake Jocassee further limiting the potential views of Bad Creek II from residence.

The construction of Bad Creek II will not affect the SMP or its implementation. The shoreline adjoining the existing Project facilities as well as the proposed Bad Creek II facilities is classified as Project Operations under the SMP (Figure 6-13). Construction of the lower reservoir inlet/outlet structure is consistent with the Project Operations shoreline classification.

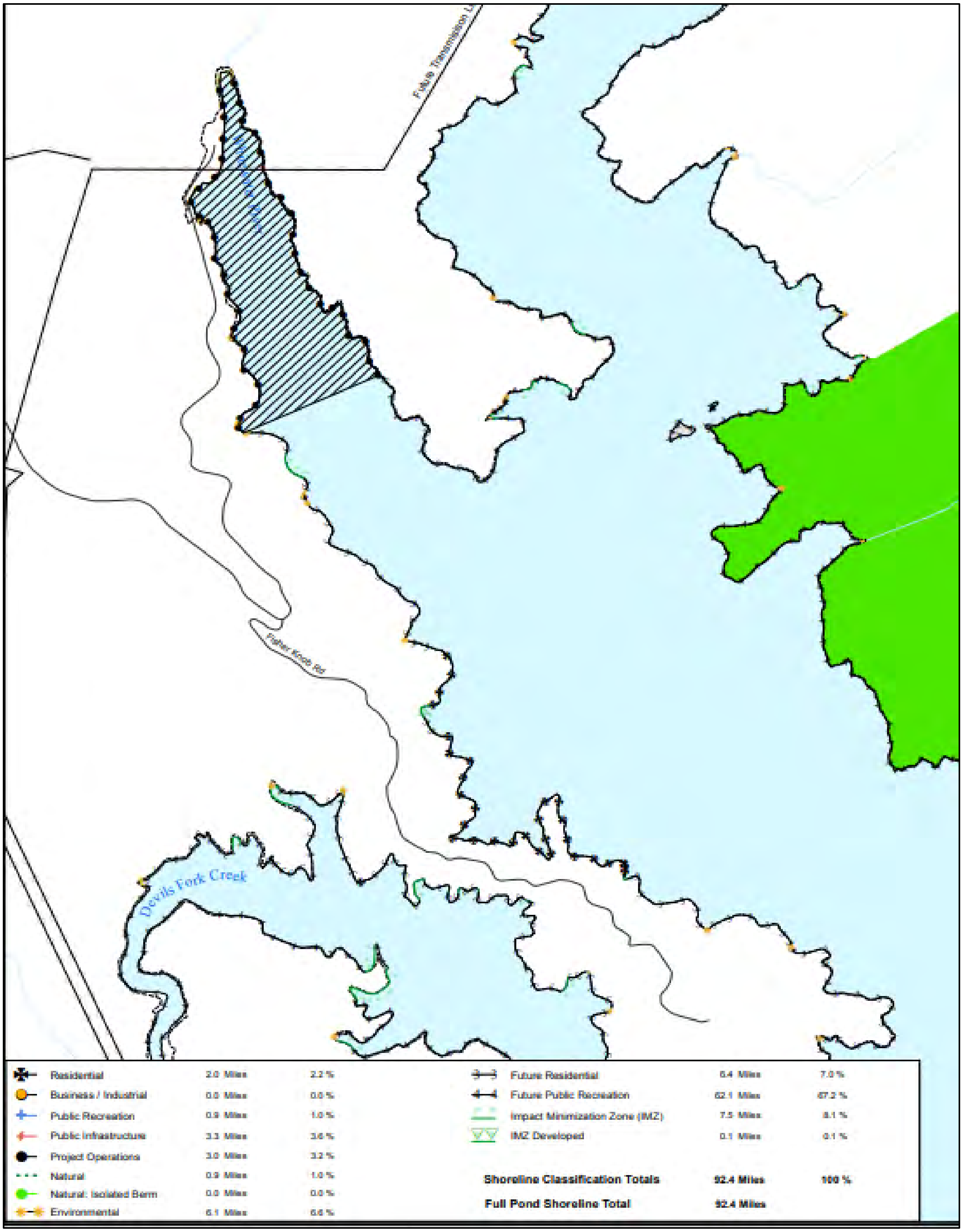


Image source: Duke Energy 2014. Jocassee Development Sheet 2 of 3.

Figure 6-13. KT SMP Shoreline Classification Map for Project Area

6.1.4 Existing Landscape Patterns

6.1.4.1 Form

The region is characterized by informal naturalistic forms of meandering lines and organic edges of the mountain ridges and lake shore edges. There are geometric forms associated with the Project, with rectangular buildings, straight lines of fences and building pads, 90-degree corners, consistent slopes and trapezoidal forms of fill slopes for spoils, pads, and dams.

6.1.4.2 Line

The predominant lines in the landscape are irregular, organic horizontal lines of the mountainous horizon, layered ridges and valleys, and forested lake shore. The Project introduces straight lines into the landscape, with vertical buildings and regularly-sloped dams and spoil areas. The cleared primary transmission corridor is a straight line in contrast to the meandering and organic ridgelines of the surrounding landscape.

6.1.4.3 Color

The primary color palette of the area is earth-toned, with shades of medium to dark green of the forest in the spring and summer, and shades of yellow, orange, and brown in the fall and winter. The sky and reflection in the reservoirs add strong areas of blue to the landscape.

The Project features are primarily light colors, with white buildings and pale stone dam embankments and service areas. Cleared grassy areas associated with the Project are a light green, which contrasts with the darker green of the surrounding forest. The primary transmission line corridor creates a color contrast of lighter colored grasses/shrubs in the corridor compared with the surrounding darker forests that it passes through.

6.1.4.4 Texture

There is a fine texture to the areas of grass and shrubs in the cleared areas around the Project and the transmission line corridor. Project buildings and transmission towers have a smooth texture, with potential for reflectivity. The forest in the area, which is the predominant matrix of the area, has a medium texture. The reservoir and lake have a smooth and reflective texture.

6.1.4.5 Pattern

The landscape is largely characterized by contiguous mixed pine-hardwood forested mountains, with limited human development along the western and southern Lake Jocassee shoreline, and to the south of Lake Jocassee. The development along the lake shore is visually insignificant, in scope, size, and scale of the buildings and development. The Project and the primary transmission line corridor are anomalies in the context of the overall landscape pattern.

6.1.5 Summary of Existing Landscape Description

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.

6.2 Task 2 – Seen Area Analysis

The Seen Area Analysis results are shown on Figure 6-14 through Figure 6-25. 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 inlet/outlet structure would be restricted to the smallest area.

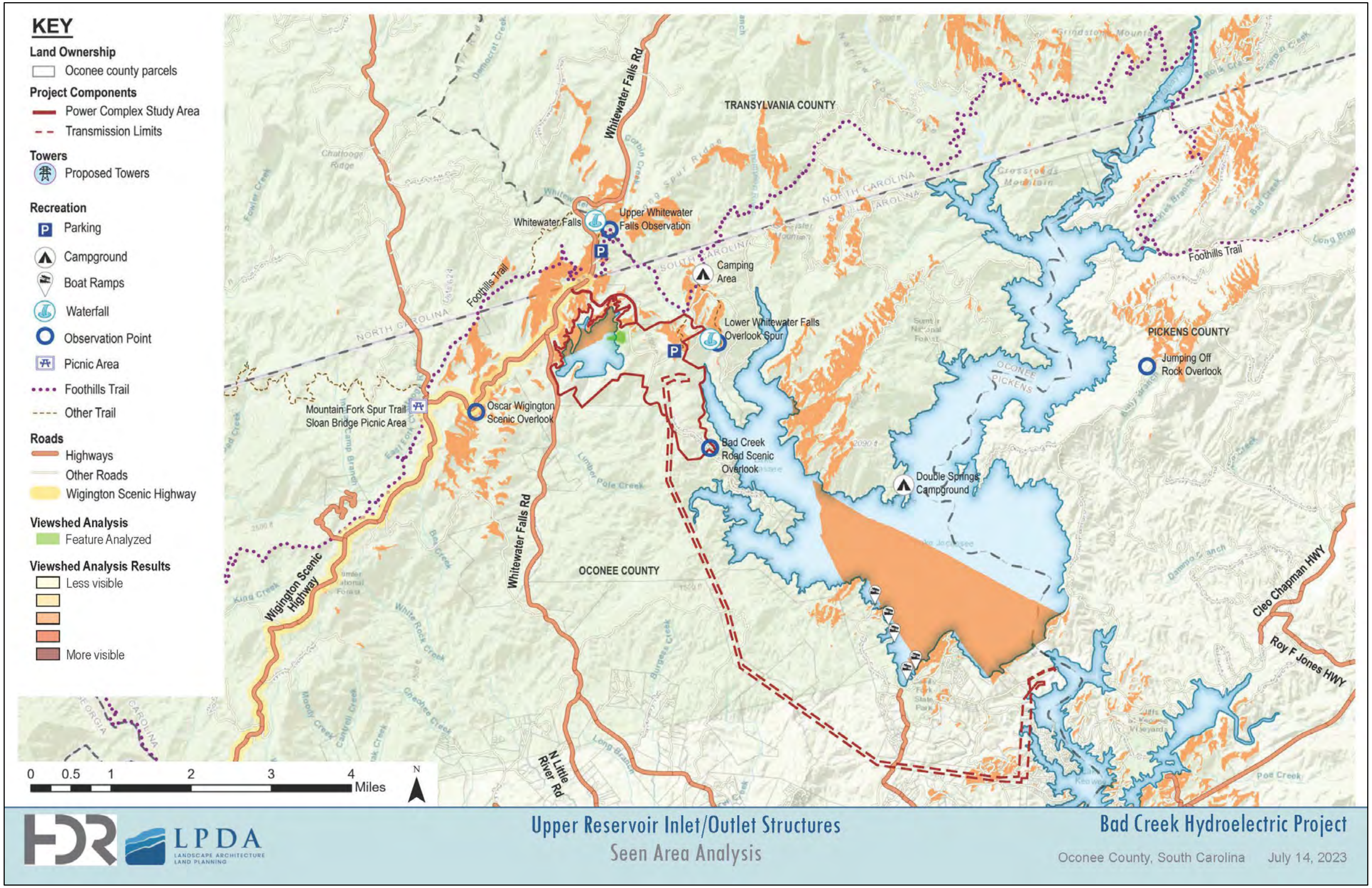


Figure 6-14. Proposed Upper Reservoir Inlet/Outlet Structure Seen Area Analysis

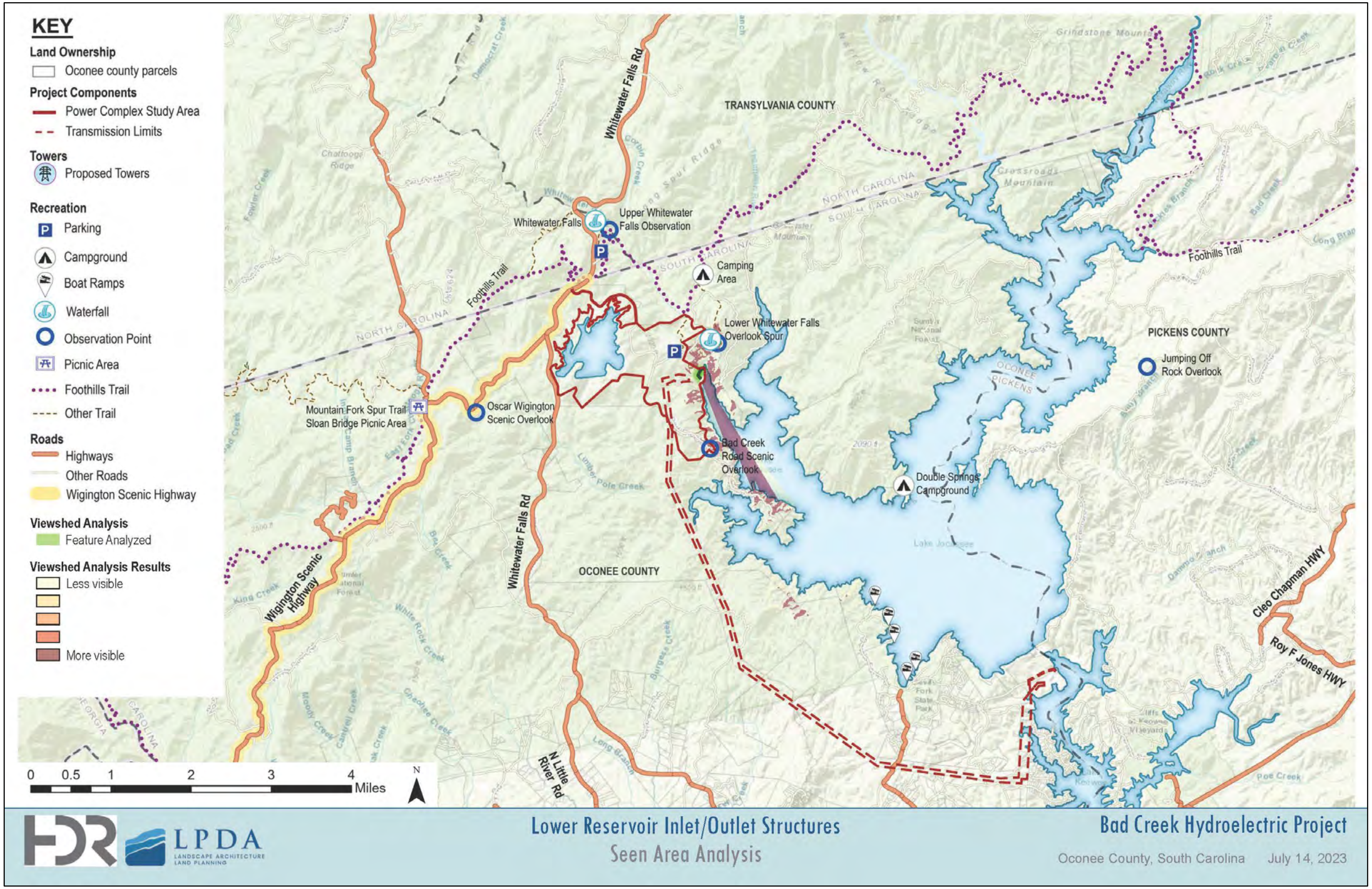


Figure 6-15. Proposed Lower Reservoir Inlet/Outlet Structures Seen Area Analysis

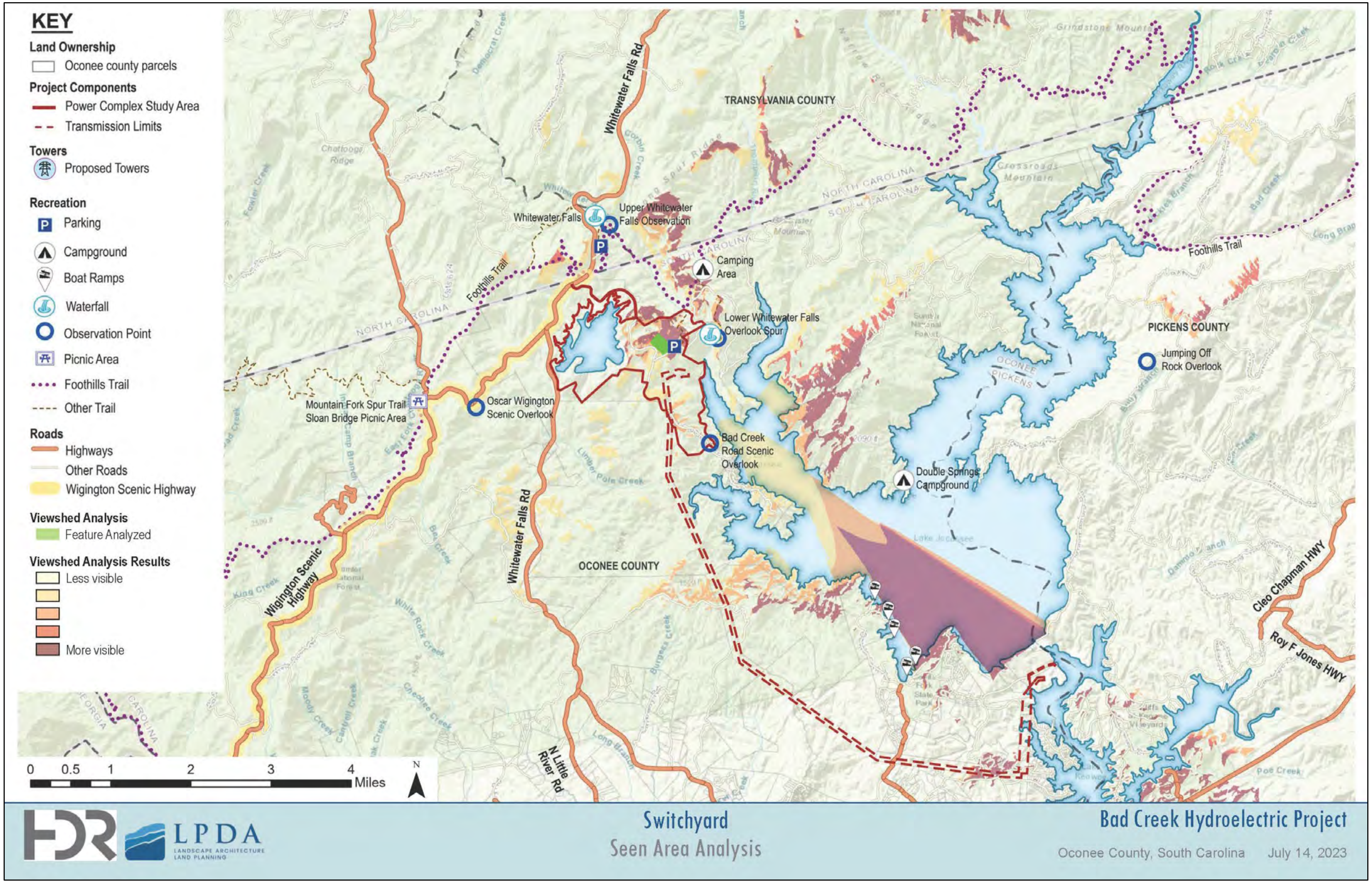


Figure 6-16. Proposed Switchyard Seen Area Analysis

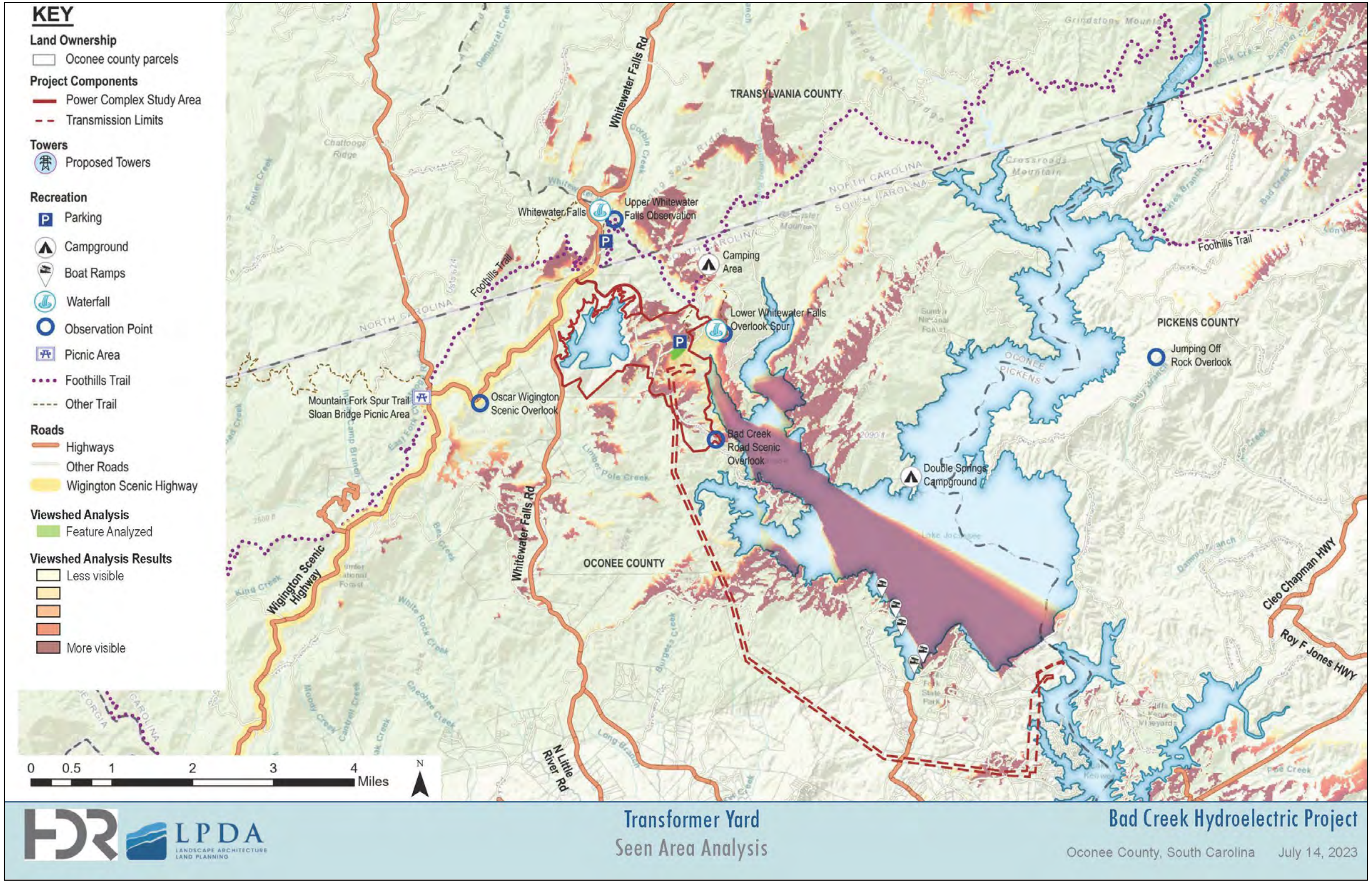


Figure 6-17. Proposed Transformer Yard Seen Area Analysis

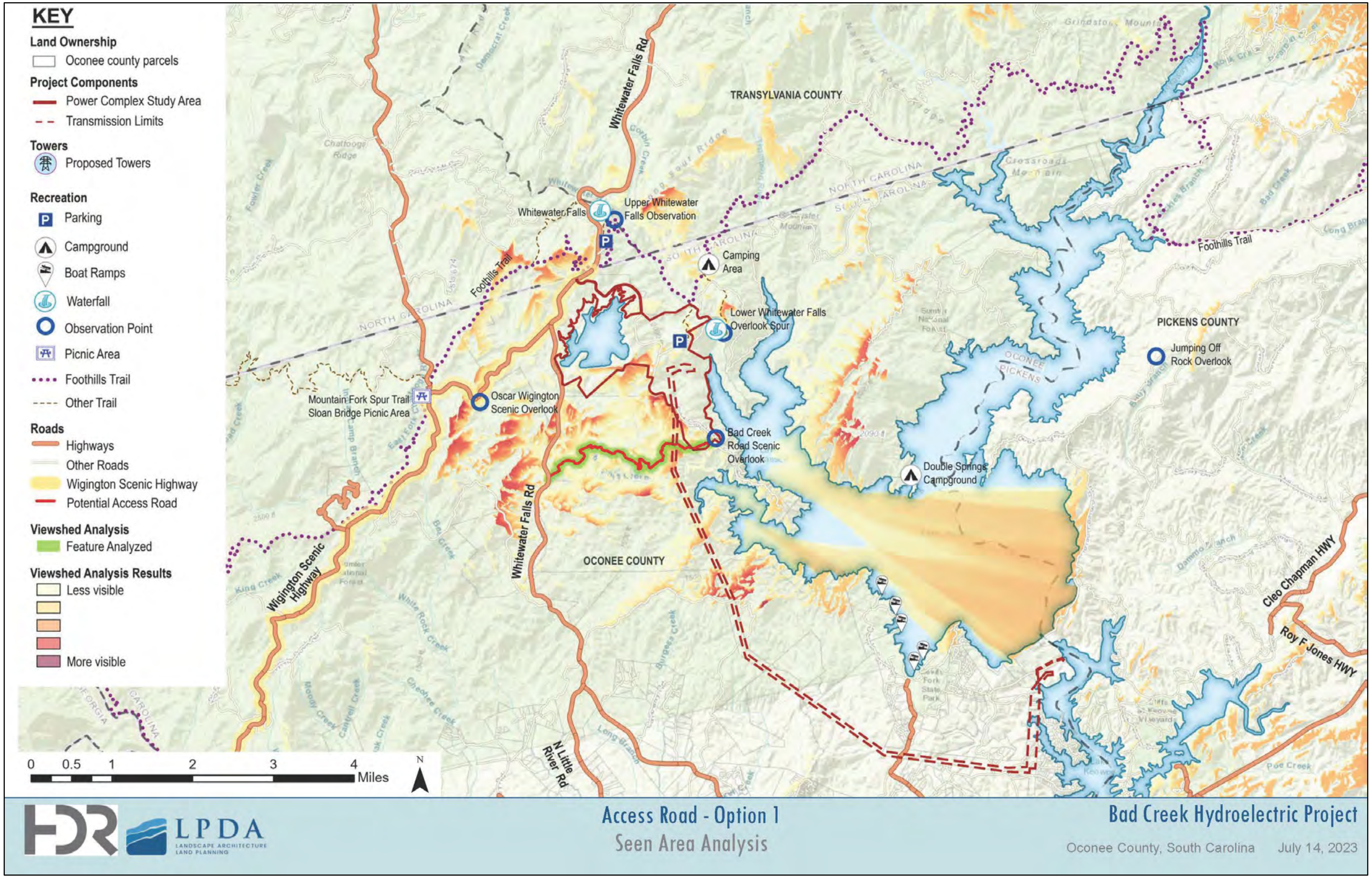


Figure 6-18. Proposed Access Road (Option 1) Seen Area Analysis

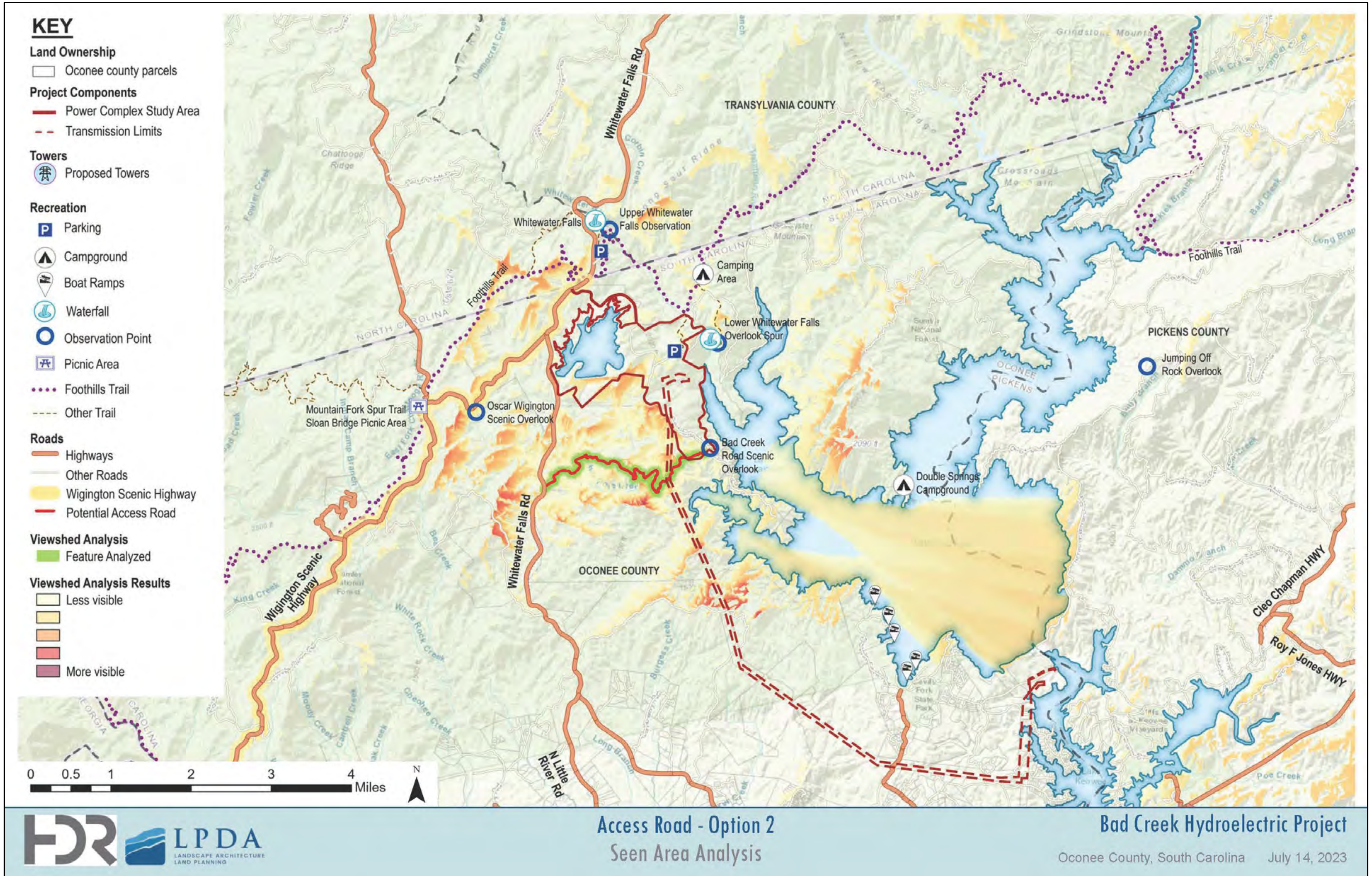


Figure 6-19. Proposed Access Road (Option 2) Seen Area Analysis

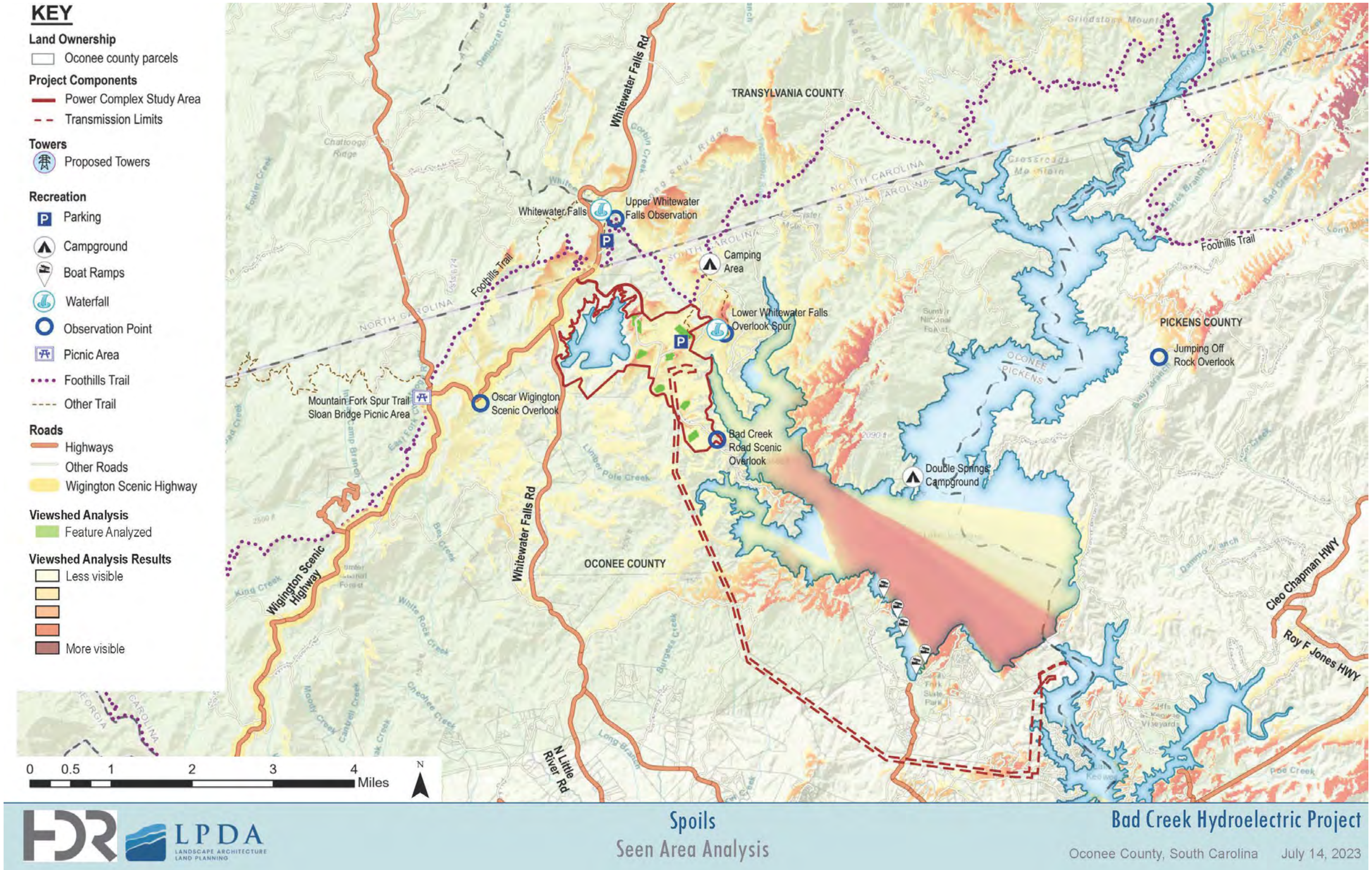


Figure 6-20. Proposed Spoil Areas Seen Area Analysis

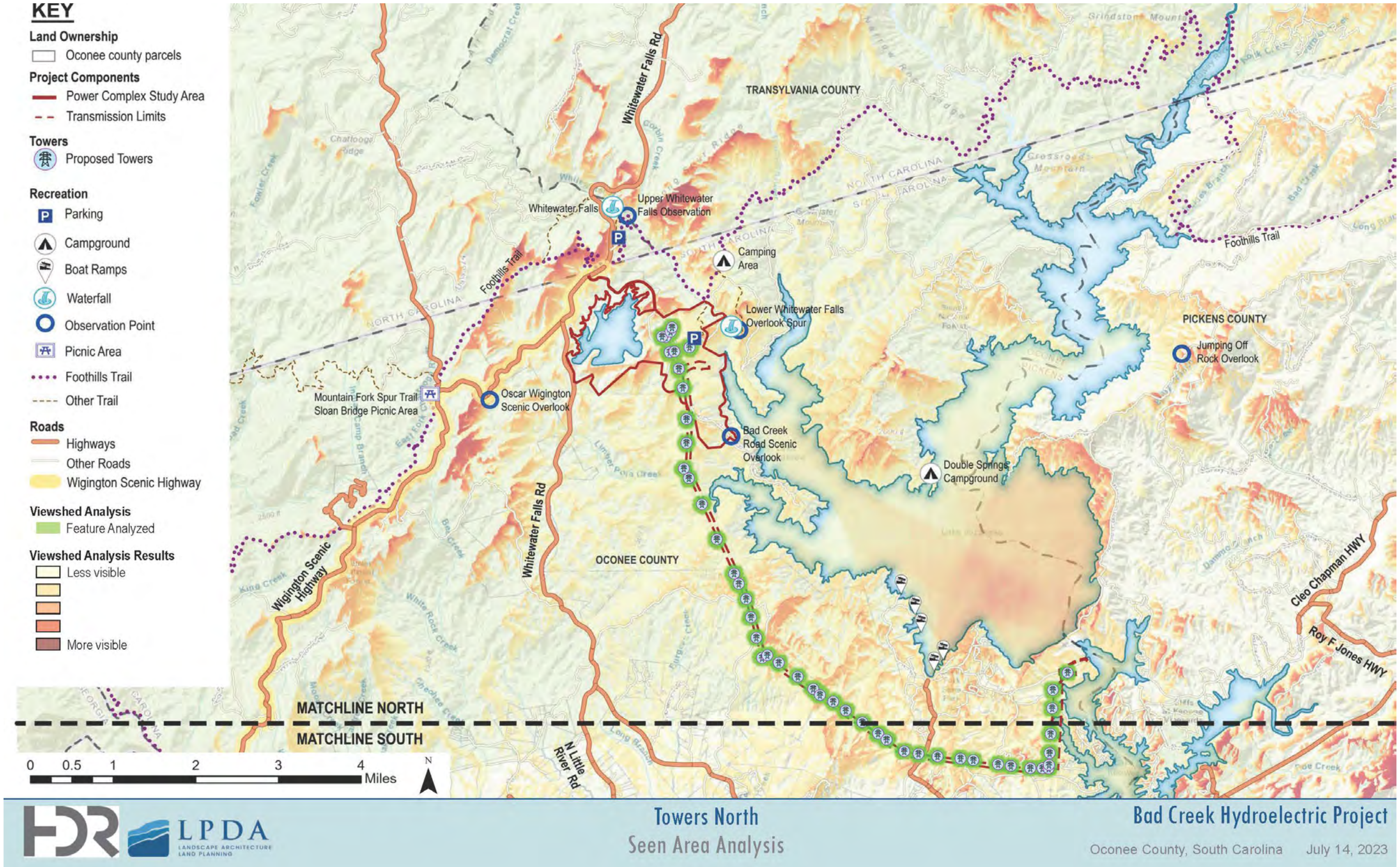


Figure 6-21. Proposed Primary Transmission Line Towers (North) Seen Area Analysis

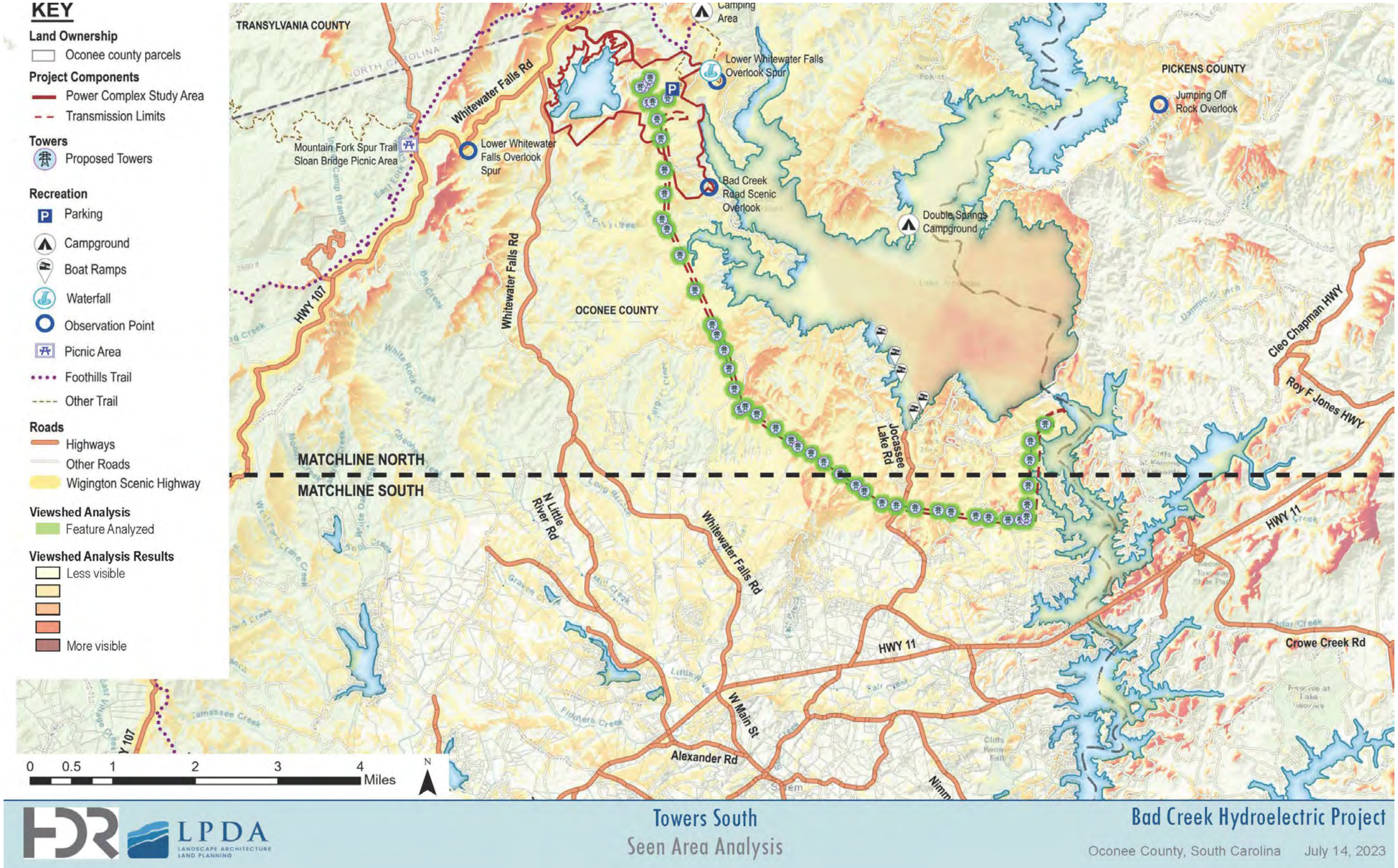


Figure 6-22. Proposed Primary Transmission Line Towers (South) Seen Area Analysis

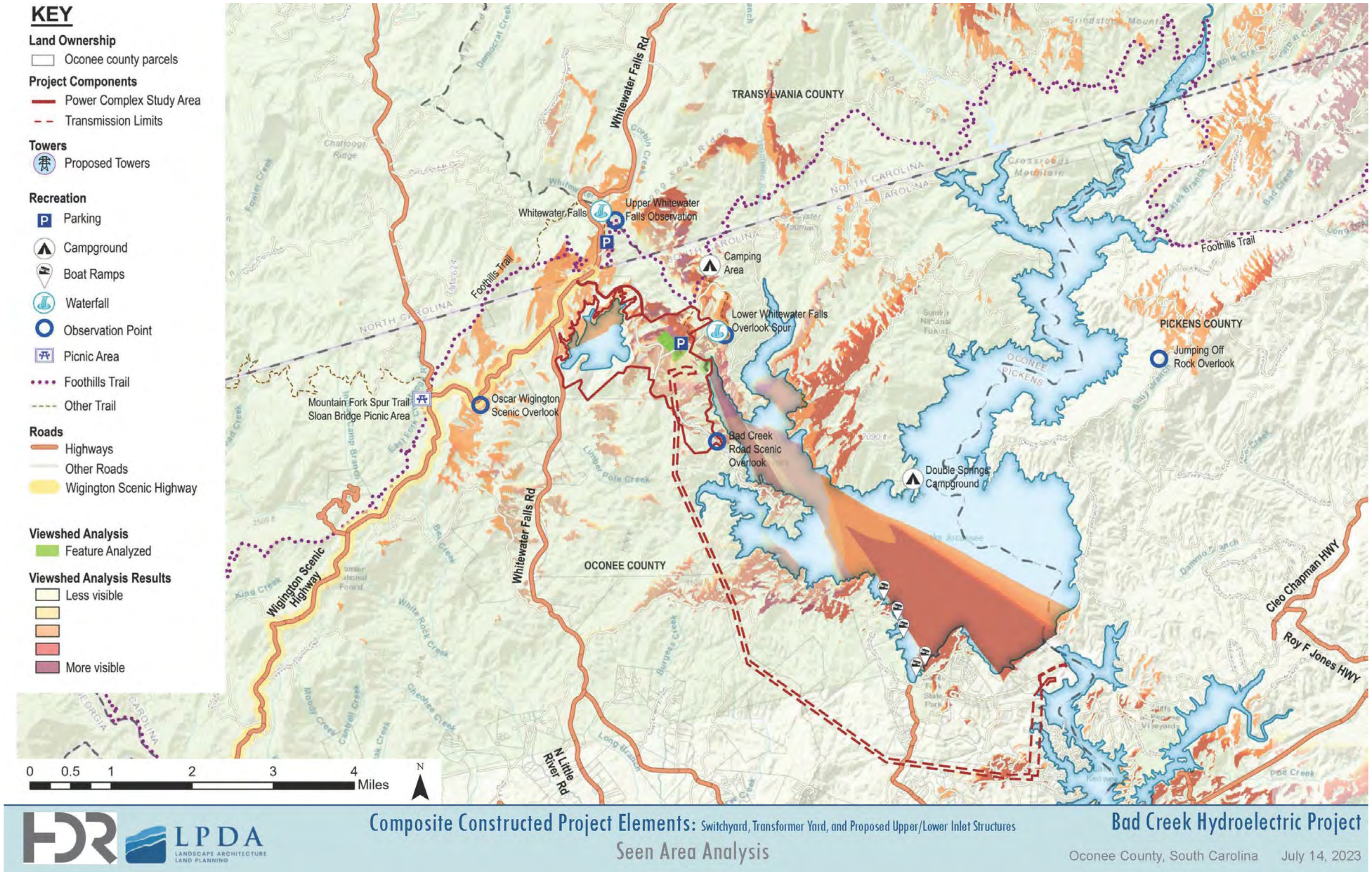


Figure 6-23. Composite Constructed Proposed Project Elements Seen Area Analysis

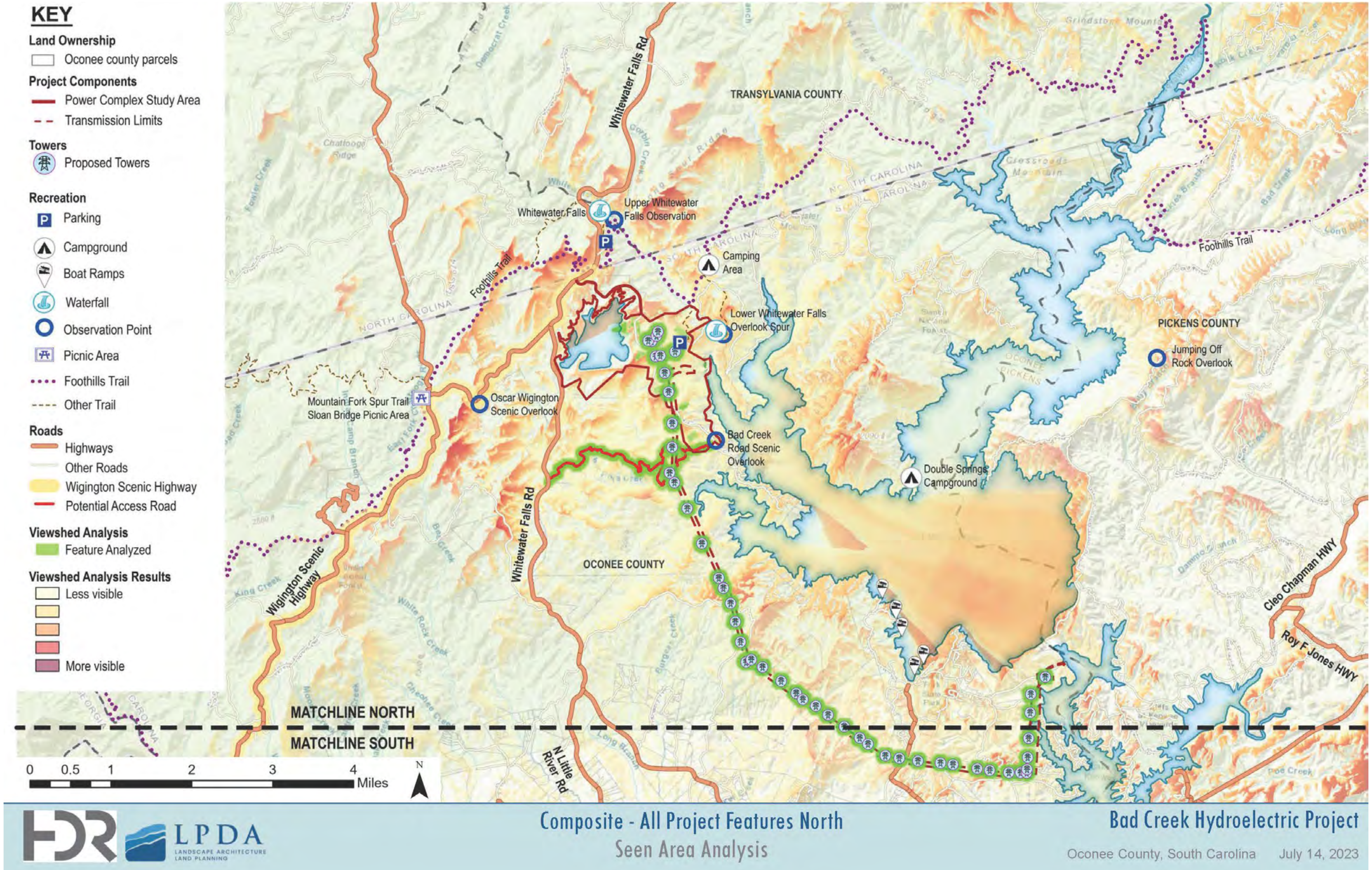


Figure 6-24. Composite – All Proposed Project Features (North) Seen Area Analysis

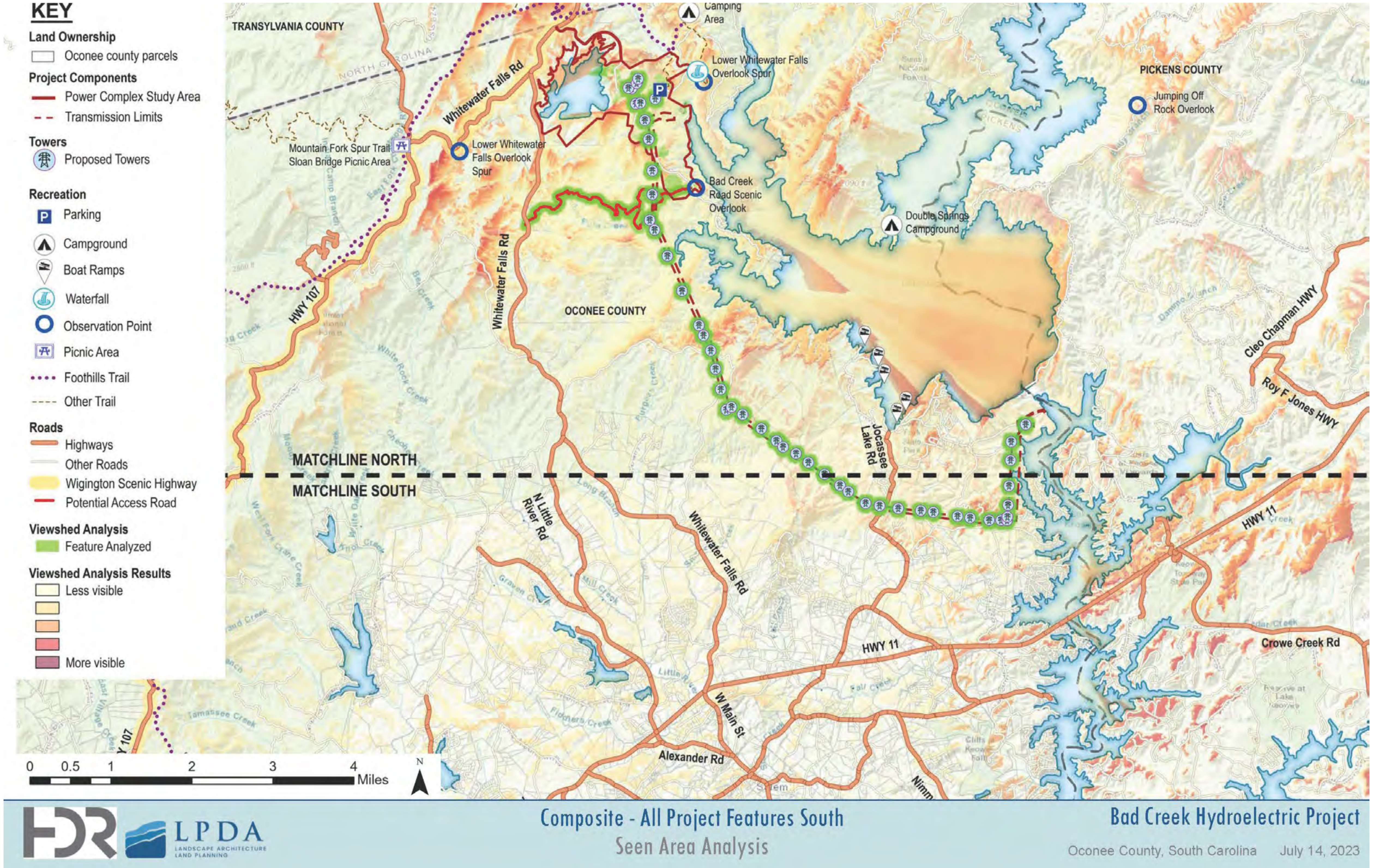


Figure 6-25. Composite – All Proposed Project Features (South) Seen Area Analysis

6.3 Tasks 3 & 4 – Field Investigation and Key Views Selection

The RC selected six potential Key Views (out of the original 11 proposed) for field investigation as shown in Table 6-1 and Figure 6-25. During the evaluation of the views, the RC reviewed the seen area analysis results, accessibility of potential Key Views to the public, and prior visualization work associated with initial project planning.

The RC 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. Duke Energy agreed to include an analysis of the visual effects along with the additional four visualizations to be developed for this study.

On October 11, 2023[13], Duke Energy provided the RC with its proposal to capture nighttime views of the existing Project to use in evaluating potential lighting effects resulting from Bad Creek II operations (lighting evaluations are for normal future Project operations, not construction). The proposal identified four potential locations as shown on Figure 6-27.

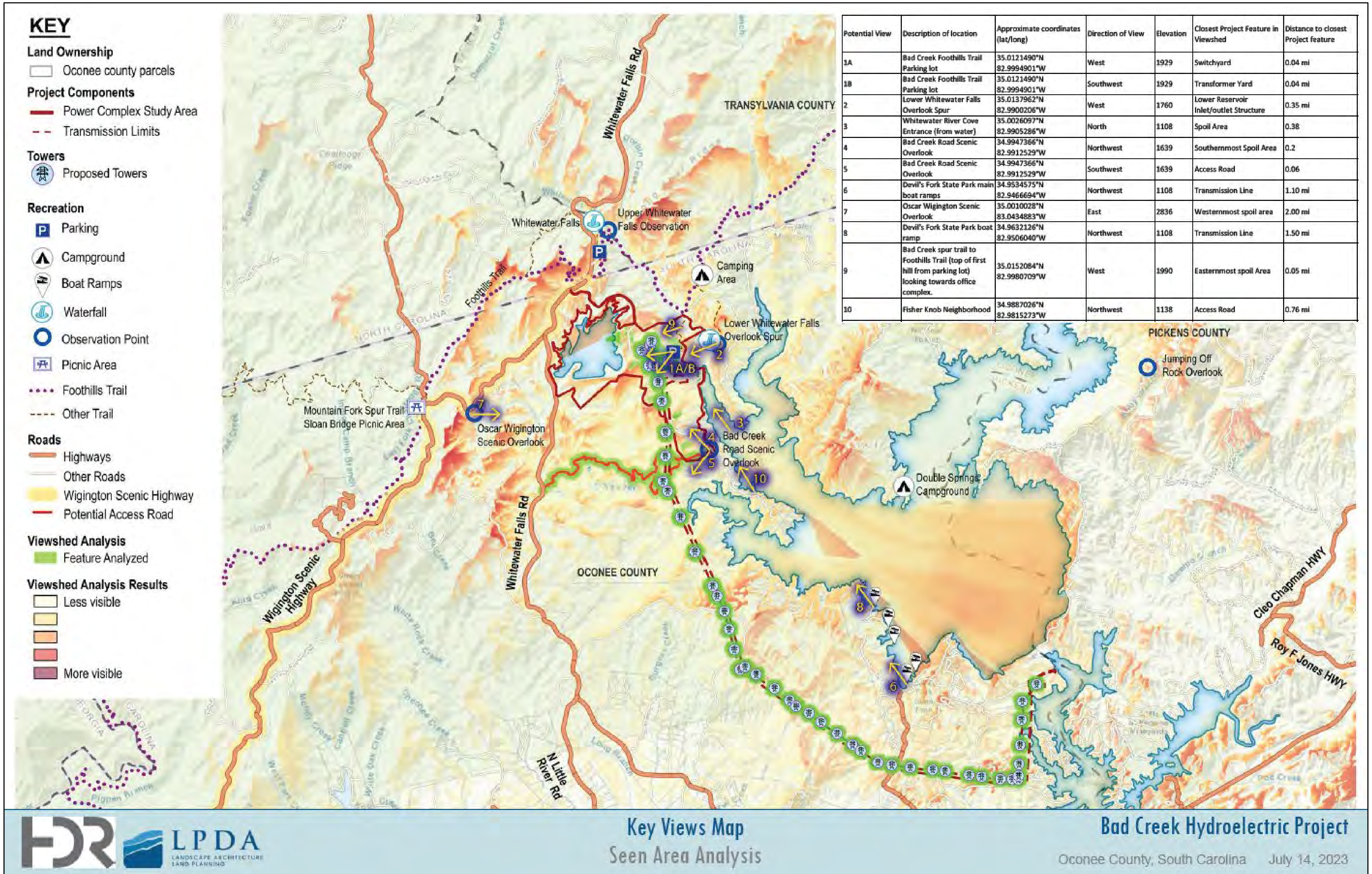
The field crew collected photos on December 6, 2023. Daytime views were collected by a three-person crew between 10:00 am and 1:30 pm; night views were collected between 6:00 pm and 9:30 pm. Weather conditions were good for photography with clear conditions during both sessions. Both 24 millimeter (mm) and 50 mm images were collected for all views.

[13] See email in Appendix A.

Table 6-1. Potential Key Views

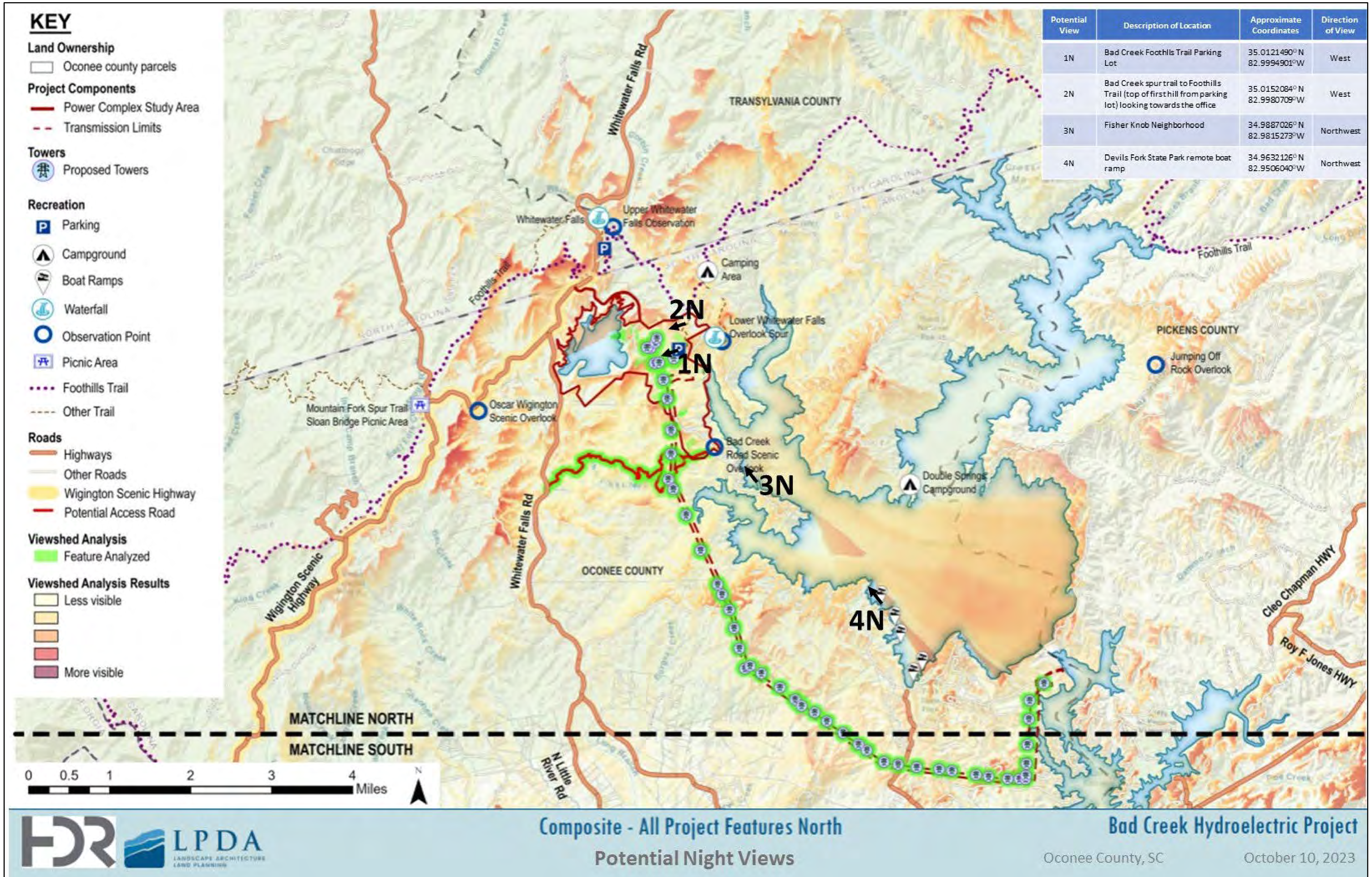
Potential View	Description of location	Approximate coordinates (lat/long)	Direction of View	Elevation (ft msl)	Potential Key View[1]
1A	Bad Creek Foothills Trail parking lot	35.0121490°N 82.9994901°W	West	1929	No
1B	Bad Creek Foothills Trail parking lot	35.0121490°N 82.9994901°W	Southwest	1929	No
2	Lower Whitewater Falls Overlook	35.0137962°N 82.9900206°W	West	1760	Yes
3	Whitewater River cove entrance (from water)	35.0026097°N 82.9905286°W	North	1108	Yes[2]
4	Bad Creek Road Scenic Overlook	34.9947366°N 82.9912529°W	Northwest	1639	Yes
5	Bad Creek Road Scenic Overlook	34.9947366°N 82.9912529°W	Southwest	1639	Yes
6	Devils Fork State Park main boat ramps	34.9534575°N 82.9466694°W	Northwest	1108	No
7	Oscar Wigington Scenic Overlook	35.0010028°N 83.0434883°W	East	2836	Yes
8	Devils Fork State Park boat ramp	34.9632126°N 82.9506040°W	Northwest	1108	No
9	Bad Creek spur trail to Foothills Trail (top of first hill from parking lot) looking towards office complex.	35.0152084°N 82.9980709°W	West	1990	Yes
10	Fisher Knob neighborhood	34.9887026°N 82.9815273°W	Northwest	1138	Yes

Notes: [1]Potential Key View selected by the RC at its July 2023 meeting for field investigation; [2]Visualization completed during project planning.



Potential View	Description of location	Approximate coordinates (lat/long)	Direction of View	Elevation	Closest Project Feature in Viewshed	Distance to closest Project feature
1A	Bad Creek Foothills Trail Parking lot	35.0121490°N 82.9994901°W	West	1929	Switchyard	0.04 mi
1B	Bad Creek Foothills Trail Parking lot	35.0121490°N 82.9994901°W	Southwest	1929	Transformer Yard	0.04 mi
2	Lower Whitewater Falls Overlook Spur	35.0137962°N 82.9900206°W	West	1760	Lower Reservoir Inlet/outlet Structure	0.35 mi
3	Whitewater River Cove Entrance (from water)	35.0026097°N 82.9905286°W	North	1108	Spoil Area	0.38
4	Bad Creek Road Scenic Overlook	34.9947366°N 82.9912529°W	Northwest	1639	Southernmost Spoil Area	0.2
5	Bad Creek Road Scenic Overlook	34.9947366°N 82.9912529°W	Southwest	1639	Access Road	0.06
6	Devil's Fork State Park main boat ramps	34.9534575°N 82.9466694°W	Northwest	1108	Transmission Line	1.10 mi
7	Oscar Wigington Scenic Overlook	35.0010028°N 83.0434883°W	East	2836	Westernmost spoil area	2.00 mi
8	Devil's Fork State Park boat ramp	34.9632126°N 82.9506040°W	Northwest	1108	Transmission Line	1.50 mi
9	Bad Creek spur trail to Foothills Trail (top of first hill from parking lot) looking towards office complex.	35.0152084°N 82.9980709°W	West	1990	Easternmost spoil Area	0.05 mi
10	Fisher Knob Neighborhood	34.9887026°N 82.9815273°W	Northwest	1138	Access Road	0.76 mi

Figure 6-26. Potential Daytime Key Views



Potential View	Description of Location	Approximate Coordinates	Direction of View
1N	Bad Creek Foothlls Trail Parking Lot	35.0121490° N 82.9994901°W	West
2N	Bad Creek spur trail to Foothills Trail (top of first hill from parking lot) looking towards the office	35.0152084° N 82.9980709°W	West
3N	Fisher Knob Neighborhood	34.9887026° N 82.9815273°W	Northwest
4N	Devils Fork State Park remote boat ramp	34.9632126° N 82.9506040°W	Northwest

Figure 6-27. Potential Night Views

The field crew made decisions to adjust view locations based on field conditions (i.e., vegetation and accessibility) and the visibility of existing and potential Bad Creek II features. Changes to the daytime view locations are as follows:

- View 5 Bad Creek Road Scenic Overlook (southwest): Views from the overlook towards the southwest were heavily dominated by vegetation. Other than a glimpse of the primary transmission line, no Project features were visible. Given the Bad Creek II primary transmission line would be adjacent to the existing line, the field crew eliminated this view.
- View 9 Bad Creek spur trail to the Foothills Trail: The spur trail is heavily screened from the site by vegetation even during leaf-off conditions. Given the limited visibility, the team evaluated shifting to the trailhead at the parking lot and the information kiosk at Musterground Road; the field crew substituted a view from the Musterground Road entrance. Because this potential view would be dominated by the transformer yard and switchyard in the foreground, only a 24-mm image was collected.
- View 10 Fisher Knob: The field crew obtained photos from two locations on Fisher Knob. One location, View 10a, is the closest existing private dock at the lake. The other location, View 10b, is farther south on a prominent point.

The field crew made the following changes to the night view locations:

- View 2N Bad Creek spur trail to the Foothills Trail: This view was eliminated based on the team's experience earlier in the day and the limited use of the trail during dark conditions.
- View 3N Fisher Knob: The crew obtained photos from the same two locations at Fisher Knob used for the daytime views. These are designated as 3N(a) and 3N(b).
- View 4N Remote Day Use Boat Ramp at Devils Fork State Park: No light was apparent from the existing Bad Creek site even without moonlight. The crew then visited Jocassee Dam to evaluate if the higher elevation would provide a view of light from the site; no such light was visible. and photos were not collected at either location.

As described in Section 5.4, the RC met on January 11, 2024, to review the photos and select those to use with the remaining study tasks. After discussion, the RC elected to proceed with the following Key Views:

- Key View 2: Lower Whitewater Falls Observation Platform
- Key View 3: Lower Reservoir Inlet/Outlet Portal from Lake Jocassee
- Key View 4: Bad Creek Visitor Overlook (Northwest)
- Key View 7: Oscar Wigington Scenic Overlook
- Key View 10b: Fisher Knob Point

The RC elected to use Night Views 1N[14] and 3Nb for the lighting assessment. Photos of Key Views are included in Appendix.

6.4 Tasks 5 & 6 – Existing Visual Quality Assessment and Visual Analysis

6.4.1 Key View 2 – Lower Whitewater Falls Observation Platform

The Lower Whitewater Falls Observation Platform (Observation Platform) is accessed from a Foothills Trail spur trail (Figure 6-28). It was developed to provide safe viewing of the Lower Whitewater Falls which is north of the lower intake/outlet portal on Lake Jocassee. Vegetation between the Observation Platform and the falls is actively managed to facilitate viewing of the falls, but no such vegetation management is currently occurring to facilitate views of Project features.

The seen area analysis results presented in Section 6.2 identified the following features as visible from the Observation Platform: upper reservoir inlet/outlet portal, lower reservoir inlet/outlet portal, spoil areas, and transmission towers. However, because of the dense vegetation present, even during leaf-off conditions, the only existing Project features that are visible from the Observation Platform are existing transformer yard structures, transmission lines and towers

[14] Design changes after the fieldwork was completed shifted the location of the Bad Creek II transformer yard such that Site 1N will be within the transformer yard. Therefore, this site was eliminated from use for additional lighting visualizations.

associated with the existing transformer yard, and the excavated wall behind the existing lower reservoir inlet/outlet portal. This demonstrates the role the heavily vegetated nature of the surrounding landscape plays in limiting views of existing Project features and proposed Bad Creek II features.

6.4.1.1 Existing Conditions

At this Key View (2), the overall scenic class rating is 4 (moderate value). The colors are generally dark greens, browns, and grays, during leaf-off conditions. Dominant lines and textures are organic with vertical lines in the immediate foreground and foreground, defined by the trees. and the effect of adjacent scenery is minimal.

The dominant view is of the immediate foreground/foreground due to the dense evergreen and deciduous vegetation, even in the leaf-off condition. The middle ground is indistinguishable due to the slope of the land between the foreground and the background. The background is visible in the leaf-off condition and would likely be obscured in the leaf-on condition. During leaf-off periods, the horizon line is attractive due to the gentle slope of the ridge and the contrast with the sky. The horizontal ridgeline is prominent. Cultural modifications include three transmission towers, transmission lines, and exposed rock areas adjacent to the outlet structure. The horizontal lines of the transmission wires mimic that of the ridgeline and are only moderately visible during the leaf-off condition. The existing outlet structure and portions of three transmission towers in the background are visible under leaf-off conditions. The outlet structure reads as a light tan patch in the surrounding landscape. The lines of the transmission tower are similar to the lines of the vegetation in this view, but the light metal color stands out against the dark background vegetation.

The overall Scenic Integrity Objective of this view is high. The noticeable deviations (the lower reservoir inlet/outlet structure and transmission towers and lines) are not visually dominant at this scale during leaf-off conditions and are anticipated to not be visible during the leaf-on condition due to dense foliage in the immediate foreground/foreground.

6.4.1.2 Proposed Conditions

The proposed conditions view includes additional transmission lines and a portion of the excavated hillside that would be located upland of the lower reservoir inlet/outlet structure portal.

The additional transmission lines are slightly more visible than the existing lines. While still mimicking the horizontal lines of the ridgeline, the pale metal lines now draw attention to the transmission structures below the ridgeline, accentuating the presence of the utilities within the landscape.

The excavated hillside is visible in the leaf off condition but is not visually obtrusive. The hillside appears as a tan patch in the lower portion of the view and does not significantly alter the scenic quality.

Figure 6-28. Key View 2: Lower Whitewater Falls Observation Platform (Top-existing Conditions; Bottom-proposed conditions)

6.4.2 Key View 3 – Lower Reservoir Inlet/Outlet Portal from Whitewater River cove of Lake Jocassee

Key View 3 provides a view of the lower reservoir inlet/outlet portal while boating on Lake Jocassee (Figure 6-29).[15] Unlike the other Key Views, Key View 3 was developed during initial project planning depicting leaf-on conditions. However, because the primary Bad Creek II facilities within the view are along the shoreline, vegetation does not obscure Project features.

6.4.2.1 Existing Conditions

At this Key View (3), the overall scenic class rating is 5 (moderate to low value). The colors are blues and grays, greens, tans and browns, in leaf-on conditions. Dominant lines are sloping and organic, defined by the steeply sloping hills, rockfaces, and reflections in the water. Textures range from smooth in the watery foreground to soft in the middle ground wooded hillside. The structures provide a contrasting sharp texture. The effect of adjacent scenery is non-existent due to the confined nature of this view.

The dominant view is of the foreground, the structures and hillside on the edge of the lake. The immediate foreground consists of calm lake water and one buoy. At the edge of the lake, still in the foreground, there are several structures that are incompatible with the scenic quality of the surrounding landscape. On the rocky hillside above the lake side structures, there is a large white retaining wall. The middle ground from this view consists of the horizon line of wooded hilltops. There is no background in this view due to the confined nature of the view.

The overall Scenic Integrity Objective of this view is low. The deviations (lakeside structures, fencing, retaining wall) dominate the view and do not share attributes with the surrounding landscape.

6.4.2.2 Proposed Conditions

The proposed condition view includes the Bad Creek II lower reservoir inlet/outlet structure, the access portal structure, and an exposed rock slope.

The proposed changes to this view are visible throughout the year and are visually noteworthy. The proposed white access portal and lower inlet/outlet structure significantly contrast with the

[15] Potential modifications associated with remediation of the landslide that occurred on January 20, 2024, are not reflected in either the existing conditions or proposed conditions.

adjacent trees and lake. The exposed rock slope behind these structures highlights the visual intrusion. The combination of proposed grading, clearing, and built structures have a substantial visual effect on the Scenic Integrity of this view.

Figure 6-29. Key View 3: Lower Reservoir Inlet/Outlet Structures Viewed from Whitewater River cove of Lake Jocassee (Top- existing conditions; Bottom-proposed conditions)

6.4.3 Key View 4 – Bad Creek Visitor Overlook (Northwest)

Duke Energy's Bad Creek Visitor Overlook is accessed from Bad Creek Road (Figure 6-30). It includes a gazebo that provides views of Lake Jocassee and the surrounding landscape. The team found the clearest view of existing Project facilities is not at the gazebo, but closer to the parking area along the fence line for the site.

6.4.3.1 Existing Conditions

At this Key View (4), the overall scenic class rating is 3 (moderate to high value). The colors are generally dark browns and grays with patches of dark green, in leaf off conditions. There is a tan line along the shoreline, which contrasts with the dark blue/black of the lake. Dominant lines and textures are defined the rolling slopes, the understory vegetation, and the undulating horizon line, The effect of adjacent scenery is predominant; framed by the slope and vegetation in the foreground.

The dominant view is of the middle ground and background, framed by shrubs and small trees in the immediate foreground and foreground. The immediate foreground is dominated by understory vegetation and a few small trees around the periphery. The middle ground from this view consists of a sloping hillside with low grassy vegetation. Also in the middle ground is the visible section of Lake Jocassee and the shoreline. There is a steep rocky ravine bisecting the mountains, providing visual interest. The cultural modifications in this view are located in the middle ground; the pale gray and tan lower inlet/outlet structure along the shoreline and a transmission tower on the sloping wooded hillside. The background is visible and dominant throughout the year due to lack of screening vegetation The horizon line is attractive due to the undulating line of the ridge and the contrast with the sky.

The overall Scenic Integrity Objective of this view is moderate. The noticeable deviations (the lower inlet/outlet structure, and transmission tower) are moderately intrusive and may not be visible during the leaf-on condition.

6.4.3.2 Proposed Conditions

As shown in the proposed conditions visualizations, an upland area would be excavated in conjunction with the development of Bad Creek II's lower reservoir inlet/outlet portal and the access portal. An area of the Whitewater River cove of Lake Jocassee would also be excavated, creating a small, recessed cove adjacent to the lower inlet/outlet portal.

The proposed grading and structures are clearly visible in this view. This disturbed area is expanded by almost 100 percent and the additional structures introduce new unnatural colors to the view (dark green or blue rooftop). The excavated cove leading to the lower inlet/outlet portal is clearly visible and reflects the excavated hillside. While the area of disturbance within the view only comprises approximately 1/60th of the view area, the location within the view is dominant; the sloping lines of the mountains and the linear shape of the lake all terminate at the project site. The colors of the proposed elements (excluding the rooftop) are mostly brown, tan, and pale gray, which reflect the colors of the winter landscape (in leaf-off condition). These colors will likely be in contrast to the vibrant greens of spring and summer, which could result in pronounced visibility of the Bad Creek II features.

Figure 6-30. Key View 4: Inlet/Outlet Portal from the Bad Creek Visitor Overlook (Top-existing conditions; Bottom-proposed conditions)

6.4.4 Key View 7 – Oscar Wigington Scenic Overlook

The Oscar Wigington Scenic Overlook is accessed from the Oscar B. Wigington Scenic Byway in the Sumter National Forest (Figure 6-31).

6.4.4.1 Existing Conditions

At this location, the overall scenic class rating is 2 (high value). The colors are blues and grays as well as greens, tans and browns during leaf-off conditions. Dominant lines are horizontal and organic, defined by the horizon, background hills, and tops of middle ground evergreen trees. There are faint horizontal lines created by the transmission lines in the close background. Textures range from fine and sharp in the foreground vegetation to smooth and soft in the lake and hills in the background. The effect of adjacent scenery is predominant and framed by the foreground vegetation.

The dominant view is of the background, supported by the low vegetation in the foreground and middle ground. The immediate foreground is dominated by the tops of deciduous trees and large shrubs. The middle ground from this view consists of a thick swatch of evergreen trees below the horizon line. The colors are predominately dark greens. The background is visible and dominant throughout the year due to lack of screening vegetation The long view to the straight and clean horizon line is attractive and displays a subtle contrast with the sky. There is a transmission line in the background that may glint in the sunlight and is likely visible throughout the year, although it is not visually dominant.

The overall Scenic Integrity Objective of this view is very high. The deviation (the transmission line) is minute and does not detract from the scenic quality.

6.4.4.2 Proposed Conditions

As with existing conditions, the only Bad Creek II features visible from the overlook are associated with the primary transmission line. Both additional conductors (i.e., wires) and transmission towers would be visible.

The visual impact of the proposed transmission lines is noticeable but not significant. The bright metallic clusters accentuate the undulating horizontal lines that stretch across the close background portion of the view, but the overall impact to the view is minimal.

Figure 6-31. Key View 7: Project Primary Transmission Line from the Oscar Wiginton Scenic Overlook (Top-existing conditions; Bottom-proposed conditions)

6.4.5 Key View 10b – Fisher Knob Point

6.4.5.1 Existing Conditions

At this Key View (10b) [16], the overall scenic class rating is 3 (moderate to high value) (Figure 6-31). The colors are blues and greens, punctuated with orange, gray and tan during leaf-off conditions. Dominant lines are horizontal, defined by the ripples in the water and the tan shoreline, and diagonal, defined by the sloping hills. Textures are generally smooth and soft in the lake and hills in the background. The effect of adjacent scenery is significant due to lack of vegetative screening or other visual obstructions.

The dominant view is of the immediate foreground - the lake. From this view, the lake comprises most of the view and provides an attractive contrast to the tree-covered hills in the middle ground and background. The middle ground from this view consists of the tan shoreline, perforated by wooden boat docks and other structures. The buildings within the middle ground appear to be constructed of wood and glass and are gray, brown, and dark green. While the colors and heights of the buildings are not overly visually intrusive, they are clearly visible and would likely not be screened during the leaf-on condition. The background is visible throughout the year due to lack of screening vegetation. The horizon line provides interest as it is located in the middle ground on the left side of the view and recedes into the background as the viewer looks to the right. As the lake extends into the background plane, there is a clear and dominant view of the lower inlet/outlet structure on the far hill side, in the center of the view.

The overall Scenic Integrity Objective of this view is moderate. The noticeable deviations (the lower inlet/outlet structure, buildings, and boat docks) are visually subordinate to the overall landscape character.

6.4.5.2 Proposed Conditions

As shown in the Proposed Conditions view, the Bad Creek II lower reservoir inlet/outlet structure, access portal, the excavated hillside associated with the structure, and a new interconnect transmission line are visible. The proposed clearing, grading and development are clearly visible in this view. Due to the central location of the Bad Creek II facilities within the

[16] Potential modifications associated with remediation of the landslide that occurred on January 20, 2024, are not reflected in either the existing conditions or proposed conditions.

view, the impact is visually significant. The colors of the proposed elements are mostly brown, tan, and pale gray, which stand in contrast to the blue-gray lake and adjacent cluster of evergreen vegetation.

Figure 6-32. Key View 10b: View of the Project from Fisher Knob Point (Top-existing conditions; Bottom-proposed conditions)

6.5 Task 7 – Visual Management Consistency Review

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 Observation area, the Visitor Overlook off Fisher Knob Road.

Stakeholders are required to be involved in the proposed development process. Various local, state, and federal entities share management of the Lake Jocassee area associated with the Project. These include Oconee County, the USFS, and the SCDNR.

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. As described below, there are no conflicts between current visual management plans and the Project or Bad Creek II.

6.5.1 Consistency with USFS Management Plans

The USFS, which manages a significant portion of the land in the northern Lake Jocassee area and some sections to the west, operates under the U.S. Code and the CFR. These codes define how the USFS manages national forest and grasslands. The agency has the responsibility to manage lands in a manner that will protect the quality of scenic values. The USFS also has guidelines in place to protect visual resources. The guidelines focus on preserving the natural landscape, minimizing visual disturbances, maintaining the overall aesthetic appeal of the forested areas, as well as managing natural resources for the good of the nation. They may include restrictions on clear-cutting, limitations on the size and location of infrastructure, and requirements for visual impact assessments.

USFS restrictions apply only USFS-managed lands and the management plans do not impose viewshed requirements on the surrounding area, therefore the proposed development of Bad Creek II does not conflict with the USFS management plans described in Section 6.1.3.1 and

Section 6.1.3.2[17]. The primary transmission line corridor bisects a section of USFS-managed land; the clear cutting required for the transmission corridor widening is in alignment of the management of this National Forest section for timber production, so there is no conflict.

6.5.2 Consistency with Jim Timmerman Natural Resources Plan

SCDNR plays a crucial role in protecting the state's natural resources, including visual resources. They collaborate with other agencies and stakeholders to develop land use plans that prioritize the conservation and preservation of scenic landscapes. These plans may include designated scenic corridors, protected viewsheds, and guidelines for managing development in sensitive areas. SCDNR has established regulations for the protection, preservation, operation, maintenance, and use of wildlife management areas and Heritage Trust areas. Regulations related to visual resource protection are not explicitly mentioned, nor would they apply to the Project or Bad Creek II.

6.5.3 Consistency with Oconee County Comprehensive Plan

Oconee County South Carolina's comprehensive plan guides future actions of the county. The plan provides direction for future activities over a 10–20-year time frame. The County has implemented land use regulations that specifically address visual resource protection. These regulations aim to maintain the scenic quality of the area by controlling development activities and ensuring that new construction projects are visually compatible with the surrounding environment. Specific regulations include setback requirements, buffer requirements, building height restrictions, and design guidelines. Utility projects are specifically excluded from the Comprehensive Plan requirements for visual resource protection, so the both the Project and Bad Creek II would be consistent with the Comprehensive Plan.

6.5.4 Consistency with KT SMP

The KT SMP was developed by Duke Energy in compliance with FERC requirements as a guiding document to "manage shoreline development to be consistent with project purposes, including the protection and enhancement of the project's scenic, recreational, cultural, and other

[17]Guidance for utility projects is available in the USFS's 2018 publication "Mitigating Visual Impacts of Utility-Scale Energy Projects". This paper focuses on approaches, processes, and techniques for mitigating visual impacts. Strategies include avoidance, siting measures, and design measures in concert to minimize and mitigate impacts.

environmental values" (Duke Energy 2023). The SMP defines acceptable activities within the KT Project boundary. The shoreline classification for the lower inlet/outlet structure is "Project Operations" and the construction of the lower inlet/outlet is consistent with this classification, including associated vegetation clearing and shoreline development.

6.6 Task 8 – Mitigation Assessment

Few adverse visual effects were identified during development of visualizations; however, potential PM&E measures that would further reduce visual effects are described in this section. A summary table of potential PM&E measures is included in Table 6-2.

6.6.1 Building and Roof Paint Colors

The existing Project buildings are generally painted light tan or various shades of blue (Figure 6-32). The roofs are silver metal. To reduce visual contrast, Bad Creek II metal or wooden buildings could be painted using earth tones (i.e., gray, light brown, khaki green) to better blend with the surrounding landscape. To reduce visual contrast in color and reflectivity, Bad Creek II metal roofs could be painted using mid-tone earth tones (i.e., gray brown, khaki green) in a matte finish to better blend with the surrounding landscape.

- **Feasibility**: High. Bad Creek II metal and wooden facilities and roofs would likely require painting, so selecting paint colors and finishes could be accomplished during project planning efforts.
- **Cost**: This would be a relatively low-cost PM&E measure since the new metal and wooden facilities would likely require painting and substituting different colors and finishes would result in little to no additional cost.
- **Effectiveness**: Paint color could decrease the contrast between Bad Creek II structures and the vegetation surrounding the site, dependent upon the color selected and time of year. However, paint colors that would blend with the surrounding landscape during leaf-off season (i.e., browns, tans, and grays) would likely not blend with leaf-on conditions (shades of green), though selecting earth-tones will match the color family. Further, paint color would not eliminate the horizontal lines associated with the structures that would contrast with the sloping lines of the mountains and hills surrounding the site.

Figure 6-33. View of Existing Warehouse and Administrative Office Complex from the Entrance to Musterground Road

6.6.2 Building and Roofing Materials

New construction can select building and roofing materials in integral colors that reduce visual contrast from the surrounding landscape and will not require later painting or other retrofit mitigation efforts in the future.

The building materials can be selected to reduce color and textural differences from the surrounding landscape. Current building siding material at the Project is often metal. Metal has a smooth finish that creates more reflectivity and differs in texture from the vegetation and rock faces in the surrounding context. Alterative siding or construction materials include wood, stone veneer, concrete block (split-face concrete block has the most texture), and fiber cement panels. These materials come in a variety of integral earth-tone colors that would blend with the surrounding landscape, and because the colors are integral to the material, will not require maintenance to maintain the color. Stone veneer and concrete masonry units can be selected to match the color of indigenous rocks, reducing the contrast of the new construction to the surrounding landscape and using the same “language” of materials.

Metal roofing (steel) is a durable, low-maintenance, and long-lived roofing material appropriate to industrial projects. The powder-coating method bonds the color to the metal surface, and will not require future painting to maintain the color. Metal roofs are available in a variety of powder-coated colors in earth-tone shades (gray, brown, khaki green). If available from the manufacturer, a matte finish could be selected to reduce the textural difference and reflectivity of the roof, to reduce its impact on the surrounding landscape.

- **Feasibility**: High. During the construction of new facilities, the materials will be selected as part of the design process. Siding materials and roof materials can be selected during this process.
- **Cost**: Low to High depending upon material. Metal siding is the most cost-effective material for industrial scale buildings. Cladding an industrial building in the other materials or constructing from block will be several times more expensive. Smaller scale office and utility housing structures are often constructed of block. Selecting a concrete masonry block unit that is textured and colored in an earth tone would be little to no additional cost. Steel metal roofing is often selected as the material for industrial buildings, including for office and utility facilities, due to its long lifespan, durability, and low maintenance. Selecting a color that is earth-toned during the design process would have no additional cost. There is potential for a matte finish selection to have low-no additional cost.
- **Effectiveness**: Moderate. Selecting materials with texture reduces the contrast of texture and reflectivity from the surrounding landscape of vegetation and exposed rock faces. Using a stone cladding or split-face concrete block in colors similar to the indigenous rock of the area will further reduce the contrast of materials, color, and texture of the buildings compared to the surroundings. The straight horizontal and vertical lines of the buildings would still be in contrast to the angles and organic lines of the surroundings, but matching materials, texture, and color would reduce the contrast. Selecting building and roof colors that match the surrounding landscape during leaf-off season (i.e., browns, tans, and grays) would likely not blend with leaf-on conditions (shades of green), though selecting colors in mid-range earth-tones would reduce contrast in both leaf-off and leaf-on conditions.

6.6.3 Exposed Rock Walls, Concrete Walls and Retaining Walls, and Concrete Treatments

The Project site contains steep topography that requires excavation and stabilization efforts resulting in exposed rock walls as well as concrete retaining walls. Some Bad Creek II structures, notably the upper and lower inlet/outlet structures and the access portal would be constructed of concrete.

Exposed rock walls, even though they are native bedrock, initially are visually different from naturally weathered rock walls. Over time, however, newly exposed rock walls will weather and darken, more closely resembling natural rock outcroppings.

Likewise, concrete retaining walls such as the wall in Figure 6-33 are lighter in color than the surrounding landscape or naturally occurring exposed rock. Further, concrete walls introduce straight lines into the landscape which are visually intrusive. In the same manner that newly exposed rock walls weather and darken over time, exposed concrete also changes color. However, it remains a lighter color than exposed rock even after significant time has passed.

Penetrating acid-based stain can be applied to new and existing concrete surfaces. The stain penetrates beyond the surface of the concrete and reacts chemically, creating a permanent bond. The stain is translucent and matte, and results in a marbling effect due to the penetration, giving it a more natural appearance. The stain is available in a variety of earth-tones. The stain can be applied to new concrete or existing concrete walls, structures, and surfaces, though the existing surfaces would first need to be cleaned by pressure-washing. As the concrete surface wears away over time, the color will fade. This treatment has an approximately 20-year lifespan. This is shorter than the lifespan of the concrete, but would address the significant difference in tone when the concrete is first installed, when it is very pale in contrast to the mid- and dark-tones of the surrounding landscape. As the stain color weathers away, the concrete surface would also collect dust and dirt, darkening the surface.

Image source: Duke Energy

Figure 6-34. Existing Lower Inlet/Outlet Structures with Concrete Retaining Wall

- **Feasibility**: Mitigation measures for exposed rock and existing concrete walls are limited given the size of these structures and requirement to access the structures to clean and then apply a stain. Staining new concrete structures is more feasible than staining existing structures because the surface is already clean and mobilization and access has already been provided at the project area.
- **Cost**: Moderate. The cost per square foot of application is relatively low, with the variables of square footage applied and potential difficulty of access increasing the mitigation cost to different levels.
- **Effectiveness**: Mitigation of exposed rock is not needed given visual effects diminish over time due to natural weathering of the rock.

  The pale color of concrete walls and structures are initially high in both color and tone contrast with the adjacent dark browns, greens, and grays of rock and vegetation. Concrete fades in brightness to a high contrast over 10-20 years. Coating the concrete walls with an acid stain at the time of installation would reduce that initially very high contrast to a similar tone and color to the surrounding landscape, allowing for a more gradual weathering process. The staining would not address the straight horizontal line of the wall, which would contrast to the sloping and varied lines of the surrounding rock and landscape, but the visibility of the line would be reduced by reducing the color and tone contrast of the wall and the surroundings. The concrete walls are a large and contiguous visually identifiable feature, especially from the waters of Lake Jocassee. Staining them would reduce their visual contrast in tone and color and reduce their visual impact.

6.6.4 Revegetation of Spoil Areas and Disturbed Areas

Duke Energy would revegetate spoil areas and other areas used during construction of Bad Creek II. Plant species selected for revegetation efforts would affect how quickly areas become revegetated and contrast with the surrounding landscape diminishes. Over time, as the plants mature and fill in over 20-30 years, the spoil areas would visually blend with the adjacent existing vegetation.

- **Feasibility**: Duke Energy would be required to permanently stabilize spoil areas with vegetation and revegetate areas disturbed during construction. Stabilization of such areas with vegetation is a standard construction technique.
- **Cost**: Since Duke Energy's construction permits would require some sort of revegetation effort, the incremental cost for this effort is relatively low.
- **Effectiveness**: Effectiveness would initially be driven by how quickly vegetation becomes reestablished and whether or not the species selected are visually consistent with the surrounding landscape. Over time as the vegetative community is established and becomes more consistent with surrounding areas, the visual effects of spoil areas would likely become minimal.

6.6.5 Fencing

Security fencing would likely be installed during construction to limit access to areas and reduce vandalism or theft of construction materials and equipment. Permanent fencing around the Bad Creek II transformer and switchyard would be installed to prevent unauthorized access to the critical infrastructure equipment similar to the fencing around the Project transformer yard fencing (Figure 6-34). The type of color of such fencing could reduce visual effects associated with fencing or screening walls. Selecting colors in dark tones of gray or brown would minimize their visual impact to the landscape, by reducing contrast.

Figure 6-35. Project Transformer Yard

- **Feasibility**: Construction of fencing around some Bad Creek II components is possible, but not all. For example, it would be neither feasible nor beneficial to fence the expanded primary transmission line corridor. However, installation of fencing around the Bad Creek II transformer yard and switchyard would occur.
- **Cost**: Installation of fencing around the transformer yard and switchyard is Duke Energy's typical practice, so the incremental cost of this measure would relatively low.
- **Effectiveness**: Installation of fencing or screening materials would introduce additional intrusions on the landscape. Darker colored fencing could decrease the visual effects of fencing and screening, particularly from a distance, but such fencing would still become apparent with proximity to the fencing.

Screening views of the principal Bad Creek II features with fencing or other types of screening would be unlikely to be effective. The Bad Creek II transformer and switchyard would be visible from Lower Whitewater Falls Trailhead and the Musterground Road entrance. The height of the equipment within both yards would exceed practicable fence designs.

6.6.6 Landscape Screening and Plantings

Landscape screening of trees and shrubs could be installed to visually shield and blend project elements into the landscape.

- **Feasibility**: Installation of landscape screening around some Bad Creek II components is possible, but not for all features. For example, it would be neither feasible nor beneficial to screen the expanded transmission line corridor. However, installation of landscaping around the Bad Creek II transformer yard and switchyard could occur, as well as around the perimeter of the Lower Whitewater Falls trailhead parking lot. There is some feasibility to install landscape screening along the water's edge to shield the existing and proposed lower inlet-outlet, by providing a landscaping buffer between the rip-rap embankment on the water's edge. Over time, however, maintenance of trees in this area may be problematic or create potential hazards to Project structures.
- **Cost**: Low - Installation of landscaping around the transformer yard and switchyard is a typical practice and landscape installation is generally cost efficient in comparison to constructed elements, as it does not require engineering or earthwork.
- **Effectiveness**: Evergreen hedges around the transformers and switchyards would visually shield the fencing and the lower segment of the installation, reducing the impact on the landscape. Due to the height of the elements, landscaping screening will not entirely shield the installations. Evergreen trees are fast growing and would provide significant screening within 10 years, but limited visual screening would be provided before then. Installing visual screening close to the viewer would provide a greater height of screening relative to a distant object than screening closer to the object (Figure 6-36). For this reason, providing visual landscape screening close around the trailhead parking lot would provide visual screening to the constructed elements around the parking lot. Installing landscaping at the lower inlet/outlet structure facility would not entirely shield the facility but would provide a softening and a blending of the constructed elements as the

landscaping matures over 15+ years. Selecting fast growing trees and evergreen trees would shorten the time to achieve visual screening. As noted above, however, it may be problematic for Project maintenance to maintain woody vegetation in this area.

Figure 6-36. Effectiveness of Landscaping for Shielding Based on Proximity to Viewer

6.6.7 Landscape Berms

Landscape berms, or constructed low hills, can be installed to visually shield and blend project elements into the landscape. The berms are often planted after installation, which give additional height to the screening plants. Landscape berms are most appropriate in locations where there is sufficient space to accommodate a berm, typically forming a 2.5:1 slope with at least 2 ft at the crest of the berm. Therefore, to accommodate a 3-ft-high berm, there would need to be at least a 17-ft-wide space. Berms can be anywhere from 2 ft to over 20 ft. Berms shield the view of anything behind them. Shorter berms can be seen over but provide a softening of the landscape and can be used in conjunction with fencing and landscaping to screen views.

- **Feasibility**: The topography of the site is generally severe and limits the availability of land suitable for constructing berms. Further, it would be necessary to ensure such berms would not adversely affect wetlands, waters, or sensitive species and their habitat.
- **Cost**: The cost associated with constructing berms varies with the site context. In areas where there is sufficient space and earthwork activities are already occurring, the cost would be relatively low. Larger berms on significant topography that expand a project's limit of disturbance would have more significant costs associated with permitting and construction.
- **Effectiveness**: As with landscape screening and plantings, the effectiveness of berms would be dependent upon the height of the berm and the proximity of the berms to the viewers with effectiveness increasing as viewers move closer to the berms.

6.6.8 Transmission Towers and Conductors: Materials

The existing Project primary line and associated conductors are made of steel with a galvanized finish. A weathered steel finish can be used which is less visually intrusive than the lighter color standard galvanized steel (Figure 6-37).

- **Feasibility**: Use of weathered steel for transmission towers and conductors is a generally accepted practice for transmission line design in visually sensitive areas.
- **Cost**: Weathered steel would cost approximately 10 percent more than galvanized steel.
- **Effectiveness**: The Bad Creek II primary line would parallel the existing Project primary line. While use of weathered steel for towers or conductors, or both, would reduce the visual effects of the feature, it would not eliminate it, particularly when the structures are in the foreground or middle ground. Furthermore, since the Bad Creek II line would parallel the existing line, the existing line visual effects would continue unabated.

Figure 6-37. Example of Weathered Steel Monopoles along a Trail

6.6.9 Transmission Towers: Location Relative to the Horizon

The current primary transmission line towers are sited on the peaks and the conductors (i.e., electrical lines) are suspended 100+ ft over valleys and ravines. This means that the towers are silhouetted and visible from a distance, increasing their visual impact to the landscape. The new primary transmission line towers could be located on the shoulders of the peaks in a manner such that the tops of the towers would be lower than the elevation of the surrounding peaks. This would likely require a less direct route for the Bad Creek II primary transmission line requiring more towers, line, and an expanded cleared ROW to accommodate the primary transmission line deviating from parallelling the existing primary transmission line towers.

- **Feasibility:** Duke Energy holds the rights to the land parcels the primary transmission line passes through and could identify locations that maintain the tower heights below the horizon. This would require significantly greater effort compared to paralleling the existing primary transmission line towers, requiring additional clearing of ROW, and construction of new access roads. Additional environmental impacts would be anticipated associated with impacts to waters and wetlands located within valleys and ravines.
- **Cost:** Duke Energy is already planning to clear additional corridor for the Bad Creek II primary transmission line. However, costs would increase significantly to locate and construct towers away from current primary transmission line towers due to difficulty accessing tower locations, environmental permitting, and mitigation for resource effects.
- **Effectiveness:** Siting the Bad Creek II transmission line to avoid silhouetting towers would reduce an element of visual impact but would also increase the visual impact of the forest clearing associated with the transmission corridor. In addition, the existing primary transmission line towers would remain in place.

6.6.10 Lighting: Motion Activated

Motion activated lighting reduces overall lighting intensity with lighting levels operating at reduced or no output as the default, increasing to the standard lumens only when actually needed (when motion is detected). Motion activated lights can be programmed to run from dusk to dawn and set to 0 to 50 percent output when no motion is detected. The option to operate the lighting at 10 to 50 percent output allows for security and wayfinding in the general area, while reducing light pollution.

- **Feasibility**: Motion activated and programmable lighting has become more widely available as smart technologies continue to expand. There are numerous manufacturers of programming systems and hardware to facilitate motion activated lighting. Motion activated and dimmable lighting are most compatible with light-emitting diode (LED) light systems. LED lighting is quickly becoming the standard lighting system due to its energy efficiency and color tone customization, which increases the feasibility of installing a motion-activated variable light intensity system at the Project. Motion activated lights are most feasible for areas that require task or transportation lighting, where motion can be detected, and where activity occurs within a discrete time window.
- **Cost**: Installing and maintaining a motion activated lighting system would require an initial additional upfront cost to the lighting system, but the energy cost savings from reduced lighting output may recoup the expenditure over the lifetime of the system.
- **Effectiveness**: Motion activated lights are highly effective at reducing aggregate light output. As discussed in Section 6.7.3, controlling lighting quantity and timing are one of the five key principals of light pollution reduction and motion activated lights are a key method to achieve this.

6.6.11 Lighting: Fully-shielded Light Fixtures

Light fixtures can be shielded with a cap to direct light to the ground where needed and prevent light from being directed above the horizon or 90 degrees. This limits light pollution, but refracted light within the fixture can still be directly upward, above 90 degrees. Fully shielded fixtures, or full-cutoff fixtures, have the bulb recessed into the fixture, which creates a more angled light beam with a sharp cut off line, directing the light exactly where it is needed, and preventing spillover of refracted light above 90 degrees (Figure 6-38). Fully shielded fixtures are a best practice standard for reducing light pollution.

Figure 6-38. Example of Fully Shielded Streetlight Fixtures

- **Feasibility**: High. There are a wide variety of fully shielded lighting styles, finishes, and price points from a range of manufacturers. DarkSky International (DarkSky) lists approved light fixtures on their website (https://darksky.org/what-we-do/darksky-approved/products-companies/) so identifying an approved fully shielded fixture is easily accessible.
- **Cost:** Low. Cost for fully shielded light fixtures would be comparable to other lighting types. The cost of lighting has already been allocated in construction costs. Therefore, the cost for installing fully shielded lighting fixtures at the proposed project would be low.
- **Effectiveness:** High. Fully shielded lights are highly effective at targeting the direction of lighting and preventing light from being directed above the horizon. Targeting light and aiming lights down are one of the five key principles of light pollution reduction, as identified by DarkSky, and fully shielded lights are the gold standard to achieve this.

6.6.12 Lighting: Elimination of Unnecessary Existing Lights

Eliminating unnecessary existing lighting or reducing excess lighting to standard levels will offset Bad Creek II lighting effects, consistent with DarkSky best practices for lighting. Further, eliminating unnecessary lighting reduces operating costs.

- **Feasibility**: Existing facility lighting could be evaluated to determine if lighting is needed for the area based on use patterns and if the lighting quantity (lumens or footcandles) meets or exceeds standards set by the Illumination Engineering Society of North America (IESNA). If the lighting levels exceed the standard, the lighting could be reduced or eliminated, as appropriate.
- **Cost**: Low. Unnecessary lighting could be removed or use discontinued with minimal effort. Costs associated with the initial removal or disconnection of fixtures could be offset by the elimination of costs associated with powering and maintaining the lights.
- **Effectiveness:** Low. Removing unnecessary existing lighting will mitigate the aggregate impact of the additional lighting that will be required for Bad Creek II. However, there may be few unnecessary existing lights compared to the number of additional lights associated with Bad Creek II required, so removing them would likely have a minimal impact on the Project lighting impacts as a whole.

6.6.13 Lighting: LED Lighting

LED lighting has been growing in popularity due to its functional features of color tone selection, dimmability, longevity, and especially for its energy efficiency. Manufacturers now offer a wide selection of fixtures available as LED.

- **Feasibility**: High. Lighting will be required with Bad Creek II. LED lighting is available in a wide variety of fixture types. Installing LED fixtures also allows for DarkSky best practices of dimming and motion sensor lighting, as well as warm color tone lighting selection.
- **Cost:** Cost for LED lighting is now comparable to other lighting types, with a lower lifespan cost due to longevity of bulbs and energy efficiency. The cost of lighting has already been allocated in construction costs. Therefore, the cost for installing LED lighting in the project would be low.

- **Effectiveness:** LED lighting is most effective as a mitigation measure when other capabilities of the lighting type are employed including dimming and light color temperature.

6.6.14 Lighting: Warm Color Spectrum

Lighting is available in a color spectrum of cool to warm, measured in Kelvins (K). White light is 4,000K-4,500K. A cool blue toned light would be 6,000K while a warm toned light would be 2,700K (Figure 6-39). According to DarkSky, research has found that cool, blue-toned lights brighten the sky more than warm, amber-toned lights, and blue light has a greater negative impact on the health of people and the environment than warm light. For this reason, DarkSky recommends outdoor lighting be in the warm color spectrum, of 3,000K or less, with a temperature of 2,700K ideally.

Figure 6-39. Color Temperature Spectrum of Lighting (Measured in Kelvins)

- **Feasibility**: High. New lighting would likely be required at Bad Creek II facilities. Selecting a warm color temperature of the lighting could be included in the design process. There is also the possibility of adjusting the color temperature of existing lighting. There is high feasibility if the fixture is an LED, the bulb can simply be replaced with warm spectrum bulb. If the existing lighting system is mercury vapor or metal halide, both cool temperature lighting, the light fixture itself would need to be replaced, which introduces additional complexity.

- **Cost**: Installing warm color spectrum lights in new installation would be low because the cost of lighting has already been allocated in construction costs. Replacing existing cool temperature LED bulbs with warm toned bulbs would also be relatively low cost because the fixtures would remain. The cost for replacing the existing lighting system, if mercury vapor or metal halide, would be moderate. The replacement would likely be with LED lights, which require less power than other lighting systems, so the utility conduit would remain in place, but the fixtures would be replaced.
- **Effectiveness:** Using warm temperature lighting is highly effective for reducing light pollution while not compromising visibility or security.

Table 6-2. Summary of Potential Visual PM&E Measures

Potential PME Measure	Feasibility	Estimated Cost Range	Effectiveness
Building paint colors	High	Low	Moderate
Building and roofing materials	High	Varies	Moderate
Retaining / concrete wall treatments	Moderate	High	Moderate
Revegetation of disturbed areas	High	Low	High
Fencing	Moderate	Low	Low
Landscape screening and plantings	High	Low	Moderate
Landscape berms	High-Low	High-Low	Moderate
Transmission tower material selection	Moderate	Moderate	Moderate
Transmission tower locations	Low	High	Moderate
Lighting: motion-activated lighting	High	Moderate	High
Lighting: fully shielded light fixtures	High	Low	High
Lighting: elimination of existing unnecessary lights	Moderate	Low	High
Lighting: LED lights	High	Low	Moderate
Lighting: warm color spectrum	High	Low	High

6.7 Task 9 – Conceptual Design of Bad Creek II

6.7.1 Site Layout and Proposed Conceptual Design

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 will be consistent with existing visual effects. Other than some potential upland spoil areas and the proposed Fisher Knob temporary access road, most Bad Creek II features are located in areas of the site that have previously been developed including some proposed spoil areas.

See Figure 6-40 for a rendering of existing and proposed Project and Bad Creek II features. This rendering is based on conditions approximately five years following revegetation of spoil areas[18].

[18] As discussed in Section 5.9 the rendering includes all potential spoil areas even though some will not be used.

Figure 6-40. Rendering of Bad Creek II Conceptual Site Layout

6.7.2 Proposed Construction Methods and Effects on Visual Resources

Construction of Bad Creek II is anticipated to require approximately seven years. As demonstrated above, direct views of the site are limited by its remote location within a sparsely populated area, site and surrounding topography, and the generally forested condition of surrounding lands. Therefore, construction of Bad Creek II facilities including the transformer yard, switchyard, many spoil areas, the upper intake/outlet portal, and the temporary access road will generally be visible only while on the site itself. The only public access that would be available during construction would be access for Fisher Knob property owners via the temporary access road. Since the public would be excluded from the site during construction, only Duke Energy personnel and construction workers would have direct views of these features. Similarly, boaters would be excluded from the Whitewater River cove during construction, limiting views of the lower intake/outlet construction from the water. Some Fisher Knob residents would continue to have views of this area from their property during construction.

Construction activities for Bad Creek II could affect visual resources as described below:

- **Vegetation removal:** When possible, Duke Energy will use existing parking lots and equipment and material storage areas to limit the amount of vegetation needing removal. However, when vegetation removal is needed for temporary laydown, construction areas, spoil areas, the temporary access road, and the Bad Creek II primary transmission line including access roads to tower locations, Duke Energy will limit such vegetation removal to only the amount necessary and revegetate areas as construction activities cease. These areas would likely be visible only to Lake Jocassee boaters and from a few homes at Fisher Knob.
- **Spoil area development and use:** As discussed in Section 5.9, Duke Energy will revegetate spoils areas when spoiling operations are complete. During construction, these areas would generally not be visible from outside the site. Over time as the vegetation continues to grow, these areas will become less apparent and blend with the surrounding landscape.
- **Turbidity in Lake Jocassee:** Erosion control measures will be implemented to reduce erosion into Lake Jocassee tributaries and prevent construction waters from leaving the site to the extent practicable. All work would be done consistent with Duke Energy's

permits which should limit visible effects to Jocassee water clarity. Since boaters will be excluded from the Whitewater River Cove during construction, increased localized turbidity within the Whitewater River cove would likely not be apparent to Lake Jocassee boaters or Fisher Knob residents.

- **Dust control measures**: Duke Energy would undertake dust control measures during construction including the application of water on haul roads and on disturbed areas that could create dust; stabilization of disturbed areas using water, tarps, or vegetative ground cover; implementation of a means for eliminating atmospheric discharges of dust during mixing, handling and storing of cement, aggregate, and similar materials; removal of soil from equipment leaving the site; and, cleaning of public roads as needed to remove visible track out of mud. These measures should limit the visibility of dust from offsite locations.

6.7.3 Lighting Evaluation

Relicensing participants have expressed concerns about the potential effects of additional lighting associated with Bad Creek II and an interest in limiting light pollution associated with the Project. This section provides an overview of lighting concepts and the potential effects of Bad Creek II. It should be noted that lighting during construction would likely differ from existing lighting effects as well as post-construction lighting.

IESNA develops American National Standards Institute (ANSI) standards related to illumination. As set forth in the IESNA Lighting Handbook (Rea and IESNA 2000), safe environments for workers and site visitors require adequate illumination levels. Engineers and architects use ANSI standards to design lighting plans, select lighting fixtures, and address other lighting-related issues to achieve safe environments. Recommended lighting levels vary by the activity to be performed, such as walking along a path or working on machinery. However, lighting can also obscure views of the stars, negatively affecting the public’s experience of the surrounding landscape, and affect wildlife (Jägebrand and Spoelstra 2023). Therefore, identifying the appropriate amount of lighting for a site requires a balancing of interests.

DarkSky is a membership-based advocacy organization focused on reducing light pollution and promoting responsible, healthy, and functional artificial lighting. DarkSky certifies lighting fixtures, designates International Dark Sky Places, advances responsible outdoor lighting, and educates the public about the effects of artificial lighting. In partnership with IESNA, DarkSky has identified five principles for responsible outdoor lighting (DarkSky 2024):

1. Useful: Use light only if it is needed. Consider how the use of lighting will impact the human and natural environment.
2. Targeted: Direct light so it falls only where it is needed. Using shielding and point light downwards.
3. Low Level: Light should be no brighter than necessary. Use the lowest light level possible and consider surface conditions which may reflect light skyward.
4. Controlled: Use light only when needed. Use timers and motion detectors that dim or turn lights off when they are not needed.
5. Warm-colored: Use warmer color lights where possible and limit the amount of shorter wavelength light.

The area immediately surrounding the Project has little outside lighting other than the lighting associated with the Project and the residences located at Fisher Knob. At the Project, lighting is generally limited to Project buildings and parking areas associated with those buildings, security gate access points, and the Bad Creek Foothills Trail parking lot (Figure 6-41). Most lighting fixtures were originally installed in conjunction with the initial construction of the site in the late 1980s through 1991. The existing light poles at Project buildings and Bad Creek Foothills Trail parking lot appears to be in the cool spectrum, above 3,000 Kelvins, which does not meet DarkSky standards for warm-colored lighting. In those areas, the light fixture heads appear to be full-cut off, which meets DarkSky standards for targeted lighting. The trailhead has lighting, which may not be needed, because most trail users hike during daylight. There is an opportunity to reduce or eliminate lighting in this area, which would meet the DarkSky standard for evaluating usefulness of lighting. Lighting levels (brightness, lumens, foot candles) are set by IESNA Lighting Handbook for different site functions. Providing greater lighting levels than the standard contradicts DarkSky best practices. The existing lighting could be reviewed to determine that existing lighting meets, and does not exceed, IESNA standards.

Figure 6-41. Project Warehouse, Administrative Building and Bad Creek Foothills Trail Access Parking as Viewed from the Entrance to Musterground Road at Night

In conjunction with the collection of potential Key View photographs, views of the site at night were collected (see Appendix B for all collected photos). The team found that lights associated with Project features are visible at the site itself and from both Fisher Knob locations. As shown in Figure 6-42, lighting associated with the lower reservoir inlet/outlet portal and lights associated with the Project's existing transformer yard are visible from Fisher Knob.

Neither Project features nor light associated with Project features were visible from Devils Fork State Park or Jocassee Dam.

Figure 6-42. View of Project from Fisher Knob Point at Night (Top-existing conditions; Bottom-proposed conditions)

At location 3Nb, a discrete area of light is displayed. The horizon is faintly visible due to a dim light source beyond the mountain. The two areas of visible light appear to be in the middle ground. The uppermost light is existing lighting associated with the existing transformer yard; no changes to this facility are being proposed at this time as shown under proposed conditions. The lights adjoining the lake are reflected in the water. The lighting to the northeast (i.e., right side) of the lower inlet/outlet portal in the existing view are associated with the existing wastewater treatment facility. The wastewater treatment facility will be permanently relocated as part of the Bad Creek II construction and the Bad Creek II lower inlet/outlet structure would be constructed in the same general area. Therefore, lighting effects under proposed conditions are anticipated to be largely similar to existing features.

7 Summary and Discussion

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. Common mitigation techniques can be applied to reduce impacts to visual resources during and after construction including siting of Bad Creek II features near existing Project facilities, careful selection of lighting consistent with DarkSky guidelines, use of appropriate landscape screenings, and other mitigation measures.

8 Variances from FERC-approved Study Plan

Variances from the FERC-approved Study Plan were generally minor, did not substantively affect the goals, objectives, or results of the study, and were made in consultation with the RC. They are briefly described below; refer to Section 5 for additional information.

- **Number of Key Views:** The study plan specified that Duke Energy would use up to four Key Views for developing visualizations and evaluating potential aesthetic effects. Instead, Duke Energy agreed to evaluate five Key Views including the visualization of the lower inlet/outlet structure developed during initial Bad Creek II planning.
- **Leaf-off Conditions:** The study plan specified that Key Views would be captured during leaf-off conditions. While this was done for the four Key Views captured in December 2023, the fifth Key View developed during Bad Creek II planning was done under fall conditions. However, since there is no vegetation between the viewer and Project features, the vegetation did not impede an evaluation of the effects of existing and proposed features.
- **Lighting Evaluation:** The description of Task 9 in the approved study plan does not specify how the lighting evaluation or lighting effects would be evaluated, nor does it include a visualization of lighting. Duke Energy elected to develop a visualization using a nighttime image for use with the evaluation. Duke Energy consulted with the RC to select viewpoints for use with the lighting visualization.

9 References

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Appendix A

Appendix A - Consultation Documentation

From:	Crutchfield Jr., John U
To:	Amy Breedlove; Andrew Gleason; Andy Douglas; Chris Starker; Dale Wilde; Dan Rankin; Elizabeth Miller; Kelly Kirven; Ken Forrester; Lynn Quattro; Salazar, Maggie; amedeemd@dhec.sc.gov; cloningerp@dnr.sc.gov; Ross Self; Rowdy Harris; Stuart, Alan Witten; suewilliams130@gmail.com; William T. Wood; Willie Simmons; Huff, Jen; phil.mitchell@gmail.com; Bill Ranson-Retired
Cc:	Kulpa, Sarah; McCarney-Castle, Kerry
Subject:	RE: Bad Creek Relicensing - Recreation Resources Committee Meeting
Date:	Thursday, June 8, 2023 6:21:33 AM

Dear Bad Creek Relicensing Recreation Resources Committee Members:

Based on the received Committee stakeholder member responses, we will meet on Thursday, July 27th, , 1-3 pm, at Duke Energy's Wenwood Operations Facility in Greenville, SC.

I will be sending each of you a meeting notice shortly. Note that lunch will be served at 12 pm, and you are invited to lunch prior to the afternoon meeting session. Please accept the meeting notice so I can get an accurate head count for ordering lunch.

Thanks, John

From: Crutchfield Jr., John U
Sent: Tuesday, May 30, 2023 1:01 PM
To: Amy Breedlove <BreedloveA@dnr.sc.gov>; Andrew Gleason <andrewandwilla@hotmail.com>; Andy Douglas <adoug41@att.net>; Bennett, Jennifer <Jennifer.Bennett@duke-energy.com>; Chris Starker <cstarker@upstateforever.org>; Dale Wilde <dwilde@keoweefolks.org>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Kelly Kirven <Kelly.Kirven@KleinschmidtGroup.com>; Ken Forrester <forresterk@dnr.sc.gov>; Lynn Quattro <quattrol@dnr.sc.gov>; Maggie Salazar <maggie.salazar@hdrinc.com>; Morgan Amedee <amedeemd@dhec.sc.gov>; Pat Cloninger <cloningerp@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Rowdy Harris <charris@scprt.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sue Williams <suewilliams130@gmail.com>; William Wood <woodw@dnr.sc.gov>; Willie Simmons <simmonsw@dnr.sc.gov>; Huff, Jen <Jen.Huff@hdrinc.com>; phil.mitchell@gmail.com; Bill Ranson <bill.ranson@retiree.furman.edu>
Cc: Sarah Kulpa <sarah.kulpa@hdrinc.com>; Kerry McCarney-Castle <kerry.mccarney-castle@hdrinc.com>
Subject: RE: Bad Creek Relicensing - Recreation Resources Committee Meeting
Importance: High

Dear Bad Creek Relicensing Recreation Resources Committee Members:

Well, unfortunately we cannot line up everyone's schedule to meet on June 30th.

Duke Energy would like to propose convening the Recreation Resources Committee on Thursday, July 27th, 1-3 pm. The meeting location will be at Duke Energy's Wenwood Operations Facility in Greenville, SC (425 Fairforest Way Greenville, SC 29607).

We will be convening the Aquatics and Water Resources Committees on this same date during the morning session (9 am -12 pm), and you are welcome to attend that session too which will discuss the CFD modeling results and CHEOPS modeling status (most you are on those committees too). Lunch will be served so if you can attend both meeting sessions or just join for lunch and the afternoon session, either will be fine. I will need to know your attendance for the lunch order.

Please let me know if you can meet on Thursday, July 27th, 1-3 pm.

-
I apologize for the multiple emails on meeting dates, but summer schedules are busy, as you know.

A reply on this meeting date would be appreciated by the end of next week.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
526 S. Church Street, EC12Q | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From: Crutchfield Jr., John U
Sent: Thursday, May 25, 2023 9:28 AM
To: Amy Breedlove <BreedloveA@dnr.sc.gov>; Andrew Gleason <andrewandwilla@hotmail.com>; Andy Douglas <adoug41@att.net>; Bennett, Jennifer <Jennifer.Bennett@duke-energy.com>; Chris Starker <cstarker@upstateforever.org>; Dale Wilde <dwilde@keoweefolks.org>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Kelly Kirven <Kelly.Kirven@KleinschmidtGroup.com>; Ken Forrester <forresterk@dnr.sc.gov>; Lynn Quattro <quattrol@dnr.sc.gov>; Maggie Salazar <maggie.salazar@hdrinc.com>; Morgan Amedee <amedeemd@dhec.sc.gov>; Pat Cloninger <cloningerp@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Rowdy Harris <charris@scprt.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sue Williams <suewilliams130@gmail.com>; William Wood <woodw@dnr.sc.gov>; Willie Simmons <simmonsw@dnr.sc.gov>; Huff, Jen <Jen.Huff@hdrinc.com>; phil.mitchell@gmail.com; Bill Ranson <bill.ranson@retiree.furman.edu>

Cc: Sarah Kulpa <sarah.kulpa@hdrinc.com>; Kerry McCarney-Castle <kerry.mccarney-castle@hdrinc.com>
Subject: RE: Bad Creek Relicensing - Recreation Resources Committee Meeting
Importance: High

Dear Bad Creek Relicensing Recreation Resources Committee Members:

Due to conflicts, I need to poll your availability to meet on Friday, June 30, 9 am to 1 pm.

Please reply back to me and let me know your availability to meet on that date by Tuesday, May 30 COB.

Thanks for your input.

John

From: Crutchfield Jr., John U
Sent: Thursday, May 18, 2023 3:06 PM
To: Amy Breedlove <BreedloveA@dnr.sc.gov>; Andrew Gleason <andrewandwilla@hotmail.com>; Andy Douglas <adoug41@att.net>; Bennett, Jennifer <Jennifer.Bennett@duke-energy.com>; Chris Starker <cstarker@upstateforever.org>; Dale Wilde <dwilde@keoweefolks.org>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Kelly Kirven <Kelly.Kirven@KleinschmidtGroup.com>; Ken Forrester <forresterk@dnr.sc.gov>; Lynn Quattro <quattrol@dnr.sc.gov>; Maggie Salazar <maggie.salazar@hdrinc.com>; Morgan Amedee <amedeemd@dhec.sc.gov>; Pat Cloninger <cloningerp@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Rowdy Harris <charris@scprt.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sue Williams <suewilliams130@gmail.com>; William Wood <woodw@dnr.sc.gov>; Willie Simmons <simmonsw@dnr.sc.gov>; Huff, Jen <Jen.Huff@hdrinc.com>; phil.mitchell@gmail.com; Bill Ranson <bill.ranson@retiree.furman.edu>
Cc: Sarah Kulpa <sarah.kulpa@hdrinc.com>; Kerry McCarney-Castle <kerry.mccarney-castle@hdrinc.com>
Subject: Bad Creek Relicensing - Recreation Resources Committee Meeting
Importance: High

Dear Bad Creek Relicensing Recreation Resources Committee Members:

Duke Energy would like to convene the Recreation Resources Committee to review the Visual Resources Initial Seen Analysis and identify potential Key Views for additional seen area analysis (Task 4-Key Views Selection under the schedule reviewed during our February 22, 2023, meeting).

The in-person meeting will be from 9 am to 1 pm at Duke Energy's Wenwood Operations Facility in Greenville, SC (425 Fairforest Way Greenville, SC 29607).

We have identified 3 potential meeting dates as noted in the table below. Please let me know your availability of meeting on these dates and send your response back via email (insert an X indicating yes, a blank means you can't attend).

Based on input, I will select the best meeting data and send out a meeting notice to the Committee members.

Name	June 22	June 28	June 29

INSERT X For Can Attend and include your name, respond back via email to John Crutchfield.

Please respond back by COB, Friday, May 26 so we can reserve the meeting room at the Wenwood Facility.

Please let me know if you have any questions.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
526 S. Church Street, EC12Q | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

Meeting Summary

Project:	Bad Creek Pumped Storage Project Relicensing
Subject:	Bad Creek Visual and Recreational Resources Committee Meeting
Date:	July 27, 2023
Location:	Duke Energy Operations Center, Greenville, SC

Attendees (in-person)

John Crutchfield, Duke Energy
Alan Stuart, Duke Energy
Jeff Lineberger, Duke
Ethan Pardue, Duke Energy
Paul Keener, Duke Energy
Sue Williams, Advocates for Quality Development
Mike Abney, Duke Energy
Andrew Gleason, Foothills Trail Conservancy
Kelly Kirven, Kleinschmidt Assoc.
Alison Jakupka, Kleinschmidt Assoc.
Rowdy Harris, SC Department of Parks, Recreation and Tourism
Elizabeth Miller, SCDNR
Amy Chastain, SCDNR
William Wood, SCDNR
Dan Rankin, SCDNR
Erika Hollis, Upstate Forever
Chris Starker, Upstate Forever
Sarah Kulpa, HDR
Joe Dvorak, HDR
Jen Huff, HDR
Kerry McCarney-Castle, HDR
Eric Mularski, HDR

Attendees (virtual)

Tristan Cleveland, LPDA

Introduction

John Crutchfield welcomed participants in the room and online to the Bad Creek Relicensing Visual and Recreational Resources Committee meeting, briefly summarized the meeting agenda, provided a safety moment on heat-related issues, introduced the relicensing studies and study leads, and noted the meeting is being recorded. J. Crutchfield summarized the status of the relicensing efforts (ILP schedule) and showed the existing Project Boundary; he then handed the presentation over to Jen Huff to provide an update on the Visual Resources Study.

Visual Resources Study Update

Task 2 – Scene Area Analysis

J. Huff briefly summarized the tasks for the Visual Resources Study and introduced Duke Energy's subconsultant, Tristan Cleveland with LPDA. T. Cleveland provided a description of the seen area analysis, reviewed the objectives and methods used, and walked through slides showing different structures/features associated with Bad Creek II that would be visible from surrounding areas up to approximately 4 miles. For the new transmission line corridor, it was assumed the expanded corridor would parallel the existing line. The composite constructed project elements figure shows areas with views of multiple structures.

Chris Starker asked for clarification on adding the new transmission line, if the towers were proposed to be 130 feet tall, and if a new set of towers would be constructed adjacent to the existing towers. Sarah Kulpa indicated tower position and design are based on conservative measures based on available information. T. Cleveland indicated the existing corridor is 200 ft wide; the new one would result in widening the right-of-way from 200 ft to 380 ft.

Alan Stuart indicated many meeting attendees do not yet know of the proposed access road. J. Huff provided an overview of the purpose of the access road and A. Stuart stated it would be a temporary road to provide access to the Fishers Knob community and for first responder access to the station and community, further noting the road would be shut down and revegetated following project construction.

Rowdy Harris asked if the access road will be wide enough to get boat trailers through since residents of Fisher Knob leave boat trailers at the park. If the access road will be any narrower, it might cause more residents to leave their trailers at the park. A. Stuart indicated Duke Energy is still designing the road (no details available at this time).

William Wood asked if the current road would be blocked during construction. A. Stuart confirmed the current road would be restricted to Duke Energy use.

Andrew Gleason asked for confirmation that first responders/emergency vehicles would be able to traverse the access road/bridges. A. Stuart agreed that the road/bridges would support emergency vehicles of all types.

Task 4 – Key Views Selection

J. Huff described the objectives of Task 4 of the Visual Resources Study. As set forth in the approved study plan, the Resource Committee (RC) is to choose up to four Key Views that encompass a variety of potential scenic and visual impacts for the proposed project. Photos from the Key Views will be taken in leaf-off conditions (November). The goal for the meeting is to choose 6 potential Key Views today. Once the photos are available, the RC will meet again and narrow it down to 4 Key Views to use for the remaining tasks. J. Huff described the initial 11 potential key views that were identified based on the seen area analysis.

A Stuart indicated the locations of the key viewpoints will be determined by the stakeholders, not Duke Energy. J. Huff agreed and proposed the RC use a consensus process (i.e., everyone can live with the decision) to select the six views. Participants agreed. She then opened up the floor to the group to start the elimination process based on the 11 initial/proposed sites. The group decided to remove views 1A, 1B, 3 (from the water), 6, and 8.

A Gleason indicated there is a spot or two along a portion of the Foothills Trail immediately northwest of the Bad Creek Reservoir where the existing project is visible, however, he doesn't recommend adding any viewpoints and noted people like to look down at the reservoir from the trail.

Sue Williams asked about location of the Fisher Knob view and noted residents are likely used to the view of the inlet/outlet structure; leaf conditions are irrelevant.

Kelly Kirven asked about the handout that was provided and the closest feature in the viewshed. T. Cleveland indicated that just because it is listed as the closest view, it may not be the most prominent view, therefore, it is useful to look at individual viewshed maps (or composite map) to view all elements.

J. Huff noted that even though the consensus is to remove view 3 (looking upstream into Whitewater River cove), we would still include existing simulation of inlet/outlet portal (with leaf on) in report.

In November, six photos will be captured and a virtual meeting will be held (December) and at that time, the group will work together to narrow it down to four viewpoints for visualizations and simulations; Duke Energy will then carry out Tasks 7-9 based on the Visual Analysis with the report ready in 3rd quarter 2024.

A Stuart asked J. Huff where lighting effects come into play. J. Huff indicated the plan is still being developed but will likely involve the use of drones to capture baseline lighting (at the Project) and then will assess what is likely to be developed due to the addition of Bad Creek II. A. Stuart asked if it would be part of the report and J. Huff confirmed.

C. Starker agreed that lighting at nighttime is a concern and asked if there would be an update between now and November. J. Huff agreed to provide an update with one of the Recreational Resources updates.

Recreational Study

K. Kirven provided an update for the Recreational Resources Study and overall tasks and objectives and the status of each task.

Task 1 Update

The Foothills Trail (FHT) Corridor recreation site inventory was completed at seven sites on May 17, 2023, and on May 28, 2023, at four other sites. Two additional sites not specified in the RSP were included in the inventory (Coon Branch spur trail and Musterground Road). Traffic and trail counters were installed at Musterground Road in September 2022 and at access areas in May 2023. Due to issues with the counter at Musterground Road, Kleinschmidt will re-install the counter in September 2023. A few other counters did not function as intended over short periods of time, but Kleinschmidt will be able to extrapolate data from the larger survey.

In-person surveys began in March 2023;155 were completed as of early July.

Task 2 Update

FHT Corridor Conditions Assessment: Todd Branham (Long Cane Trails) began the assessment in June. He is using the Fulcrum app and is hiking the 43-mile portion of the trail in sections.

Task 3 Update

Whitewater River Cove Existing Recreational Use Evaluation: This work is underway. Drone flights will occur 20 days over the season though Labor Day with hourly flights between 8am and 4pm on the hour.

Task 4 Update

Has not started.

C. Starker asked about the survey response rate. K. Kirven stated the response rate is close to 100% because surveys are in person as opposed to sending them out and waiting for the survey to come back. A Stuart asked if Kleinschmidt is tracking the number of people who are asked to participate in the survey but decline; K. Kirven confirmed.

A. Gleason asked about trail counters being vandalized. K. Kirven indicated the one at Fisher Knob community has been stolen twice and the one at Chimneytop Gap on the trail has been stolen once (along with the post).

Action Items

- HDR/Duke Energy will post meeting notes, the recording, and presentation to SharePoint site.
- HDR/Duke Energy to revise key views based on input received today.
- HDR/Duke Energy to provide an update on the lighting evaluation in a future Recreation Study progress report.

Bad Creek Pumped Storage Project No. 2740

Recreation & Visual Resources Resource Committee Meeting

DUKE ENERGY.
BUILDING A SMARTER ENERGY FUTURE®

JULY 27, 2023

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Meeting Agenda

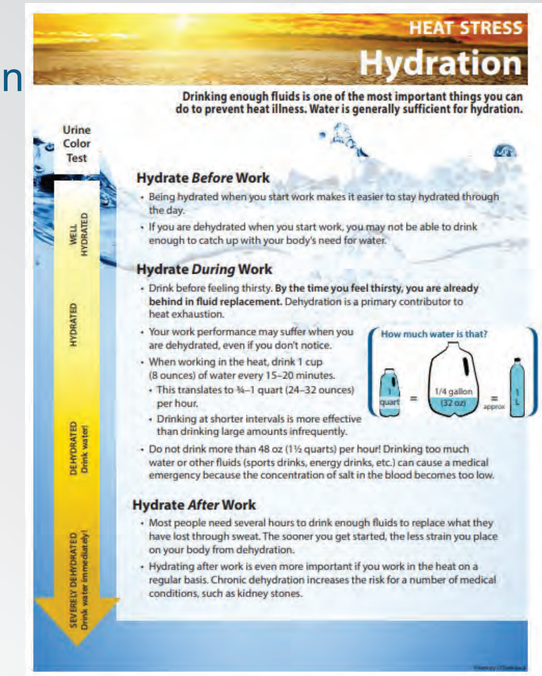
- Welcome and Meeting Purpose
- Safety Moment
- Introductions and FERC ILP Schedule
- Visual Resources Study
  - Task 2: Seen Area Analysis
  - Task 4: Key Views Selection
- Recreational Resources Study

2

Safety Moment – Heat Safety & Hydration

More than 700 Americans die from heat-related causes annually!

Steps to prevent heat stress
- Limit exposure (start early!)
- Pace yourself
- Loose, lightweight, light-colored clothing
- **Proper hydration**



Source: https://www.cdc.gov/nceh/features/extremeheat/index.html

FERC ILP Schedule

Activity	Responsible Parties	Timeframe	Estimated Filing Date or Deadline
File Notice of Intent (NOI) and Pre-application Document (PAD) (18 CFR §5.5(d))	Licensee	Within 5 years to 5.5 years prior to license expiration	Feb 23, 2022
Initial Tribal Consultation Meeting (18 CFR §5.7)	FERC	No later than 30 days following filing of NOI/PAD	Mar 25, 2022
Issue Notice of NOI/PAD and Scoping Document 1 (SD1) (18 CFR §5.8(a))	FERC	Within 60 days following filing of NOI/PAD	Apr 24, 2022
Conduct Scoping Meetings and site visit (18 CFR §5.8(b)(viii))	FERC	Within 30 days following Notice of NOI/PAD and SD1	May 16-17, 2022
Comments on PAD, SD1, and Study Requests (18 CFR §5.9(a))	Licensee Stakeholders	Within 60 days following Notice of NOI/PAD and SD1	June 23, 2022
Issue Scoping Document 2 (SD2) (18 CFR §5.10)	FERC	Within 45 days following deadline for filing comments on PAD/SD1	Aug 7, 2022
File Proposed Study Plan (PSP) (18 CFR §5.11)	Licensee	Within 45 days following deadline for filing comments on PAD/SD1	Aug 7, 2022
PSP Meeting (18 CFR §5.11(e))	Licensee	Within 30 days following filing of PSP	Sept 7, 2022
Comments on PSP (18 CFR §5.12)	Stakeholders	Within 90 days following filing of PSP	Nov 5, 2022
File Revised Study Plan (RSP) (18 CFR §5.13(a))	Licensee	Within 30 days following deadline for comments on PSP	Dec 5, 2022
Comments on RSP (18 CFR §5.13(b))	Stakeholders	Within 15 days following filing of RSP	Dec 20, 2022
Issue Study Plan Determination (18 CFR §5.13(c))	FERC	Within 30 days following filing of RSP	Jan 4, 2023
Conduct First Season of Studies (18 CFR §5.15)	Licensee	-	Spring-Fall 2023
File Study Progress Reports (18 CFR §5.15(b))	Licensee	Quarterly	Spring 2023 -Fall 2024
File Initial Study Report (ISR) (18 CFR §5.15(c))	Licensee	Pursuant to the Commission-approved study plan or no later than 1 year after Commission approval of the study plan, whichever comes first	Jan 4, 2024

Recreation & Visual Resources Resource Committee

- Resource Committee Lead: Alan Stuart
- Lead Technical Manager: John Crutchfield
- Recreation Resources Study Lead: Kelly Kirven, Kleinschmidt Associates
- Visual Resources Study Lead: Jen Huff, HDR
- Visual Resources Landscape Architect: Tristan Cleveland, LPDA Associates

Recreation & Visual Resources Resource Committee – July 27, 2023 | 5

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Visual Resources Study

Task Refresher

- Task 1 – Existing Landscape Description
- **Task 2 – Seen Area Analysis**
- Task 3 – Field Investigation
- **Task 4 – Key Views Selection**
- Task 5 - Existing Visual Quality Assessment
- Task 6 – Visual Analysis
- Task 7 – Visual Management Consistency Review
- Task 8 – Mitigation Assessment
- Task 9 – Conceptual Design of Bad Creek II Complex

Recreation & Visual Resources Resource Committee – July 27, 2023 | 6

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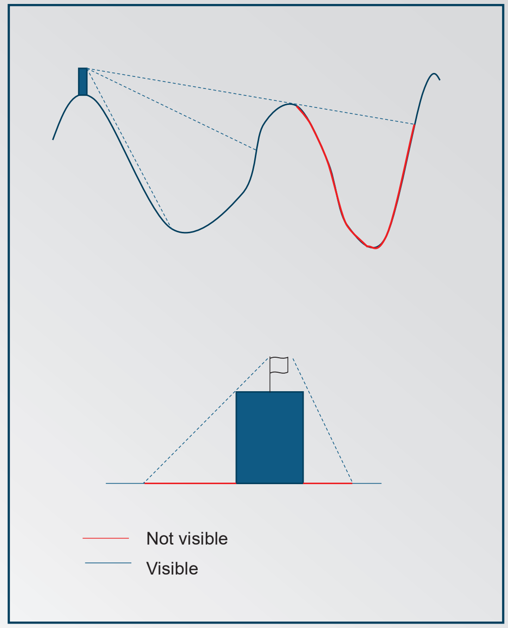
Task 2 - Seen Area Analysis

Objective: Identify areas from which Bad Creek II would be visible

Methodology:

- Geographic Information System (GIS): ESRI ArcGIS Pro Viewshed Analysis Spatial Analyst Tool
- USGS Digital Elevation Model (DEM)
- Conservative analysis
  - Bare earth basis (trees, structures)
  - Atmospheric effects (clouds, humidity, fog)
  - Revegetation of spoils area
  - Structure design



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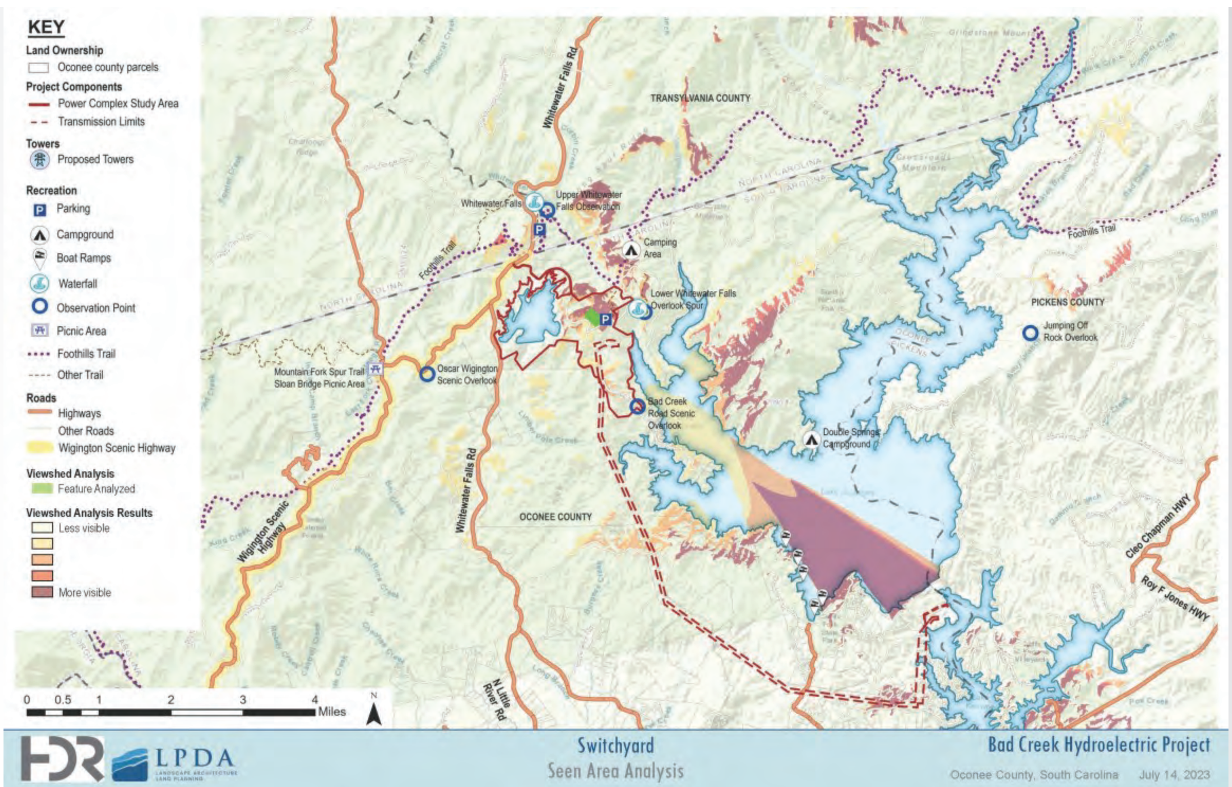

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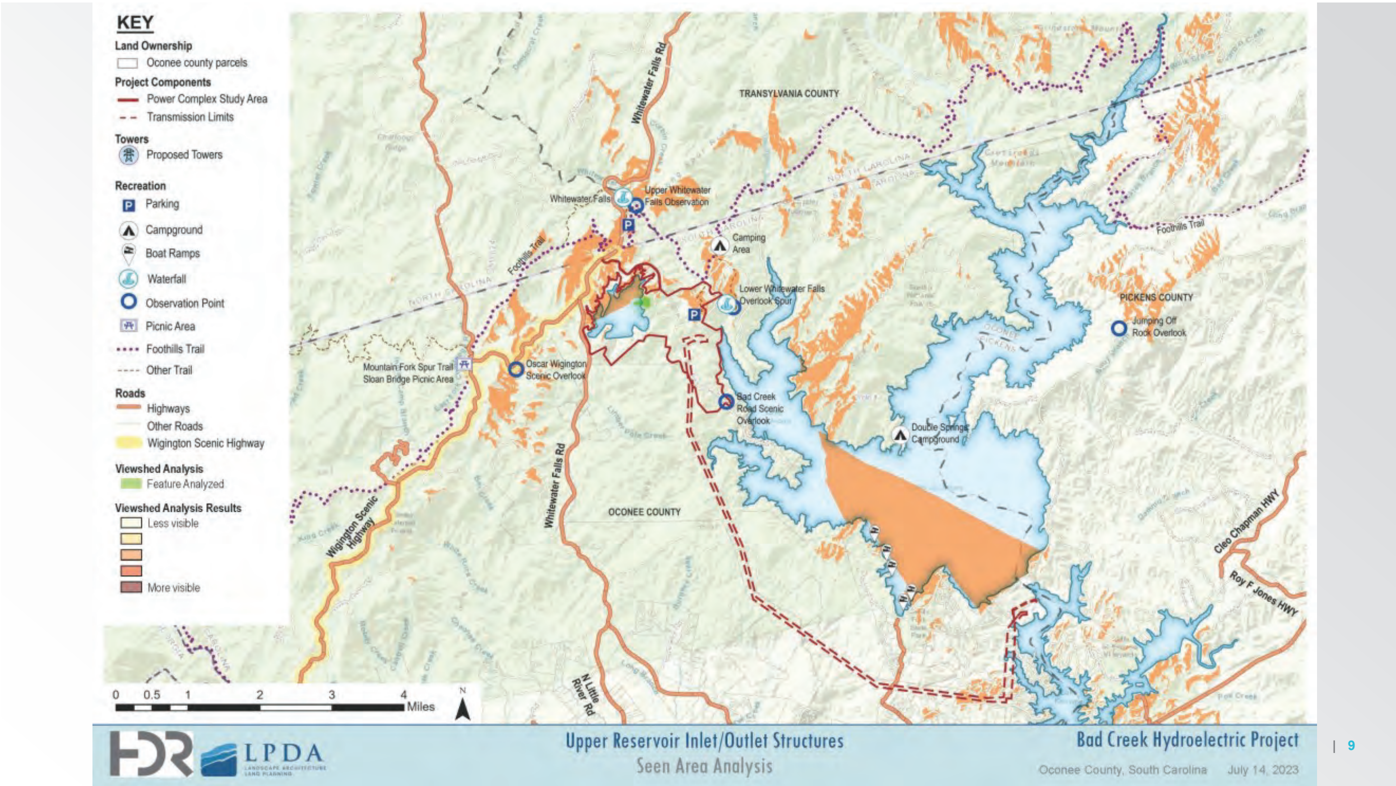
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Oconee County, South Carolina July 14, 2023
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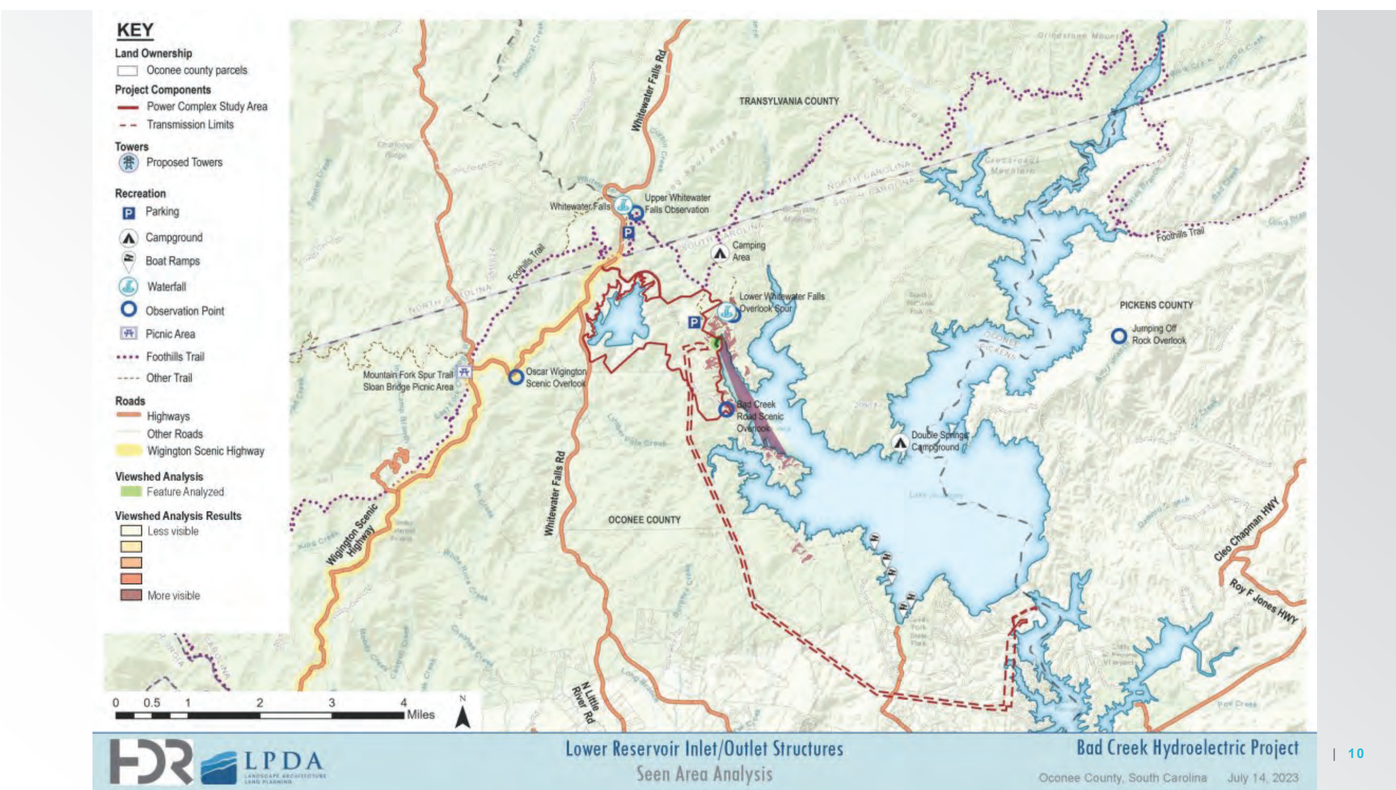
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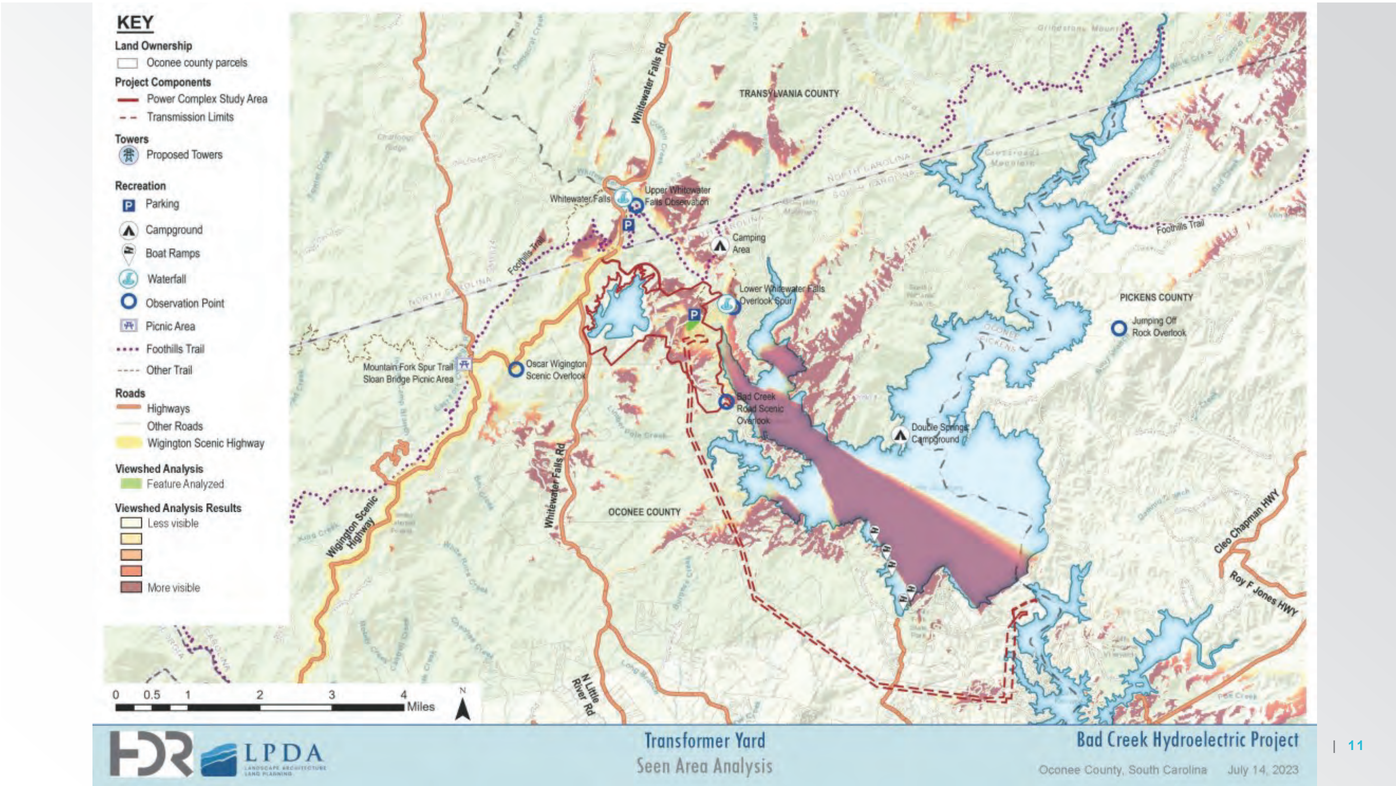
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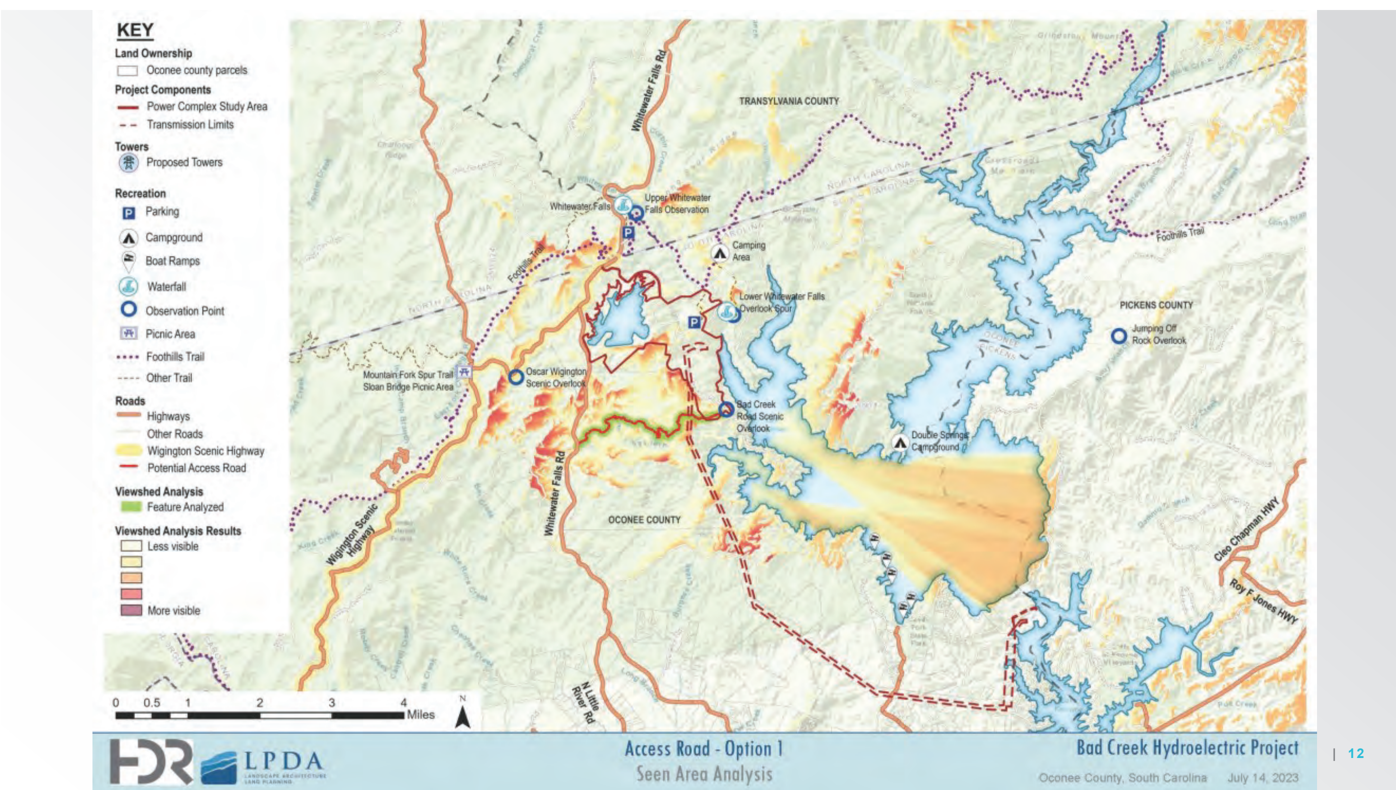
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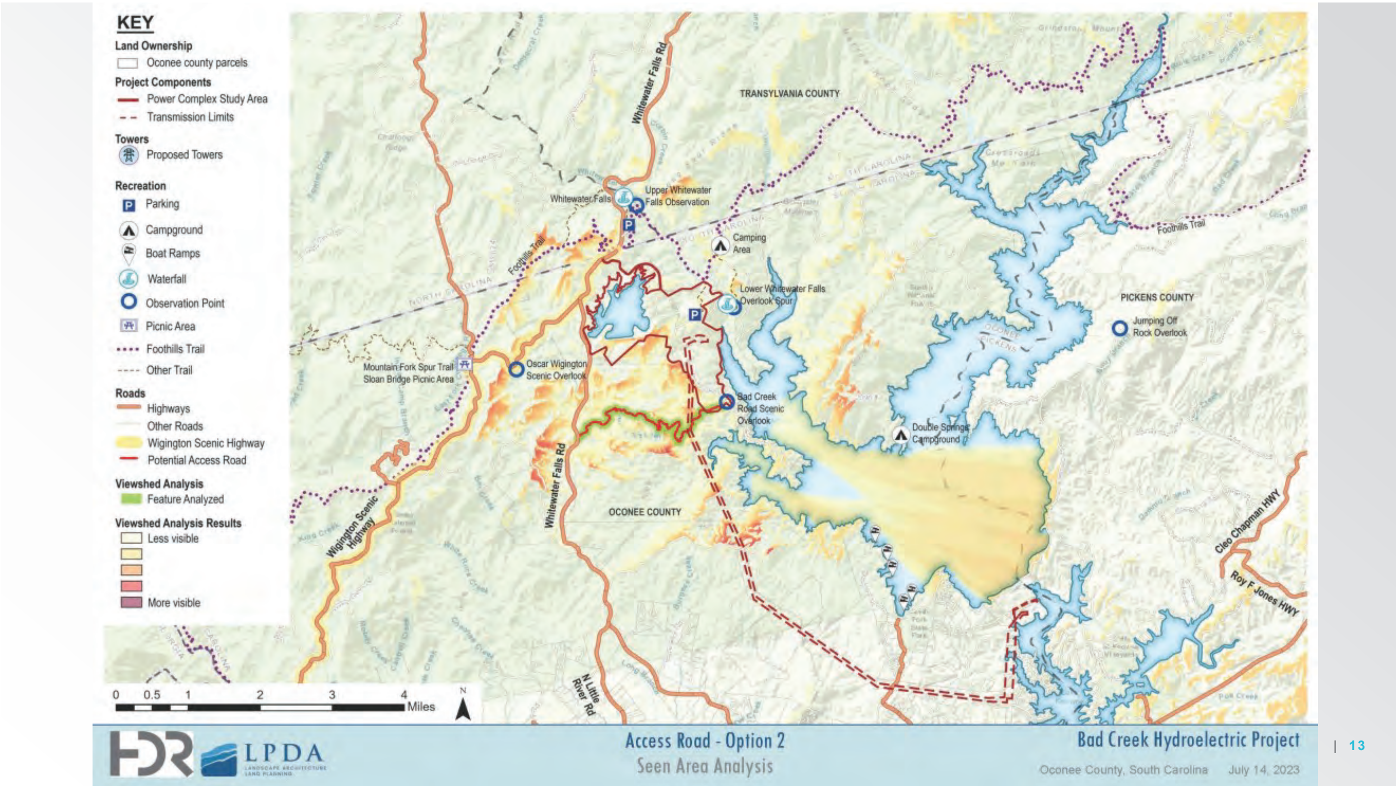
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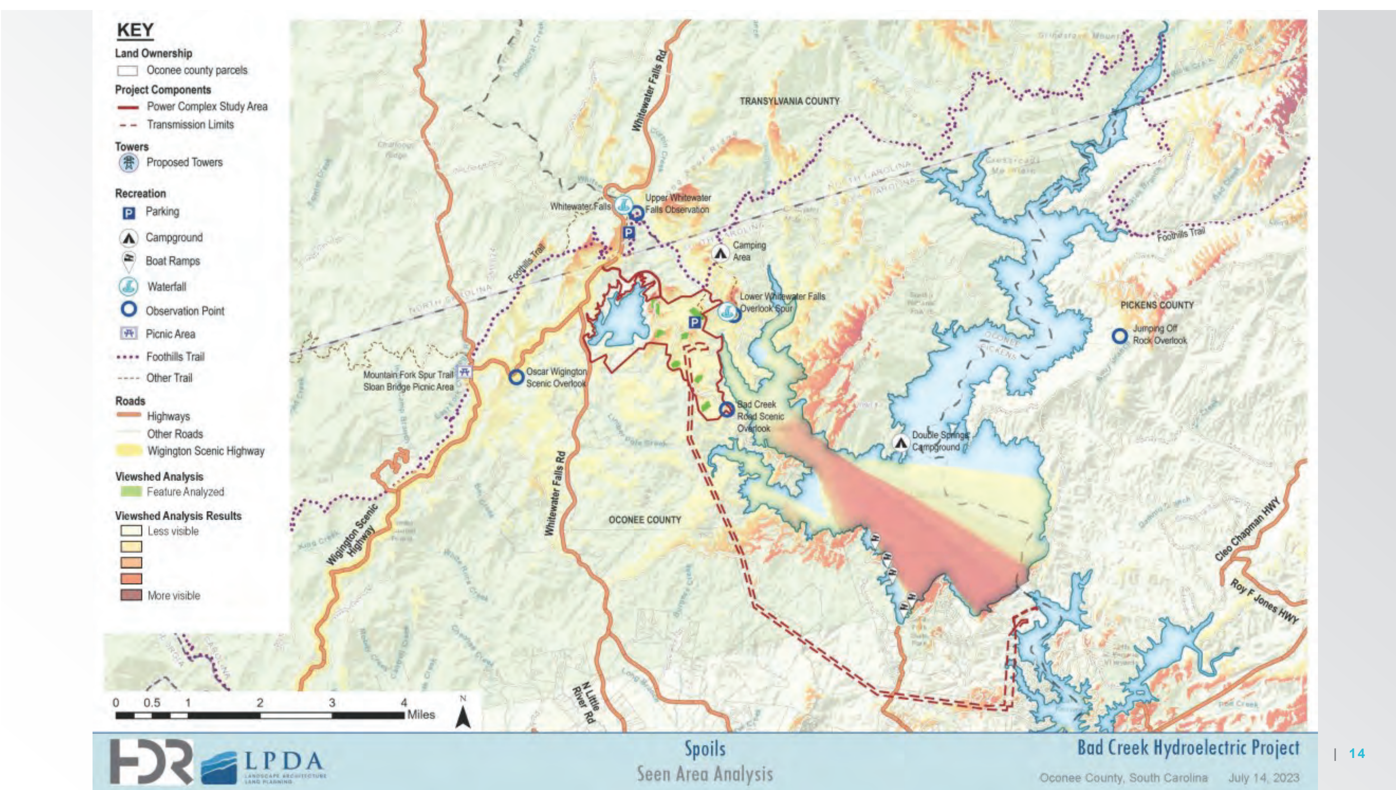
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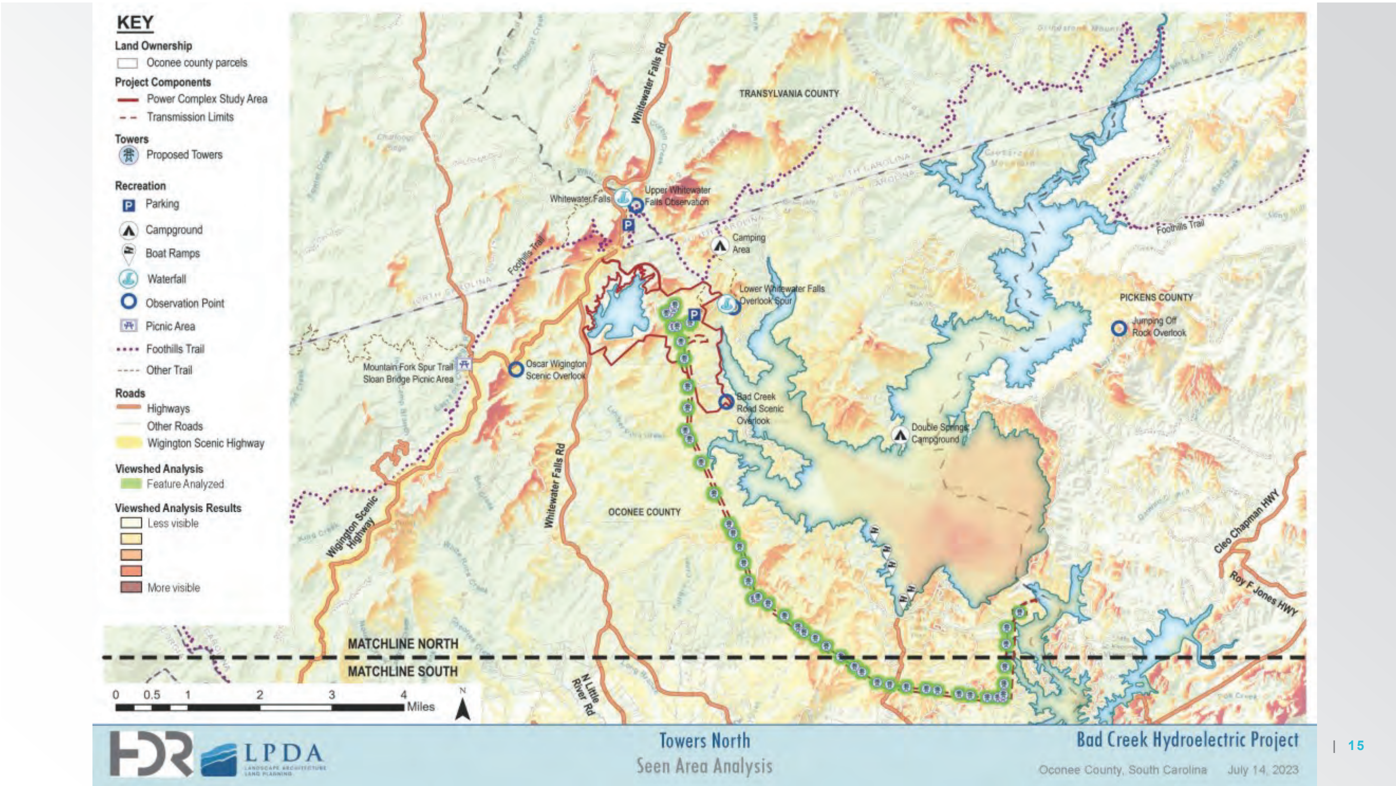
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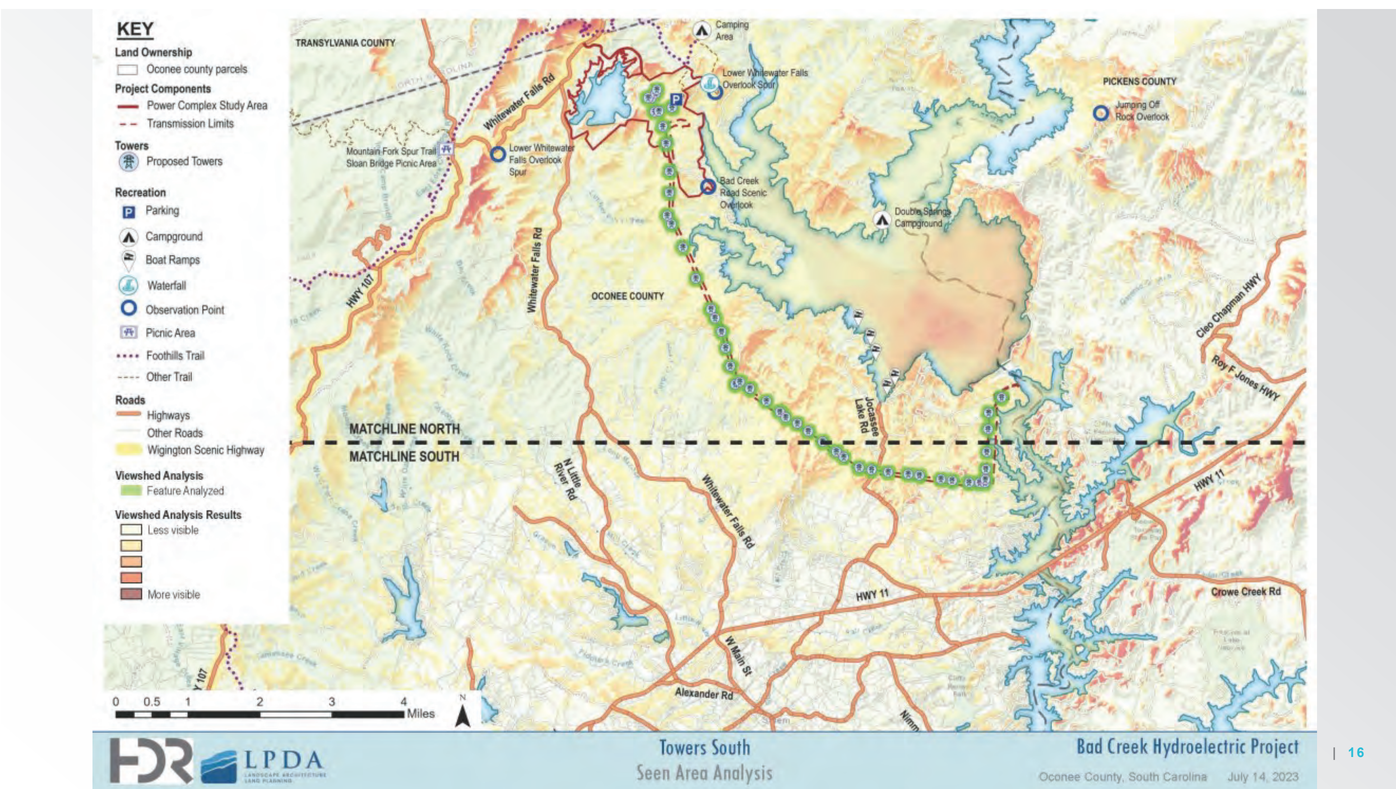
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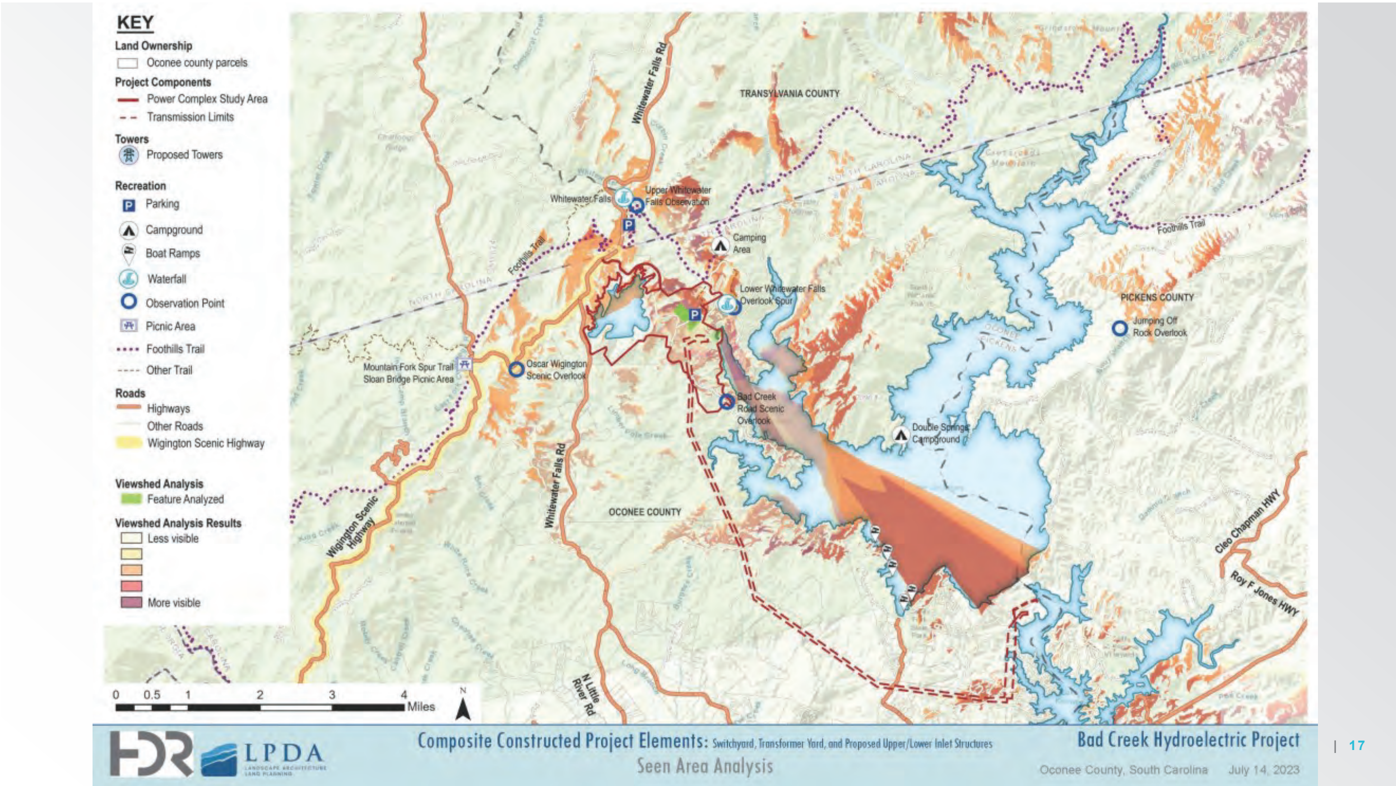
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Composite Constructed Project Elements: Switchyard, Transformer Yard, and Proposed Upper/Lower Inlet Structures
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Bad Creek Hydroelectric Project
Oconee County, South Carolina July 14, 2023
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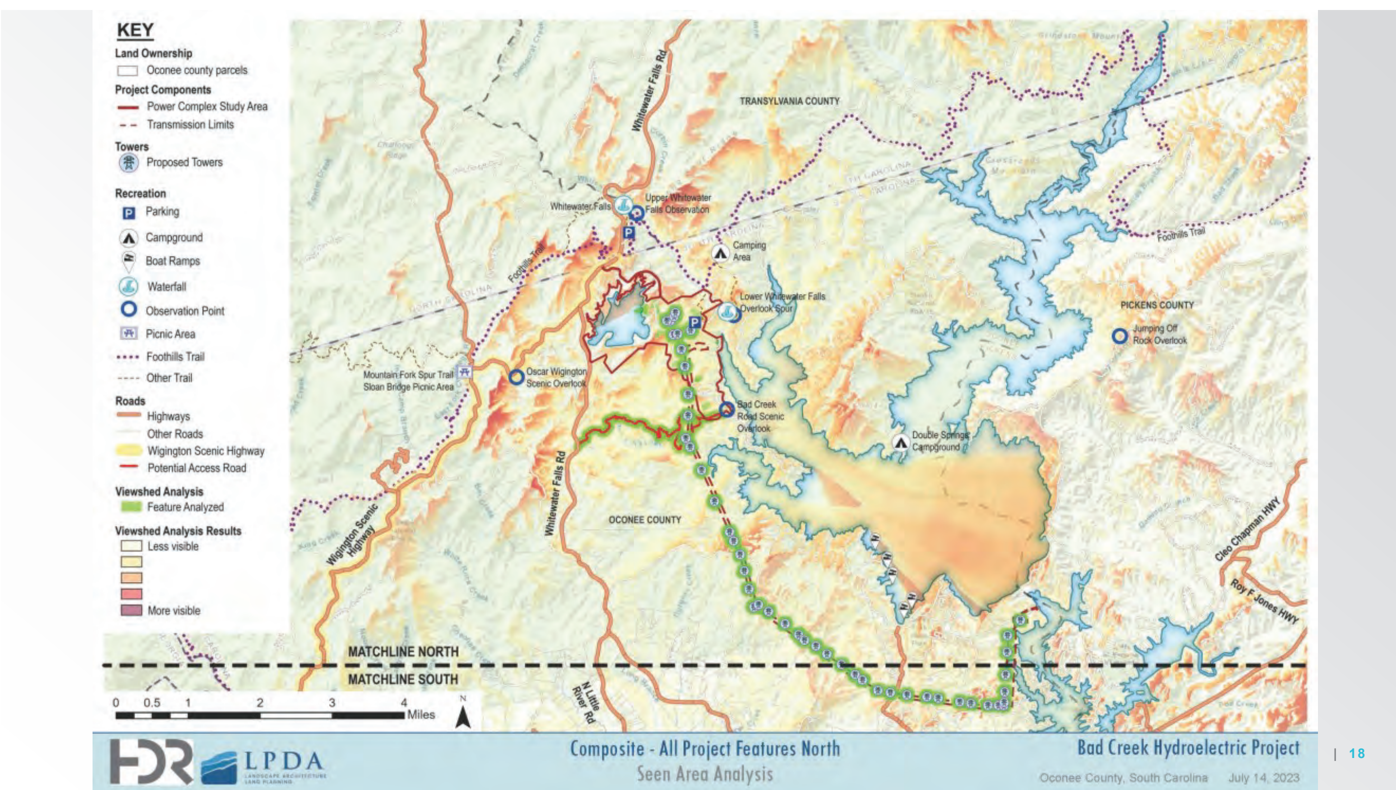
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Composite - All Project Features North
Seen Area Analysis
Bad Creek Hydroelectric Project
Oconee County, South Carolina July 14, 2023
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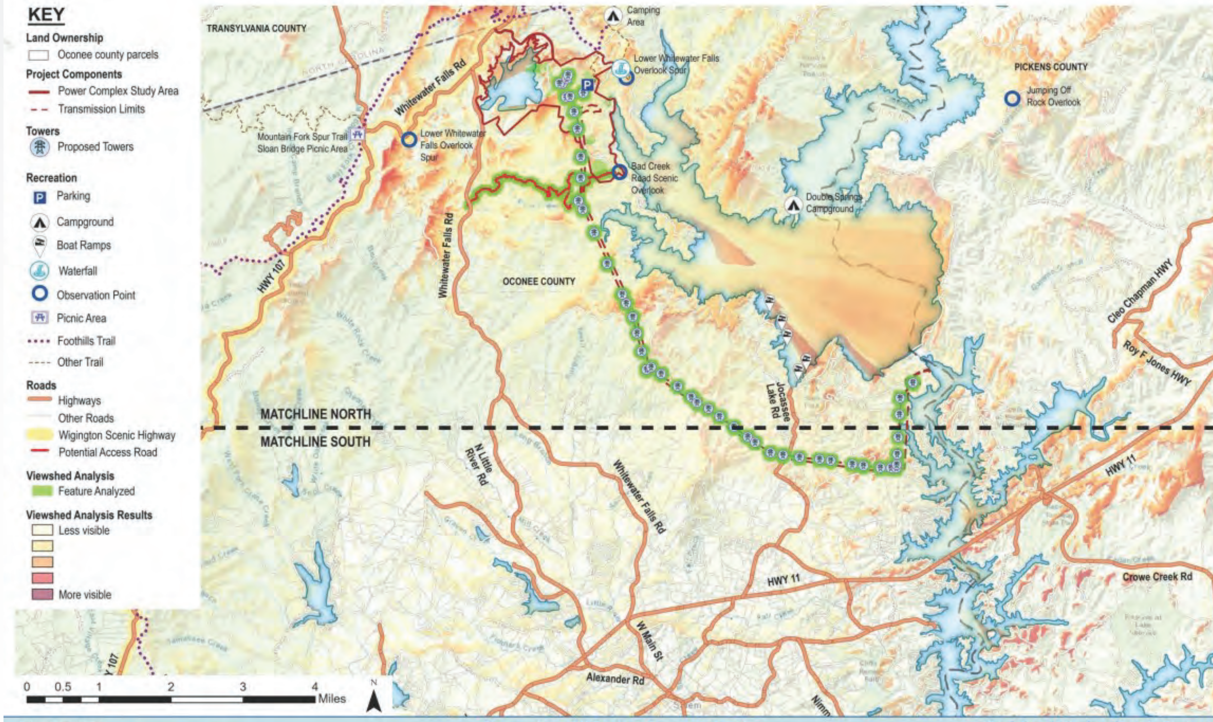

Composite - All Project Features South
Seen Area Analysis

Bad Creek Hydroelectric Project
Oconee County, South Carolina July 14, 2023

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Task 4 – Key Views Selection

"The objective will be to identify a set of Key Views (**up to four**) that adequately covers the range of visibility and potential scenic and visual impacts for the Project. Considerations that will be used in selecting specific Key Views **include viewing distance, to ensure adequate representation of potential foreground, middleground, and background views of the Project features; viewing direction; and the types of viewer groups** (typically including residents, recreational users and motorists) that might experience views of the Project facilities."

Recreation & Visual Resources Resource Committee – July 27, 2023 | 20

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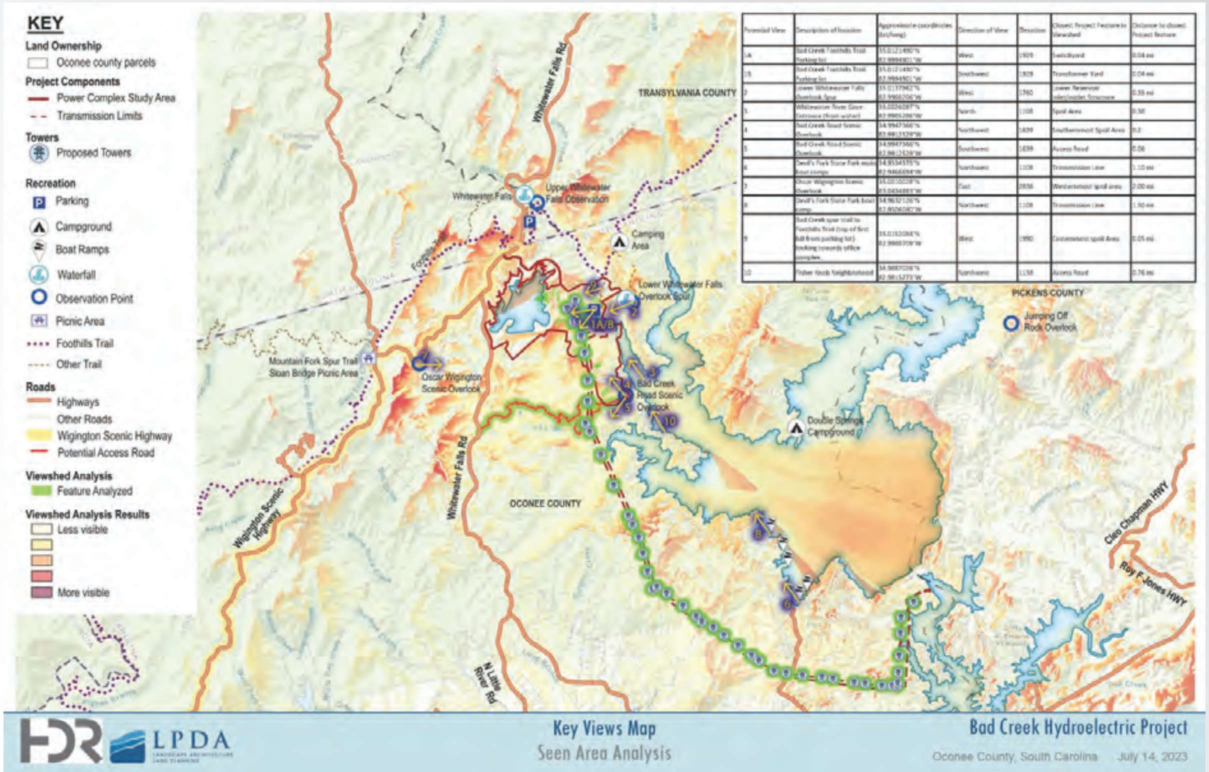


Potential Key Views

Potential View	Description of location	Approximate coordinates (lat/long)	Direction of View	Elevation	Closest Project Feature in Viewshed	Distance to closest Project feature (mi)
1A	Bad Creek Foothills Trail Parking lot	35.0121490°N 82.9994901°W	West	1929	Switchyard	0.04
1B	Bad Creek Foothills Trail Parking lot	35.0121490°N 82.9994901°W	Southwest	1929	Transformer Yard	0.04
2	Lower Whitewater Falls Overlook Spur	35.0137962°N 82.9900206°W	West	1760	Lower Reservoir Inlet/outlet Structure	0.35
3	Whitewater River Cove Entrance (from water)	35.0026097°N 82.9905286°W	North	1108	Spoil Area	0.38
4	Bad Creek Road Scenic Overlook	34.9947366°N 82.9912529°W	Northwest	1639	Southernmost Spoil Area	0.20
5	Bad Creek Road Scenic Overlook	34.9947366°N 82.9912529°W	Southwest	1639	Access Road	0.06
6	Devil's Fork State Park main boat ramps	34.9534575°N 82.9466694°W	Northwest	1108	Transmission Line	1.10
7	Oscar Wigington Scenic Overlook	35.0010028°N 83.0434883°W	East	2836	Westernmost spoil area	2.00
8	Devil's Fork State Park boat ramp	34.9632126°N 82.9506040°W	Northwest	1108	Transmission Line	1.50
9	Bad Creek spur trail to Foothills Trail (top of first hill from parking lot) looking towards office complex.	35.0152084°N 82.9980709°W	West	1990	Easternmost spoil Area	0.05
10	Fisher Knob Neighborhood	34.9887026°N 82.9815273°W	Northwest	1138	Access Road	0.76

Key Views: Next Steps

- Task 3 – Field Investigation (November)
  - Capture views
  - Finalize Key Views (virtual meeting)
- Task 5 – Existing Visual Quality Assessment
- Task 6 – Visual Analysis
  - Develop visualizations
- Task 7 – Visual Management Consistency Review
- Task 8 – Mitigation Assessment
- Task 9 – Conceptual Design of Bad Creek II Complex
- Task 10 – Report (3rd quarter, 2024)

Recreation Resources Study

Recreation Resources Study - Task 1: Foothills Trail Corridor Recreation Use and Needs

Recreation Site Inventory

The inventory was completed at the following sites on May 17, 2023:

- Sassafras Mountain Trail Access
- Chimney Top Gap Trail Access
- Laurel Valley Trail Access
- Lower Whitewater Falls Overlook
- Bad Creek Trail Access
- Coon Branch Spur Trail
- Musterground Road

The inventory was completed at the following sites on May 28, 2023:

- Laurel Fork Creek Falls Spur Trail Access
- Toxaway River Trail access
- Canebrake Trail Access
- Horsepasture River Trail Access

Recreation Resources Study - Task 1: Foothills Trail Corridor Recreation Use and Needs

Traffic and Trail Counts

- Traffic and trail counters were installed at access areas in late February/early March 2023. The traffic counter at Musterground Road was installed in mid-September 2022.
  - Due to significant counter malfunctions, data was not collected at Musterground Road over a long period of time in fall 2022. Kleinschmidt will reinstall the traffic counter at Musterground Road by September 15, 2023, to ensure a complete dataset is collected between September 15 and January 15.

Recreation Resources Study - Task 1: Foothills Trail Corridor Recreation Use and Needs

User Surveys

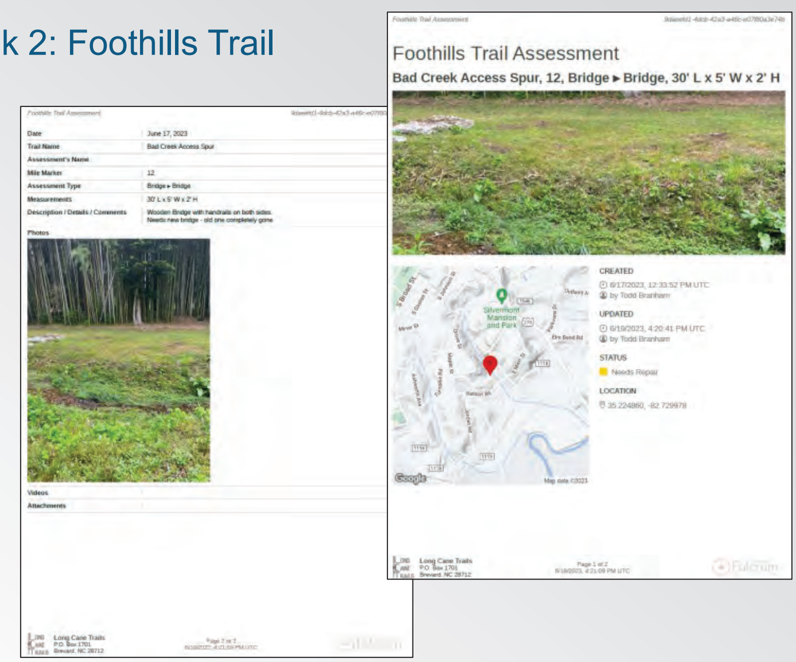
- In-person user surveys began in March 2023 at the Toxaway River Trail Access, the Horsepasture River Trail Access, the Bad Creek Hydro Trail Access, and the Laurel Valley Trail Access.

Number of surveys completed by recreation site and using the QR code through July 5, 2023

Site Name	# Surveys Completed
Bad Creek Hydro Trail Access	44
Horsepasture River Trail Access	13
Laurel Valley Trail Access	31
Toxaway River Trail Access	26
QR Code	41
Total	155

Recreation Resources Study - Task 2: Foothills Trail Corridor Conditions Assessment

- Todd Branham (Long Cane Trails) began hiking the 43 miles of trail in late June and is collecting information using the Fulcrum app.



Date	June 17, 2023
Trail Name	Bad Creek Access Spur
Assessment's Name	
Mile Marker	12
Assessment Type	Bridge ▸ Bridge
Measurements	30' L x 5' W x 2' H
Description / Details / Comments	Wooden Bridge with handrails on both sides. Needs new bridge - old one completely gone

Photos

Videos

Attachments

Foothills Trail Assessment

Bad Creek Access Spur, 12, Bridge ▸ Bridge, 30' L x 5' W x 2' H

CREATED

6/17/2023, 12:33:52 PM UTC

by Todd Branham

UPDATED

6/19/2023, 4:20:41 PM UTC

by Todd Branham

STATUS

Needs Repair

LOCATION

35.224860, -82.729978

Recreation Resources Study - Task 3: Whitewater Cove Existing Recreational Use Evaluation

Drone Flight Summary at Whitewater River Cove

Date	# of Images Collected	~ High Temp (ºF)	Notes
28-May	49	63 ºF	
31-May	40	75 ºF	
2-Jun	93	86 ºF	
3-Jun	69	88 ºF	
13-Jun	49	79 ºF	
24-Jun	105	82 ºF	
28-Jun	80	89 ºF	
1-Jul	102	93 ºF	
4-Jul	105	89 ºF	
14-Jul	74	92 ºF	Due to lightning, flights ended at 2:30
15-Jul	83	95 ºF	Due to storms, flights ended at 3:00

Recreation & Visual Resources Resource Committee – July 27, 2023 | 29

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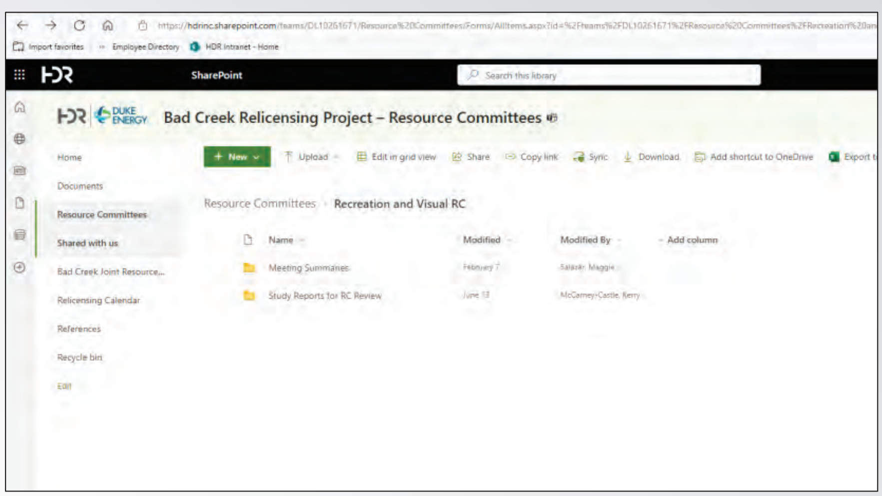
Closing Remarks

- Action item review
- Meeting summary



Recreation & Visual Resources Resource Committee – July 27, 2023 | 30

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BUILDING A SMARTER ENERGY FUTURE®

31

From: maggie.salazar@hdrinc.com
Subject: FW: Bad Creek Relicensing - Visual Resources Lighting Evaluation Study
Attachments: potential night views.pdf

Importance: High

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Wednesday, October 11, 2023 8:15 AM
To: Amy Breedlove <BreedloveA@dnr.sc.gov>; Andrew Gleason <andrewandwilla@hotmail.com>; Andy Douglas <adoug41@att.net>; Chris Starker <cstarker@upstateforever.org>; Dale Wilde <dwilde@keoweefolks.org>; RankinD <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Kelly Kirven <Kelly.Kirven@KleinschmidtGroup.com>; Ken Forrester <forresterk@dnr.sc.gov>; quattrol <quattrol@dnr.sc.gov>; Salazar, Maggie <maggie.salazar@hdrinc.com>; Amedee, Morgan D. <amedeemd@dhec.sc.gov>; cloningerp@dnr.sc.gov; SelfR <SelfR@dnr.sc.gov>; Rowdy Harris <charris@scprt.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; suewilliams130@gmail.com; William T. Wood <woodw@dnr.sc.gov>; Willie Simmons <simmonsw@dnr.sc.gov>; Huff, Jen <Jen.Huff@hdrinc.com>; phil.mitchell@gmail.com; Bill Ranson-Retired <bill.ranson@retiree.furman.edu>
Cc: Kulpa, Sarah <sarah.kulpa@hdrinc.com>; McCarney-Castle, Kerry <kerry.mccarney-castle@hdrinc.com>
Subject: Bad Creek Relicensing - Visual Resources Lighting Evaluation Study
Importance: High

Dear Bad Creek Relicensing Recreation & Visual Resources Committee Members:

Per discussion during the July 27, 2023 Resource Committee meeting, please find attached the proposal for the lighting evaluation component of Task 9 (Conceptual Design of Bad Creek II Complex) for the Bad Creek Visual Resources Study.

Duke Energy is planning to use a similar process to plan for collecting images and developing visualizations of Project features for use with Task 4 (Key Views Selection). We are focused on two categories of views for the lighting evaluation: near and distance views. The near views will have a clear view of the facility while the distant views will be focused on evaluating the effects of additional facility lighting on the surrounding landscape.

Similar to the process we will use for the daytime views, we will provide the four (4) images to the Resource Committee for them to select two (2) that will then be used for visualizations. In selecting the four views, we focused on areas that are likely to have nighttime use and potentially already experience some sort of lighting effects. The four views we are proposing are:

- View from the Bad Creek Foothills Trail parking lot
- View from the top of the first hill on the spur trail from the parking lot to the Foothills Trail
- View from a dock at Fishers Knob looking towards the site. Note the location of this site is dependent on gaining homeowner agreement from a resident on Fishers Knob.
- View from the northernmost boat ramp at Devils Fork State Park looking towards the site

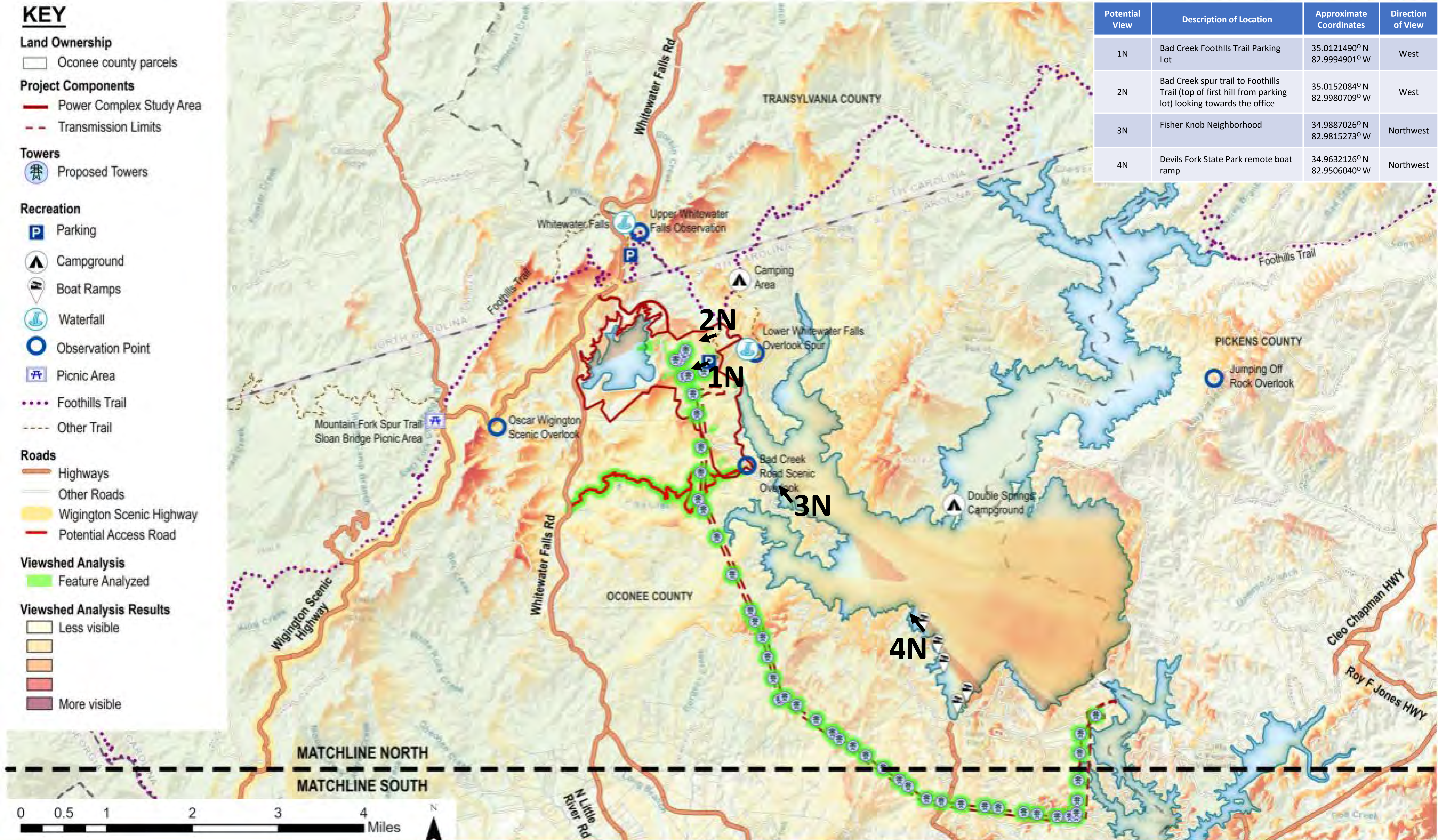
The attached drawing shows the approximate locations.

We will capture nighttime images that are representative of the viewer experience (as opposed to longer exposure or enhanced visibility images). We are targeting a moon phase of quarter moon to half-moon in November, so we are likely looking at the last week of November – weather permitting. We will plan to capture the daytime and nighttime images on the same day.

Please provide comments to me regarding the above proposal by **October 27, 2023.** If you have questions, please reach out to me or Jen Huff at Jen.Huff@hdrinc.com.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095



Potential View	Description of Location	Approximate Coordinates	Direction of View
1N	Bad Creek Foothlls Trail Parking Lot	35.0121490° N 82.9994901° W	West
2N	Bad Creek spur trail to Foothills Trail (top of first hill from parking lot) looking towards the office	35.0152084° N 82.9980709° W	West
3N	Fisher Knob Neighborhood	34.9887026° N 82.9815273° W	Northwest
4N	Devils Fork State Park remote boat ramp	34.9632126° N 82.9506040° W	Northwest

FDR LPDA LANDSCAPE ARCHITECTURE LAND PLANNING

Composite - All Project Features North

Potential Night Views

Bad Creek Hydroelectric Project

Oconee County, SC

October 10, 2023

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From:	Crutchfield Jr., John U
To:	Stuart, Alan Witten; Huff, Jen; Kulpa, Sarah; McCarney-Castle, Kerry
Subject:	FW: [EXTERNAL] Re: Bad Creek Relicensing - Visual Resources Lighting Evaluation Study
Date:	Tuesday, October 17, 2023 6:26:23 AM

FYI.

From: Dale Wilde <dwilde@keoweefolks.org>
Sent: Tuesday, October 17, 2023 3:58 AM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Subject: [EXTERNAL] Re: Bad Creek Relicensing - Visual Resources Lighting Evaluation Study

John,

FOLKS has no comments on this lighting evaluation study.

Ms. Dale Wilde
President, FOLKS
C: 207-604-6539
E: dwilde@keoweefolks.org

"Friends of Lake Keowee Society is dedicated to the preservation and enhancement of Lake Keowee and its watershed through advocacy, conservation, and education."

> On Oct 11, 2023, at 8:15 AM, Crutchfield Jr., John U <John.Crutchfield@duke-energy.com> wrote:
>
> Dear Bad Creek Relicensing Recreation & Visual Resources Committee Members:
>
> Per discussion during the July 27, 2023 Resource Committee meeting, please find attached the proposal for the lighting evaluation component of Task 9 (Conceptual Design of Bad Creek II Complex) for the Bad Creek Visual Resources Study.
>
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The attached drawing shows the approximate locations.

We will capture nighttime images that are representative of the viewer experience (as opposed to longer exposure or enhanced visibility images). We are targeting a moon phase of quarter moon to half-moon in November, so we are likely looking at the last week of November – weather permitting. We will plan to capture the daytime and nighttime images on the same day.

Please provide comments to me regarding the above proposal by **October 27, 2023.** If you have questions, please reach out to me or Jen Huff at Jen.Huff@hdrinc.com.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

<potential night views.pdf>

From:	Crutchfield Jr., John U
To:	Amy Breedlove; Andrew Gleason; Andy Douglas; Chris Starker; Dale Wilde; RankinD; Elizabeth Miller; Kelly Kirven; Ken Forrester; quattrol; Salazar, Maggie; Amedee, Morgan D.; Pat Cloninger; SelfR; Rowdy Harris; Stuart, Alan Witten; suewilliams130@gmail.com; William T. Wood; Willie Simmons; Huff, Jen
Cc:	Kulpa, Sarah; McCarney-Castle, Kerry; Settevendemio, Erin
Subject:	Bad Creek Relicensing - Visual Resources Committee Virtual Meeting for View Selection Analysis
Date:	Tuesday, December 5, 2023 1:22:48 PM
Importance:	High

Dear Bad Creek Relicensing Recreation and Visual Resources Committee Members:

Please recall that the Visual Resources Study called for Duke Energy's relicensing consultant, HDR, to capture photographs at six locations in the vicinity of the site during leaf-off conditions. That has now been done, so the next step in the process is for the Recreation and Visual Resources Resource Committee to select four of the six locations, plus two nighttime views, to use for the remaining study tasks. That includes the development of photo simulations of Bad Creek II and an analysis of the effects of the expanded facility on the surrounding landscape.

Duke Energy would like to convene the Resource Committee via a Teams virtual meeting to provide input and gain consensus on the view site selection. We will convene the meeting during the week of January 8-12, 2024, and the meeting will be scheduled for 2 hours, either in the morning (9-11 am) or afternoon (1-3 pm).

Please use the Doodle Poll link below to provide your availability to attend this virtual meeting.

https://doodle.com/meeting/participate/id/elvBZwjb

I would appreciate if you would respond to the Doodle Poll meeting availability by no later than Friday, December 15, COB.

I will schedule the Teams meeting via Outlook calendar soon after the Doodle Poll closes.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

Bad Creek Relicensing - Visual Resources Committee Virtual Meeting for View Selection Analysis

Friday, December 29, 2023 10:57 AM

Meeting Date: 1/11/2024 9:00 AM
Location: Microsoft Teams Meeting
Link to Outlook Item: *click here*
Invitation Message

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Dear Bad Creek Relicensing Recreation and Visual Resources Committee Members:

Please recall that the Visual Resources Study called for Duke Energy's relicensing consultant, HDR, to capture photographs at six locations in the vicinity of the site during leaf-off conditions. That has now been done, so the next step in the process is for the Recreation and Visual Resources Resource Committee to select four of the six locations, plus two nighttime views, to use for the remaining study tasks. That includes the development of photo simulations of Bad Creek II and an analysis of the effects of the expanded facility on the surrounding landscape.

Duke Energy would like to convene the Resource Committee via a Teams virtual meeting to provide input and gain consensus on the view site selection.

An agenda will be provided for the meeting.

Please contact John Crutchfield if you have any questions regarding the meeting.

____

Microsoft Teams meeting

Join on your computer, mobile app or room device
Click here to join the meeting
Meeting ID: 215 178 507 820
Passcode: Cf6udk
Download Teams| Join on the web
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duke-energy@m.webex.com
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Or call in (audio only)
+1 704-659-4701,,981740090# United States, Charlotte
Phone Conference ID: 981 740 090#
Find a local number| Reset PIN
Learn More| Help| Meeting options

____

Participants

- Crutchfield Jr., John U (Meeting Organizer)
- Amy Breedlove
- Andrew Gleason

- Andy Douglas
- Chris Starker
- Dale Wilde
- Dan Rankin
- Elizabeth Miller
- Kelly Kirven
- Ken Forrester
- quattrol
- Salazar, Maggie
- Amedee, Morgan D.
- Pat Cloninger
- SelfR
- Rowdy Harris
- Stuart, Alan Witten
- suewilliams130@gmail.com
- William T. Wood
- Willie Simmons
- Huff, Jen
- Kulpa, Sarah
- McCarney-Castle, Kerry

From:	Crutchfield Jr., John U
To:	Amy Breedlove; Andrew Gleason; Andy Douglas; Chris Starker; Dale Wilde; Dan Rankin; Elizabeth Miller; Kelly Kirven; Ken Forrester; quattrol; Salazar, Maggie; Amedee, Morgan D.; Pat Cloninger; SelfR; Rowdy Harris; Stuart, Alan Witten; suewilliams130@gmail.com; William T. Wood; Willie Simmons; Huff, Jen
Cc:	Kulpa, Sarah; McCarney-Castle, Kerry
Subject:	Bad Creek Relicensing-Recreation & Visual Resources Committee Meeting Materials (1/11/2024 Meeting)
Date:	Tuesday, January 16, 2024 11:41:27 AM
Attachments:	2024 01 11 rec rc mtg summary.pdf
Importance:	High

Dear Bad Creek Relicensing Recreation & Visual Resources Committee Members:

Please find attached the summary of Visual Resources Study meeting held on January 11, 2024. I have also included below the SharePoint link to access the meeting summary, PowerPoint presentation, and the recorded Teams meeting.

Bad Creek Relicensing Project – Resource Committees - 2024 01 11 Rec RC Mtg - All Documents (sharepoint.com)

For those who attended the meeting, please review the meeting summary, and let me know if you have any comments or edits by Friday, February 2 (COB).

Please let Alan or me know if you have any questions about the meeting materials.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

Meeting Minutes

Project:	Bad Creek Relicensing
Subject:	Visual Resources Meeting for Key View Selection
Date:	Thursday, January 11, 2024
Location:	Microsoft Teams
Attendees:	Sue Williams – AQD Alan Stuart – Duke Energy John Crutchfield – Duke Energy Andrew Gleason – Foothills Trail Conservancy Amy Chastain – SCDNR Chris Starker – Upstate Forever Jen Huff – HDR Kerry McCarney-Castle – HDR James Lane - HDR

Introduction

John Crutchfield opened the meeting at 9:00 am and let folks know the meeting would be recorded for those who could not be in attendance as well as for future reference. He asked for objections; no one objected. Duke Energy will make available the meeting summary, PowerPoint presentation, and recording on the SharePoint site in the next couple of weeks.

J. Crutchfield reviewed the agenda and purpose of meeting. As a reminder, six potential Key Observation Points (KOPs) were agreed upon during the Visual Resources meeting in July 2023. The purpose of today's meeting is for the Visual Resources committee to choose four (out of the six originally agreed upon) KOPs based on photos captured during leaf-off conditions in November 2023 (not yet seen by the Recreation & Visual Resources Resource Committee [RC]) and to obtain input and consensus for selection of the nighttime views for photo rendering.

Safety Moment (J. Crutchfield) – Cold Stress

KOP Selection

Jen Huff provided a refresher on the Seen Area Analysis and potential KOPs from the July 2023 meeting in Greenville, SC. At that meeting, it was decided the KOP3 photo (from Whitewater River cove) would not be re-collected since the photo rendering is already complete for the additional inlet/outlet associated with Bad Creek II. Six potential KOPs were identified during the July Resource Committee meeting. Selected KOPs will be used to complete the remaining Visual Resources Study tasks.

KOP Selection (Task 4) and Field Work (Task 3) – J. Huff showed a map of locations where images were collected and explained necessary location changes (i.e., decisions made in the field based on field conditions/views/best professional judgement). Changes included:

- Elimination of potential KOP5 at the Bad Creek Visitor Overlook. The intention of the view was to capture the transmission line, but only an extremely limited view was observable.
- Elimination of potential KOP 9: KOP 9 was intended to capture a view of the office/warehouse complex from the Bad Creek spur trail. However, no views were observed, so the field crew moved the view to potential KOP 11.
- Addition of potential KOP 11: Given the elimination of KOP 9, the crew first evaluated adding a potential KOP at the parking lot trailhead. However, upon further consideration, the field crew elected to capture a view from potential KOP 11 at the entrance to Musterground Road which captured the most effect.

Field work was done on 12/6/2023 during leaf-off conditions. HDR photographer collected 24mm and 50mm views in the daytime (10 am - 1:30 pm) under sunny with scattered clouds and windy conditions and nighttime (6 pm – 9:30 pm) with clear, calm conditions. The nighttime views were collected prior to moonrise, and it was fully dark during image collection for nighttime views. J. Huff showed a series of images of the potential KOPs:

1. **KOP2**: Lower Whitewater Falls overlook toward Bad Creek, 24mm and 50mm views. Some project facilities were visible but not noticeable. Would likely not be able to see any facilities during leaf-on conditions.
2. **KOP4**: Bad Creek Visitor Overlook near the split rail fence , 24mm and 50mm views. Inlet/outlet structure visible.
3. **KOP7**: Oscar Wiggington Overlook, 24mm and 50mm views. Portions of transmission line visible.
4. **KOP10a**: View from privately-owned dock at Fisher Knob, 24 mm and 50 mm views. Closest private dock to inlet/outlet structure; inlet/outlet portal visible.
5. **KOP10b**: View from privately-owned residence at Fisher Knob, 24 mm and 50 mm views. Homeowner’s yard from point where land juts out into Whitewater River Cove. Inlet/outlet structure visible more clearly.
6. **KOP11**: Entrance to Musterground Road near the Foothills Trial information kiosk (added in-field), 24 mm view. View of open field with warehouse and Duke Energy office building; open field will be future location of new transmission line switchyard.

J. Huff opened the floor to discussion and led meeting participants through the process of choosing four out of the six potential KOPs to retain for the study. Jen said the selection would be through consensus of the RC, i.e., the committee members could live with the selected KOPs.

Sue Williams asked if the transmission line (new) will follow the existing transmission line. J. Huff answered yes, that is correct. S. Williams indicated there may not be much value from the Oscar Wigginton Overlook (KOP7) for transmission line views since it would be the basically the same view.

Chris Starker countered it might be worth keeping the power line views at Oscar Wiggington (KOP7) since the existing transmission corridor is 200 feet wide and will be expanded to nearly

380 feet. Widening the corridor could change the view, even though the transmission lines would follow the existing lines.

C. Starker stated KOP11 (Musterground Road kiosk) may not be useful since it is a parking lot and not an area of recreation, though the new transmission line switchyard at that site may have the effect of making the area feel more industrial and recreators may feel less secure.

J. Huff asked about removing KOPs10a and 10b. C. Starker asked for confirmation if both KOPs are homeowner views and noted the concern is more for the public, not for private property owners (who already experience the view). Amy Chastain stated that KOP10b would be useful to keep from a boating standpoint, as that is the view one sees when entering Whitewater River Cove via boat. Alan Stuart agreed that the 10a and 10b views were from the water views so may be important to keep at least one of them.

A. Chastain also suggested removing KOP11 since it is a parking lot, and a switchyard likely wouldn't deter visitors from hiking.

J. Huff reminded the group photo simulations were already done from the water for KOP3, which was taken from the Whitewater River Cove.

J. Huff asked for RC consensus on keeping photo simulations for KOP2. The RC agreed.

C. Starker noted that with leaf-on conditions, one wouldn't normally see anything as long as there is a healthy canopy (persistent) in place. The photo from Oscar Wiggington Overlook may be important from that standpoint because that canopy would need to be maintained (cut).

Andrew Gleason stated in his opinion, KOP11 (Musterground Parking lot) could be dropped from further evaluation, given the area will be closed off during construction. J. Huff reminded the group that the open field would have a switchyard for the life of the project.

J. Huff noted while they were on-site collecting images, two other cars accessed the Bad Creek Visitors Overlook, therefore, it is regularly used (KOP4). The RC reached consensus on keeping KOP4.

J. Huff returned to KOPs10a and 10b and reminded the group about KOP3. Sue Williams favors 10b to keep. Group consensus to eliminate KOP10a.

<u>KOP Selection Final Consensus</u>: Eliminate KOP11 (Musterground Road entrance) and KOP10a (homeowner dock). Retain KOPs 2, 4, 7, 10b, and existing KOP3.

Lighting Evaluation

Nighttime views were collected December 6, 2023. J. Huff showed map of locations where images were collected and noted changes that were made in the field based on view/field conditions/best professional judgement. Nighttime photography was challenging – collecting nighttime views are difficult because it's necessary to use long photographic exposures. While HDR's photographer (James Lane) is experienced in nighttime photography, some exposures led to lighter views (in photos) than what was experienced in the field.

J. Huff indicated there were two views where neither the Project nor light associated with it were visible at all – the top of Jocassee Dam and Devil's Fork State Park at the remote boat launch area. C. Starker asked about not seeing lights at certain views and that the concern is that additional light would be added from Bad Creek II. J. Huff indicated for photo simulations, Duke Energy would be replicating the current amount of light to represent Bad Creek II (and when there is nothing but darkness, only darkness could be replicated).

Photo 1N: View from the entrance to Musterground Road.

Photo 3N(a): View from Fisher Knob homeowner site (KOP10a); can see lights of the inlet/outlet structure.f

Photo 3N(b): View from Fisher Knob homeowner (3Nb); can see lights from inlet/outlet as well as existing transformer yard on top of the hill.

A. Stuart asked about faint visible light to the north of ridge (north of the Project) above the ridge crest in the 3N(b) photos since there is no city nearby. J. Huff noted that faint light near ridgetops is an artifact of the long photographic exposure.

J. Huff asked if there would be interest / value in seeing a photo simulation of the future switchyard at night from location 1N. C. Starker agreed there would be interest and asked if it would be very illuminated at night. J. Huff said no, the switchyard would have some security lights but would not be brightly lit.

J. Huff noted 3Nb might be the best (at the 24mm) image to use as it shows the view from a boat on Whitewater River Cove. A. Chastain agrees as does S. Williams. C. Starker asked if 3Na and 3Nb are the same view. Jen replied 3N(a) is from the dock closest to the intake/outlet and the other is further out on the point at Fisher Knob. C. Starker asked what nighttime would look like from either of the overlooks. J. Huff indicated photos were not collected from the overlooks because it is assumed that people don't view vistas in the dark.

Nighttime Lighting Final Consensus:1N and 3nb (24mm)

Next Steps

Tasks 5-10 will be completed, and the Visual Resources Study Report will be distributed for RC review during the second quarter of this year (2024).

C. Starker asked if anybody is aware of astronomy clubs that use these areas. A. Gleason responded he is aware of the Roper Mountain Astronomy Club, but they use Sassafras Mountain which is east of Lake Jocassee. A. Stuart is not aware of any and he had asked the same question. J. Huff is not familiar with folks doing night hikes or visiting the site for star gazing but will look into it. A. Gleason noted he was not aware of any activities at Bad Creek.

J. Huff reiterated the meeting summary, recording, and presentation would be made available via the SharePoint Site. J. Crutchfield thanked everybody for their input and adjourned the meeting at 9:50 am.

Bad Creek Pumped Storage Project No. 2740

Visual Resources Study - Recreation & Visual Resources Resource Committee

DUKE ENERGY.

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JANUARY 11, 2024

1

Meeting Agenda

- Welcome and Meeting Purpose
- Safety Moment
- Introductions
- Visual Resources Study Refresher
  - Task 2: Seen Area Analysis
  - Task 4: Potential Key Views Selection
- Key Views Selection
  - Daytime Key Observation Points
  - Lighting Effects
- Next Steps & Schedule

2

Safety Moment – Cold Stress

- Know the symptoms of cold stress.
- Monitor your physical condition and that of others.
- Take regular breaks to warm up when needed.
- Dress properly for the cold.
  - At least 3 layers!
  - Tight clothing reduces blood circulation to the extremities.
- Stay dry in the cold. Moisture or dampness, including sweating, can increase the rate of heat loss from the body.
- Keep extra clothing (including underwear) handy in case you get wet and need to change.
- Drink warm sweetened fluids (no alcohol).
- Include chemical hot packs in your first aid kit.
- Avoid touching cold metal or wet surfaces with bare skin.

Condition	Symptoms	
Hypothermia	*Early Symptoms* • Shivering • Fatigue • Loss of coordination • Confusion, disorientation	*Late Symptoms* • No shivering • Blue skin • Dilated pupils • Slowed pulse and breathing • Loss of consciousness
Frostbite	• Reduced blood flow to hands, feet • Numbness	• Aching • Tingling or stinging • Bluish or pale, waxy skin
Trench Foot	• Reddening of the skin • Numbness • Leg cramps • Swelling • Tingling pain	• Blisters, ulcers • Bleeding under the skin • Gangrene (foot may turn dark purple, blue, or gray)
Chillblains	• Redness • Itching • Possible blistering	• Inflammation • Possible ulceration in severe cases

Source: https://www.cdc.gov/niosh/docs/2010-115/pdfs/2010-115.pdf

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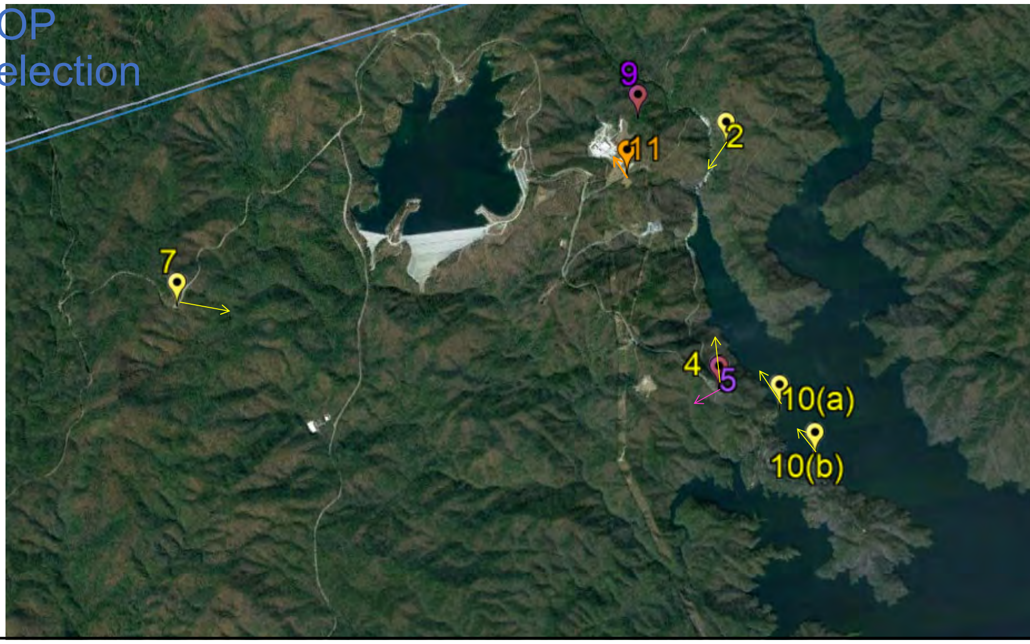
3

Visual Resources Study Refresher

- Seen Area Analysis
- Potential Key Observation Points (KOP) selected (July 27, 2023)
  - KOP 3 decision
  - Task 5: Existing landscape quality and characteristics (near foreground, foreground, midground, background)
  - Task 6: Proposed landscape described based on the photosimulation
  - Task 7: Consistency of proposed features with management goals and plans
  - Task 8: Mitigation recommendations to address significant differences between existing & proposed conditions
- Lighting Evaluation Photo Points (October 11, 2023)

4

Task 4: KOP Selection



Daytime Potential Key Views

- Image collected
- Eliminated by field crew
- Added by field crew

5

Task 3: Fieldwork

- December 6, 2023
- Leaf-off conditions
- 24mm and 50 mm
- Daytime
  - 10:00 am – 1:30 pm
  - Sunny with scattered clouds, windy
- Evening
  - 6:00 pm – 9:30 pm
  - Clear, calm, moonrise after midnight

6

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KOP 4
(50 mm)

11

KOP 7
(24 mm)

12

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KOP 10b
(50 mm)

17

KOP 11
(24 mm)

18

Goal: Select No More than 4!

2

4

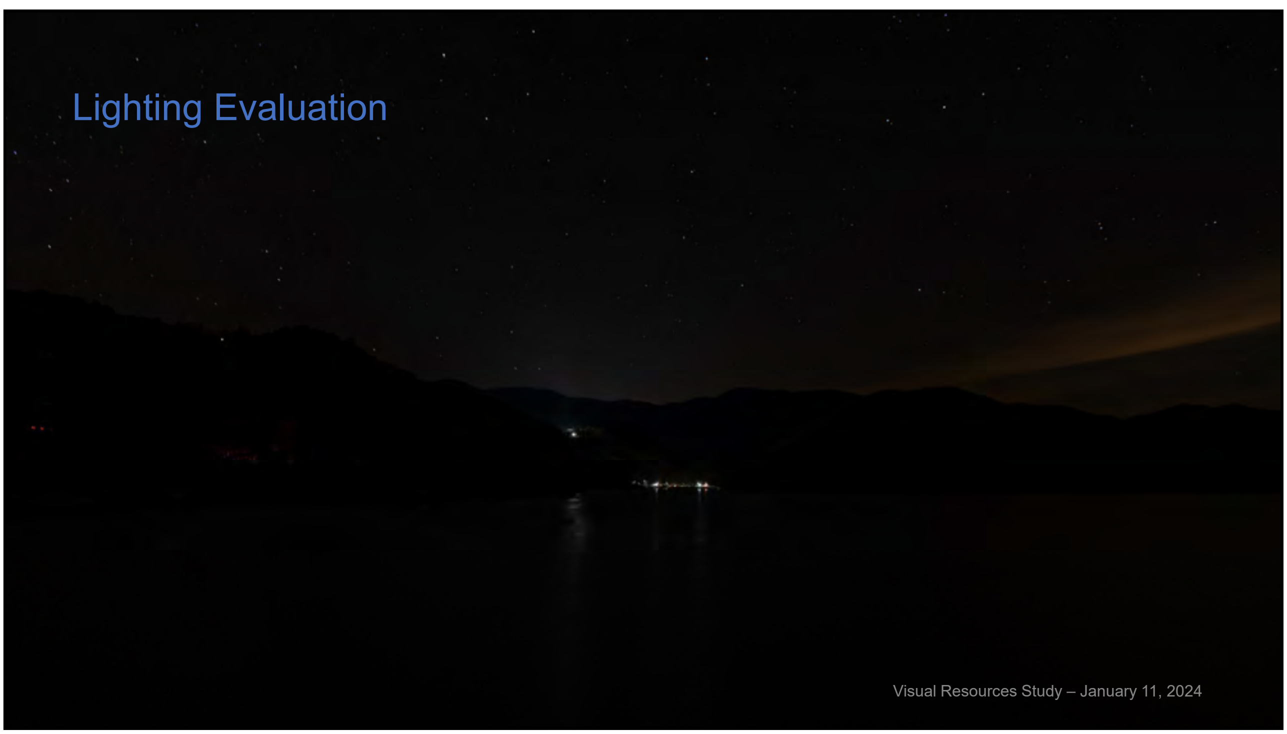
7

10a

10b

11

19



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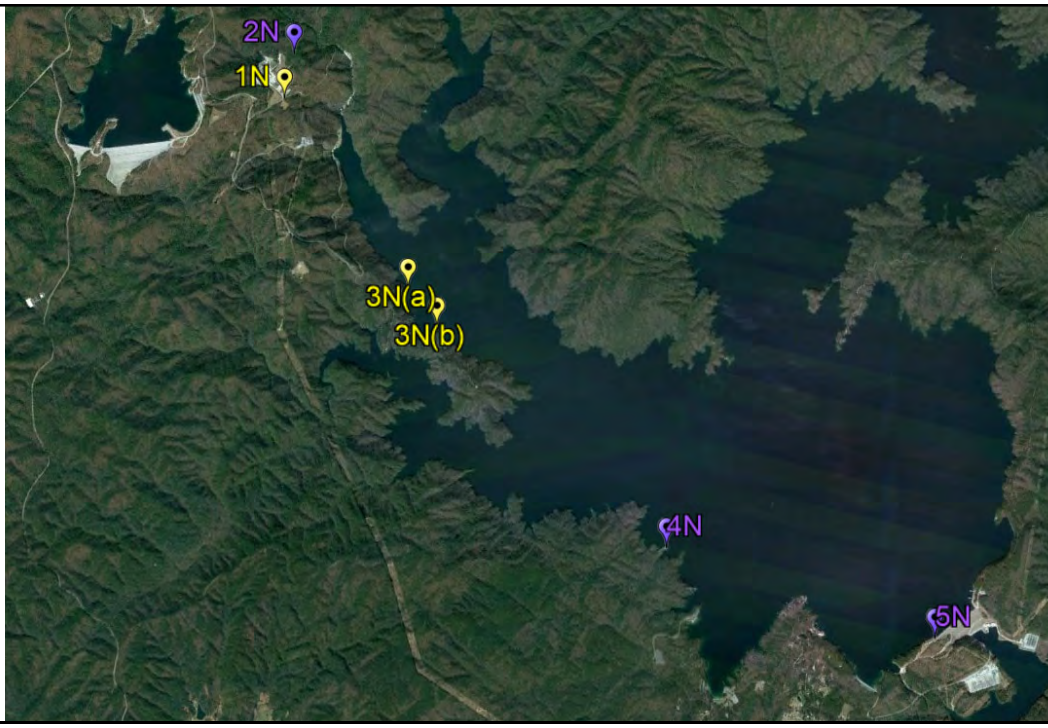
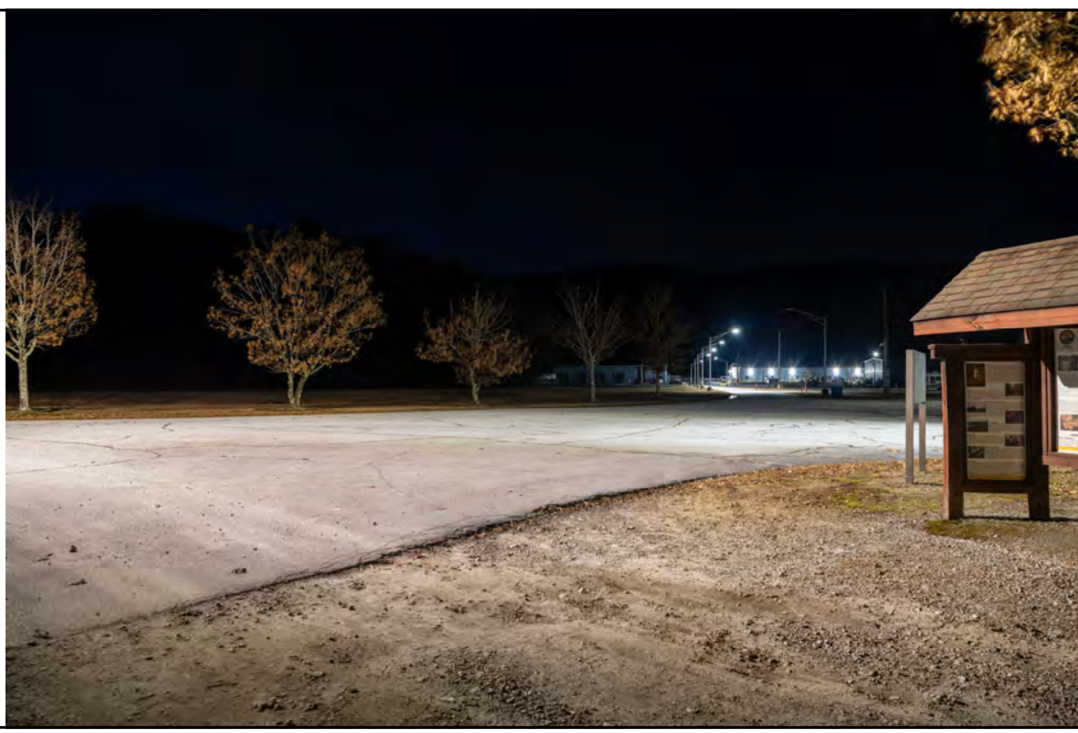


Potential Lighting Views

Image collected

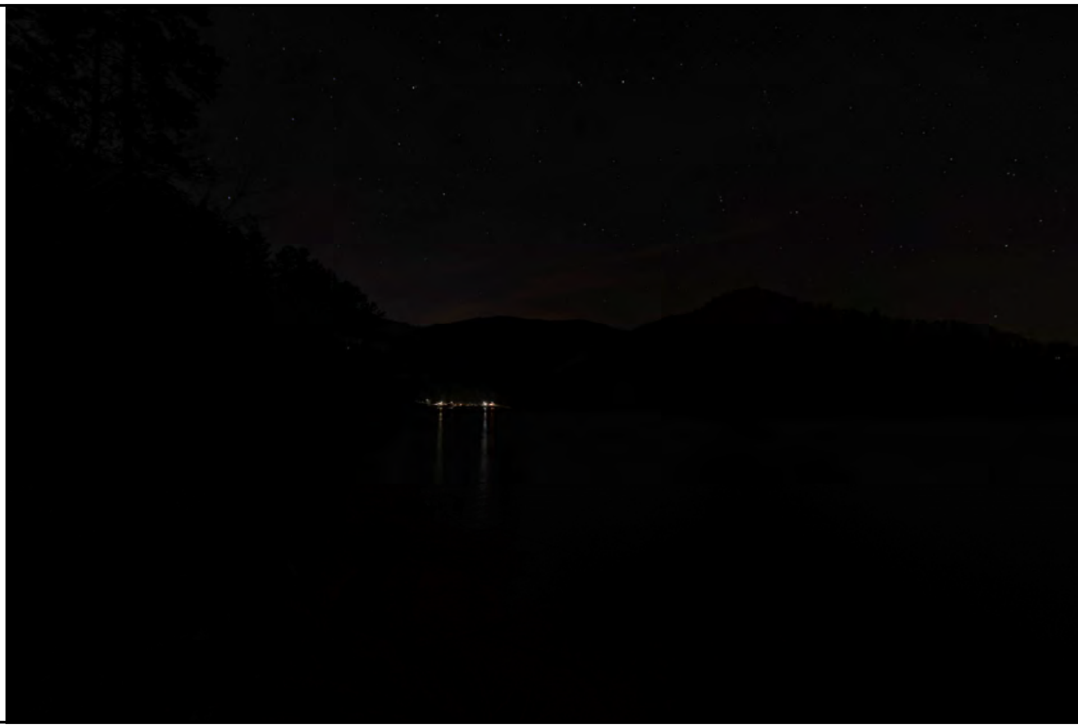
Eliminated by field crew

21



1N
(24 mm)

22



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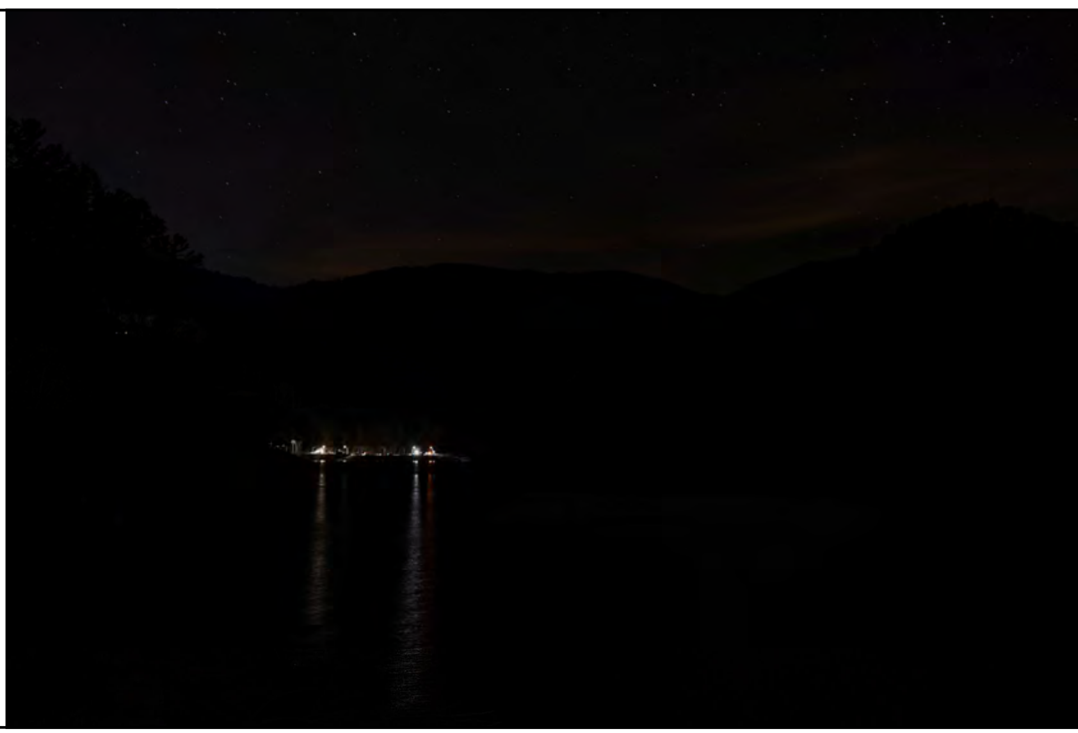


24

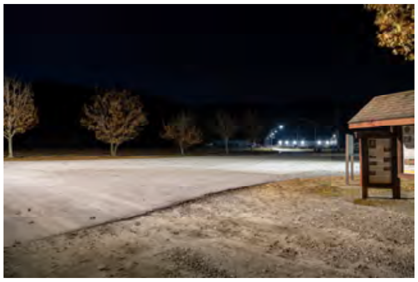
3N(b)
(24 mm)

25

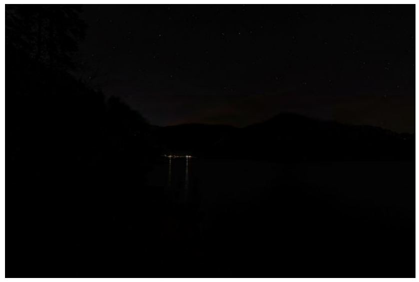
3N(b)
(50 mm)

26

Goal: Select No More than 2!

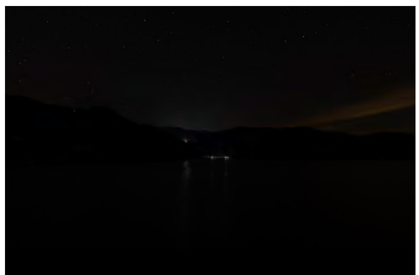


1N

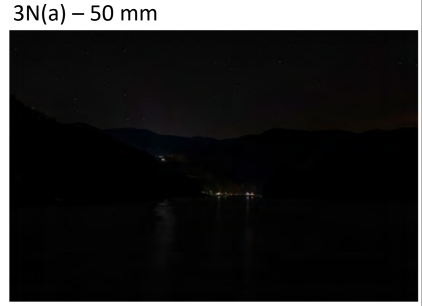


3N(a) – 24 mm

3N(a) – 50 mm



3N(b) – 24 mm



3N(b) – 50 mm

27

Visual Resource Study - Next Steps

- Task 5 – Existing Visual Quality Assessment
- Task 6 – Visual Analysis
  - Develop visualizations
- Task 7 – Visual Management Consistency Review
- Task 8 – Mitigation Assessment
- Task 9 – Conceptual Design of Bad Creek II Complex
  - Evaluate Lighting Effects
- Task 10 – Report (2nd quarter, 2024)

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From:	Sue Williams
To:	Crutchfield Jr., John U
Cc:	Amy Breedlove; Andrew Gleason; Andy Douglas; Chris Starker; Dale Wilde; Dan Rankin; Elizabeth Miller; Kelly Kirven; Ken Forrester; quattrol; Salazar, Maggie; Amedee, Morgan D.; Pat Cloninger; SelfR; Rowdy Harris; Stuart, Alan Witten; William T. Wood; Willie Simmons; Huff, Jen; Kulpa, Sarah; McCarney-Castle, Kerry
Subject:	Re: Bad Creek Relicensing-Recreation & Visual Resources Committee Meeting Materials (1/11/2024 Meeting)
Date:	Tuesday, January 16, 2024 12:16:57 PM

With the exception of a possible typo under the Lighting Evaluation, it all looks good to me. The paragraph Photo 3N(a) has the letter f following the period.

Sue Williams
Six Mile, SC

> On Jan 16, 2024, at 11:41, Crutchfield Jr., John U <John.Crutchfield@duke-energy.com> wrote:
>
> Dear Bad Creek Relicensing Recreation & Visual Resources Committee Members:
>
> Please find attached the summary of Visual Resources Study meeting held on January 11, 2024. I have also included below the SharePoint link to access the meeting summary, PowerPoint presentation, and the recorded Teams meeting.
>
> Bad Creek Relicensing Project – Resource Committees - 2024 01 11 Rec RC Mtg - All Documents (sharepoint.com)
>
> For those who attended the meeting, please review the meeting summary, and let me know if you have any comments or edits by Friday, February 2 (COB).
>
> Please let Alan or me know if you have any questions about the meeting materials.
>
> Regards,
>
> ***John Crutchfield***
> Project Manager II
> Water Strategy, Hydro Licensing & Lake Services
> Regulated & Renewable Energy
> Duke Energy
> 525 South Tryon Street, DEP-35B | Charlotte, NC 28202
> Office 980-373-2288| Cell 919-757-1095

<2024 01 11 rec rc mtg summary.pdf>

From:	Crutchfield Jr., John U
To:	Amy Breedlove; Andrew Gleason; Andy Douglas; Chris Starker; Dale Wilde; Dan Rankin; Elizabeth Miller; Kelly Kirven; Ken Forrester; quattrol; Salazar, Maggie; Amedee, Morgan D.; Pat Cloninger; SelfR; Rowdy Harris; Stuart, Alan Witten; suewilliams130@gmail.com; William T. Wood; Willie Simmons; Huff, Jen; Pardue, Ethan; glenn@hilliardgrp.com
Cc:	Kulpa, Sarah; McCarney-Castle, Kerry
Subject:	RE: Bad Creek Relicensing-Recreation & Visual Resources Committee Meeting Materials (1/11/2024 Meeting)
Date:	Friday, February 9, 2024 6:20:32 AM
Importance:	High

Dear Bad Creek Relicensing Recreation & Visual Resources Committee Members:

The summary of Visual Resources Study meeting held on January 11, 2024 has been finalized and can be accessed at the SharePoint link below.

Bad Creek Relicensing Project – Resource Committees - 2024 01 11 Rec RC Mtg - All Documents (sharepoint.com)

Thanks, John Crutchfield

From: Crutchfield Jr., John U
Sent: Monday, January 29, 2024 6:13 AM
To: Amy Breedlove <BreedloveA@dnr.sc.gov>; Andrew Gleason <andrewandwilla@hotmail.com>; Andy Douglas <adoug41@att.net>; Chris Starker <cstarker@upstateforever.org>; Dale Wilde <dwilde@keoweefolks.org>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Kelly Kirven <Kelly.Kirven@KleinschmidtGroup.com>; Ken Forrester <forresterk@dnr.sc.gov>; Lynn Quattro <quattrol@dnr.sc.gov>; Maggie Salazar <maggie.salazar@hdrinc.com>; Morgan Amedee <amedeemd@dhec.sc.gov>; Pat Cloninger <cloningerp@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Rowdy Harris <charris@scprt.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sue Williams <suewilliams130@gmail.com>; William Wood <woodw@dnr.sc.gov>; Willie Simmons <simmonsw@dnr.sc.gov>; Huff, Jen <Jen.Huff@hdrinc.com>
Cc: Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>
Subject: RE: Bad Creek Relicensing-Recreation & Visual Resources Committee Meeting Materials (1/11/2024 Meeting)
Importance: High

Dear Bad Creek Relicensing Recreation & Visual Resources Committee Members:

Just a reminder for those who attended the meeting, please provide any comments on the meeting minutes by Friday, February 2 (if you have not commented yet).

Thanks, John

From: Crutchfield Jr., John U
Sent: Tuesday, January 16, 2024 11:41 AM
To: Amy Breedlove <BreedloveA@dnr.sc.gov>; Andrew Gleason <andrewandwilla@hotmail.com>; Andy Douglas <adoug41@att.net>; Chris Starker <cstarker@upstateforever.org>; Dale Wilde <dwilde@keoweefolks.org>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Kelly Kirven <Kelly.Kirven@KleinschmidtGroup.com>; Ken Forrester <forresterk@dnr.sc.gov>; Lynn Quattro <quattrol@dnr.sc.gov>; Maggie Salazar <maggie.salazar@hdrinc.com>; Morgan Amedee <amedeemd@dhec.sc.gov>; Pat Cloninger <cloningerp@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Rowdy Harris <charris@scprt.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sue Williams <suewilliams130@gmail.com>; William Wood <woodw@dnr.sc.gov>; Willie Simmons <simmonsw@dnr.sc.gov>; Huff, Jen <Jen.Huff@hdrinc.com>
Cc: Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>
Subject: Bad Creek Relicensing-Recreation & Visual Resources Committee Meeting Materials (1/11/2024 Meeting)
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Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

Meeting Minutes

Project:	Bad Creek Relicensing
Subject:	Visual Resources Meeting for Key View Selection
Date:	Thursday, January 11, 2024
Location:	Microsoft Teams

Attendees:
Sue Williams – AQD
Alan Stuart – Duke Energy
John Crutchfield – Duke Energy
Andrew Gleason – Foothills Trail Conservancy
Amy Chastain – SCDNR
Chris Starker – Upstate Forever
Jen Huff – HDR
Kerry McCarney-Castle – HDR
James Lane - HDR

Introduction

John Crutchfield opened the meeting at 9:00 am and let folks know the meeting would be recorded for those who could not be in attendance as well as for future reference. He asked for objections; no one objected. Duke Energy will make available the meeting summary, PowerPoint presentation, and recording on the SharePoint site in the next couple of weeks.

J. Crutchfield reviewed the agenda and purpose of meeting. As a reminder, six potential Key Observation Points (KOPs) were agreed upon during the Visual Resources meeting in July 2023. The purpose of today's meeting is for the Visual Resources committee to choose four (out of the six originally agreed upon) KOPs based on photos captured during leaf-off conditions in November 2023 (not yet seen by the Recreation & Visual Resources Resource Committee [RC]) and to obtain input and consensus for selection of the nighttime views for photo rendering.

Safety Moment (J. Crutchfield) – Cold Stress

KOP Selection

Jen Huff provided a refresher on the Seen Area Analysis and potential KOPs from the July 2023 meeting in Greenville, SC. At that meeting, it was decided the KOP3 photo (from Whitewater River cove) would not be re-collected since the photo rendering is already complete for the additional inlet/outlet associated with Bad Creek II. Six potential KOPs were identified during the July Resource Committee meeting. Selected KOPs will be used to complete the remaining Visual Resources Study tasks.

KOP Selection (Task 4) and Field Work (Task 3) – J. Huff showed a map of locations where images were collected and explained necessary location changes (i.e., decisions made in the field based on field conditions/views/best professional judgement). Changes included:

- Elimination of potential KOP5 at the Bad Creek Visitor Overlook. The intention of the view was to capture the transmission line, but only an extremely limited view was observable.
- Elimination of potential KOP 9: KOP 9 was intended to capture a view of the office/warehouse complex from the Bad Creek spur trail. However, no views were observed, so the field crew moved the view to potential KOP 11.
- Addition of potential KOP 11: Given the elimination of KOP 9, the crew first evaluated adding a potential KOP at the parking lot trailhead. However, upon further consideration, the field crew elected to capture a view from potential KOP 11 at the entrance to Musterground Road which captured the most effect.

Field work was done on 12/6/2023 during leaf-off conditions. HDR photographer collected 24mm and 50mm views in the daytime (10 am - 1:30 pm) under sunny with scattered clouds and windy conditions and nighttime (6 pm – 9:30 pm) with clear, calm conditions. The nighttime views were collected prior to moonrise, and it was fully dark during image collection for nighttime views. J. Huff showed a series of images of the potential KOPs:

1. **KOP2**: Lower Whitewater Falls overlook toward Bad Creek, 24mm and 50mm views. Some project facilities were visible but not noticeable. Would likely not be able to see any facilities during leaf-on conditions.
2. **KOP4**: Bad Creek Visitor Overlook near the split rail fence , 24mm and 50mm views. Inlet/outlet structure visible.
3. **KOP7**: Oscar Wiggington Overlook, 24mm and 50mm views. Portions of transmission line visible.
4. **KOP10a**: View from privately-owned dock at Fisher Knob, 24 mm and 50 mm views. Closest private dock to inlet/outlet structure; inlet/outlet portal visible.
5. **KOP10b**: View from privately-owned residence at Fisher Knob, 24 mm and 50 mm views. Homeowner’s yard from point where land juts out into Whitewater River Cove. Inlet/outlet structure visible more clearly.
6. **KOP11**: Entrance to Musterground Road near the Foothills Trial information kiosk (added in-field), 24 mm view. View of open field with warehouse and Duke Energy office building; open field will be future location of new transmission line switchyard.

J. Huff opened the floor to discussion and led meeting participants through the process of choosing four out of the six potential KOPs to retain for the study. Jen said the selection would be through consensus of the RC, i.e., the committee members could live with the selected KOPs.

Sue Williams asked if the transmission line (new) will follow the existing transmission line. J. Huff answered yes, that is correct. S. Williams indicated there may not be much value from the Oscar Wigginton Overlook (KOP7) for transmission line views since it would be the basically the same view.

Chris Starker countered it might be worth keeping the power line views at Oscar Wiggington (KOP7) since the existing transmission corridor is 200 feet wide and will be expanded to nearly

380 feet. Widening the corridor could change the view, even though the transmission lines would follow the existing lines.

C. Starker stated KOP11 (Musterground Road kiosk) may not be useful since it is a parking lot and not an area of recreation, though the new transmission line switchyard at that site may have the effect of making the area feel more industrial and recreators may feel less secure.

J. Huff asked about removing KOPs10a and 10b. C. Starker asked for confirmation if both KOPs are homeowner views and noted the concern is more for the public, not for private property owners (who already experience the view). Amy Chastain stated that KOP10b would be useful to keep from a boating standpoint, as that is the view one sees when entering Whitewater River Cove via boat. Alan Stuart agreed that the 10a and 10b views were from the water views so may be important to keep at least one of them.

A. Chastain also suggested removing KOP11 since it is a parking lot, and a switchyard likely wouldn't deter visitors from hiking.

J. Huff reminded the group photo simulations were already done from the water for KOP3, which was taken from the Whitewater River Cove.

J. Huff asked for RC consensus on keeping photo simulations for KOP2. The RC agreed.

C. Starker noted that with leaf-on conditions, one wouldn't normally see anything as long as there is a healthy canopy (persistent) in place. The photo from Oscar Wiggington Overlook may be important from that standpoint because that canopy would need to be maintained (cut).

Andrew Gleason stated in his opinion, KOP11 (Musterground Parking lot) could be dropped from further evaluation, given the area will be closed off during construction. J. Huff reminded the group that the open field would have a switchyard for the life of the project.

J. Huff noted while they were on-site collecting images, two other cars accessed the Bad Creek Visitors Overlook, therefore, it is regularly used (KOP4). The RC reached consensus on keeping KOP4.

J. Huff returned to KOPs10a and 10b and reminded the group about KOP3. Sue Williams favors 10b to keep. Group consensus to eliminate KOP10a.

KOP Selection Final Consensus: Eliminate KOP11 (Musterground Road entrance) and KOP10a (homeowner dock). Retain KOPs 2, 4, 7, 10b, and existing KOP3.

Lighting Evaluation

Nighttime views were collected December 6, 2023. J. Huff showed map of locations where images were collected and noted changes that were made in the field based on view/field conditions/best professional judgement. Nighttime photography was challenging – collecting nighttime views are difficult because it's necessary to use long photographic exposures. While HDR's photographer (James Lane) is experienced in nighttime photography, some exposures led to lighter views (in photos) than what was experienced in the field.

J. Huff indicated there were two views where neither the Project nor light associated with it were visible at all – the top of Jocassee Dam and Devil's Fork State Park at the remote boat launch area. C. Starker asked about not seeing lights at certain views and that the concern is that additional light would be added from Bad Creek II. J. Huff indicated for photo simulations, Duke Energy would be replicating the current amount of light to represent Bad Creek II (and when there is nothing but darkness, only darkness could be replicated).

Photo 1N: View from the entrance to Musterground Road.

Photo 3N(a): View from Fisher Knob homeowner site (KOP10a); can see lights of the inlet/outlet structure.f

Photo 3N(b): View from Fisher Knob homeowner (3Nb); can see lights from inlet/outlet as well as existing transformer yard on top of the hill.

A. Stuart asked about faint visible light to the north of ridge (north of the Project) above the ridge crest in the 3N(b) photos since there is no city nearby. J. Huff noted that faint light near ridgetops is an artifact of the long photographic exposure.

J. Huff asked if there would be interest / value in seeing a photo simulation of the future switchyard at night from location 1N. C. Starker agreed there would be interest and asked if it would be very illuminated at night. J. Huff said no, the switchyard would have some security lights but would not be brightly lit.

J. Huff noted 3Nb might be the best (at the 24mm) image to use as it shows the view from a boat on Whitewater River Cove. A. Chastain agrees as does S. Williams. C. Starker asked if 3Na and 3Nb are the same view. Jen replied 3N(a) is from the dock closest to the intake/outlet and the other is further out on the point at Fisher Knob. C. Starker asked what nighttime would look like from either of the overlooks. J. Huff indicated photos were not collected from the overlooks because it is assumed that people don't view vistas in the dark.

Nighttime Lighting Final Consensus:1N and 3nb (24mm)

Next Steps

Tasks 5-10 will be completed, and the Visual Resources Study Report will be distributed for RC review during the second quarter of this year (2024).

C. Starker asked if anybody is aware of astronomy clubs that use these areas. A. Gleason responded he is aware of the Roper Mountain Astronomy Club, but they use Sassafras Mountain which is east of Lake Jocassee. A. Stuart is not aware of any and he had asked the same question. J. Huff is not familiar with folks doing night hikes or visiting the site for star gazing but will look into it. A. Gleason noted he was not aware of any activities at Bad Creek.

J. Huff reiterated the meeting summary, recording, and presentation would be made available via the SharePoint Site. J. Crutchfield thanked everybody for their input and adjourned the meeting at 9:50 am.

Bad Creek Pumped Storage Project No. 2740

Visual Resources Study -
Recreation & Visual Resources
Resource Committee

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Safety Moment – Cold Stress

- Know the symptoms of cold stress.
- Monitor your physical condition and that of others.
- Take regular breaks to warm up when needed.
- Dress properly for the cold.
    - At least 3 layers!
    - Tight clothing reduces blood circulation to the extremities.
- Stay dry in the cold. Moisture or dampness, including sweating, can increase the rate of heat loss from the body.
- Keep extra clothing (including underwear) handy in case you get wet and need to change.
- Drink warm sweetened fluids (no alcohol).
- Include chemical hot packs in your first aid kit.
- Avoid touching cold metal or wet surfaces with bare skin.

Condition	Symptoms	
Hypothermia	*Early Symptoms* • Shivering • Fatigue • Loss of coordination • Confusion, disorientation	*Late Symptoms* • No shivering • Blue skin • Dilated pupils • Slowed pulse and breathing • Loss of consciousness
Frostbite	• Reduced blood flow to hands, feet • Numbness	• Aching • Tingling or stinging • Bluish or pale, waxy skin
Trench Foot	• Reddening of the skin • Numbness • Leg cramps • Swelling • Tingling pain	• Blisters, ulcers • Bleeding under the skin • Gangrene (foot may turn dark purple, blue, or gray)
Chillblains	• Redness • Itching • Possible blistering	• Inflammation • Possible ulceration in severe cases

Source: https://www.cdc.gov/niosh/docs/2010-115/pdfs/2010-115.pdf

3

Visual Resources Study Refresher

- Seen Area Analysis
- Potential Key Observation Points (KOP) selected (July 27, 2023)
    - KOP 3 decision
    - Task 5: Existing landscape quality and characteristics (near foreground, foreground, midground, background)
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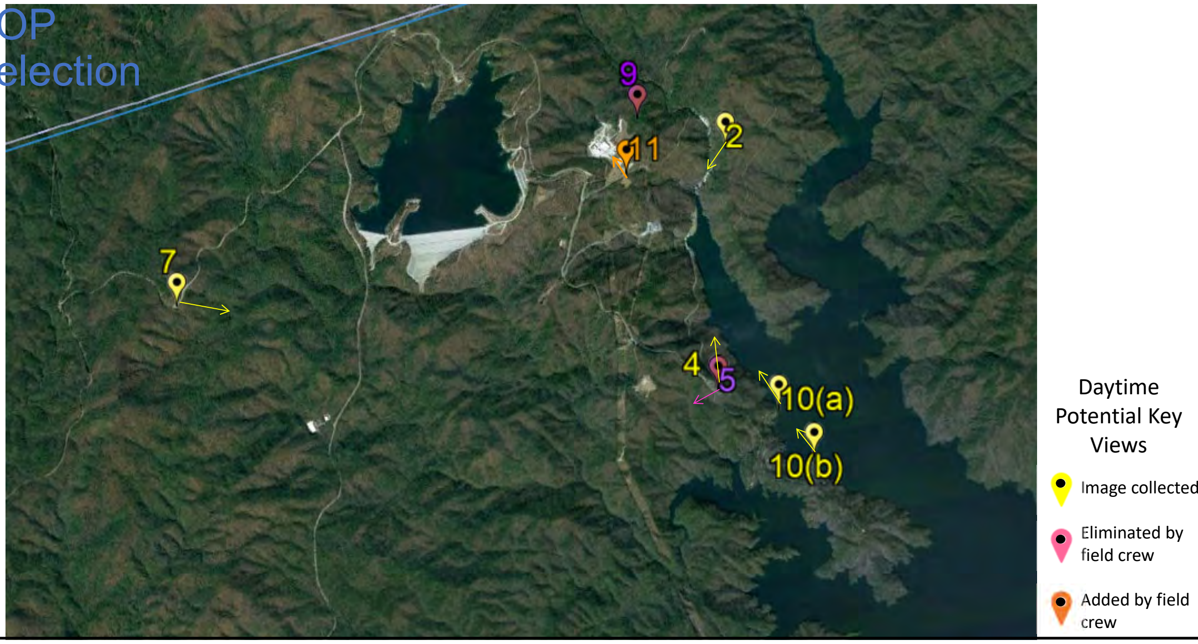
4

Task 4: KOP Selection



5

Task 3: Fieldwork

- December 6, 2023
- Leaf-off conditions
- 24mm and 50 mm
- Daytime
  - 10:00 am – 1:30 pm
  - Sunny with scattered clouds, windy
- Evening
  - 6:00 pm – 9:30 pm
  - Clear, calm, moonrise after midnight

6

KOP 2
(24 mm)

7

KOP 2
(24 mm)

8


KOP 2
(50 mm)

9


KOP 4
(24 mm)

10


KOP 4
(50 mm)

11


KOP 7
(24 mm)

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16

KOP 10b
(50 mm)

17

KOP 11
(24 mm)

18

Goal: Select No More than 4!


2


4

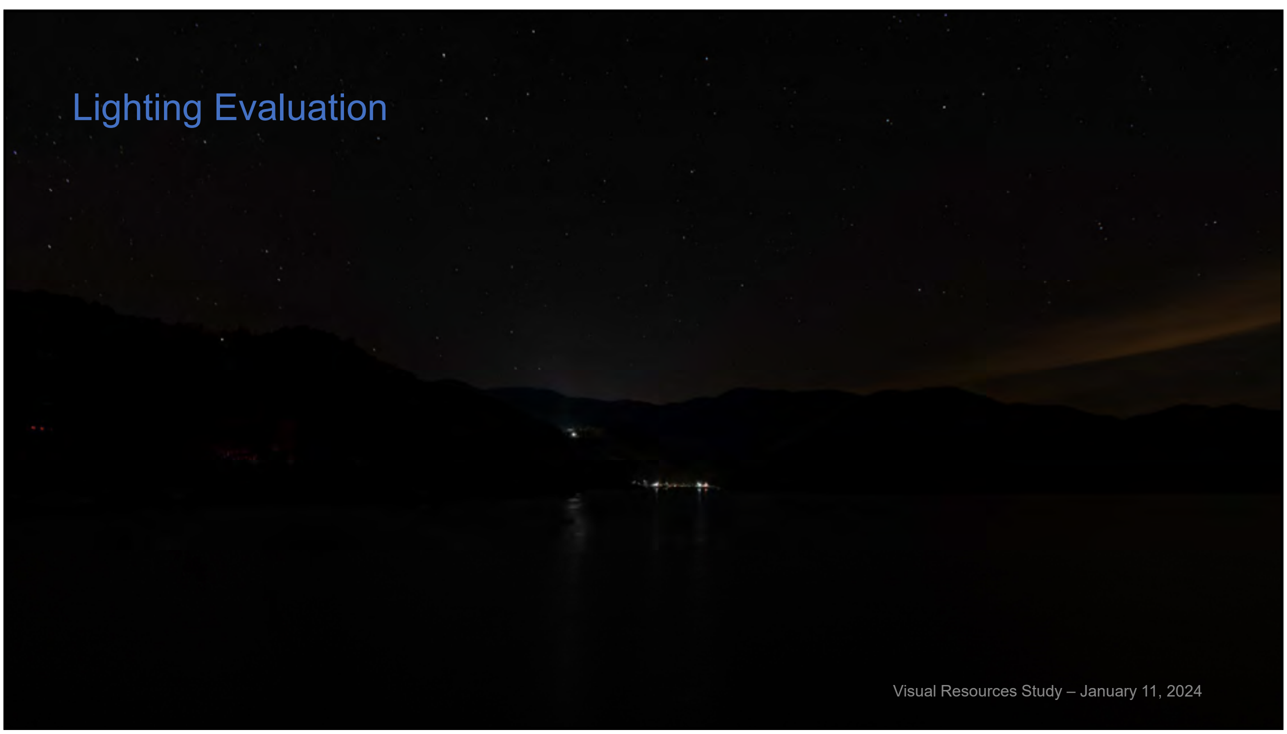

7


10a


10b


11

19



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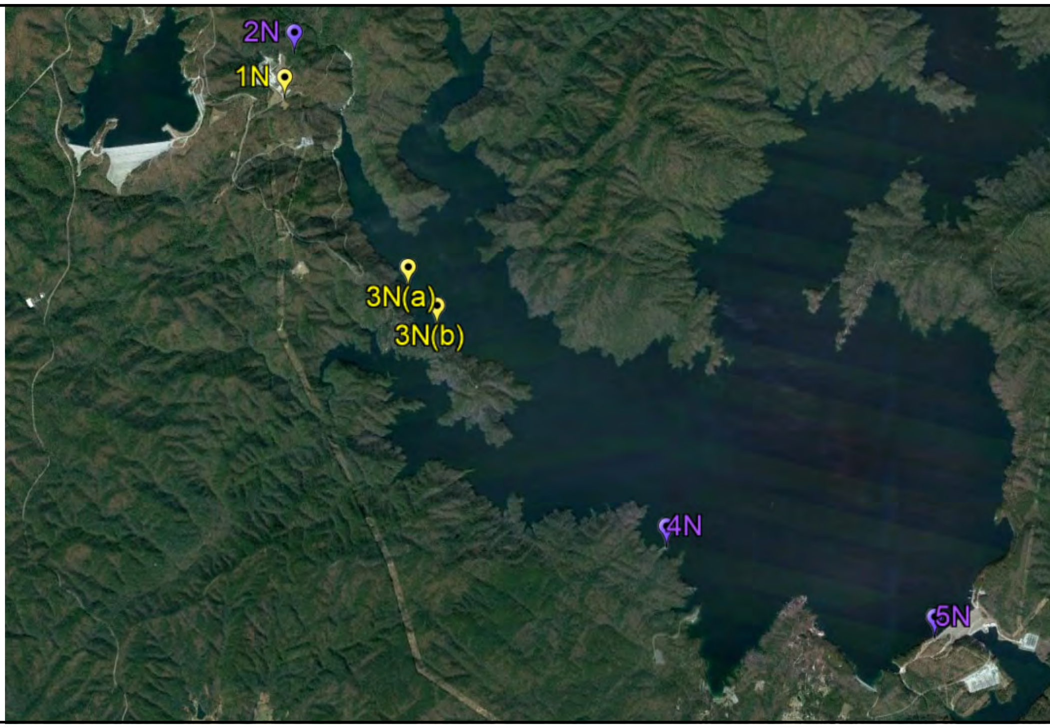
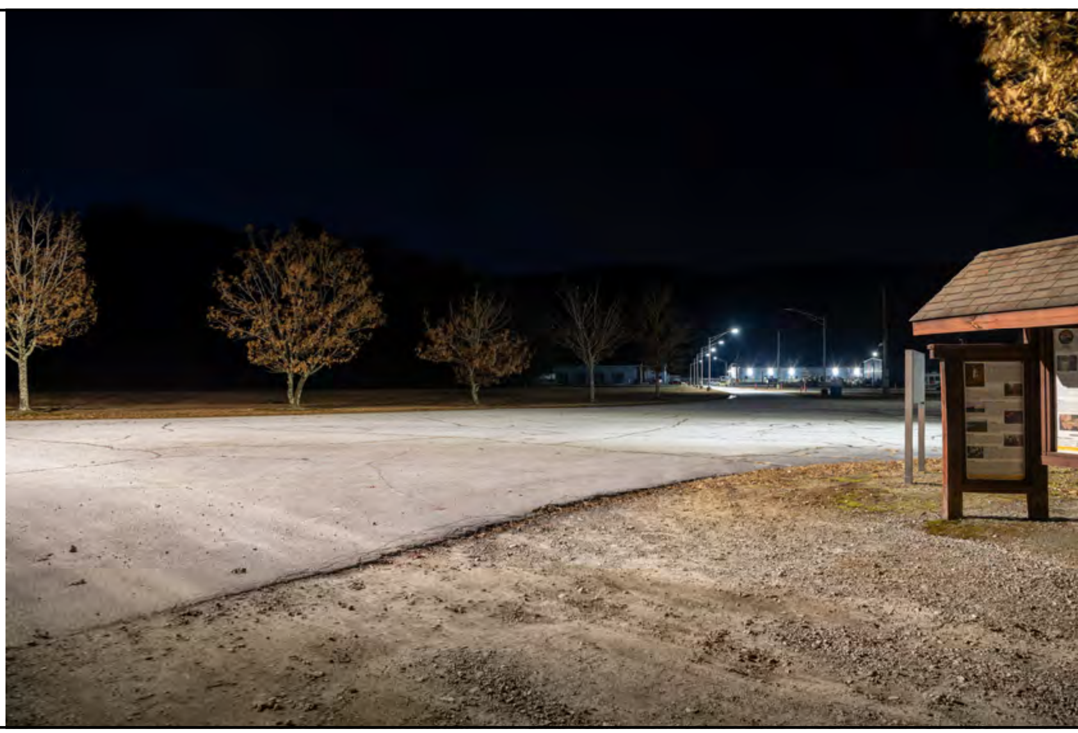


Potential Lighting Views

Image collected

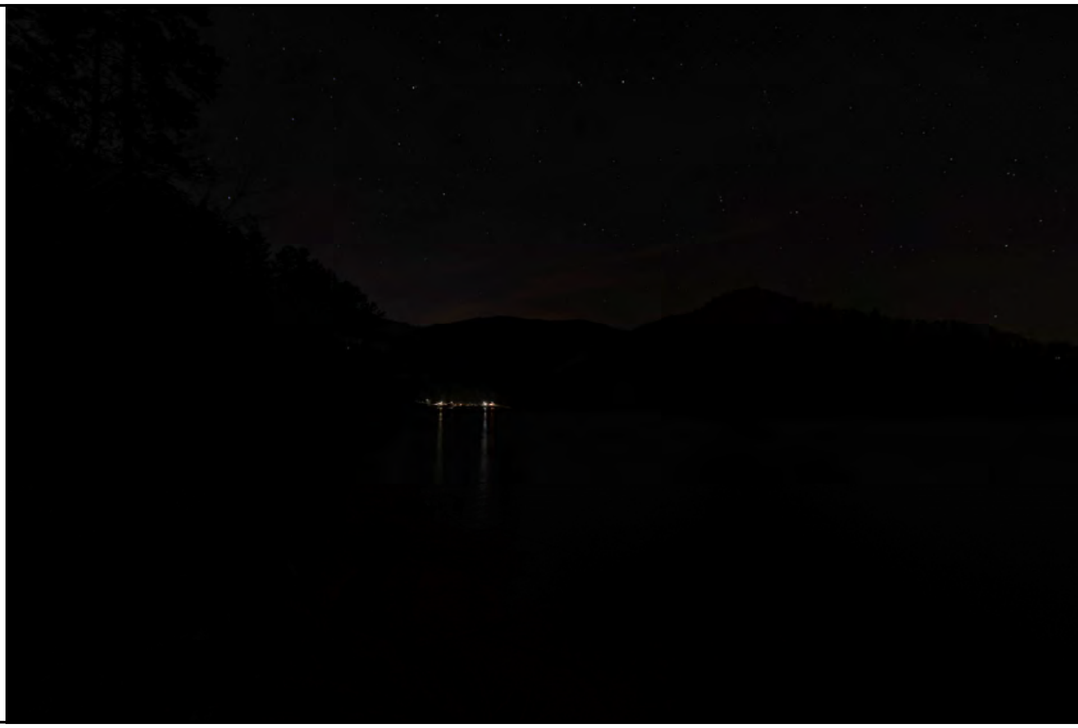
Eliminated by field crew

21



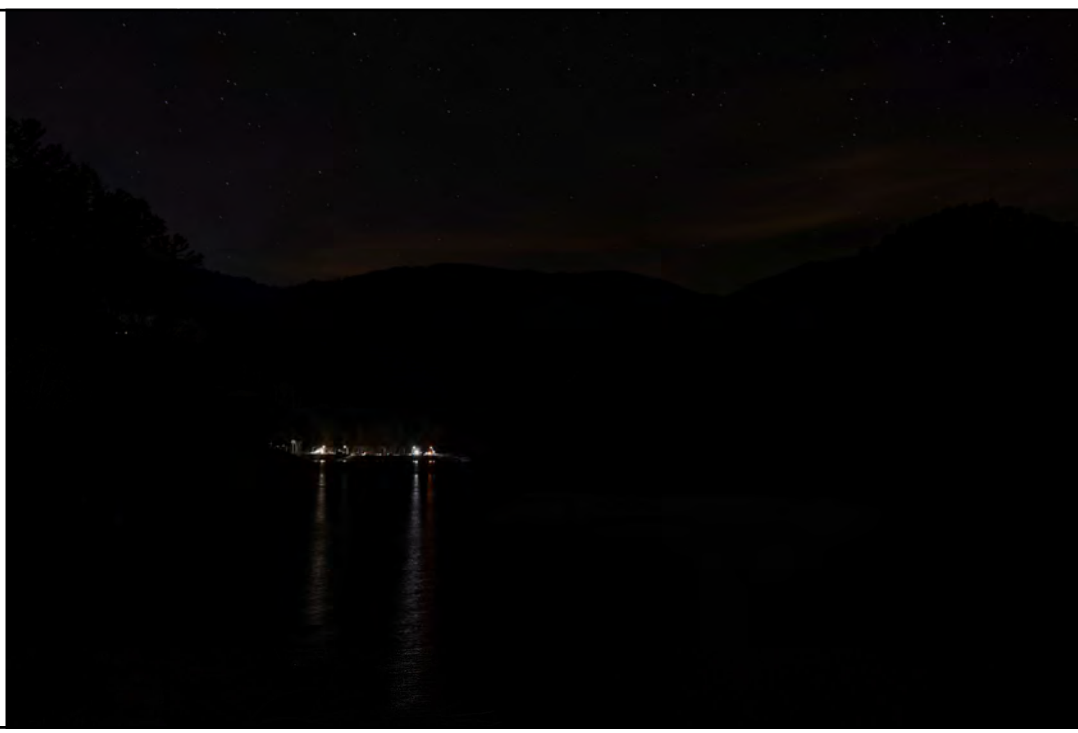
1N
(24 mm)

22



3N(a)
(24 mm)

23



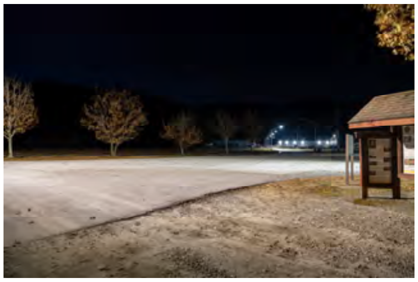
3N(a)
(50 mm)

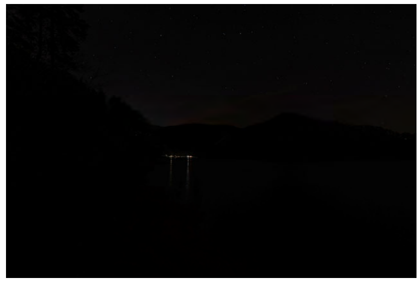
24

25

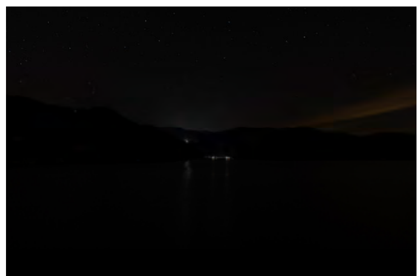
26

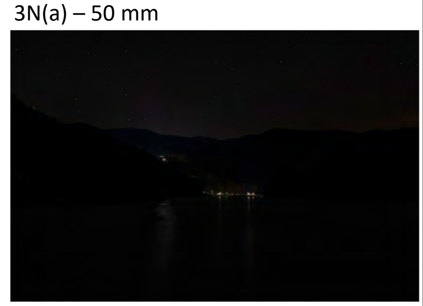
Goal: Select No More than 2!


1N


3N(a) – 24 mm


3N(a) – 50 mm


3N(b) – 24 mm


3N(b) – 50 mm

27

Visual Resource Study - Next Steps

- Task 5 – Existing Visual Quality Assessment
- Task 6 – Visual Analysis
  - Develop visualizations
- Task 7 – Visual Management Consistency Review
- Task 8 – Mitigation Assessment
- Task 9 – Conceptual Design of Bad Creek II Complex
  - Evaluate Lighting Effects
- Task 10 – Report (2nd quarter, 2024)

Visual Resources Study – January 11, 2024 | 28

28

From:	Crutchfield Jr., John U
To:	Amy Breedlove; Andrew Gleason; Andy Douglas; Chris Starker; Dale Wilde; Dan Rankin; Elizabeth Miller; glenn@hilliardgrp.com; Kelly Kirven; Ken Forrester; quattrol; Salazar, Maggie; Amedee, Morgan D.; Pat Cloninger; SelfR; Charles (Rowdy) B Harris; Stuart, Alan Witten; suewilliams130@gmail.com; William T. Wood; Willie Simmons; Huff, Jen; Pardue, Ethan; Churchill, Christy; PShirley; Bill Ranson-Retired; phil.mitchell@gmail.com
Cc:	Kulpa, Sarah; McCarney-Castle, Kerry; Huff, Jen
Subject:	RE: Bad Creek Relicensing Recreation & Visual Resources Committee - Visual Resources Study DRAFT Report (READY for REVIEW)
Date:	Wednesday, May 22, 2024 10:07:15 AM
Attachments:	image001.png image002.png
Importance:	High

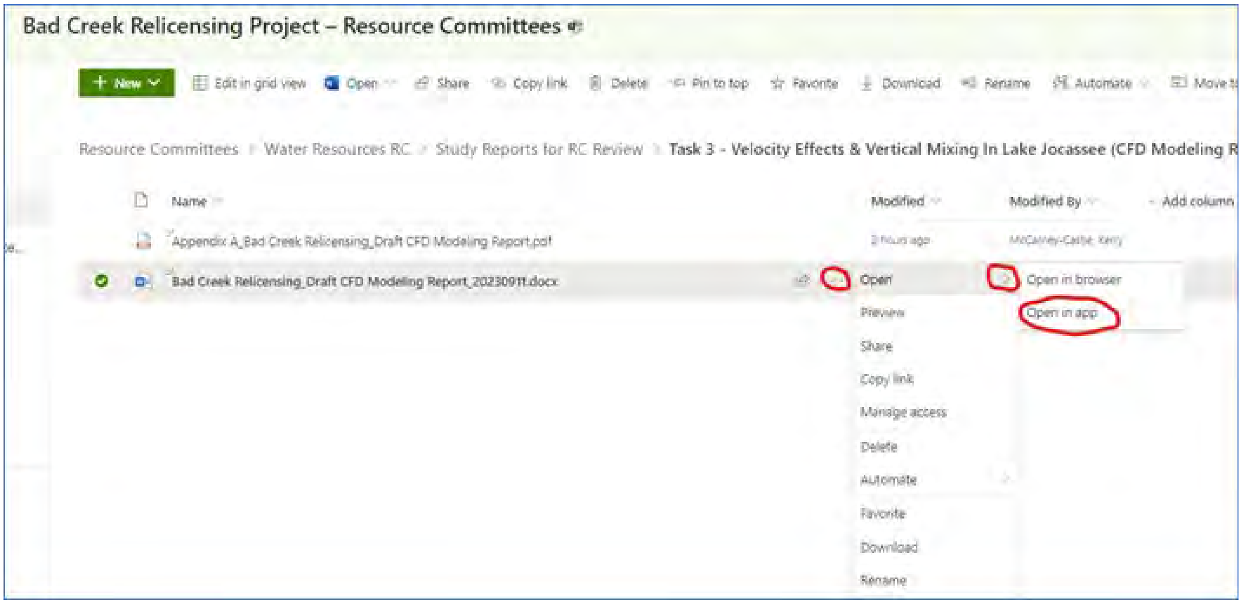
Dear Bad Creek Relicensing Recreation and Visual Resources Committee:

Duke Energy is pleased to distribute the **Visual Resources Study Draft Report** for Resource Committee review. The deliverable is available on the Bad Creek Relicensing SharePoint site at the following link: Visual Resources. Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **June 21**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

Important – Please Read!

- As discussed in the kick-off meeting (July 2022), Duke Energy would like to make relicensing deliverables available on a shared platform (i.e., SharePoint) so all stakeholders can access, review, and comment; therefore, we request all comments be made in the SharePoint Word document using tracked changes. This will eliminate version control issues and result in a consolidated document for comment response.
- We strongly recommend opening the document in Word; otherwise, the formatting will look distorted. The simplest way to do this is to click on the three dots to the right of the document (example shown below), choose "Open", then choose "Open in app". This will open the document in Word, and you'll have the functionality you are accustomed to. Your changes will be saved automatically as you review. Please feel free to reach out to @McCarney-Castle, Kerry for SharePoint assistance.

  (Note: If you are new to SharePoint, a very brief tutorial with screenshots is available on the home page of the Resource Committees tab called **"**Editing a Document in SharePoint". This is the same tutorial that was presented during the kick-off meeting. [*The tutorial provides an alternative way to open the document in Word – either technique works!]*)



If you have any questions, please contact Alan Stuart or me.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From:	Crutchfield Jr., John U
To:	McCarney-Castle, Kerry
Subject:	FW: [EXTERNAL] Re: Bad Creek Relicensing Recreation & Visual Resources Committee - Visual Resources Study DRAFT Report (READY for REVIEW)
Date:	Wednesday, May 22, 2024 5:42:58 PM
Attachments:	image001.png image002.png

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

From: Charles (Rowdy) B Harris <charris@scprt.com>
Sent: Wednesday, May 22, 2024 4:34 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Subject: [EXTERNAL] Re: Bad Creek Relicensing Recreation & Visual Resources Committee - Visual Resources Study DRAFT Report (READY for REVIEW)

***** CAUTION! EXTERNAL SENDER *** STOP. ASSESS. VERIFY!!** Were you expecting this email? Are grammar and spelling correct? Does the content make sense? Can you verify the sender? If suspicious report it, then do not click links, open attachments or enter your ID or password.

SCPRT has not comments.

Rowdy Harris
Park Manager
Devils Fork State Park
SC Department of Parks, Recreation & Tourism
161 Holcombe Circle
Salem, SC 29676
Office: (864) 944-2639
SCPRT.com
SouthCarolinaParks.com

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Wednesday, May 22, 2024 10:06 AM
To: Amy Breedlove <BreedloveA@dnr.sc.gov>; Andrew Gleason <andrewandwilla@hotmail.com>; Andy Douglas <adoug41@att.net>; Chris Starker <cstarker@upstateforever.org>; Dale Wilde <dwilde@keoweefolks.org>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Glenn Hilliard <glenn@hilliardgrp.com>; Kelly Kirven <Kelly.Kirven@KleinschmidtGroup.com>; Ken Forrester <forresterk@dnr.sc.gov>; Lynn Quattro <quattrol@dnr.sc.gov>; Maggie Salazar <maggie.salazar@hdrinc.com>; Morgan Amedee

<amedeemd@dhec.sc.gov>; Pat Cloninger <cloningerp@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Charles (Rowdy) B Harris <charris@scprt.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sue Williams <suewilliams130@gmail.com>; William Wood <woodw@dnr.sc.gov>; Willie Simmons <simmonsw@dnr.sc.gov>; Huff, Jen <Jen.Huff@hdrinc.com>; Pardue, Ethan <Ethan.Pardue@duke-energy.com>; Churchill, Christy <Christy.Churchill@duke-energy.com>; PShirley@oconeeco.com <PShirley@oconeeco.com>; Bill Ranson <bill.ranson@retiree.furman.edu>; phil.mitchell@gmail.com <phil.mitchell@gmail.com>
Cc: Kulpa, Sarah -hdrinc <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Jen Huff <jen.huff@hdrinc.com>
Subject: RE: Bad Creek Relicensing Recreation & Visual Resources Committee - Visual Resources Study DRAFT Report (READY for REVIEW)

Dear Bad Creek Relicensing Recreation and Visual Resources Committee:

Duke Energy is pleased to distribute the **Visual Resources Study Draft Report** for Resource Committee review. The deliverable is available on the Bad Creek Relicensing SharePoint site at the following link: Visual Resources. Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **June 21**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

Important – Please Read!

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- We strongly recommend opening the document in Word; otherwise, the formatting will look distorted. The simplest way to do this is to click on the three dots to the right of the document (example shown below), choose "Open", then choose "Open in app". This will open the document in Word, and you'll have the functionality you are accustomed to. Your changes will be saved automatically as you review. Please feel free to reach out to @McCarney-Castle, Kerry for SharePoint assistance.

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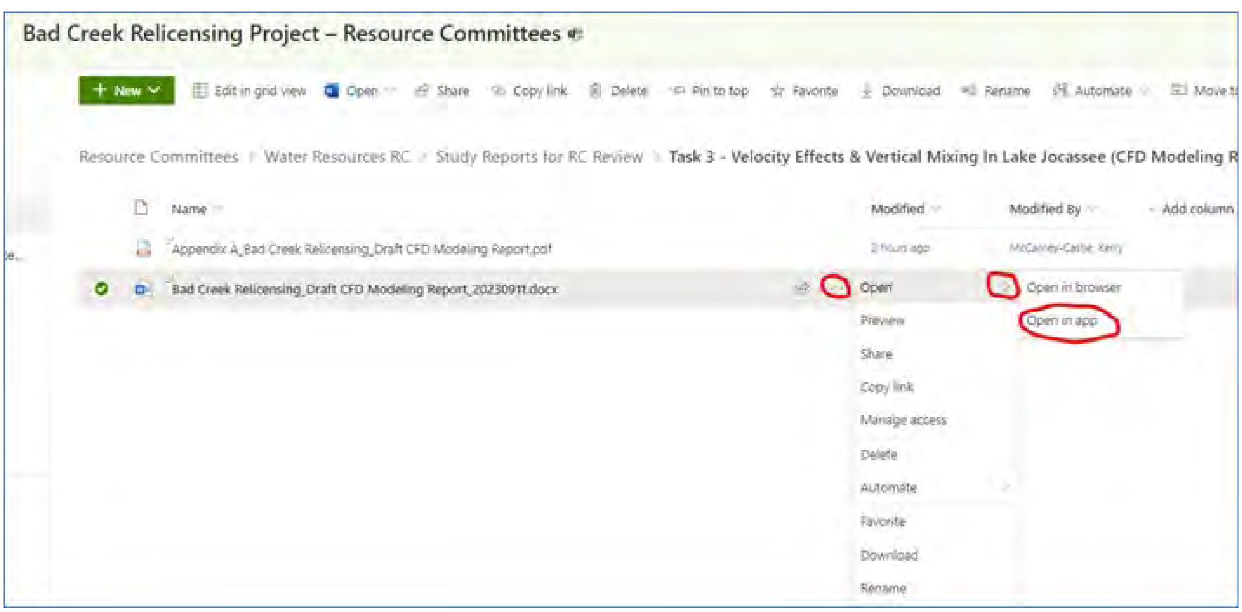

If you have any questions, please contact Alan Stuart or me.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From:	Crutchfield Jr., John U
To:	McCarney-Castle, Kerry
Subject:	FW: [EXTERNAL] Re: Bad Creek Relicensing Recreation & Visual Resources Committee - Visual Resources Study DRAFT Report (READY for REVIEW)
Date:	Friday, May 24, 2024 6:13:00 AM

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

From: Sue Williams <suewilliams130@gmail.com>
Sent: Thursday, May 23, 2024 5:16 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Subject: [EXTERNAL] Re: Bad Creek Relicensing Recreation & Visual Resources Committee - Visual Resources Study DRAFT Report (READY for REVIEW)

***** CAUTION! EXTERNAL SENDER *** STOP. ASSESS. VERIFY!!** Were you expecting this email? Are grammar and spelling correct? Does the content make sense? Can you verify the sender? If suspicious report it, then do not click links, open attachments or enter your ID or password.

John,

I have reviewed this report. I don't have any comments regarding it.

Sue Williams
Six Mile, SC

On May 22, 2024, at 10:07, Crutchfield Jr., John U <John.Crutchfield@duke-energy.com> wrote:

Dear Bad Creek Relicensing Recreation and Visual Resources Committee:

Duke Energy is pleased to distribute the **Visual Resources Study Draft Report** for Resource Committee review. The deliverable is available on the Bad Creek Relicensing SharePoint site at the following link:
<image001.png>
Visual Resources. Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **June 21**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

Important – Please Read!

1. As discussed in the kick-off meeting (July 2022), Duke Energy would like to make relicensing deliverables available on a shared platform (i.e., SharePoint) so all stakeholders can access, review, and comment; therefore, we request all comments be made in the SharePoint Word document using tracked changes. This will eliminate version control issues and result in a consolidated document for comment response.
2. We strongly recommend opening the document in Word; otherwise, the formatting will look distorted. The simplest way to do this is to click on the three dots to the right of the document (example shown below), choose "Open", then choose "Open in app". This will open the document in Word, and you'll have the functionality you are accustomed to. Your changes will be saved automatically as you review. Please feel free to reach out to @McCarney-Castle, Kerry for SharePoint assistance.

    (Note: If you are new to SharePoint, a very brief tutorial with screenshots is available on the home page of the Resource Committees tab called **"**Editing a Document in SharePoint". This is the same tutorial that was presented during the kick-off meeting. [*The tutorial provides an alternative way to open the document in Word – either technique works!*])

<image002.png>

If you have any questions, please contact Alan Stuart or me.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

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Appendix B

Appendix B - Potential Key Views Photo Log

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Potential Key View 2

Conditions: Sunny with scattered clouds. Humidity: 46%; winds: 10 mph with gusts of 22 mph.[1]

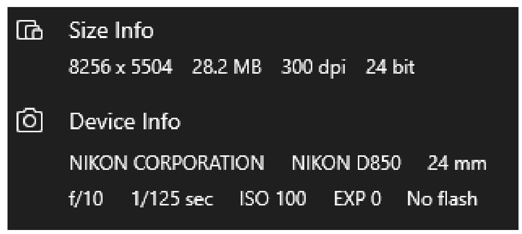
Location: 35.013786, -82.989953

Time:10:00 am

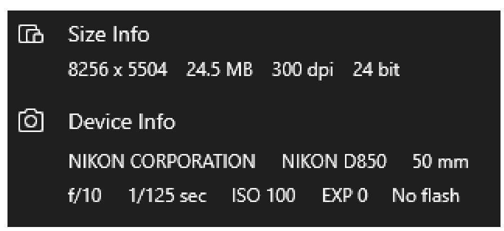
Photo heading: 216°

Field Crew: James Lane (HDR), Jen Huff (HDR), Tristan Cleveland (Kimley-Horn)

24 mm



50 mm



[1] Humidity and windspeed were obtained from Lake Jocassee Station [Greer, SC undefined | Weather Underground (wunderground.com)](). Accessed on February7, 2024.

Potential Key View 4

Conditions: Sunny with scattered clouds. Humidity: 38%. Winds: 14 mph with gusts of 24 mph.

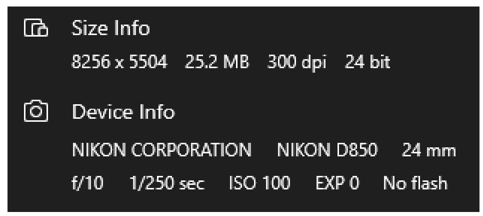
Location: 34.994431, 82.990653

Time: 11:45 am

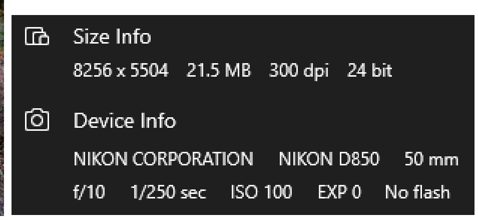
Photo heading: 351°

Field Crew: James Lane (HDR), Jen Huff (HDR), Tristan Cleveland (Kimley-Horn)

24 mm



50 mm



Potential Key View 7

Conditions: Sunny with scattered clouds. Humidity: 36%; winds: 13 mph with gusts of 24 mph.

Time: 1:15 pm

Location: 35.001059, -83.043739

Photo heading: 119°

Field Crew: James Lane (HDR), Jen Huff (HDR), Tristan Cleveland (Kimley-Horn)

24 mm

Size Info
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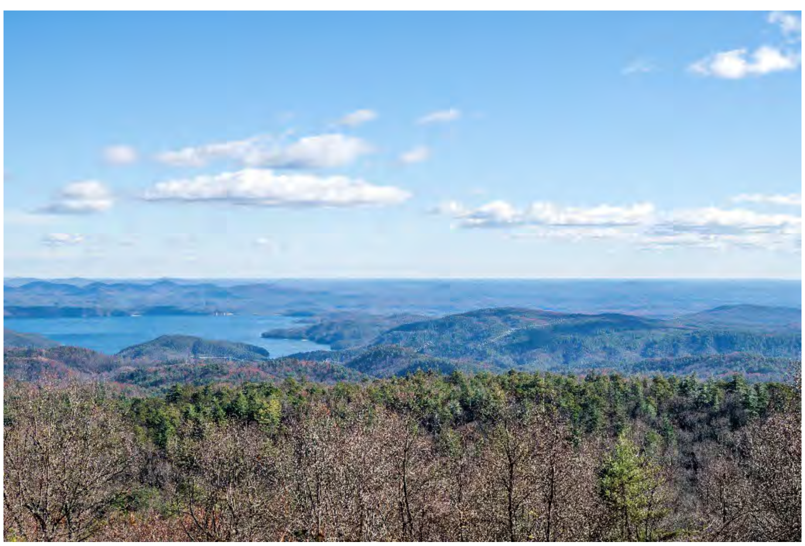
Device Info
NIKON CORPORATION NIKON D850 24 mm
f/10 1/250 sec ISO 100 EXP 0 No flash

50 mm



Size Info
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Device Info
NIKON CORPORATION NIKON D850 50 mm
f/10 1/250 sec ISO 100 EXP 0 No flash

Potential Key View 10a

Conditions: Sunny with scattered clouds. Humidity: 38%; winds: 14 mph with gusts of 24 mph.

Location: 34.992872, -82.984822

Time: 12:09 pm

Photo heading: 341°

Field Crew: James Lane (HDR), Jen Huff (HDR), Tristan Cleveland (Kimley-Horn)

24 mm

Size Info
8256 x 5504 19 MB 300 dpi 24 bit

Device Info
NIKON CORPORATION NIKON D850 24 mm
f/10 1/200 sec ISO 100 EXP 0 No flash

50 mm

Size Info
8256 x 5504 18.4 MB 300 dpi 24 bit

Device Info
NIKON CORPORATION NIKON D850 50 mm
f/10 1/200 sec ISO 100 EXP 0 No flash

Potential Key View 10b

Conditions: Sunny with scattered clouds. Humidity: 36%; winds: 13 mph with gusts of 24 mph.

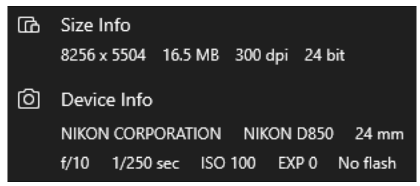
Location: 34.989064, -82.981367

Time: 12:40 pm

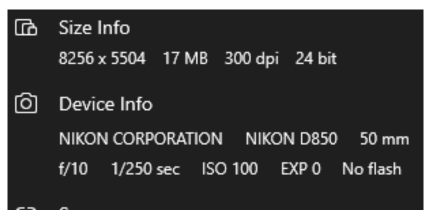
Photo heading: 328°

Field Crew: James Lane (HDR), Jen Huff (HDR), Tristan Cleveland (Kimley-Horn)

24 mm



50 mm



Potential Key View 11

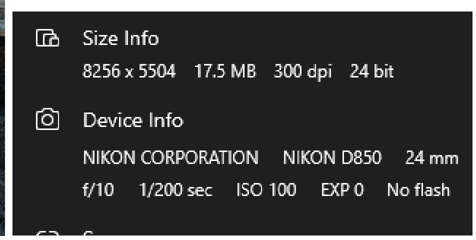
Conditions: Sunny with scattered clouds. Humidity: 39%; winds: 12 mph with gusts of 28 mph.

Location: 35.011594, -82.999658

Time: 11:15 am

Photo heading: 302°

Field Crew: James Lane (HDR), Jen Huff (HDR), Tristan Cleveland (Kimley-Horn)



Potential Night View 1N

Conditions: Clear. Humidity: 55%. Winds: 6 mph and steady.

Location: 35.011594, -82.999658

Time: 6:30 pm

Photo heading: 302°

Field Crew: James Lane (HDR), Jen Huff (HDR)

See discussion in 6.3 regarding development of this image.

Potential Night View 3Na

Conditions: Clear. Humidity: 55%; winds: 6 mph and steady.

Location: 34.992872, -82.984822

Time: 7:04 pm

Photo heading: 341°

Field Crew: James Lane (HDR), Jen Huff (HDR)

24 mm

Size Info
8256 x 5504 2.9 MB 300 dpi 24 bit

Device Info
NIKON CORPORATION NIKON D850 24 mm
f/4 30 sec ISO 400 EXP 0 No flash

50 mm

Size Info
8256 x 5504 2.9 MB 300 dpi 24 bit

Device Info
NIKON CORPORATION NIKON D850 50 mm
f/4 30 sec ISO 400 EXP 0 No flash

Potential Night View 3Nb

Conditions: Clear. Humidity: 55%; winds: 6 mph and steady.

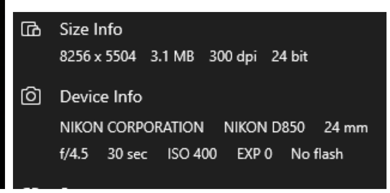
Location: 34.989064, -82.981367

Time: 7:29 pm

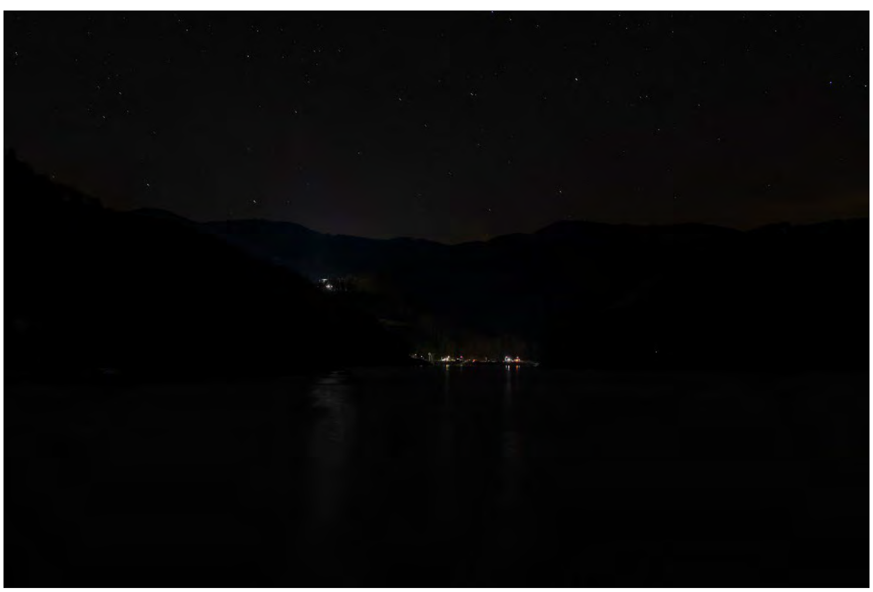
Photo heading: 328°

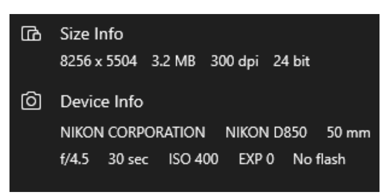
Field Crew: James Lane (HDR), Jen Huff (HDR)

24 mm



50 mm





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Appendix C

Appendix C - Annotated Visualizations

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Key View 2: Lower Whitewater Falls Observation Platform

Existing

Proposed

1. Transmission lines
2. Lower inlet/outlet bank

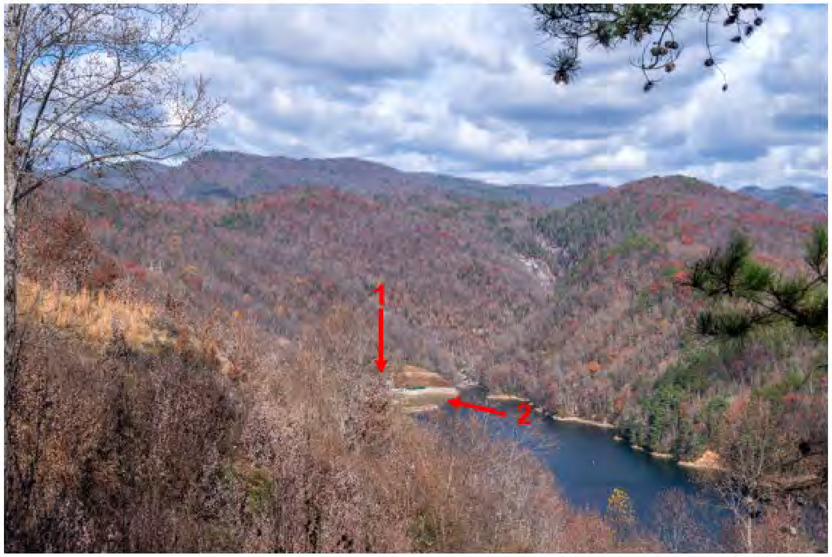
Key View 3: Lower Inlet/Outlet Portal from Whitewater Cove

Existing

Proposed

Key View 4: Bad Creek Visitor Overlook

Existing



Proposed

1. Inlet/outlet portal
2. Inlet/outlet cove

Key View 7: Oscar Wigington Scenic Overlook

Existing

Proposed

Key View 10b: Fisher Knob Point

Existing

Proposed

1. Transmission lines
2. Lower inlet/outlet portal

Night View 3N: Fisher Knob Point

Existing

1. Transformer yard
2. Wastewater treatment, parking
3. Lower inlet/outlet

Proposed

1. Lower inlet/outlet portal

Proposed Site Layout

1. Spoil areas
2. Upper inlet/outlet structure
3. Transformer yard, switchyard, access road
4. Interconnect line
5. Lower inlet/outlet
6. Primary transmission line
7. Temporary access road

Attachment D: Bat Study Plan

U.S. Fish and Wildlife Service

Study Plan Form for Bat Surveys and Monitoring (v. 2.1)[1]

PROJECT & SURVEY INFORMATION

Project Name: Bad Creek II Power Complex

Proposed Survey Start Date: May 2024

Project Proponent's Name (e.g., client/company/institution): Duke Energy

Project Location: State(s): South Carolina

County(s): Oconee

Latitude: 35.008647

Longitude: -83.004316

REQUIRED: Attach or provide links to Google Earth® KMZ files (preferred) and/or shapefiles (mapping must show project boundaries, impacted forest habitat (if known) and all proposed survey sites)

Files are attached: Yes ☑ No ☐

File Links: ______________________________

Project Summary. In the space provided below, please provide a description of the proposed action, including any activities that will permanently or temporarily alter the current environment and existing habitat features.

See attached.

CONTACT INFORMATION

Project Manager/Primary Point of Contact (POC): James McRacken (Duke Energy)

Phone: 980.875.5279

Field Survey Crew Leader (if different from POC): Dylan Brooks (Biotope)

Cell Phone: 704.996.8671

Institution/Company Name: Duke Energy

Mailing Address: 1339 Hagers Ferry Road (MG03A3) Huntersville, NC 28078

POC Email Address: james.mcracken@duke-energy.com

USFWS Sec. 10(a)(1)(A) Permit No.(s) (if applicable): TE-81492B-1, TE88227B-1

State Permit No.(s) (if applicable): To be acquired. Awaiting approval

[1] Unless otherwise directed by the Service, surveyors may complete this fillable form, in lieu of a traditional narrative format, and submit it (and supporting files) to the Ecological Services Field Office in the state(s) where the work is to be completed (https://www.fws.gov/our-facilities). Use of this form is not a requirement at this time. Our goal is to improve pre-survey coordination and to expedite the Field Office review and approval process. Please submit your study plan at least 15 working days in advance of your proposed survey start date. Suggestions for improving this document may be sent to R4_Bat_Survey_Guidance@fws.gov.

Have project proponents been informed that abiding by protective time-of-year restrictions (where available) may be sufficient to avoid take of federally listed bats and (in some cases) may negate the need for a bat survey? Yes ☑ No ☐

Have project proponents been informed that the Service does not require presence/probable absence surveys for federally listed species and that presence can be assumed in a project area containing suitable habitat? Yes ☑ No ☐

Will this survey be conducted on private or public lands? *(Check both if applicable)*: Private ☑ Public ☑

Has permission of all necessary landowners/managing agencies been obtained? Yes ☑ No ☐

If no, explain: ______

Does this project have a federal nexus[2]? Yes ☑ No ☐ Unsure ☐

If yes, explain: FERC (No.2740) Relicensing and USACE Section 404 Individual Permit

IPaC[3] Consultation Code (if applicable): 2024-0079174

Purpose of Survey: Official P/A Survey ☑ Research ☐ Monitoring ☐ Educational Outreach/Training Other: ______

Survey Target Species: Indiana bat (IBAT) ☐ Northern long-eared bat (NLEB) ☑ Tricolored bat (TCB) ☑ Other: Gray Bat

Has a Phase-1 Habitat Assessment* of the project area been conducted? Yes ☑ No ☐
If yes, how was the habitat assessment conducted? Field ☑ Desktop ☑ Combo ☑
*(*if available, attach a written report)*

Is suitable habitat[4] present (or assumed present) for all "target" species? Yes ☑ No ☐

If no, explain: ______

Does this project fall within the outer-tier[5] of any "target" species known home range? Yes ☐ No ☑ Unsure ☐

If yes, which species: ______

Project Configuration

Is this project **linear** (>1 km in total length)? Yes ☑ No ☐ Combo ☐ Unsure ☐

If yes, how many 1-km sections containing suitable IBAT/NLEB habitat will be impacted? 45

Is this project **non-linear**? Yes ☑ No ☐ Combo ☐ Unsure ☐

If yes, how many acres of suitable IBAT/NLEB habitat is in the overall project area? 179.3

If yes, how many acres of suitable IBAT/NLEB habitat will be directly impacted/cleared? 179.3

PROPOSED METHODS & SURVEY LEVEL OF EFFORT[6]

ACOUSTICS

Total number of detector sites proposed to be surveyed: 37 Number of detector nights/site: linear-4, nonlinear-3

[2] A project or action that is carried out, authorized, funded, and/or permitted by a federal agency.
[3] https://ipac.ecosphere.fws.gov/
[4] See Appendix A of the Guidelines regarding suitable habitat definitions.
[5] See Appendix G of the Guidelines if you are unclear what the out-tier of a known range includes.
[6] Survey level of effort (acoustic or netting) must be spread over at least two calendar nights/survey site.

Total number of detector nights for entire survey: 144

Total proposed number of calendar nights to complete the entire survey: 12

Detector(s) (Brand, Model): Anabat Express   Microphone(s): directional ☑ omnidirectional ☑

Recording Format: Full Spectrum ☑ Zero-Crossing ☐

FWS-Approved[7] Acoustic Bat ID Software: KPro vers. 5.6.3 KPro Classifier, NA vers. 5.4 BCID vers.____
Other Candidate Programs (e.g., Sonobat) vers.: ________________

Species to be included for automatic software ID classification analysis:

EPFU ☑ CORA ☑ COTO ☐ LABO ☑ LACI ☑ LANO ☑ LASE ☑ TABR ☑ MYCI ☐ MYEV ☑ MYGR ☑ MYLU ☑
MYLE ☑ MYSE ☑ MYSO ☐ MYTH ☐ MYVO ☐ NYHU ☑ PESU ☑ Others: MYAU

Will qualitative analysis (i.e., manual vetting) be used? Yes ☑ No ☐ Unsure ☐

Name(s) of qualified biologist(s) conducting qualitative/manual identifications (attach resume or link with qualifications):
Dylan Brooks, John Manuel, Patrick Eli Corwin (resumes attached)

MIST-NETTING

Total number of net sites to be surveyed: 15 Total number of net nights/site: 4, one site with 5

Total number of net nights for entire survey (No. of sites X No. of net nights/site): 61

Total proposed number of calendar nights to complete the entire survey: 10 (3 teams)

A) Maximum number of net set-ups that will be operated/checked (10-min interval) on a given calendar night at a given survey site: 3
B) Minimum Number of personnel present to operate/check X (see A) net set-ups on a given site: 2
C) Proposed Staffing Rate (A divided by B): 1.5

Staffing Rate

Number of Section 10-permitted biologists per net site (or state-permitted in USFWS R5): 1

Do you propose to band bats? Yes ☐ No ☑

If yes, please answer the following:

What species will be banded? COTO ☐ MYGR ☑ MYLU ☑ MYSE ☑ MYSO ☐ PESU ☑
Others:________________ All captured bats:
If banding *Myotis* sp. or PESU, specify band size: ____________
Describe your proposed bands (color and letter-numbers) and banding scheme: ________________
Will banding pliers be used? Yes ☐ No ☐

Will any biological samples be collected from captured bats (e.g., guano, hair, swab, wing punch)? Yes ☐ No ☑

If yes, explain: ______________________________

Name of institution or facility to conduct DNA analysis: ______________________

RADIO-TRACKING

Will any bats be radio-tagged and tracked? Yes ☐ No ☑

[7] https://www.fws.gov/media/automated-acoustic-bat-id-software-programs

If yes, please answer following:

Which species will be radio-tagged? ____________________

Name of USFWS Section 10 permitted biologist(s) who will apply transmitter(s): ______________________

Make/model and approximate weight of transmitter(s) to be used: ____________________

Manufacturer date and estimated life-span of transmitters to be used: ____________________

Frequency range (MHz) of transmitters (e.g., 150.xxx or 172.xxx): ____________________

If radio-tracking multiple targeted bats/species, what criteria will be used in selecting which bats will be tracked?

____

Will all radio-tagged bats be tracked (min. of 4-hrs. search effort/day) to their diurnal roosts for the minimum recommended period of 7 days? Yes☐ No☐

If no, explain: ____

Will night-time foraging data/telemetry be collected? Yes☐ No☐

Glue used for attaching transmitters: Type: Latex-based Surgical Cement Name: Ostobond

Manufacturer: Montreal Ostomy Product Other: ______________________

EMERGENCE SURVEYS

After diurnal roost sites of radio-tagged bats are identified, will emergence surveys be conducted at each identified roost (assuming landowner permission is obtained)? Yes☐ No☐

If yes, how many emergence surveys/roost? ____________

Have you identified a small number (e.g., ≤10) of potentially suitable roost trees* that you propose to conduct emergence surveys for? Yes☐ No☐

*(*If yes, provide photographs of each tree documenting that all of the tree can be observed by the surveyor along with coordinates (lat/long and/or KML/shapefile) of all trees to be surveyed.)*

POTENTIAL HIBERNACULA SURVEYS

Are you aware of any known hibernacula used by the target species within the project area itself or nearby?

Yes☐ No☑ Unknown☐

If yes or unknown, list sites or explain: ____

Has your desktop analysis identified any natural or man-made features that could be used as a hibernaculum by any of the target bat species? Yes☐ No☐ Unknown☐

If yes, underground features (e.g., caves, mines, tunnels, bunkers, cisterns) present: Yes☐ No☐

If yes, above-ground features* (e.g., crawl spaces) present: Yes☐ No☐

If unknown, explain: ____

Are you requesting approval of a field survey for potential hibernacula at this time? Yes*☐ No☐

*(*If yes, attach a separate narrative explaining how the project area(s) will be surveyed for potential hibernacula.)*

Are you submitting the results of a Phase 1 Habitat Assessment of potentially suitable hibernacula identified from field surveys? Yes*☐ No☐

*(*If yes, provide a Phase 1 Habitat Assessment Data Sheet for each potential hibernaculum/portal(s)[8] identified to be surveyed.)*

BRIDGE & CULVERT ASSESSMENTS

Will any bridges or culverts be surveyed for bat presence? Yes☐ No☑

If yes, please answer the following:

---

[8] If multiple cave entrances/portals, please list all locations.

Structure type(s) (check all that apply): Bridge☐ Culvert☐ Other☐
If "other", explain: ____

Survey methodology for structure(s) (check all that apply):
Visual inspection☐ Guano collection☐ Emergence survey☐ Acoustics*☐
Mist-net*☐ Harp-trap*☐ Other ______________________________
*(*Due to site-specific conditions of structures, coordination with the local USFWS Field Office and appropriate state agency(ies) is necessary before proceeding with these survey methodologies)*

Will guano be collected and analyzed to confirm species ID? Yes☐ No☐
If "yes", name of institution/entity performing analysis: ______________________________

ADDITIONAL SURVEY INFORMATION[9]

Will the proposed bat survey deviate from the current version of the USFWS Survey Guidelines?[10] Yes☐ No☑

If yes, provide justification for any departures or modifications to the guidelines (if applicable) below:

I hereby acknowledge that the information being provided to the Service is accurate and complete as of today's date.

Signature: ______________________ Date (*Original*): 5/7/2024

Date (*Revised*): 5/24/2024

[9] Attach additional pages to this form, if needed.
[10] Proposed surveys deviating from the current Range-wide IBAT & NLEB Survey Guidelines will only be accepted with a thoroughly described justification. Coordinate with your local USFWS Field Office (https://www.fws.gov/our-facilities) for acceptable modifications.

*******FOR U.S. FISH AND WILDLIFE SERVICE USE ONLY**********

United States Department of the Interior

Fish and Wildlife Service

Generic ES Field Office

Street Address

General Office Phone:

SITE-SPECIFIC AUTHORIZATION - BAT WORK

Our Field Office has reviewed your study plan and found it to contain sufficient information for our approval. When signed, this statement serves as your site-specific authorization to conduct the proposed activities at the specified locations included in the attached Study Plan Form and supporting files and must be carried with your federal permit when conducting work for this project. All activities must be carried out with strict adherence to permit conditions and authorizations specified in your federal permit as well as your state permit(s) (if needed). The section 10(a)(1)(A) permit authorizing the activities must remain with the surveyor at all times. This authorization is not valid if you have not obtained permission from the owner of the lands where activities will occur.

For federal permit reporting purposes, please use the appropriate USFWS bat survey data spreadsheet, available on the IBAT and NLEB Summer Survey Guidance website[1]. To mitigate the risk of humans transmitting viruses (e.g., SARS-CoV-2) to bats or viral transmission from bats to humans, the U.S. Fish and Wildlife Service requests anyone directly handling or working in close proximity to bats follow current guidelines prepared by the CDC[2] and IUCN Bat Specialist Group[3] in addition to the following the standard WNS decontamination protocols[4].

If the work expands beyond the scope of your original study plan or if there are adverse effects to bats that were not anticipated, cease all survey and/or research activities, and contact this office prior to continuing. Additionally, if a federally listed bat is captured, this USFWS Field Office must be notified within 48 hours with information regarding species, sex, age, and whether or not the bat has a transmitter attached.

Field Office POC: ____

email: ____ phone:____________________________

☐ **Authorized as Proposed**

☐ **Authorized with Conditions** (see below)

You are authorized to proceed provided that the following adjustment(s) and/or conditions are met.

☐ **Not Authorized.**

Comments:

Signature & Date:

NOTE: Please check the appropriate box above before signing/locking the document.

[1] https://www.fws.gov/library/collections/range-wide-indiana-bat-and-northern-long-eared-bat-survey-guidelines
[2] https://www.cdc.gov/healthypets/covid-19/wildlife.html
[3] https://www.iucnbsg.org/uploads/6/5/0/9/6509077/amp_recommendations_for_researchers_final.pdf
[4] https://www.whitenosesyndrome.org/mmedia-education/national-wns-decontamination-protocol-u-s

Project Summary

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Project Purpose and Summary

Duke Energy's Bad Creek Pump Storage Project (Bad Creek or Project), FERC Project No. 2740, is located in Oconee County, South Carolina, approximately eight miles north of Salem. 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 the Duke Energy Keowee-Toxaway (KT) Hydroelectric Project (FERC Project No. 2503), serves as the lower reservoir. The structures and features included in the Bad Creek Project License include the upper reservoir and dams, inlet/outlet 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 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 Original License for the existing Project expires on July 31, 2027, therefore the Project is currently undergoing relicensing through the FERC Integrated Licensing Process (ILP) for continued operation of the Project over the new 40 to 50-year license term.

Given the need for additional significant energy storage and renewable energy generation across Duke Energy's service territories over the Project's new license term, Duke Energy is evaluating opportunities to add pumping and generating capacity at the Project. Additional energy storage and generation capacity could be developed by constructing a new power complex (including a new underground powerhouse) adjacent to the existing Bad Creek Powerhouse. Construction of the 1,400-MW Bad Creek II Power Complex (Bad Creek II Complex) is, therefore, an alternative relicensing proposal presently being evaluated by Duke Energy.

The relicensing for the Project which included the proposal for the Bad Creek II Complex was initiated in February 2022 with the filing of the Pre-Application Document. Throughout the relicensing, various state and federal government resource agencies, Indian Tribes, non-governmental organizations, and other interested parties (stakeholders) have been consulted for identification of potential resources areas of interest and informational needs. In consideration of the New License, formal consultation under Section 106 of the National Historic Preservation Act (NHPA) and Section 7 of the Environmental Species Act will be initiated.

If Duke Energy decides to pursue the Bad Creek II Complex and obtains all necessary regulatory approvals for construction, the period for construction of the Bad Creek II Complex is expected to span approximately 7 years. Assuming commencement of construction shortly following the New FERC License issuance by July 2027, the Bad Creek II Complex is expected to be fully in service in 2034.

Purpose of Survey

Construction of the proposed Bad Creek II Complex will require the removal of trees, potentially impacting suitable habitat for state and federally protected bats. Mist-net surveys and acoustic surveys will be used to assess the presence/probable absence (P/A) of the federally proposed tricolored bat (*Perimyotis subflavus*) and federally endangered northern long-eared bat (*Myotis septentrionalis;* NLEB) as well as state listed species of concern known to be present in Oconee

County, including little brown bat (*Myotis lucifugus*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii),* tricolored bat, hoary bat (*Lasiurus cinereus*), and gray bat (*Myotis grisescens).* The project area is in the seasonal range (non-coastal area) for the NLEB and tricolored bat. The survey will follow the 2024 Range-wide Indiana Bat and Northern Long-eared Bat Survey Guidelines.[1]

Existing Habitats

The Project Area is located in the Blue Ridge ecoregion with upland areas that support mixed hardwoods-pine forests including species as Virginia pine, short-leaf pine, pitch pine, white pine, chestnut oak, scarlet oak, northern red oak, black oak, and hickories. Mountain laurel and rhododendron are common understory species. Riparian areas and ravines and steep slopes adjacent to stream channels in forested areas and support hardwood forests that contain tulip poplar, red maple, white oak, northern red oak, American beech, and sweetgum with common understory species that include eastern hemlock, rhododendron, mountain laurel, birch, sourwood, black cherry, doghobble, sassafras, spicebush, and huckleberry.

Suitable summer habitat for NLEB including potential roost trees and snags as well as foraging and commuting habitats are located throughout the Project Area. Existing suitable tricolored bat roost, forage, and travel habitat found in the Project Area included a variety of forested habitats, riparian corridors, and adjacent non-forested habitats including open areas, shrub lands including existing right of ways, and access roads through existing forested areas.

The potential impact area contains suitable summer habitat, as outlined by 2024 USFWS guidelines, that require bat surveys according to linear and non-linear project protocols since tree clearing needs to take place during the restricted cutting timeframes.

Proposed Impact Areas

Spoil Areas: Excavation required for construction of the Bad Creek II Complex will result in a significant quantity of earth and rock (or "spoil") material (4.4 million cubic yards) to be generated. Duke Energy is presently evaluating a range of upland areas within the FERC Project Boundary and/or on property owned by Duke Energy adjacent to the Project Boundary for spoil of excavated earth and additional rock (spoil areas). Construction of the proposed Bad Creek II Complex infrastructure and selected spoil areas will require vegetative clearing. Spoil area alternatives are currently under evaluation and not all spoil alternatives detailed in the attached Google Earth® KMZ files or in Table 1 will be utilized. Some potential spoil areas are within the existing footprint of spoil areas created for the original Project. A vegetative restoration plan will be developed and implemented for the spoil areas following construction.

Temporary Access Road: Duke Energy is proposing the development of a temporary access road (Fisher Knob access road) to provide an alternate route to the Fisher Knob residential community during Bad Creek II Complex construction. The proposed road will be constructed of mostly gravel and will begin at Whitewater Road and traverse approximately 3.7 miles (5.9 km) to the Fisher Knob community.

[1] Range-wide Indiana Bat and Northern Long-eared Bat Survey Guidelines | FWS.gov

New Transmission Line: Duke Energy currently owns or maintains under a property easement all lands that would be required for construction of the Bad Creek II Complex. A portion of the transmission line corridor is currently maintained under a property easement and additional lands may be required to accommodate the corridor for the proposed 9.3 mile (14.9 km) new Whitewater 525kV transmission line. Approximately 15.03 miles (24.2 km) of access road has been identified to serve as construction and maintenance access for the proposed transmission line.

Table 1 represents the linear and non-linear project components along with proposed acres of forested areas to be cleared by potential project activities.

Table 1. Areas of Direct Impacts (Clearing)

Linear		
Description	**Length in miles (km)**	**Acres to be Directly Impacted/Cleared**
Whitewater525 kV Line	9.3 (14.9)	192 (assuming new 200-foot wide right-of way to be cleared in non-hazardous areas)
Fisher Knob Access Road	3.7 (5.9)	11.4 (assuming 16-foot-wide access road)
Proposed Transmission Access Roads	15 (24.2)	29.3 (assuming 5 feet on either side of the existing road will be trimmed/cleared for construction access)
Total:	**28 (45)**	**232.7**
Non-Linear		
Bad Creek II Power Complex Infrastructure		
Upper Reservoir I/O Structure		8.76
Vertical Shaft		8.96
Transformer Yard		6.49
525kV Switchyard		15.04
Former Construction Yard		8.39
Lower Reservoir I/O Structure		5.86
Lower Reservoir Laydown Yard		10.19
Proposed Spoil Areas Alternatives		
Spoil Area B		22.70
Spoil Area C		9.9
Spoil Area D		10.76
Spoil Area G		10.47
Spoil Area I		8.56
Spoil Area J		14.46
Spoil Area K		17.57
Spoil Area L		16.5
Spoil Area M		4.7
Total Acres:		**179.31 (rounded up to 246 to calculate LOE)**

Spatial Data

The attached Google Earth® KMZ files include:

- Bad Creek FERC Project Boundary – Red polygon
- Spoil Area Alternative Sites – Purple polygon
- Proposed Forest Clearing Areas – Red transparent polygon
- Proposed Access Roads – Gray polyline
- U.S. Forest Service Property – Green transparent polygon
- Fisher Knob Access Road – Yellow polyline
- Proposed new 525kV Transmission and Right-of-Way – Red polyline (transmission centerline) and yellow polygon (new 525kV right-of-way)
- Bat Habitat Assessment Notes – Save the KMZ locally to hard drive and click on purple dots to view the photographs and notes.
- Bat Survey Linear Areas – Red Polyline = Limited Access; Potentially dangerous access for surveys or areas that are currently privately owned. These areas account for approximately 9.3 miles (15 km) or 33 percent of the total linear areas to be impacted by the proposed project. Green polyline = Accessible areas.
- Potential Bat Survey Monitoring Locations – Yellow = Mist net and acoustic. Green dots = Acoustic only.
- Bat Survey Locations from 2021 ERM Bat Survey – Orange triangles = Acoustic Site Locations. Green triangles = Mist Nest Site Locations

Survey Level of Effort and Proposed Methods

The Level of Effort calculations are based on the 2024 USFWS Range-wide Indiana Bat & Northern Long-eared Bat Survey Guideline’s (USFWS Guidelines) Table 2. Summary of Current Limit of Effort’s (LOE) for Indiana bat (IBAT) and NLEB and in Appendix I: Calculating LOE for a Combined Acoustic and Mist-Netting Survey Pilot Guidance. The USFWS Guidelines state that non-linear projects located in the seasonally active NLEB range require ten net nights per 123 acres of summer suitable habitat while linear projects require four net nights per kilometer of suitable summer habitat within a square kilometer block around the line median.

Based on field reconnaissance site visits, it is estimated that approximately 30 percent of the linear and non-linear project areas are suitable for mist-net set-ups but more conducive for acoustic set-ups. Table 2 (below) represents the LOE percentages based on the USFWS Guidelines.

Table 2. LOE Calculation

Linear

Suitability	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Net Nights	0	18	36	54	72	90	108	126	144	162	180
Suitability	**100%**	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
Acoustic Nights	180	162	144	126	108	90	72	54	36	18	0

Non-linear

Suitability	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Net Nights	0	2	4	6	8	10	12	14	16	18	20
Suitability	**100%**	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
Acoustic Nights	28	26	23	20	17	14	12	9	6	3	0

As listed in Table 1, the desktop analysis of the Project Area includes approximately 45 km of linear habitat and 179.3 acres of non-linear habitat to be potentially impacted. The minimum USFWS effort LOE will be satisfied by a combined survey approach with 60 mist-net nights and 144 acoustic nights. Duke Energy proposes to add 10 acoustic detector nights as a buffer to account for any potential technical issues, totaling 154 acoustic nights. Qualitative call identification (manual vetting) will be included as part of the acoustic monitoring analysis as necessary. Table 3 represents the proposed combined LOE monitoring.

Table 3. Proposed Combined LOE Monitoring

Linear						**Non-Linear**					
Mist-Netting			**Acoustic**			**Mist-Netting**			**Acoustic**		
Net Sites	Net Nights	Calander Nights/Site	Acoustic Sites	Acoustic Nights	Calendar Nights	Net Sites	Net Nights	Calander Nights/Site	Acoustic Sites	Acoustic Nights	Calendar Nights
12	60	2	33	132	2	3	12	2	4	12	3

The study plan proposed by Duke Energy's consultant, Biotope Forestry & Environmental (Biotope), proposes to survey 12 linear mist-net sites and three non-linear mist-net sites, where two mist-nets will be deployed on the first night and second night, totaling four net nights over two calendar nights to give 48 and 12 net nights within each area respectively. To satisfy the acoustic efforts, 33 linear acoustic sites are proposed, each to be surveyed using two detectors over two calendar nights, totaling 132 detector nights. Four non-linear acoustic sites, each to be surveyed using one detector over three calendar nights, totaling 12 detector nights.

Mist-nets will be deployed for two calendar nights within impact areas. Nets will be opened prior to sunset and left open for a minimum of five hours post sunset under appropriate weather conditions. For all bats captured, general demographic data will be collected including sex, age (adult or juvenile), weight, right forearm length, reproductive condition, and general appearance. Biologists will assess each bat for evidence of white-nose syndrome. All appropriate mist-netting survey protocols (USFWS Guidelines Appendix B) will be followed.

Acoustic detectors will be deployed at each site prior to sunset on night one and record for the minimum desired calendar nights under appropriate weather conditions. For each day with a weather delay as outlined in USFWS Guidelines, the acoustic detector(s) will be deployed an additional calendar night. Following the completion of the field work at each acoustic detector site, data will be compiled and processed using Wildlife Acoustics Kaleidoscope software. If any target species calls are flagged during this process, the data will be manually vetted by an experienced biologist to confirm the presence of these species on the project area.

Acoustic monitors are also proposed to be placed at a rock shelter identified during the Cultural Resources Survey as well as near the entrance to the existing Project's powerhouse access tunnel as recommended by the S.C. Department of Natural Resources.

Proposed Field Survey Schedule

- May 29, 2024 through June 21, 2024

USFWS IPaC and NLEB Technical Assistance Letter

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Carolina Ecological Services
176 Croghan Spur Road, Suite 200
Charleston, SC 29407-7558
Phone: (843) 727-4707 Fax: (843) 727-4218

In Reply Refer To: 04/18/2024 19:02:18 UTC
Project Code: 2024-0079174
Project Name: Bad Creek II Power Complex (P-2740)

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts, see https://www.fws.gov/program/migratory-bird-permit/what-we-do.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures, see https://www.fws.gov/library/collections/threats-birds.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/partner/council-conservation-migratory-birds.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
- USFWS National Wildlife Refuges and Fish Hatcheries
- Bald & Golden Eagles
- Migratory Birds
- Wetlands

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

South Carolina Ecological Services
176 Croghan Spur Road, Suite 200
Charleston, SC 29407-7558
(843) 727-4707

PROJECT SUMMARY

Project Code:	2024-0079174
Project Name:	Bad Creek II Power Complex (P-2740)
Project Type:	Power Gen - Hydropower - FERC
Project Description:	The proposed Bad Creek II Complex would consist of a new inlet/outlet structure in the existing upper reservoir, water conveyance system, underground powerhouse, powerhouse access tunnels, lower reservoir inlet/outlet structure, switchyard, transformer yard, and transmission line. No modifications to the existing upper and lower reservoirs would be required for the Bad Creek II Complex other than construction of an upper reservoir inlet/outlet structure within the Bad Creek Reservoir and a lower reservoir inlet/outlet structure within Lake Jocassee. Currently licensed operating bands in both reservoirs would not be modified. The Bad Creek II Complex powerhouse would include four new, variable-speed pump-turbine units with a combined installed generating capacity of 1,400 MW. With both powerhouses generating, full drawdown of the upper reservoir (i.e., 160 ft) will require approximately 11.4 hours, and full refill of the reservoir will require approximately 13 hours. In this manner, the addition of the Bad Creek II Complex introduces more capacity and generation into the power grid during a shorter period of time, which could increase the number of pumping-generating cycles per year, in turn increasing annual generation from the Project. Historical average annual generation since the Project began operation in 1992 is 1,954,292 MW-hours (MWh). While annual generation for a pumped storage project is solely dependent upon how the station is used to supplement/integrate with the Duke Energy power grid, assuming the same utilization factor for the existing Project and a total Project installed capacity of 2,800 MW, the annual generation for the Bad Creek Project, with the Bad Creek II Complex added, would increase to an estimated 4,886,000 MWh, an increase of 2,932,000 MWh per year. Duke Energy is proposing the development of a temporary access road (Fisher Knob access road) to provide an alternate route to the Fisher Knob residential community during the Bad Creek II Complex construction. The proposed gravel road will begin at Whitewater Road and traverse approximately 3.7 miles/5.9 kilometers to the Fisher Knob community. Surface waters along the route have been identified and qualitatively evaluated as part of the FERC relicensing studies. Surface waters will be bridged, and no permanent or temporary impacts are anticipated. Road construction is anticipated to begin in the Spring 2026 and the road will be decommissioned following project construction. If Duke Energy decides to pursue the Bad Creek II Complex and obtains

all necessary regulatory approvals for construction, the period for construction of the Bad Creek II Complex is expected to span approximately 7 years. Assuming commencement of construction shortly following the New FERC License issuance by July 2027, the Bad Creek II Complex is expected to be fully in service in 2034.

Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@34.9773504,-82.9937585164285,14z

Counties: Oconee County, South Carolina

ENDANGERED SPECIES ACT SPECIES

There is a total of 5 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

MAMMALS

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Endangered
Tricolored Bat *Perimyotis subflavus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10515	Proposed Endangered

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

FLOWERING PLANTS

NAME	STATUS
Small Whorled Pogonia *Isotria medeoloides* Population: No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/1890	Threatened
Smooth Coneflower *Echinacea laevigata* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/3473	Threatened

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

USFWS NATIONAL WILDLIFE REFUGE LANDS AND FISH HATCHERIES

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS OR FISH HATCHERIES WITHIN YOUR PROJECT AREA.

BALD & GOLDEN EAGLES

Bald and golden eagles are protected under the Bald and Golden Eagle Protection Act[1] and the Migratory Bird Treaty Act[2].

Any person or organization who plans or conducts activities that may result in impacts to bald or golden eagles, or their habitats[3], should follow appropriate regulations and consider implementing appropriate conservation measures, as described in the links below. Specifically, please review the "Supplemental Information on Migratory Birds and Eagles".

---

1. The Bald and Golden Eagle Protection Act of 1940.
2. The Migratory Birds Treaty Act of 1918.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

There are likely bald eagles present in your project area. For additional information on bald eagles, refer to Bald Eagle Nesting and Sensitivity to Human Activity

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, see the PROBABILITY OF PRESENCE SUMMARY below to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Sep 1 to Aug 31

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

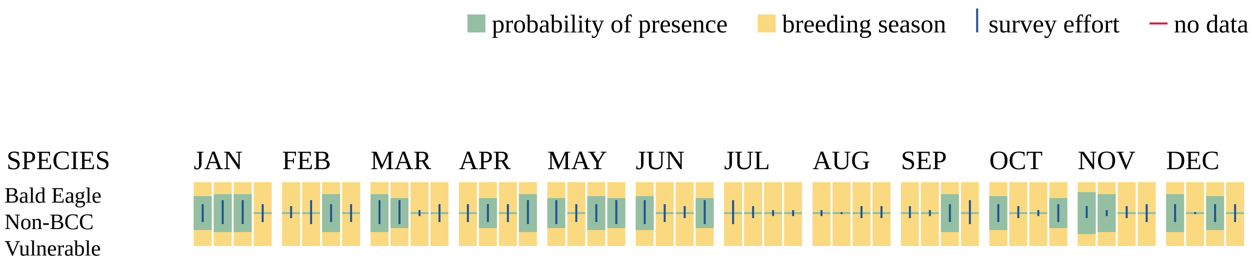
Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season (■)

Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)
Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.



Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

MIGRATORY BIRDS

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats[3] should follow appropriate regulations and consider implementing appropriate conservation measures, as described in the links below. Specifically, please review the "Supplemental Information on Migratory Birds and Eagles".

---

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, see the PROBABILITY OF PRESENCE SUMMARY below to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Sep 1 to Aug 31
Bobolink *Dolichonyx oryzivorus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9454	Breeds May 20 to Jul 31
Canada Warbler *Cardellina canadensis* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9643	Breeds May 20 to Aug 10
Chimney Swift *Chaetura pelagica* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9406	Breeds Mar 15 to Aug 25
Chuck-will's-widow *Antrostomus carolinensis* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/9604	Breeds May 10 to Jul 10
Eastern Whip-poor-will *Antrostomus vociferus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/10678	Breeds May 1 to Aug 20
Golden-winged Warbler *Vermivora chrysoptera* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/8745	Breeds May 1 to Jul 20
Prothonotary Warbler *Protonotaria citrea* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9439	Breeds Apr 1 to Jul 31
Red-headed Woodpecker *Melanerpes erythrocephalus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9398	Breeds May 10 to Sep 10

NAME	BREEDING SEASON
Wood Thrush *Hylocichla mustelina* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9431	Breeds May 10 to Aug 31

PROBABILITY OF PRESENCE SUMMARY

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read "Supplemental Information on Migratory Birds and Eagles", specifically the FAQ section titled "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

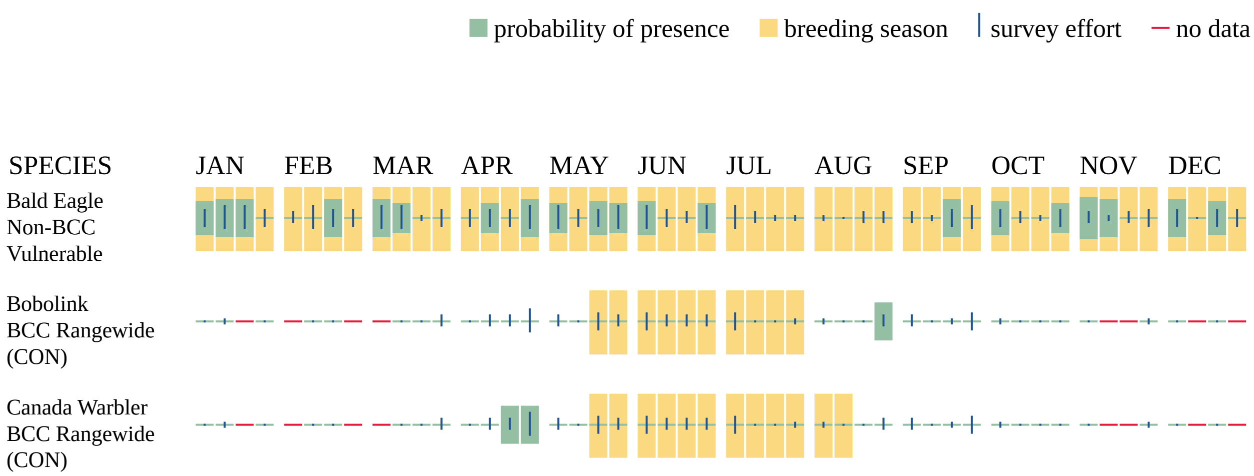
Probability of Presence ( )

Green bars; the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during that week of the year.

Breeding Season ( )
Yellow bars; liberal estimate of the timeframe inside which the bird breeds across its entire range.

Survey Effort (|)
Vertical black lines; the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps.

No Data (–)
A week is marked as having no data if there were no survey events for that week.



Additional information can be found using the following links:

- Eagle Management https://www.fws.gov/program/eagle-management
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf
- Supplemental Information for Migratory Birds and Eagles in IPaC https://www.fws.gov/media/supplemental-information-migratory-birds-and-bald-and-golden-eagles-may-occur-project-action

WETLANDS

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

Please note that the NWI data being shown may be out of date. We are currently working to update our NWI data set. We recommend you verify these results with a site visit to determine the actual extent of wetlands on site.

FRESHWATER EMERGENT WETLAND
- PEM1A

FRESHWATER POND
- PUBHx
- PUBFx
- PUSCh
- PUBHh

RIVERINE
- R4SBC
- R3UBH
- R5UBH

FRESHWATER FORESTED/SHRUB WETLAND
- PFO1A

LAKE
- L2USAh
- L1UBHh

IPAC USER CONTACT INFORMATION

Agency: Private Entity
Name: Eric Mularski
Address: 440 S. Church Street
City: Charlotte
State: NC
Zip: 28202
Email eric.mularski@hdrinc.com
Phone: 7049736878

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Federal Energy Regulatory Commission

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Carolina Ecological Services
176 Croghan Spur Road, Suite 200
Charleston, SC 29407-7558
Phone: (843) 727-4707 Fax: (843) 727-4218

In Reply Refer To: 04/18/2024 19:26:29 UTC
Project code: 2024-0079174
Project Name: Bad Creek II Power Complex (P-2740)

Federal Nexus: yes
Federal Action Agency (if applicable): Federal Energy Regulatory Commission

Subject: Technical assistance for 'Bad Creek II Power Complex (P-2740)'

Dear Eric Mularski:

This letter records your determination using the Information for Planning and Consultation (IPaC) system provided to the U.S. Fish and Wildlife Service (Service) on April 18, 2024, for 'Bad Creek II Power Complex (P-2740)' (here forward, Project). This project has been assigned Project Code 2024-0079174 and all future correspondence should clearly reference this number. **Please carefully review this letter. Your Endangered Species Act (Act) requirements are not complete.**

Ensuring Accurate Determinations When Using IPaC

The Service developed the IPaC system and associated species' determination keys in accordance with the Endangered Species Act of 1973 (ESA; 87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.) and based on a standing analysis. All information submitted by the Project proponent into IPaC must accurately represent the full scope and details of the Project. **Failure to accurately represent or implement the Project as detailed in IPaC or the Northern Long-eared Bat Rangewide Determination Key (Dkey), invalidates this letter.**

Determination for the Northern Long-Eared Bat

Based on your IPaC submission and the standing analysis for the Dkey, your project has reached the determination of "May Affect" the northern long-eared bat.

Next Steps

Your action may qualify for the Interim Consultation Framework for the northern long-eared bat. To determine if it qualifies, review the Interim Consultation Framework posted here https://www.fws.gov/library/collections/interim-consultation-framework-northern-long-eared-bat. If you determine it meets the requirements of the Interim Consultation Framework, follow the procedures outlined there to complete section 7 consultation.

If your project does **not** meet the requirements of the Interim Consultation Framework, please contact the South Carolina Ecological Services for further coordination on this project. Further consultation or coordination with the Service is necessary for those species or designated critical habitats with a determination of “May Affect”.

Other Species and Critical Habitat that May be Present in the Action Area

The IPaC-assisted determination for the northern long-eared bat does not apply to the following ESA-protected species and/or critical habitat that also may occur in your Action area:

- Monarch Butterfly *Danaus plexippus* Candidate
- Small Whorled Pogonia *Isotria medeoloides* Threatened
- Smooth Coneflower *Echinacea laevigata* Threatened
- Tricolored Bat *Perimyotis subflavus* Proposed Endangered

You may coordinate with our Office to determine whether the Action may cause prohibited take of the species listed above.

Action Description
You provided to IPaC the following name and description for the subject Action.

1. Name

Bad Creek II Power Complex (P-2740)

2. Description

The following description was provided for the project 'Bad Creek II Power Complex (P-2740)':

> The proposed Bad Creek II Complex would consist of a new inlet/outlet structure in the existing upper reservoir, water conveyance system, underground powerhouse, powerhouse access tunnels, lower reservoir inlet/outlet structure, switchyard, transformer yard, and transmission line. No modifications to the existing upper and lower reservoirs would be required for the Bad Creek II Complex other than construction of an upper reservoir inlet/outlet structure within the Bad Creek Reservoir and a lower reservoir inlet/outlet structure within Lake Jocassee. Currently licensed operating bands in both reservoirs would not be modified.
>
> The Bad Creek II Complex powerhouse would include four new, variable-speed pump-turbine units with a combined installed generating capacity of 1,400 MW. With both powerhouses generating, full drawdown of the upper reservoir (i.e., 160 ft) will require approximately 11.4 hours, and full refill of the reservoir will require approximately 13 hours. In this manner, the addition of the Bad Creek II Complex introduces more capacity and generation into the power grid during a shorter period of time, which could increase the number of pumping-generating cycles per year, in turn increasing annual generation from the Project. Historical average annual generation since the Project began operation in 1992 is 1,954,292 MW-hours (MWh). While annual generation for a pumped storage project is solely dependent upon how the station is used to supplement/integrate with the Duke Energy power grid, assuming the same utilization factor for the existing Project and a total Project installed capacity of 2,800 MW, the annual generation for the Bad Creek Project, with the Bad Creek II Complex added, would increase to an estimated 4,886,000 MWh, an increase of 2,932,000 MWh per year.
>
> Duke Energy is proposing the development of a temporary access road (Fisher Knob access road) to provide an alternate route to the Fisher Knob residential community during the Bad Creek II Complex construction. The proposed gravel road will begin at Whitewater Road and traverse approximately 3.7 miles/5.9 kilometers to the Fisher Knob community. Surface waters along the route have been identified and qualitatively evaluated as part of the FERC relicensing studies. Surface waters will be bridged, and no permanent or temporary impacts are anticipated. Road construction is anticipated to begin in the Spring 2026 and the road will be decommissioned following project construction.

> If Duke Energy decides to pursue the Bad Creek II Complex and obtains all necessary regulatory approvals for construction, the period for construction of the Bad Creek II Complex is expected to span approximately 7 years. Assuming commencement of construction shortly following the New FERC License issuance by July 2027, the Bad Creek II Complex is expected to be fully in service in 2034.

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@34.9773504,-82.9937585164285,14z

DETERMINATION KEY RESULT

Based on the answers provided, the proposed Action is consistent with a determination of "may affect" for the Endangered northern long-eared bat (*Myotis septentrionalis*).

QUALIFICATION INTERVIEW

1. Does the proposed project include, or is it reasonably certain to cause, intentional take of the northern long-eared bat or any other listed species?

   Note: Intentional take is defined as take that is the intended result of a project. Intentional take could refer to research, direct species management, surveys, and/or studies that include intentional handling/encountering, harassment, collection, or capturing of any individual of a federally listed threatened, endangered or proposed species?

   No
2. Does any component of the action involve construction or operation of wind turbines?

   Note: For federal actions, answer 'yes' if the construction or operation of wind power facilities is either (1) part of the federal action or (2) would not occur but for a federal agency action (federal permit, funding, etc.).

   No
3. Is the proposed action authorized, permitted, licensed, funded, or being carried out by a Federal agency in whole or in part?

   Yes
4. Is the Federal Highway Administration (FHWA), Federal Railroad Administration (FRA), or Federal Transit Administration (FTA) funding or authorizing the proposed action, in whole or in part?

   No
5. Are you an employee of the federal action agency or have you been officially designated in writing by the agency as its designated non-federal representative for the purposes of Endangered Species Act Section 7 informal consultation per 50 CFR § 402.08?

   Note: This key may be used for federal actions and for non-federal actions to facilitate section 7 consultation and to help determine whether an incidental take permit may be needed, respectively. This question is for information purposes only.

   No
6. Is the lead federal action agency the Environmental Protection Agency (EPA) or Federal Communications Commission (FCC)? Is the Environmental Protection Agency (EPA) or Federal Communications Commission (FCC) funding or authorizing the proposed action, in whole or in part?

   No

7. Is the lead federal action agency the Federal Energy Regulatory Commission (FERC)?

   Yes

8. Is FERC reviewing the proposed action under the Natural Gas Act, in whole or in part?

   No

9. Have you determined that your proposed action will have no effect on the northern long-eared bat? Remember to consider the effects of any activities that would not occur but for the proposed action.

   If you think that the northern long-eared bat may be affected by your project or if you would like assistance in deciding, answer "No" below and continue through the key. If you have determined that the northern long-eared bat does not occur in your project's action area and/or that your project will have no effects whatsoever on the species despite the potential for it to occur in the action area, you may make a "no effect" determination for the northern long-eared bat.

   Note: Federal agencies (or their designated non-federal representatives) must consult with USFWS on federal agency actions that may affect listed species [50 CFR 402.14(a)]. Consultation is not required for actions that will not affect listed species or critical habitat. Therefore, this determination key will not provide a consistency or verification letter for actions that will not affect listed species. If you believe that the northern long-eared bat may be affected by your project or if you would like assistance in deciding, please answer "No" and continue through the key. Remember that this key addresses only effects to the northern long-eared bat. Consultation with USFWS would be required if your action may affect another listed species or critical habitat. The definition of Effects of the Action can be found here: https://www.fws.gov/media/northern-long-eared-bat-assisted-determination-key-selected-definitions

   No

10. [Semantic] Is the action area located within 0.5 miles of a known northern long-eared bat hibernaculum?

    Note: The map queried for this question contains proprietary information and cannot be displayed. If you need additional information, please contact your State wildlife agency.

    Automatically answered
    No

11. Does the action area contain any caves (or associated sinkholes, fissures, or other karst features), mines, rocky outcroppings, or tunnels that could provide habitat for hibernating northern long-eared bats?

    Yes

12. Have you conducted, or will you conduct, a voluntary Phase 1 habitat assessment for potentially suitable hibernacula in accordance with the guidance in Appendix H of the USFWS' current Range-wide Indiana bat and Northern long-eared bat Survey Guidelines?

    Note: The survey guidelines can be found at: https://www.fws.gov/library/collections/range-wide-indiana-bat-and-northern-long-eared-bat-survey-guidelines.

    No

13. Will the proposed action result in the cutting or other means of knocking down, bringing down, or trimming of any trees suitable for northern long-eared bat roosting?

    Note: Suitable northern long-eared bat roost trees are live trees and/or snags ≥3 inches dbh that have exfoliating bark, cracks, crevices, and/or cavities.

    Yes

PROJECT QUESTIONNAIRE

Enter the extent of the action area (in acres) from which trees will be removed - round up to the nearest tenth of an acre. For this question, include the entire area where tree removal will take place, even if some live or dead trees will be left standing.

412

In what extent of the area (in acres) will trees be cut, knocked down, or trimmed during the inactive (hibernation) season for northern long-eared bat? **Note:** Inactive Season dates for spring staging/fall swarming areas can be found here: https://www.fws.gov/media/inactive-season-dates-swarming-and-staging-areas

206

In what extent of the area (in acres) will trees be cut, knocked down, or trimmed during the active (non-hibernation) season for northern long-eared bat? **Note:** Inactive Season dates for spring staging/fall swarming areas can be found here: https://www.fws.gov/media/inactive-season-dates-swarming-and-staging-areas

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Will all potential northern long-eared bat (NLEB) roost trees (trees ≥3 inches diameter at breast height, dbh) be cut, knocked, or brought down from any portion of the action area greater than or equal to 0.1 acre? If all NLEB roost trees will be removed from multiple areas, select 'Yes' if the cumulative extent of those areas meets or exceeds 0.1 acre.

Yes

Enter the extent of the action area (in acres) from which all potential NLEB roost trees will be removed. If all NLEB roost trees will be removed from multiple areas, entire the total extent of those areas. Round up to the nearest tenth of an acre.

412

For the area from which all potential northern long-eared bat (NLEB) roost trees will be removed, on how many acres (round to the nearest tenth of an acre) will trees be allowed to regrow? Enter '0' if the entire area from which all potential NLEB roost trees are removed will be developed or otherwise converted to non-forest for the foreseeable future.

256.3

Will any snags (standing dead trees) ≥3 inches dbh be left standing in the area(s) in which all northern long-eared bat roost trees will be cut, knocked down, or otherwise brought down?

No

Will all project activities by completed by April 1, 2024?

No

IPAC USER CONTACT INFORMATION

Agency: Private Entity
Name: Eric Mularski
Address: 440 S. Church Street
City: Charlotte
State: NC
Zip: 28202
Email eric.mularski@hdrinc.com
Phone: 7049736878

LEAD AGENCY CONTACT INFORMATION

Lead Agency: Federal Energy Regulatory Commission
Name: Sarah Salazar
Email: Sarah.Salzar@ferc.gov
Phone: 2025026863

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Biotope Resumes

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Dylan Brooks
dylan.biotope@gmail.com
(828) 507-5523

Resume

Education

2011 Haywood Community College
- Associate in Applied Science: Fisheries and Wildlife Management Technology

2015 Western Carolina University
- Bachelor of Science: Natural Resource Conservation and Management

Background

Mr. Brooks has more than 12 years of project experience in ecological and environmental services. In that time, he has conducted ecological field investigations on a variety of different projects including habitat assessments as well as endangered species surveys for various natural resource extraction companies. Much of Mr. Brooks' experience is comprised of presence/absence surveys for threatened and endangered bat species (*Myotis sodalis and Myotis septentrionalis*). The majority of Mr. Brooks' experience has been as a team leader and/or permitted biologist on site. Mr. Brooks has held a **Federal Recovery Permit (ES81492B-1)** to collect *M. sodalis* and *M. septentrionalis* since 2014 and has held state permits in MD, MN, PA, WV, IA, OH, MI, IL, IN, VA, TN, NC, SC, GA, AR, MS, and TX.

Qualification and Experience with Bats

Mr. Brooks is knowledgeable and experienced in the application of the following equipment and techniques as they relate to the detection, capture, and handling of bat species:

- Bat handling (species level identification and various physical measurements)
- Mist-net site selection, set up, and operation
- Harp trap site selection, set up, and operation
- Radio telemetry
- Estimated 4,000 contact hours performing surveys for listed bats
- Application of split-ring metal forearm identification bands
- Reichard's Wing Damage Index Scoring
- Suitability assessments for both summer and winter bat habitat
- Acoustical monitoring and call analysis
- Autumn portal/cave evaluations and surveys
- White-nose syndrome disinfection protocols
- Collecting swab and tissue samples

Dylan Brooks
dylan.biotope@gmail.com
(828) 507-5523

Identified Bat Species

- Indiana bat (*Myotis sodalis*)
- Northern long-eared bat (*Myotis septentrionalis*)
- Gray bat (*Myotis grisescens*)
- Eastern small-footed bat (*Myotis leibii*)
- Little brown bat (*Myotis lucifugus*)
- Silver-haired bat (*Lasionycteris noctivagans*)
- Tricolored bat (*Perimyotis subflavus*)
- Evening bat (*Nycticeius humeralis*)
- Hoary bat (*Lasiurus cinereus*)
- Eastern red bat (*Lasiurus borealis*)
- Big brown bat (*Eptesicus fuscus*)
- Southeastern myotis (*Myotis austroriparius*)
- Rafinesque's big-eared bat (*Corynorhinus rafinesquii*)

Indiana Bat (*Myotis sodalis*) Experience

- Captured and processed approximately 34 *Myotis sodalis*
- Placed radio transmitters on 13 *Myotis sodalis*
- Conducted approximately 2,500 hours of radio-telemetry (night time foraging and roost tree locations) for the Indiana bat (*Myotis sodalis*)

Northern Long-eared Bat (*Myotis septentrionalis*) Experience

- Captured and processed approximately 325 *Myotis septentrionalis*
- Placed radio-transmitters on 36 *Myotis septentrionalis*
- Conducted approximately 4,200 hours of radio-telemetry (night time foraging and roost tree locations) for the Northern long-eared bat (*Myotis septentrionalis*)

Gray Bat (*Myotis grisescens*) Experience

- Captured and processed 7 *Myotis grisescens*
- No radio-transmitters were placed on *Myotis grisescens* since their roosts were known to be caves near project area
- No radio-telemetry was required for this species for the purposes of these studies

Tricolored Bat (*Perimyotis subflavus*) Experience

- Captured and processed approximately 400 *Perimyotis subflavus*
- Placed radio-transmitters on 1 *Perimyotis subflavus*
- Conducted approximately 50 hours of radio-telemetry (diurnal roost tree locations) for the tricolored bat (*Perimyotis subflavus*)

Project Experience

- **Project Manager** – Allegheny National Forest Bat Survey Project**:** 2023. Mist-net and structure survey for the federally endangered Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), the proposed federally endangered tricolored bat (*Perimyotis subflavus*), and the little brown bat (*Myotis lucifugus*) throughout the Allegheny National Forest in Pennsylvania.

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- **Project Manager** – TVA Pumped Storage-Rorex Creek Project: 2023. Mist-net survey for the federally endangered Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), gray bat (*Myotis* grisescens) the proposed federally endangered tricolored bat (*Perimyotis subflavus*), and the little brown bat (*Myotis lucifugus*) in Jackson County, Alabama.

- **Project Manager** – Hillsboro Solar Project: 2023. Mist-net survey for the federally endangered Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), the proposed federally endangered tricolored bat (*Perimyotis subflavus*), and the little brown bat (*Myotis lucifugus*) in Lawrence County, Alabama.

- **Project Manager** – Trifecta Solar Project: 2023. Mist-net survey for the federally endangered northern long-eared bat (*Myotis septentrionalis*) and the little brown bat (*Myotis lucifugus*) in Choctaw County, Mississippi.

- **Project Manager** – Stamey Solar Project: 2023. Mist-net survey for the proposed federally endangered tricolored bat (*Perimyotis subflavus*) in Darlington County, South Carolina.

- **Project Manager** – Blackfin Pipeline Project: 2023. Mist-net survey for the proposed federally endangered tricolored bat (*Perimyotis subflavus*) throughout multiple counties in eastern Texas.

- **Project Manager** – Navigator Carbon Sequestration Pipeline Project**:** 2022. Mist-net survey for the federally endangered Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*) as well as the proposed federally endangered tricolored bat (*Perimyotis subflavus*) throughout multiple counties in eastern Illinois.

- **Project Manager** – Chester Solar Farm Bat Survey: 2022. Mist-net survey for the federally endangered northern long-eared bat (*Myotis septentrionalis*) for a proposed solar farm in Chester, VA.

- **Project Manager** – Timberwolf Wind Energy Project: 2021. Mist-net survey for the federally endangered Indiana bat (*Myotis sodalis*) and northern long-eared bat for the proposed Timberwolf Wind Project in Fillmore County, Minnesota.

- **Project Manager** – Prairie Creek Wind Energy Project: 2021. Mist-net survey for the federally endangered Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*) in Blackford County, IN.

- **Project Manager** – Mobley to Majorsville: 2018. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area in Wheeling, WV.

- **Project Manager** – Brues to Glendale: 2018. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area in Wheeling, WV.

- **Project Manager –** EASTERN NORTH CAROLINA NORTHERN LONG-EARED BAT RESEARCH STUDY: 2017-2019. A survey used to determine the habitat preferences and distribution of the federally threatened northern long-eared bat (*Myotis septentrionalis*) in North Carolina, further document fall/winter activity, and develop greater understanding of winter habitat use and behavior in the region.

- **Project Manager –** DIAMOND TRAIL WIND ENERGY PROJECT: 2017. A summer survey and winter habitat assessment for the federally threatened northern long-eared bat (*Myotis*

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septentrionalis) on Invenergy property in multiple counties throughout central Iowa

- **Project Manager –** CLEAN LINE AND PLAINS PIPELINE: 2016. A linear summer survey for the federally endangered Indiana bat (*Myotis sodalis)* and threatened northern long-eared bat (*Myotis septentrionalis*) near known maternity colony trees, Multiple counties throughout eastern Arkansas.

- **Project Manager –** NEW KENT BAT SURVEY: 2016. A summer survey and winter habitat assessment for the federally threatened northern long-eared bat (*Myotis septentrionalis)* on military land in New Kent County, VA.

- **Project Manager** - ROVER PIPELINE: 2015. A linear summer survey for the federally endangered Indiana bat (*Myotis sodalis)* and threatened northern long-eared bat (*Myotis septentrionalis*) near known maternity colony trees, Multiple counties throughout Ohio and West Virginia.

- **Project Manager** – SUNOCO TETRATECH PIPELINE: 2014. A linear summer survey for the federally endangered Indiana bat (*Myotis sodalis*), eastern small-footed bat (*Myotis leibii*) and northern long eared bat (*Myotis septentrionalis*) near known maternity colony trees, Multiple counties throughout southern Pennsylvania.

- **Project Manager** – AMEI COAL MINING: 2014. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area in Wallace, WV.

- **Project Manager** – WILLIAMS PIPELINE: 2013. A linear summer survey for the federally endangered Indiana bat (*Myotis sodalis*) and northern long eared bat (*Myotis septentrionalis*) near known maternity colony trees, Multiple counties in western PA.

- **Project Manager** – BLACK CASTLE MINING COMPANY: 2013. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) near known maternity colony trees, Boone County, WV.

- **Project Manager** – REPUBLIC ENERGY CORPORATION: 2013. A summer, spring, and fall survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area near a known colony, Fayette & Kanawha Counties, WV (Application No. S-3010-11).

- **Project Manager** – COAL RIVER MINING: 2013. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis)* at a proposed surface mine project area in Kanwaha County, WV.

- **Project Manager** – CARDNO MM&A: 2013. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis)* at a proposed surface mine area in Raleigh County, WV.

- **Project Manager** – BANDMILL COAL CORPORATION: 2013. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis)* at a proposed surface mine in Logan County, WV.

- **Project Manager** – NATIONAL RESOURCES: 2013. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis)* at a proposed surface mine in Wyoming and McDowell County, WV.

- **Project Manager** – ALPHA NATURAL RESOURCES: 2012. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) near known

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maternity colony trees, Boone County, WV.

- **Project Manager** – ALPHA NATURAL RESOURCES: 2012. A summer, spring, and fall survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area near a known colony, Fayette & Kanawha Counties, WV.
- **Project Manager** – MARSHALL MILLER: 2012. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed fine coal refuse disposal facility near Wyoming, Wyoming County, WV.
- **Project Manager** – ALPHA NATURAL RESOURCES: 2012. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area near Stollings, Logan County, WV.
- **Project Manager** – ALPHA NATURAL RESOURCES: 2012. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area near Peytona, Boone County, WV.
- **Biologist** – MARFORK COAL COMPANY: 2012. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed coal surface mine near Colcord, Raleigh County, WV.
- **Biologist** – ALPHA NATURAL RESOURCES: 2011. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) near known maternity colony trees, Boone County, WV.
- **Biologist** – ALPHA NATURAL RESOURCES: 2011. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed project area near Cabin Creek, Kanawha County, WV.
- **Wildlife Technician** – ALPHA NATURAL RESOURCES: 2011. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed Browns Branch Surface Mine near Bandytown, Boone County, WV.
- **Wildlife Technician** – MARSHALL MILLER: 2011. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed Toney Fork West Surface Mine near Lorado, Boone and Logan Counties, WV.
- **Wildlife Technician** – ALPHA NATURAL RESOURCES: 2011. A summer survey and winter habitat assessment for the federally endangered Indiana bat (*Myotis sodalis*) at a proposed Mt. McGuire Surface Mine near Hickory Camp Branch, Fayette County, WV.

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Eli Corwin

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Background

Mr. Corwin has more than 10 years of project experience in ecological and environmental services. In that time, he has conducted and managed ecological field investigations on a variety of different projects from large and small transportation as well as endangered species surveys for various natural resource extraction companies. Much of Mr. Corwin's experience is comprised of presence/absence surveys for threatened and endangered bat species (*Myotis sodalis, M. septentrionalis, M. grisescens, Perimyotis subflavus*). Currently, Mr. Corwin has conducted approximately 400 summer mist-net surveys and 90 fall portal surveys; most of which Mr. Corwin has been the team leader and/or permitted biologist on site. Furthermore, Mr. Corwin is experienced in the application of split-ring metal arm bands and radio transmitters to listed bat species as well as the subsequent radio telemetry.

Vascular Plants of the Eastern United States

Mr. Corwin has completed numerous classes pertaining to the identification of flora of the eastern United States, including field botany, plant physiology, plant morphology, wetland ecology, plant ecology, and forest ecology. Furthermore, he has conducted ecological field investigations on a variety of projects that have provided him a solid foundation for identifying vascular plants of the eastern United States including site assessments and biological inventories, natural resource extraction and transportation, and transmission line installation.

Qualification and Experience with Bats

Mr. Corwin is knowledgeable and experienced in the application of the following equipment and techniques as they relate to the detection, capture, and handling of bat species:

- Bat handling (species level identification and various physical measurements)
- Mist-net site selection, set up, and operation
- Harp trap site selection, set up, and operation
- Radio telemetry
- Estimated 4700 contact hours performing surveys for listed bat species
- Application of split-ring metal forearm identification bands
- Application of radio-transmitters
- Reichard's Wing Damage Index Scoring used for characterizing wing condition of bats affected by white-nose syndrome
- Suitability assessments for both summer and winter bat habitat
- Acoustical monitoring and call analysis
- Hibernacula surveys
- White-nose Syndrome disinfection protocols

Indiana Bat (*Myotis sodalis*) Experience

- Captured and processed 26 *Myotis sodalis*
- Placed radio transmitters on 4 *Myotis sodalis*
- Conducted approximately 300 hours of radio telemetry (night time foraging and roost tree locations) for *Myotis sodalis*

Northern Long-eared Bat (*Myotis septentrionalis*) Experience

- Captured and processed approximately 37 *Myotis septentrionalis*
- Placed radio transmitters on one *Myotis septentrionalis*
- Conducted 150 hours of radio telemetry (roost tree locations) for the Northern Long-Eared Bat (*Myotis septentrionalis*)

Gray Bat (*Myotis grisescens*) Experience

- Captured and processed and/or identified 39 *Myotis grisescens*

Tricolored Bat (*Perimyotis subflavus*) Experience

- Captured and processed and/or identified approximately 15 *Perimyotis subflavus*
- Placed radio transmitters on 1 *Perimyotis subflavus*
- Conducted 140 hours of radio telemetry (roost tree locations) for Tricolored bats.

Qualifications and Experience with Ecological & Environmental Services

Mr. Corwin's field and natural history skills include a variety of taxa and disciplines from:

- Herbaceous and woody vegetation identification
- Federal and state listed threatened and endangered species surveys
- Habitat assessments
- Geographic Information Systems
- Geospatial Analysis
- Acoustic Survey Techniques and Data Analysis

Selected Project Experience

West Virginia

- Habitat assessment survey for the proposed Pennsylvania Pipeline Project
- Mist-net survey for the Federally Endangered Indiana Bat for Black Castle Surface Mine in Boone County, WV
- Mist-net survey for the Federally Endangered Indiana Bat for Long Branch Surface Mine in Kanawha and Fayette Counties, WV
- Hibernacula survey for the Federally Endangered Indiana Bat for Long Branch Surface Mine in Kanawha and Fayette Counties, WV
- Mist-net survey for the Federally Endangered Indiana Bat for Marfork Surface Mine in Raleigh County, WV
- Mist-net survey for threatened and endangered bats on the Rover Pipeline throughout West Virginia

Ohio

- Wetland survey for the proposed Pennsylvania Pipeline Project throughout Ohio
- Mist-net survey for threatened and endangered bats on the Rover Pipeline throughout Ohio
- Mist-net survey for threatened and endangered bats on the The Greenery Bat Survey (Lewis Field)
- Mist-net survey for threatened and endangered bats on the Johnstown Bat Survey

Pennsylvania

- Habitat assessment for the Federally Endangered Indiana Bat for the proposed Pennsylvania Pipeline Project

Arkansas

- Mist-net survey for threatened and endangered bats on the Clean-Line Transmission Line Project throughout Arkansas

Illinois

- Mist-net survey for threatened and endangered bats for the Country Mark Pipeline in Marion County, IL

Kansas

- Mist-net survey for threatened and endangered bat species at a U.S. Army Corps of Engineers facility in Johnson County, Kansas

Missouri

- Mist-net survey to determine bat community composition at multiple Army National Guard facilities in Missouri

Tennessee

- Mist-net survey to determine bat community composition at multiple Tennessee Army National Guard facilities in Tennessee and Georgia

Georgia

- Mist-net survey to determine bat community composition at multiple Tennessee Army National Guard facilities in Tennessee and Georgia

North Carolina

- Mist-net survey for threatened and endangered bat species on Eastern Band of Cherokee lands for the Eastern Band of Cherokee Wildlife Division in Cherokee County, North Carolina

South Carolina

- Mist-net survey for all bat species on conservation easement properties in coastal South Carolina

Virginia

- Mist-net survey for threatened and endangered bat species on the Chester Solar Technology Park Project in Chesterfield County

Alabama

- Mist-net survey for threatened and endangered bat species on the TVA Pumped Storage

project in Jackson County
- Mist-net survey for threatened and endangered bat species on the Loves Good-Hope project in Cullman County
- Mist-net survey for threatened and endangered bat species on the Hillsboro Solar project in Lawrence County

Mississippi
- Mist-net survey for threatened and endangered bat species on the Trifecta Project in Choctaw County

Texas
- Mist-net survey for threatened and endangered bat species on the Blackfin Bat Surveys Project in Haller and Waldin Counties

Permits

- Has held state permits in has held state permits in PA, MO, WV, AL, OH, VA, TN, NC, SC, GA, AR, KS, IL, MS, and TX.
- Pennsylvania Qualified Bat Surveyor
- USFWS Native Endangered Species Recovery (**ES81492B-1**)

Education

University of North Carolina at Wilmington
Bachelor of Science: Major Geography, Minor Geospatial Technology

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Jay B Deatherage **Resume**

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Summary

Mr. Deatherage has more than 12 years of project experience in natural resources management and consulting. Mr. Deatherage's bat research has entailed presence/absence surveys for threatened and endangered bat species (*Myotis sodalis, Myotis grisescens, Perimyotis subflavus, Myotis lucifugus,* and *Myotis septentrionalis*) on various projects. Mr. Deatherage is experienced in habitat assessments, radio tracking for both forage and roost tree data, emergence counts, portal assessment and exclusion, and acoustic surveys. Furthermore, Mr. Deatherage is experienced in the application of split-ring metal forearm bands and radio transmitters to listed bat species. He currently holds a **Federal Recovery Permit (ES88227B-1**) to collect *M. sodalis* and *M. septentrionalis* and has held state permits in WV, IA, AL, OH, IL, PA, MS, TX, NC, and VA.

Qualifications and Experience with Bats

Mr. Deatherage is knowledgeable and experienced in the application of the following equipment and techniques as they relate to the detection, capture, and handling of bat species:

- Bat handling (species level identification and various physical measurements)
- Mist-net site selection, set up, and operation
- Harp trap site selection, set up, and operation
- Radio telemetry
- Application of split-ring metal forearm identification bands
- Reichard's Wing Damage Index Scoring
- Suitability assessments for both summer and winter bat habitat
- Acoustical monitoring and call analysis
- Autumn portal/cave evaluations and surveys
- White-nose syndrome disinfection protocols
- Collecting swab and tissue samples

Identified Bat Species

- Indiana Bat (*Myotis sodalis*)
- Northern Long-eared Bat (*Myotis septentrionalis*)
- Eastern Small-footed Bat (*Myotis leibii*)
- Little Brown Bat (*Myotis lucifugus*)
- Gray bat (*Myotis grisescens*)

- Southeastern Myotis (*Myotis austroriparius*)
- Silver-haired Bat (*Lasionycteris noctivagans*)
- Tricolored Bat (*Perimyotis subflavus*)
- Evening Bat (*Nycticeius humeralis*)
- Hoary Bat (*Lasiurus cinereus*)
- Eastern Red Bat (*Lasiurus borealis*)
- Big Brown Bat (*Eptesicus fuscus*)
- Seminole Bat *(Lasiurus seminolus)*
- Rafinesque's Big-Eared Bat *(Corynorhinus rafinesquii)*

Selected Project Experience

Pennsylvania

- **Project Manager** – ALLEGHENY NATIONAL FOREST BAT SURVEY PROJECT: 2023. A summer mist-net and structure survey for *M. sodalis, M. grisescens, M. lucifugus, P. subflavus*, and *M. septentrionalis* throughout the Allegheny National Forest.

Alabama

- **Project Manager** – TVA ROREX PUMPED STORAGE PROJECT: 2023. A summer mist-net survey for *M. sodalis, M. grisescens, M. lucifugus, P. subflavus*, and *M. septentrionalis* on future TVA property in Jackson County.
- **Project Manager** – COVIA HOLDINGS, LLC MINING PROJECT: 2022. A summer mist-net survey for *M. sodalis* and *M. septentrionalis* on Covia property in Tuscaloosa County.

Iowa

- **Project Manager** - DIAMOND TRAIL WIND ENERGY PROJECT: 2017. A summer mist-net survey for *M. sodalis* and *M. septentrionalis* on Invenergy property in multiple counties throughout central Iowa.

Virginia

- **Lead Biologist** – Chester Solar Project: 2022. *M. septentrionalis* summer mist-net survey on project area for a proposed solar farm in Chester County.

West Virginia

- **Project Manager** – APPALACHIAN POWER: 2021. *M. sodalis* summer mist-net survey for a proposed transmission line through Wyoming and Raleigh Counties.
- **Project Manager** – APPALACHIAN POWER: 2021. *M. sodalis* summer mist-net survey for a proposed coal mine expansion in Logan County.
- **Project Manager** - REPUBLIC ENERGY, INC: 2012. *M. sodalis* summer, spring, and fall surveys, and winter habitat assessment on a proposed coal mine in Kanawha and Fayette Counties
- **Project Manager** - MARSHAL MILLER: 2012. *M. sodalis* summer mist-net survey and winter habitat assessment on a proposed coal refuse site located in Wyoming and Logan Counties, WV.
- **Project Manager** - MARFORK COAL COMPANY: 2012. *M. sodalis* summer mist-net survey and winter habitat assessment on a proposed coal mine in Raleigh County, WV.
- **Project Manager** - ALPHA NATURAL RESOURCES: 2012. *M. sodalis* summer mist-net survey and winter habitat assessment on a proposed coal mine in Boone and Logan Counties, WV.
- **Lead Biologist** - ALPHA NATURAL RESOURCES: 2011. *M. sodalis* summer mist-net survey and winter habitat assessment on three proposed coal mines in Boone County, WV.

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Education and Professional Trainings

- Stephen F. Austin State University
  - Bachelor of Science in Forest Wildlife Management 2011

Kentucky Bat Working group workshop for bat handling and identification
Texas Accredited Forester

Resume

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Work Experience

- **Currently—Biotope Forestry and Environmental, Wildlife Biologist III (3).** Responsible for performing mist-net surveys for threatened and endangered bat species as well as forest inventory and habitat assessments.
  - **Fall 2023—**Bat acoustic analysis for projects located throughout the Carolinas.
  - **Summer 2023—**Mist-net survey for *Perimyotis subflavus* and *Myotis lucifugus* in northeastern Alabama. Many *Myotis grisescens* were handled and identified along with two *P. subflavus.* One *P. subflavus* was affixed with a transmitter. I located two roosts located for *P. subflavus* on this project.
  - **September 2022–** Indiana Bat Portal Searches in West Virginia and eastern Kentucky.
  - **June 2022-August 2022–** Northeast Ohio Regional Airport Bat Survey, Mill Creek Habitat Restoration Bat survey.
- **January 2021-December 2021—NC Forest Service, (Buncombe County) Assistant County Ranger.** Wildfire suppression, prescribed burning, forest management, forestation, urban forestry.
- **Spring/Summer 2021 Volunteer with Indiana State University and NCWRC**–Bat mist-netting surveys. Team lead for the application of radio transmitters to *Myotis grisescens*.
  - **April 2021-** Netting target bridges in Asheville area.
- **April 2020-July 2020–ISU Bat Center, Bat Technician.** Assisted with Joy O'Keefe and Joey Weber's gray bat project along French Broad River which included bridge inspections, acoustic station maintenance, and identification of gray bats and other species.
- **September 2018-December 2020—Biotope Forestry and Environmental, Forest Technician**. Forest Inventory for clients Campbell Global, F&W Forestry Services and American Forest Management in the coastal plain of the Carolinas, Florida, Mississippi, and Texas
- **Summer of 2018—Ecological Engineering, Wildlife Technician.** Mist-net surveys for threatened and endangered bat species. Radio telemetry tracking of northern long-eared bats in Francis Marion NF (longleaf pine forest and swamp habitat). Identified the following bat species: *Myotis septentrionalis, Lasiurus borealis, Lasiurus seminolus, Nycticeius humeralis, Eptesicus fuscus, Perimyotis subflavus, and Tadarida brasiliensis.* Work also included surveying for host plants for various butterfly, skipper and moth species (various species of *Asclepius, Pontedaria, Pieris,* and *Gymnopogon ambiguus).*
- **May 2018—Ecological Solutions and Innovations, Forest Technician**. Forest health assessment and merchantable timber inventory.
- **April 2018—Biotope Forestry & Environmental, Forest Technician**. Clients included Campbell Global and American Forest Management

- **Winter 2017-2018—Calyx Engineers and Consultants, Staff Scientist**. Mist-net surveys for threatened and endangered bat species in northeastern North Carolina. Radio telemetry tracking of northern long-eared bat. Study areas were North River Gamelands, Merchants Millpond State Park, and Great Dismal Swamp State Park. Identified the following bat species: *Myotis spetentrionalis, Myotis austroriparius, Myotis lucifugus, Lasiurus borealis, Corynorhinus rafinesquii,* and *Eptesicus fuscus.*
- **Fall 2017—Apogee Environmental, Bat Biologist (WV).** Fall portal netting and harp trapping old, abandoned coal mines near Mahan, WV. Identified *Myotis sodalis, Myotis leibii, and Eptesicus fuscus.*
- **Fall 2017—Borealis Biological, Bat technician**. Fall portal netting old, abandoned coal mines and adits near Man, WV. Identified *Myotis leibii.*
- **Summers and Falls 2014-2017—Apogee Environmental, Bat Biologist (WV).** Summer mist netting and radio telemetry tracking of Indiana bats. Worked in PA, OH, TN, and GA as a technician. Identified *Myotis sodalis, Myotis leibii, Myotis septentrionalis, Lasionycteris noctivagans, Perimyotis subflavus, Eptesicus fuscus, Nycticeius humeralis, Lasiurus borealis, Lasiurus cinereus.* Applied transmitters to northern long-eared bats many times. WV permitted Bat Biologist, and Bat Identifier (BI) in PA.
- **2013—Seasonal Park Technician at Chimney Rock State Park, NC.** Work included surveying and controlling invasive plant species, creating a blooming calendar of native wildflowers, outreach, and general park maintenance.
- **Fall 2010- Fall 2011—Duke Forest (Duke University), Forest Technician.** Work included the decadal forest inventory of the forest property (> 7,000 acres) using the double sampling method with a prism-point sampling technique. Prepared forests for timber sales and inspected logging operations. Invasive species control, trail maintenance, and grounds maintenance. Regularly used ArcGIS to make detailed sale area maps, and inventory maps.
- **Summer of 2010—Student Conservation Association, Trail Maintenance Worker.** Trail restoration.

Education

Western Carolina University (Cullowhee, NC)—Bachelor's degree in Natural Resource Management with a concentration in Forest Management
Haywood Community College (Clyde, NC)—Associates of Applied Science in Forest Management Technology. Graduated magna cum laude.

Awards, Certificates, and Training

Federal Recovery Permit for bats (**ES81492B-1**)
2021 NWCG- S-212 Chainsaw Certification
2018-Workshop on using Sonobat and Kaleidoscope at SBDN in Roanoke, VG
2012 Asheville-Buncombe Tech Community College – Welding Program (MIG and TIG)
2011 National Wildfire Coordinating Group – Introduction to Wildland Fire Behavior (S-190)
2011 National Wildfire Coordinating Group – Firefighter Training (S-130)

2011 National Wildfire Coordinating Group – Human Factors in the Wildland Fire Service (L-180)
2011 National Wildfire Coordinating Group – Pack Test
2010 Council of Eastern Forest Technician Schools—Award for Superior Academic Achievement

References

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Stephanie R Penk

Resume

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Summary

Dr. Penk has 11 years of experience working in the environmental services field. During that time, she has quickly distinguished herself as a capable and competent biologist, swiftly building her credentials and confidence in endangered species surveys for *Myotis sodalis* and *Myotis septentrionalis*. At this point in her career Dr. Penk has performed approximately 265 mist-net surveys, two thirds of which she acted as the team lead. For three summer net season's Dr. Penk managed the mist-netting and telemetry effort on a variety of projects across Pennsylvania, West Virginia, Ohio, Virginia, Illinois, Minnesota, Arkansas, Maryland, and Iowa. In 2016, Dr. Penk received her independent Qualified Bat Surveyor permit from the Pennsylvania Game commission as well as her West Virginia state endangered species collection permit. She has since received a **Federal Recovery Permit (ES 81353B-1)** to capture *Myotis sodalis* and *Myotis septentrionalis* with mist-nets. She has continued to work seasonally performing mist-net surveys as a lead biologist nearly every summer since 2016, maintaining her surveying skills and continuing to collect state permits as her experience broadens (e.g., TN, AL, VA, NC, PA, MN, IA, IL, AR, MD, VA, KY, OH, TX).

Qualifications and Experience with Bats

Dr. Penk is experienced in the use of the following equipment and techniques as they relate to the detection, capture, and handling of bats including federally protected species:

- Bat handling and identification of Eastern U.S bat species and others
    - *Myotis sodalis*, *Myotis septentrionalis*, *Myotis lucifugus*, *Myotis leibii*, *Myotis austroriparius*, *Nycticeius humeralis*, *Perimyotis subflavus*, *Eptesicus fuscus*, *Lasiurus borealis*, *Lasiurus cinereus*, *Lasionycteris noctivagans, Dobsonia beauforti*, *Pteropus hypomelanus*
- Determining sex, age, and necessary measurements of bats
- Suitable survey site selection
- Mist-net set up and operation
- Harp trap set up and operation
- Radio telemetry; foraging and roost tree locating
- Analysis of telemetry data using LOAS programs
- Transmitter application
- Application of split-ring metal and celluloid identification bands
- Wing Damage Index Scoring
- Bat habitat assessments
- Acoustic monitor placement and data analysis

- White-nose Syndrome decontamination protocols
- Wing swab collection

Indiana Bat (*Myotis sodalis*) Experience

- Captured and processed 27 *Myotis sodalis* (Mist-net and harp trapping)
- Personally placed 3 radio transmitters on *Myotis sodalis*; assisted with 1
- Conducted approximately 160 hours of radio telemetry (nighttime foraging and roost tree locations) for the Indiana Bat
- Performed over 25 emergence counts on known *Myotis sodalis* roost trees
- Performed mist-net site reconnaissance

Northern Long-eared Bat (*Myotis septentrionalis*) Experience

- Captured and processed an estimated 101 *Myotis septentrionalis*; 66 as the team lead
- Personally placed 14 radio transmitters on *Myotis septentrionalis*; assisted with 14
- Conducted over 420 hours of radio telemetry to determine roost tree locations
- Performed approximately 120 emergence counts on said roost trees
- Performed mist-net site reconnaissance; yielded high rate of *Myotis septentrionalis* captures

Selected Project Experience

Pennsylvania

- Mist-net survey for the Federally Endangered Indiana Bat, northern long-eared bat, tricolored bat, and little brown bat for the proposed Pennsylvania Pipeline Project throughout Pennsylvania.
- Mist-net survey for the Federally Endangered Indiana Bat for the proposed Pennsylvania Pipeline Project throughout Pennsylvania.
- Project manager for US Forest Service inventory of bats in Allegheny National Forest using mist-nets on forest sites as well as innovative traps for structure emergence surveys.

Ohio

- Habitat Assessment for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Rover Pipeline throughout Ohio.
- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Rover Pipeline throughout Ohio.
- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Dr. No Well Pad in Monroe County, Ohio.
- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Valenka-2 Well Pad in Monroe County, Ohio.

West Virginia

- Habitat Assessment for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Rover Pipeline throughout West Virginia.
- Mist-net survey for the Federally Endangered Indiana Bat for Long Branch Surface Mine in Kanawha and Raleigh Counties, West Virginia.

- Mist-net survey for the Federally Endangered Indiana Bat for Blue Pennant Surface Mine in Boone and Raleigh Counties, West Virginia.
- Habitat Assessment for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Inception Gas Pipeline in Harrison County, West Virginia.

Maryland

- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Terrapin Hills Wind Project in Garrett County, Maryland.

Minnesota

- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Timberwolf Wind Project in Fillmore County, Minnesota.

North Carolina

- Mist-net survey for long term monitoring of bat species with the Eastern Band of Cherokee Fish and Wildlife service in Cherokee, North Carolina.
- Mist-net survey for northern long-eared bat research project on National game lands in Camden, North Carolina.

Virginia

- Mist-net survey for the Federally Endangered northern long-eared bat for the RAYTHEON project conducted with the US Navy in New Kent, Virginia.
- Mist-net survey for the Federally Endangered northern long-eared bat for the Chester Solar Project conducted with a private energy firm in Chester, Virginia.

Illinois

- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Navigator HGP project across from Springfield to Quincy, Illinois. Tricolored bats included as a target species.

Indiana

- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Prairie Creek Windfarm Project in Blackford County, Indiana.

Iowa

- Mist-net survey for the Federally Endangered Indiana Bat and northern long-eared bat for the proposed Diamond Trail Wind Project in Iowa County, Iowa.

Education and Professional Trainings

- University of Guelph, Guelph ON, Canada
    - Bachelor of Science Honors, Major: Wildlife Biology
    - Graduated with Distinction 2012
- University of Toronto, Toronto ON, Canada
    - PhD graduate March 2022
    - Department of Ecology and Evolutionary Biology
        - Emphasis on mathematical modeling in ecology

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Attachment E: Small Whorled Pogonia Study Plan

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Memo

Date:	Wednesday, June 05, 2024
Project:	Bad Creek II Power Complex
To:	Alan Stuart, Duke Energy
From:	Eric Mularski, HDR
Subject:	Small Whorled Pogonia Study Plan

Project Understanding

Duke Energy Carolinas, LLC (Duke Energy) is the owner and operator of the 1,400-megawatt Bad Creek Pumped Storage Project (Project; Federal Energy Regulatory Commission [FERC] Project No. 2740) located in Oconee County, South Carolina. The existing (original) license for the Project was issued by the Commission for a 50-year term, with an effective date of August 1, 1977, and expires July 31, 2027, therefore, Duke Energy is pursuing a new license for the Project pursuant to the Commission's Integrated Licensing Process (ILP) (18 Code of Federal Regulations Part 5). An alternative relicensing proposal presently being evaluated by Duke Energy is the construction of a second 1,400-megawatt power complex (Bad Creek II Power Complex) adjacent to the existing Project to increase renewable pumping and generating capacity at the Project.

In response to a written request from the South Carolina Department of Natural Resources (SCDNR) in comments submitted to the Commission on the Initial Study Report (Duke Energy 2024) and to support Clean Water Act Section 404 U.S. Army Corps of Engineers permitting, Duke Energy proposed to survey the area around the proposed Fisher Knob Access Road for the federally threatened small whorled pogonia (*Isotria medeoloides*) during the appropriate survey window (mid-May through early July).[1]

The SCDNR Natural Heritage Trust Program, which documents and tracks element of occurrence data for rare, threatened, and endangered species (both federal and state) indicates no record of the small whorled pogonia within a 2-mile of radius of the Project (SCNHP 2023), however, this species is listed on the U.S. Fish and Wildlife Survey (USFWS) Information for Planning and Consultation (IPaC) database as having the potential to occur in the project vicinity, therefore surveys are proposed to determine the presence or absence of this protected species prior to land disturbance activities associated with the access road and overall construction of the Bad Creek II Power Complex. This will aid in the quality and comprehensiveness of the statewide dataset for rare, threatened, and endangered species. Additionally, field biologists will record incidental observations of priority plant species identified in the SC Wildlife Action Plan (SWAP) during the survey.

[1] A Natural Resources Survey was carried out by Duke Energy in 2021 and indicated that suitable habitat for the small whorled pogonia was present at the site, however, the study was performed outside of the survey window. The Natural Resources Survey was filed with the Pre-Application Document in February, 2023.

This document provides an overview of the approach to the proposed small whorled pogonia surveys.

Small Whorled Pogonia

Species Description

The small whorled pogonia is a perennial orchid that produces a smooth, hollow stem from 2 to 14 inches tall and topped by five to six leaves in circular arrangement (false whorl). One or two flowers stand in the center of the whorl of leaves. The leaves are milky-green or grayish-green, and the flower is yellowish-green with a greenish-white lip (USFWS 2024). Flowers appear soon after the plants emerge in mid-May or June. This species is non-clonal, and plants may emerge each spring or they may remain vegetatively dormant and below the ground for one to several years. Each plant produces only one, rarely more than one, overwintering bud per year (USFWS 2022).

Habitat

The small whorled pogonia occurs in young as well as maturing (second to third successional growth) mixed-deciduous or mixed-deciduous/coniferous forests. 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 that create long-persisting breaks in the forest canopy. It prefers acidic soils with a thick layer of dead leaved and sparse to moderate ground cover (USFWS 2024).

Proposed Survey Methods

Surveys will be conducted during the USFWS recommended optimal survey window of mid-May – early July. Potential habitat will be surveyed along a 50-foot-wide buffer of the proposed Fisher Knob Access Road and within the proposed limits of disturbance and spoil area alternatives, as well as along proposed transmission line access roads related to the Bad Creek II Power Complex proposed infrastructure (Figure 1).

Survey areas can be visually delineated by local topography (ravines, slopes, benches) or by landmarks (boulders, downed or otherwise conspicuous trees, or old roads) (USFWS 2016). The survey methodology will consist of slowly traversing back and forth across transects; surveyors will be spaced approximately 25-feet apart focusing the immediate area within a 10-to-15-foot radius depending on habitat type and visibility. Handheld Global Positioning System (GPS) units will be used to navigate throughout the site to avoid survey gaps.

Small whorled pogonia plants favor certain micro-habitats such as:

- Vernal or ephemeral runoff courses (leaf piles)
- Terraces or benches and base-of-slope areas
- Small canopy openings, fern patches

If one or more small whorled pogonia plants are identified during the survey, the surveyor will do the following:

- Delineate a polygon of the location and demarcate the boundaries using brightly colored flagging. A GPS unit will be used to collect boundary coordinates.
- Photo-document the plants sufficiently to confirm the identification of the species.
- Describe the size of each population (e.g., in square feet).
- Record a detailed written description and photo-document of specific and surrounding habitat.
- Contact USFWS and SCDNR representatives within 48 hours of species sightings.

Vegetation cover type and specific habitats /substrates will be noted by surveyor. No voucher specimens will be collected, and any plant locations will be considered to be “Privileged Non-Public Information”. Additionally, field biologists will record incidental observations of priority plant species identified in the South Carolina SWAP; a list of priority plants included in the SWAP that may occur in Blue Ridge Ecoregion is provided in Table 1.

Results and Conclusions

Results and conclusions of the field surveys will be provided in a summary report during the third quarter of 2024.

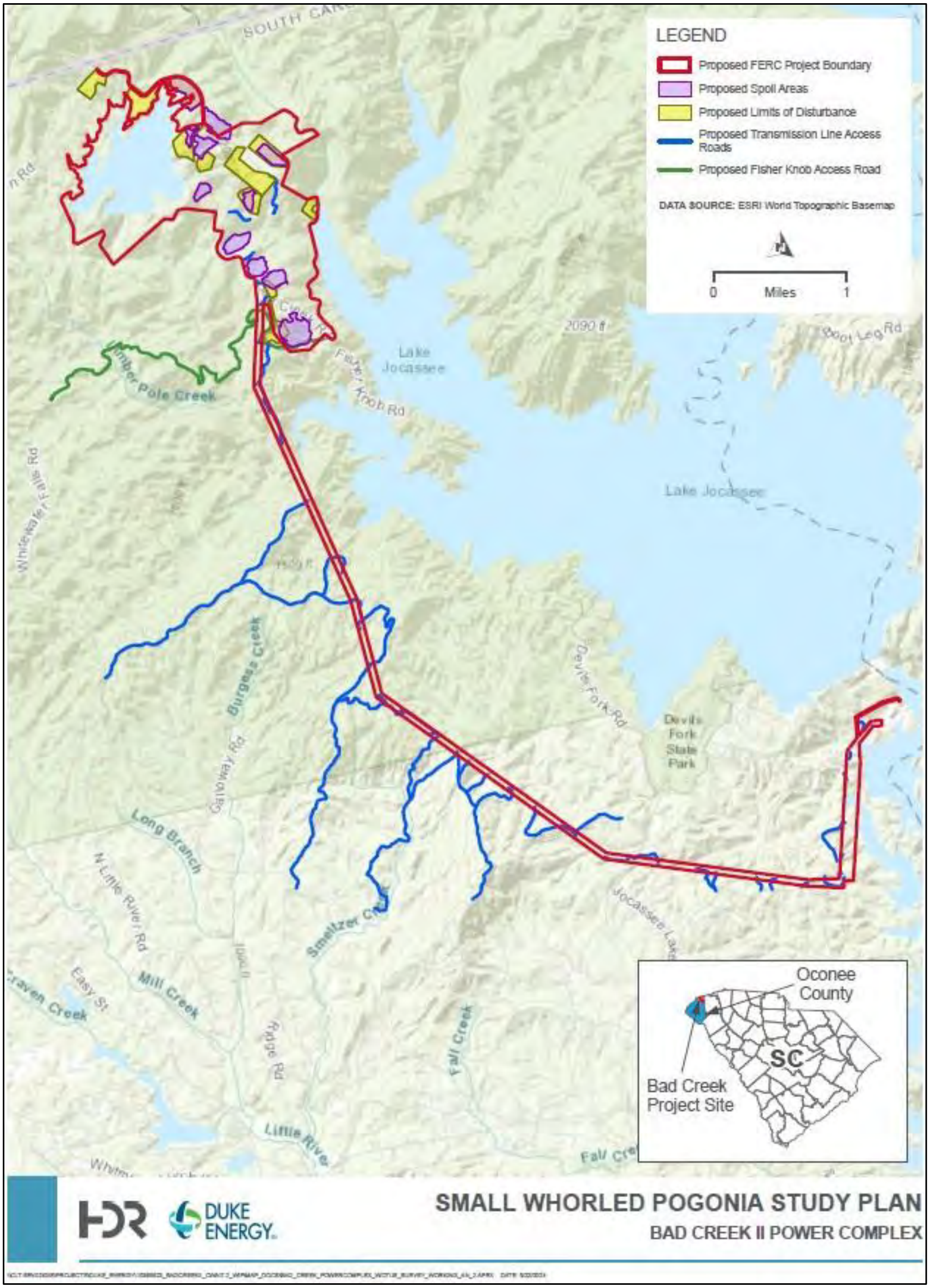

Figure 1. Bad Creek Site Vicinity and Proposed Area of Small Whorled Pogonia Surveys

Table 1. List of South Carolina State Wildlife Action Plan Priority Plant that May Occur in Blue Ridge Ecoregion

Scientific Name	Common Name	Legal Status	Priority	Habitat
Agrimonia pubescens	Soft Groovebur		Moderate	Low Elevation Basic and Acidic Mesic Forests
Arnoglossum muehlenbergii	Great Indian Plantain		Moderate	Low Elevation Basic and Acidic Mesic Forests; Bottomlands and Riparian Zones
Asplenium monanthes	Single-sorus Spleenwort		Moderate	Wet/Moist Unique Landforms
Asplenium pinnatifidum	Lobed Spleenwort		Moderate	Rock Outcrops
Asplenium resiliens	Black-stem Spleenwort		Moderate	Wet/Moist Unique Landforms
Betula alleghaniensis	Yellow Birch		Moderate	Bottomlands and Riparian Zones
Bryocrumia vivicolor	Bryocrumia Moss		High	Bottomlands and Riparian Zones
Cardamine flagellifera	Blue-Ridge Bittercress		High	Bottomlands and Riparian Zones
Carex appalachica	Appalachian Sedge		Moderate	Appalachian Oak Forest; High Elevation Forest; Rock Outcrops; Wet/Moist Unique Landforms
Carex biltmoreana	Biltmore Sedge		High	Rock Outcrops; Wet/Moist Unique Landforms
Carex communis var. amplisquama	Fort Mountain Sedge		High	Low Elevation Basic Mesic Forest
Carex decomposita	Cypress-knee Sedge		High	Depressions; Wet/Moist Unique Landforms
Carex folliculata	Long Sedge		Moderate	High Elevation Forest; Wet/Moist Unique Landforms
Carex manhartii	Manhart Sedge		Moderate	Bottomlands and Riparian Zones
Carex pedunculata	Longstalk Sedge		Moderate	Low Elevation Basic Mesic Forest
Carex radfordii	Radford's Sedge		High	Appalachian Oak Forest; Low Elevation Basic Mesic Forest
Carex woodii	Pretty Sedge		Moderate	Bottomlands and Riparian Zones
Cheilolejeunea evansii	Evan's Cheilolejeunea		High	Bottomlands and Riparian Zones; Wet/Moist Unique Landforms
Chrysosplenium americanum	American Golden-saxifrage		Moderate	Low Elevation Acidic Mesic Forest; Wet/Moist Unique Landforms
Cladrastis kentukea	Yellowwood		Moderate	Low Elevation Basic Mesic Forest
Collinsonia verticillata	Whorled Horse-balm		Moderate	Low Elevation Basic Mesic Forest; Low Elevation Acidic Mesic Forest
Comptonia peregrina	Sweet Fern		Moderate	Grasslands/Early-Successional

Scientific Name	Common Name	Legal Status	Priority	Habitat
Convallaria majuscula	American Lily-of-the-valley		Moderate	High Elevation Forest
Coreopsis latifolia	Broad-leaved Tickseed		High	Low Elevation Basic Mesic Forest
Cornus racemosa	Stiff Dogwood		Moderate	Bottomlands and Riparian Zones
Cystopteris bulbifera	Bulblet Fern		Moderate	Rock Outcrops
Danthonia epilis	Bog Oat-grass		Moderate	Rock Outcrops; Wet/Moist Unique Landforms
Deschampsia flexuosa	Crinkled Hairgrass		Moderate	Rock Outcrops
Dicentra eximia	Wild Bleeding-heart		Moderate	Low Elevation Basic Mesic Forest
Diplazium pycnocarpon	Glade Fern		Moderate	Low Elevation Basic Mesic Forest
Dryopteris goldiana	Goldie's Woodfern		Moderate	Low Elevation Basic Mesic Forest; Rock Outcrops
Echinacea laevigata	Smooth Coneflower	LE: Endangered	Highest	Grasslands/Early-Successional
Eurybia avita	Alexander's Rock Aster		High	Rock Outcrops
Fothergilla major	Mountain Witch-alder		High	Low Elevation Basic Mesic Forest
Gaylussacia baccata	Black Huckleberry		Moderate	Appalachian Oak Forest; Low Elevation Acidic Mesic Forest
Gymnoderma lineare	Rocky Gnome Lichen	LE: Endangered	Highest	Rock Outcrops
Helenium brevifolium	Shortleaf Sneezeweed		Moderate	Bottomlands and Riparian Zones
Helianthus glaucophyllus	White-leaved Sunflower		Moderate	Low Elevation Basic Mesic Forest
Helonias bullata	Swamp-pink	LT: Threatened	Highest	Wet/Moist Unique Landforms
Hydrangea cinerea	Ashy-hydrangea		Moderate	Low Elevation Basic Mesic Forest
Hydrocotyle americana	American Water-pennywort		Moderate	Bottomlands and Riparian Zones; Depressions
Hymenophyllum tayloriae	Taylor's Fern		High	Wet/Moist Unique Landforms
Hymenophyllum tunbrigense	Tunbridge Fern		Moderate	Wet/Moist Unique Landforms
Hypericum buckleii	Blue Ridge St. John's-wort		High	Rock Outcrops
Impatiens pallida	Pale Jewel-weed		Moderate	Bottomlands and Riparian Zones; Depressions
Isoetes caroliniana	Engelmann's Quillwort		Moderate	Depressions
Isotria medeoloides	Small Whorled Pogonia	LT: Threatened	Highest	Wet/Moist Unique Landforms
Juncus subcaudatus	Woods-rush		Moderate	Depressions

Scientific Name	Common Name	Legal Status	Priority	Habitat
Juniperus communis var. depressa	Dwarf Juniper		Moderate	High Elevation Forest
Krigia montana	False Dandelion		High	Rock Outcrops
Lejeunea blomquistii	"A Liverwort"		High	Rock Outcrops
Leptohymenium sharpii	Sharp's Leptohymenium Moss		High	Wet/Moist Unique Landforms
Liatris microcephala	Small-head Gayfeather		Moderate	Rock Outcrops
Liparis liliifolia	Large Twayblade		Moderate	Low Elevation Basic Mesic and Acidic Forests
Listera smallii	Kidney-leaf Twayblade		Moderate	Low Elevation Acidic Mesic Forest
Lophocolea appalachiana	Appalachian Lophocolea		High	Wet/Moist Unique Landforms
Lycopodium clavatum	Running Pine		Moderate	Appalachian Oak Forest; High Elevation Forest
Lycopodium porophilum	Rock Clubmoss		Moderate	Rock Outcrops
Lycopodium tristachyum	Deep-root Clubmoss		Moderate	High Elevation Forest
Lysimachia fraseri	Fraser Loosestrife		High	Bottomlands and Riparian Zones
Lysimachia hybrida	Lance-leaf Loosestrife		Moderate	Depressions
Magnolia cordata	Piedmont Cucumber Tree		Moderate	Low Elevation Basic Mesic Forest
Mitella diphylla	Two-leaf Bishop's-cap		Moderate	Low Elevation Basic Mesic Forest
Monotropsis odorata	Sweet Pinesap		High	Appalachian Oak Forest; High Elevation Forest
Oenothera perennis	Small Sundrops		Moderate	Depressions
Panax quinquefolius	American Ginseng		High	Low Elevation Basic Mesic Forest
Parnassia grandifolia	Large-leaved Grass-of-parnassus		High	Wet/Moist Unique Landforms
Pellaea atropurpurea	Purple-stem Cliff-brake		Moderate	Rock Outcrops
Pellaea wrightiana	Cliff-brake Fern		Moderate	Rock Outcrops
Pellia appalachiana	Appalachian Pellia		Moderate	Bottomlands and Riparian Zones; Wet/Moist Unique Landforms
Phacelia bipinnatifida	Fernleaf Phacelia		Moderate	Low Elevation Basic Mesic Forest; Bottomlands and Riparian Zones
Plagiochila caduciloba	Gorge Leafy Liverwort		High	Wet/Moist Unique Landforms
Plagiochila sharpii	"A Liverwort"		High	Wet/Moist Unique Landforms
Plagiochila sullivantii	"A Liverwort"		High	Wet/Moist Unique Landforms

Scientific Name	Common Name	Legal Status	Priority	Habitat
Plagiomnium carolinianum	Mountain Wavy-leaf Moss		High	Wet/Moist Unique Landforms
Platanthera integrilabia	White Fringeless Orchid	C: Candidate	Highest	Bottomlands and Riparian Zones; Depressions
Platyhypnidium pringlei	Pringle's Platyhypnidium Moss		High	Wet/Moist Unique Landforms
Poa alsodes	Blue-grass		Moderate	Low Elevation Basic Mesic Forest
Porella japonica ssp. appalachiana	"A Liverwort"		Moderate	Bottomlands and Riparian Zones
Pycnanthemum montanum	Single-haired Mountain-mint		Moderate	Appalachian Oak Forest; High Elevation Forest; Low Elevation Basic Mesic Forest
Rhododendron catawbiense	Catawba Rhododendron		Moderate	High Elevation Forest
Rudbeckia heliopsidis	Sun-facing Coneflower		High	Low Elevation Acidic Mesic Forest
Sarracenia rubra ssp. jonesii	Mountain Sweet Pitcher-plant	LE: Endangered	Highest	Rock Outcrops; Wet/Moist Unique Landforms
Saxifraga careyana	Carey Saxifrage		High	High Elevation Forest; Low Elevation Basic Mesic Forest; Rock Outcrops
Senecio millefolium	Piedmont Ragwort		High	Rock Outcrops
Shortia galacifolia	Oconee bells		High	High Elevation Forest; Low Elevation Basic Mesic Forest; Rock Outcrops; Wet/Moist Unique Landforms
Silene ovata	Ovate Catchfly		High	Appalachian Oak Forest; High Elevation Forest; Low Elevation Basic Mesic Forest
Solidago simulans	Granite Dome Goldenrod		High	High Elevation Forest; Low Elevation Basic Mesic Forest; Rock Outcrops
Stachys clingmanii	Clingman's Hedge-nettle		High	Appalachian Oak Forest; High Elevation Forest
Thermopsis mollis	Soft-haired Thermopsis		Moderate	Low Elevation Acidic Mesic Forest
Tradescantia virginiana	Virginia Spiderwort		Moderate	High Elevation Forest; Low Elevation Basic Mesic Forest
Trichomanes boschianum	Bristle-fern		Moderate	Low Elevation Basic Mesic Forest; Rock Outcrops; Depressions
Trichophorum cespitosum	Deer-haired Bulrush		Moderate	High Elevation Forest
Trillium grandiflorum	Large-flower Trillium		Moderate	High Elevation Forest; Depressions

Scientific Name	Common Name	Legal Status	Priority	Habitat
Trillium rugelii	Southern Nodding Trillium		High	Low Elevation Basic Mesic Forest; Depressions
Trillium simile	Sweet White Trillium		High	Low Elevation Basic Mesic Forest; Depressions
Triphora trianthophora	Nodding Pogonia		Moderate	Depressions
Viola conspersa	American Bog Violet		Moderate	Low Elevation Basic Mesic Forest
Xyris torta	Twisted Yellow-eyed-grass		Moderate	Wet/Moist Unique Landforms

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