# Appendix B – Aquatic Resources Study Report

Bad Creek Pumped Storage Project

*Oconee County, South Carolina*

January 2025

# 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 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. Duke Energy completed its first year of studies in 2023 with stakeholder consultation as required by the Commission's SPD. Duke Energy filed the Initial Study Report (ISR) on January 4, 2023, and per the Commission's regulations at 18 CFR §5.15(c), Duke Energy held an ISR meeting with participants and FERC staff within 15 days of filing the ISR on Wednesday, January 17, 2024. Duke Energy completed its second and final year of studies in 2024; this Updated Study Report [18 CFR §5.15(c)] describes the Licensee's methods and results of the studies conducted in support of preparing an application for a new license for the existing Project and construction of the proposed Bad Creek II Power Complex (Bad Creek II).

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

# 2 Aquatic Resources Study

## 2.1 FERC Environmental Resource Issues

The Commission issued Scoping Document 2 on August 5, 2022, which identified the following environmental resource issues to be analyzed in the National Environmental Policy Act (NEPA) document for the Project relicensing related to aquatic resources. These resource issues address the effects of continued Project operations as well as potential construction and operation of Bad Creek II during the new license term:

- Effects of construction-related erosion, sedimentation, and spoils disposal on water quality, aquatic habitat, and aquatic biota in Lake Jocassee and streams in the Project vicinity.
- Effects of Project operation on water levels in Lake Jocassee.
- Effects of Project operation on water quality in Lake Jocassee, including water temperature, dissolved oxygen (DO) concentrations, and vertical mixing of DO.
- Effects of reservoir fluctuations associated with Project operation on aquatic habitat and biota in Lake Jocassee.
- Effects of vertical mixing of DO associated with Project operation on fish populations in Lake Jocassee.
- Effects of Project operation on aquatic habitat and biota in Howard Creek.
- Effects of Project-induced impingement, entrainment, and turbine mortality on fish populations in Lake Jocassee.
- Effects of Project recreation on aquatic resources.
- Effects of construction-related erosion, sedimentation, and spoils disposal in the Bad Creek reservoir on Lake Jocassee.

The Aquatic Resources Study evaluated impacts associated with construction and operation of Bad Creek II on water quality and water resources related to aquatic life and habitat, while the Water Resources Study (Appendix A) focused on historical water quality data of Lake Jocassee, potential impacts to surface waters due to construction of Bad Creek II, and water resources affected by a second inlet/outlet structure in the Whitewater River cove of Lake Jocassee. The Aquatic Resources Study is complete, and this report presents methods and results of individual study tasks.

## 2.2 Study Goals and Objectives

Tasks carried out for the Bad Creek Aquatic Resources Study employed standard methodologies consistent with the scope and level of effort described in the RSP. The goal of the Aquatic Resources study was to evaluate potential impacts to fish and aquatic life populations, communities, and habitats, due to the construction and operation of the proposed facility. The main objectives of this study are as follows:

- To evaluate the potential for increased fish entrainment due to the addition of Bad Creek II and consult with agencies and other Project stakeholders regarding results of the 2021 desktop Entrainment Study.
- To assess changes to pelagic and littoral aquatic habitat in Lake Jocassee resulting from the expanded underwater weir and additional discharge, using models developed for the Water Resources Study and Keowee-Toxaway Hydroelectric Project relicensing.
- To evaluate potential direct impacts to aquatic habitat (including wetlands) related to Bad Creek II construction activities and weir expansion by quantifying and characterizing surface waters including resource quality. Presence/absence mussel surveys of streams located in upland areas where spoil deposition may occur were also conducted.

Objectives of the Aquatic Resources Study were met through the three study tasks listed in Table 1 below.

# 3 Report Layout

All tasks for the Aquatic Resources Study are complete and study task reports have been developed in consultation with the Aquatic Resources Resource Committee; study task reports are final and attached to this report as shown in Table 1.[2] Documentation of consultation with the Resource Committee is presented in Attachment 4.

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[2] The Task 1 report is unchanged from the final deliverable filed with the ISR; however, additional modeling was carried out due to unit technology modifications resulting in increased hydraulic capacities at Bad Creek II, therefore, the report is being filed again with an addendum presenting these recent results (Addendum 1) as well as additional documentation of species literature search (Addendum 2).

### Table 1. Aquatic Resources Study Attachments

| Study Report Title | Attachment | Attachment Title |
|---|---|---|
| Appendix B – Aquatic Resources Study Report | 1 | Desktop Entrainment Analysis Final Report |
| | 2 | Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat Final Report |
| | 3 | Impacts to Surface Waters and Associated Aquatic Fauna Final Report |
| | 4 | Consultation Documentation |

# Attachment 1

## Desktop Entrainment Analysis Final Report

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# DESKTOP ENTRAINMENT ANALYSES

BAD CREEK PUMPED STORAGE PROJECT
(FERC NO. P-2740)

Prepared for:
**Duke Energy**

Prepared by:
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December 2021
*Revised November 2023*

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# 1.0 INTRODUCTION

The Bad Creek Pumped Storage Project (FERC No. 2740) (Bad Creek Project) (Figure 1.1) is a 1,400 megawatt[1] (MW) pumped-storage hydroelectric facility that has served the Duke Energy Carolinas' (Duke Energy) customer base for nearly 30 years. Duke Energy is currently conducting the Federal Energy Regulatory Commission (FERC) relicensing process to obtain a new federal operating license for the Bad Creek Project. This process involves the consideration of environmental, social, and developmental resources of the Bad Creek Project and the applicable surrounding area. To that end, the fisheries resources of Lake Jocassee, the Bad Creek Project's lower reservoir for pumped-storage operations, and the potential impacts of Bad Creek Project operations on these resources, are being analyzed during the relicensing process in consultation with state and federal resource agencies and other interested parties.

The Bad Creek Project's configuration and projected use of the waterways for power generation is also a subject of consideration during relicensing; specifically, when weighing the benefits of power and non-power resources. Recent developments in the regional power grid provide a strategic rationale for considering Bad Creek Project capacity increases. This was reviewed most recently when the original license for the Bad Creek Project was amended in 2018 to accommodate turbine upgrades. The resulting improved pump-turbine, motor-generator design will increase the Bad Creek Project's life expectancy and provide a cost-effective option for adding an additional 290 MW of generating capacity and 240 MW of pumping capacity to the Project at the historical average available gross head. Once complete, Bad Creek Project upgrades provide for an environmentally sound method for adding capacity to support intermittent renewable resources, such as regional sources of solar energy generation, as the upgrades only affect the rate at which water flows through the Bad Creek Project units. The upgrades will not affect the quantity of water pumped or discharged or impoundment levels or the ultimate magnitude of fluctuations of the upper and lower reservoirs.

Duke Energy is additionally considering the construction of a new powerhouse (Bad Creek II) equal in size and capacity to augment the existing powerhouse through the relicensing process. The storage capacity of the upper reservoir would not change. Thus, pumping capacity would increase from 3019 cubic feet per second (cfs) to 6038 cfs, meaning

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[1] Upgraded capacity per 164 FERC ¶ 62,066.

pumping time would be reduced by half of existing to more efficiently support intermittent renewable energy sources and stability of the regional power grid.

The issue of fish entrainment at a hydroelectric facility is a subject typically analyzed during a FERC relicensing process. Fish entrainment at the existing Bad Creek Project has been a subject of extensive studies throughout the Bad Creek Project's history. Therefore, a significant baseline of entrainment information is currently available for review. This report was developed in support of the relicensing and proposed project expansion (i.e., the addition of a second powerhouse, identical in size and capacity to the existing powerhouse and adjacent to the existing powerhouse). More specifically, this report considers the potential for the entrainment of Lake Jocassee fishes through the Project under the proposed action (i.e., two powerhouses).

## 1.1 Background

Fish entrained through hydroelectric facilities like the Bad Creek Project (Figure 1.1) are exposed to turbine passage mortality stressors. While mortality and entrainment rates are well-documented separately, the cumulative effects on aquatic populations are not. Researchers often lack the necessary parameters to accurately model the fate of all impacted species (natural mortality, recruitment, etc.), yet they are routinely required to assess the cumulative population-level effects of those species impacted. Another approach to assess cumulative system-wide effects to the suite of species impacted by hydroelectric development is needed.

Risk analysis offers a potential solution to this need. An entrainment risk assessment (ERA) identifies and analyzes potential future entrainment mortality events while assessing the resiliency of the population (i.e., its ability to tolerate the expected level of mortality). Applying a risk assessment framework to evaluate impacts to fisheries is not new. Patrick et al. (2009) developed the expanded productivity and susceptibility assessment (ePSA) to understand data-poor fish stocks. The ePSA assesses the risk of a fish stock becoming overfished as a function of its productivity (replenish rate) and susceptibility to the fishery. The ePSA incorporates demographic parameters like the maximum age and size of a fish, individual growth rates, natural mortality, fecundity, breeding strategy, recruitment pattern, and age at maturity. The ePSA has been used to assess fishing risks for other species including elasmobranchs (Cortés et al. 2010; Furlong-Estrada, Galván-Magaña, and Tovar-Ávila 2017) and grouper (Pontón-Cevallos et al. 2020). The ePSA is one of a broad class of applications that assess anthropogenic sources of risk on fishery populations.

The ERA method is not new to assessing entrainment risk at hydropower projects. In 2021, van Treeck et al. developed the European Fish Hazard Index to assess entrainment risk at hydropower projects. This tool considered plant design and operation, the sensitivity and mortality of species due to entrainment, and overarching conservation goals for the river. It assessed entrainment mortality with empirically derived functions for Kaplan and Francis turbines. The United States has seen development of ERA methods as well. In 2012, Cada and Schweizer developed the qualitative traits-based assessment to evaluate the entrainment risk of data-poor species.

The rate at which fish are entrained through hydroelectric facilities is also a well-studied phenomenon. Entrainment rates for this assessment have been developed from observed entrainment via hydroacoustic monitoring at the Bad Creek Project intake. Entrainment rates are typically expressed in fish per million cubic feet of water (fish/Mft$^3$). Because the number of hours the Bad Creek Project is expected to run each day and the total volume of water pumped in Mft$^3$ is known, the number of fish expected to be entrained can be estimated. The analysis employed to assess entrainment risk at the Bad Creek Project is therefore quantitative.

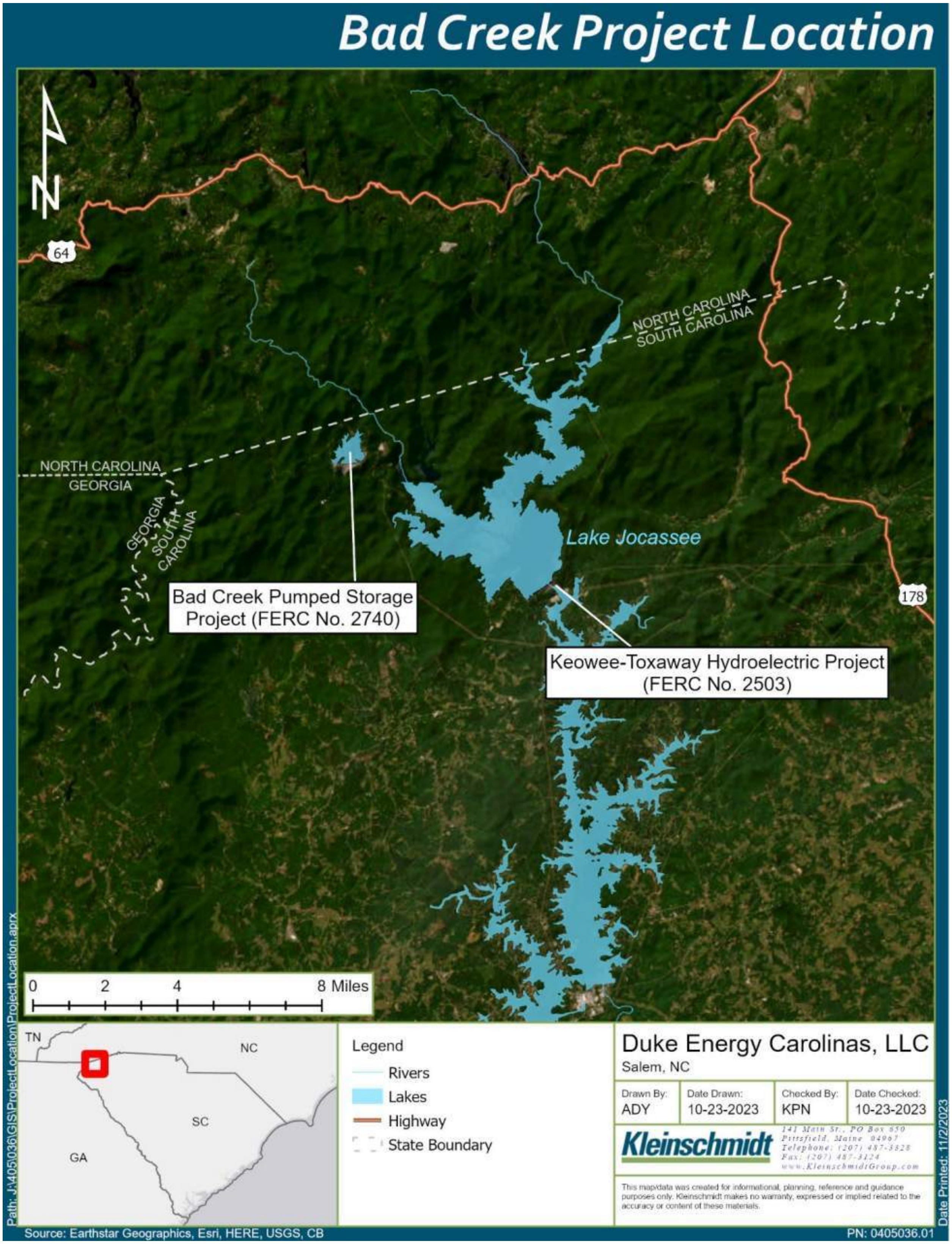

**Figure 1.1 Bad Creek Project Location Map**

# 2.0 METHODS

An ERA consists of two major components: (1) a Monte-Carlo simulation model that estimates the number of fish entrained and the number of expected mortalities; and (2) an objective method of ranking the relative vulnerability of those species subjected to entrainment. The methods section will start with a selection of target species, followed by an exploratory data analysis, the description of the simulation, and finally the assignment of risk.

## 2.1 Exploratory Analysis

Duke Energy provided Kleinschmidt Associates (Kleinschmidt) with numerous datasets describing Lake Jocassee forebay operating levels, water quality, entrainment, and current Bad Creek Project operations. The first dataset (Dataset A) titled "1990.1994 Jocassee Hydro plant log" included date, time, corresponding forebay elevations, and hourly rain totals. A second dataset (Dataset B) titled "historical" was created from individual daily hydroacoustic monitoring files, which included date, time and corresponding entrainment observations for each bay from 1991 to 1993. Duke Energy provided four datasets comprised of water quality data from 1973 to 2020, which included date, time, elevation, and depth of sample as well as the pH, dissolved oxygen, water temperature, and conductivity. After organizing the dataset, data were then queried to create a single temperature dataset (Dataset C). Forebay elevation and temperature data were assessed to determine the effects of Bad Creek Project operations on entrainment. Hourly operations data (Dataset D) representing operations that respond to the solar market were also provided by Duke Energy[2].

Forebay elevation and water temperature data were complete in that they comprised the entire time-period of the original impact study from 1991–1994. However, the timestamps were not standardized across datasets. Once these datasets were normalized, temperature and Lake Jocassee forebay elevation observations were imputed using piece-wise linear interpolation. This effectively filled the gaps within the entrainment dataset so that there was a temperature and forebay elevation observation for every entrainment observation. Temperature values were collected once per month, while Lake Jocassee forebay elevation data were collected three times per day. A clustering algorithm called a Gaussian Mixture Model was used to separate elevation observations into low and high

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[2] The Project is primarily operated to respond to the variable reliability of regional solar resources.

operation classes for every entrainment observation. This allowed classification of each entrainment observation as having occurred during low or high operating levels. Lake Jocassee full pond elevation is 100 ft, local datum (1,110 ftmsl), for this analysis, elevation levels below, or equal to, 89 ft local datum (1,099 ftmsl) are defined as “low” and elevation levels above 89 ft local datum (1,099 ftmsl) are defined as “high.”

The final set of data analyzed were unit operations. This consisted of first identifying pumping or generating operations in the data. A value of 1 was used if a unit was pumping and a value of 0 was used if it was generating. This logic was applied to all units and then summed for the total number of 15-minute intervals per day. That number was then divided by four to get total hours pumping per day. The operating hours were then analyzed by month and season, as well as weekday versus weekend, to determine any irregularities or trends.

## 2.2 Selection of Target Species

The species assemblage for this analysis was determined from prior empirical entrainment studies conducted at the Bad Creek Project. From 1991-1993, full discharge netting was employed at the Bad Creek Project, where the relative abundance of entrained species were calculated (Table 2.1).

**Table 2.1 Monthly Sum of Entrainment at Bad Creek Project from 1991 to 1993**

| Species | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Black Crappie | | | | 18 | 73 | 1 | | | | | | 4 |
| Blackbanded Darter | | | | | 134 | 9 | | 5 | | | | |
| Blueback Herring | 2086 | 2093 | 1267 | 2885 | 1753 | 5837 | 5955 | 1854 | 7836 | 7736 | 9170 | 5466 |
| Bluegill | 8 | | 30 | 116 | 2537 | 796 | 6626 | 1388 | 3941 | 2399 | 68 | 80 |
| Brown Trout | 5 | | | 56 | 149 | 41 | | | | | | 14 |
| Channel Catfish | | | 1 | | 60 | 9 | | 5 | | | | |
| Common Carp | | | | | 277 | 54 | | | 11 | | | |
| Flat Bullhead | | | | | 55 | | | 98 | | | | |
| Golden Shiner | | | 2 | 18 | 153 | 9 | | 2 | | | | |
| Green Sunfish | | | | | | | | 3 | 111 | 181 | | |
| Hybrid Sunfish | | | | | | | | | 37 | | | |
| Largemouth Bass | | | | | 37 | 17 | 97 | 5 | 97 | 410 | | |
| Quillback | | | | | 18 | | | | | | | |
| Rainbow Trout | 27 | | | | | 6 | | | | | | |
| Redbreast Sunfish | | | | 18 | 220 | 15 | 1392 | 547 | 611 | 480 | 1 | 16 |
| Redear Sunfish | | | | | 18 | | | | | | | |
| Redeye Bass | | | | | | | 14 | 2 | 48 | 62 | | |
| Spottail Shiner | | | | | 18 | | | | | | | |
| Striped Jumprock | | | | | | | | | | | | 14 |
| Threadfin Shad | 3033 | 4072 | 5290 | 8656 | 2302 | 1588 | 3485 | 425 | 24365 | 41867 | 71009 | 134314 |
| Warmouth | | | | 124 | 311 | 63 | 419 | 4 | 49 | 113 | | |
| White Bass | | | | | 2 | 16 | | | 113 | | 1 | |
| White Catfish | 3 | | 6 | 207 | 2961 | 196 | 2723 | 1765 | 1679 | 1339 | 68 | 2 |
| Whitefin Shiner | | | | | 20 | | | | 49 | | | |
| Yellow Perch | 140 | 64 | 54 | 177 | 385 | | | 55 | 75 | | 1 | 7 |
| Yellowfin Shiner | | | | | 18 | | | | | | | |

### 2.3 Entrainment Mortality Event Simulation

Entrainment mortality events were simulated with the open-source software package Stryke[3]. Stryke is an individual based model (IBM), which follows the fate of a population of fish as they migrate past a hydroelectric project. Movement and survival are simulated with Monte Carlo methods. The software is written in Python 3.7.x and utilizes Networkx[4] to simulate routes of passage and Numpy[5] and Scipy[6] for pseudo-random probability distribution draws.

The assessment at the Bad Creek Project was less complex than most entrainment analyses because there are only three states within the model: lower reservoir, Bad Creek Project powerhouses, and upper reservoir. It was also assumed that all fish simulated are routed through the Bad Creek Project powerhouses and that there is 100% mortality.

#### 2.3.1 Seasonal Entrainment Rate

An investigation of the 1997 Electric Power Research Institute (EPRI) entrainment database (EPRI 1997) indicated that the overall pattern of entrainment rates (fish/Mft$^3$) for different species across the eastern United States were similar. Similarly, this pattern was observed at the Bad Creek Project as noted during the initial hydroacoustic monitoring entrainment survey (1991-1993). Across species, regions, and watersheds of all sizes, a small proportion of entrainment events comprised most of the overall impact, while the majority of the events constituted only a limited number of individuals. What leads to these large entertainment events is of no concern for the model because it only needs to be able to simulate their relative magnitude and frequency of occurrence.

Historic hourly entrainment data were analyzed, collected from 1991- 1993 at the Bad Creek Project intake during normal operations. The original dataset provided fish per hour measurements by unit that were enumerated with hydroacoustic monitoring. Assuming a constant flow rate of 3,690 cfs, the number of fish and total cubic feet pumped was summed for every day and then converted into an entrainment rate of fish/Mft$^3$. Also of note, there were days when the Bad Creek Project operated but no fish were entrained. The probability of entraining fish on a given day was described with a binomial distribution, thus simulating an entrainment event occurs in two steps: 1) draw from

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[3] https://github.com/knebiolo/stryke

[4] https://networkx.github.io/

[5] https://numpy.org/

[6] https://scipy.org/

binomial distribution to simulate presence, and 2) draw from a distribution of entrainment rates.

### 2.3.2 Scenario Development

Kleinschmidt developed scenarios that describe entrainment across seasons and forebay operating levels. Seasonal entrainment rates fish/Mft$^3$ (Table 2.2) were described with Log Normal distributions. Bad Creek Project, under the proposed action of adding an additional twin powerhouse, is intended to pump up to 6 hours per day on weekdays and 2 hours per day on weekends. Duke Energy provided operations data from 2014 to 2018 in 15-minute increments that would also be reflective of the new pumping operations. It was assumed that if a unit was pumping, it was pumping at max capacity for the entire 15-minute period. Therefore, the number of hours operated per day is the number of 15-minute intervals with pumping operations divided by 4.

Lake Jocassee full pond elevation is 100 feet local datum (1,110 ftmsl), for this analysis, elevation levels below, or equal to, 89 feet, local datum (1,099 ftmsl) are defined as “low” and elevation levels above 89 feet, local datum (1,099 ftmsl) are defined as “high.” In accordance with the current 10-Year Work Plan, if Lake Jocassee pool elevation falls below 1,099 ft msl, Duke Energy will implement operational changes at the Bad Creek Project based on hydro unit availability and other operational considerations to minimize fish entrainment (FERC 2017). These protocols include turning lights off near the inlet/outlet structure so as not to attract fish to the area and implementing a unit startup and shutdown sequence that minimizes fish entrainment. It was assumed that when forebay elevations are below 89 feet local datum (1,099 feet ftmsl), per the Memorandum of Understanding (MOU[7]), that units (U) were operated in the order of U4, U2, U3, U1 and that operations were dependent. In other words, the number of hours unit 2 is run is conditional on the number of hours U4 is run. The number of hours operated per day was described with a log normal distribution (Table 2.3). It is assumed that Bad Creek II (new powerhouse) is identical to Bad Creek Project’s existing powerhouse and the overall order of unit prioritization between the two powerhouses is: BC2-U4, BC2-U2, BC2-U3, BC2-U1, BC1-U4, BC1-U2, BC1-U3, BC1-U1 at elevation below 89 feet local datum (1,099ftsml). At

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[7] developed in collaboration w/ Duke Energy and SCDNR to establish framework to help maintain high-quality fisheries of lakes Jocassee and Keowee" in 1996. The MOU and first 10-Year Work Plan were approved pursuant to Article 32(b)(1) of the license for the Bad Creek Project on May 1, 1997.

elevations above 89 feet (1,099 ftmsl), operations of units are independent of one another and respond to market demand, with preference to operate Bad Creek II powerhouse first.

Stryke simulated a hydrograph, which was the station capacity (3,690 cfs * 8 units = 29,520 cfs) for 365 days. For every day, Stryke first simulates operations with a draw from a binomial distribution. If Bad Creek is operating, then the number of hours per unit for each unit was simulated with a draw from a log normal distribution that was conditional on the unit that came before it. Then, it simulates whether an entrainment event occurs with a sample from a binomial distribution. If fish are present, Stryke simulates a daily entrainment event (fish/Mft$^3$), and then expands that to a daily entrainment estimate (fish) by multiplying the entrainment rate by the total volume of water pumped (Mft$^3$) that day. After iterating through each scenario and species combination, Stryke then summarizes results.

**Table 2.2 Seasonal Entrainment Event Scenarios**

| Season | Operating Level | Probability of Occurrence | Log Normal Shape Parameters | | |
|---|---|---|---|---|---|
| | | | Shape | Location | Scale |
| Winter | High | 0.602 | 1.967 | 0.018 | 0.419 |
| Spring | High | 0.552 | 1.561 | 0.007 | 0.225 |
| Summer | High | 0.627 | 1.722 | 0.011 | 0.168 |
| Fall | High | 0.597 | 0.671 | 0.012 | 0.852 |
| Fall[8] | Low | 0.966 | 18.477 | 5.19 | 15.88 |

**Table 2.3 Bad Creek 1 Seasonal Unit Operations**

| Unit | Season | Probability Not Operating | Log Normal Shape Parameters | | | Months |
|---|---|---|---|---|---|---|
| | | | shape | location | scale | |
| U1 | Winter High | 0.175 | 0.226 | -9.037 | 15.014 | 12,1,2 |
| | Spring High | 0.247 | 0.011 | -249.468 | 255.914 | 3,4,5 |
| | Summer High | 0.045 | 0.004 | -610.193 | 618.06 | 6,7,8 |
| | Fall High | 0.240 | 0.097 | -20.237 | 27.214 | 9,10,11 |
| | Fall Low | 0.240 | 0.097 | -20.237 | 27.214 | 9,10,11 |

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[8] The period of low elevation for this analysis only occurred in the Fall, as depicted in Table 2.3.

| Unit | Season | Probability Not Operating | Log Normal Shape Parameters | | | Months |
|---|---|---|---|---|---|---|
| | | | shape | location | scale | |
| U2 | Winter High | 0.248 | 0.354 | -3.728 | 9.652 | 12,1,2 |
| | Spring High | 0.368 | 0.031 | -74.131 | 80.674 | 3,4,5 |
| | Summer High | 0.059 | 0.006 | -347.383 | 355.431 | 6,7,8 |
| | Fall High | 0.217 | 0.442 | -1.769 | 8.998 | 9,10,11 |
| | Fall Low | 0.217 | 0.442 | -1.769 | 8.998 | 9,10,11 |
| U3 | Winter High | 0.307 | 0.126 | -17.456 | 23.149 | 12,1,2 |
| | Spring High | 0.449 | 0.010 | -238.518 | 244.828 | 3,4,5 |
| | Summer High | 0.092 | 0.003 | -751.043 | 758.749 | 6,7,8 |
| | Fall High | 0.146 | 0.039 | -56.370 | 62.818 | 9,10,11 |
| | Fall Low | 0.146 | 0.039 | -56.370 | 62.818 | 9,10,11 |
| U4 | Winter High | 0.350 | 0.209 | -9.370 | 15.605 | 12,1,2 |
| | Spring High | 0.438 | 0.052 | -44.005 | 51.045 | 3,4,5 |
| | Summer High | 0.089 | 0.004 | -469.695 | 477.749 | 6,7,8 |
| | Fall High | 0.209 | 0.066 | -31.032 | 37.785 | 9,10,11 |
| | Fall Low | 0.209 | 0.066 | -31.032 | 37.785 | 9,10,11 |

Note: It is assumed Bad Creek is operated the same under ‘Normal’ and ‘Low’ forebay elevation scenarios.

## 2.4 Vulnerability to Entrainment

The second component of an ERA is to objectively assess the vulnerability of those species subjected to entrainment. Large impacts to highly vulnerable species carry the most risk to population impacts. As such, an assessment of species vulnerability characteristics becomes an important component of this analysis. Cada and Schweizer (2012) developed a traits-based assessment (TBA) to estimate fish population sustainability for data poor fish populations. This qualitative assessment extended experimental results from tested fish species to predict passage survival of other untested species based on phylogenic relationships or ecological similarities. The concepts of the Cada and Schweizer (2012) TBA and the Patrick et al. (2009) ePSA were used as a framework for assessing vulnerability. However, a straightforward quantitative approach was used for assessing fish population sustainability. Specifically, fish population growth rates were used for each species to evaluate a population’s ability to make up for turbine passage losses with compensatory mechanisms. If these compensatory mechanisms are not enough to overcome losses, the fish population sustainability is vulnerable to entrainment stressors.

The sustainability of fish populations is influenced by several demographic traits. These traits include natural life span, natural mortality rates, generation time or interval between reproductive events, the number of reproductive events per year, and the number of offspring per reproductive event (Cada and Schweizer 2012). Species that have a low natural mortality rate, short generation time, and produce a large number of eggs are less likely to experience population level effects. Patrick et. al. (2009) also incorporated the individual growth rate (von Bertanlaffy) and trophic level in their assessment of vulnerability. These traits all impact how quickly a population will increase in number when it is depleted, meaning when the population is not nearing the carrying capacity in the local environment.

Both the ePSA and TBA methods used a set of traits and combined them into a qualitative categorization of vulnerability. However, quantitative estimates of the combined impact of these population traits are available in the literature for many species in the form of population growth rates or doubling rates for depleted populations. By using these estimates directly, subjective selection of traits to include and subjective methodology for weighting the importance of each individual trait can be avoided. Rather, the traits have been incorporated into well-established population modeling techniques and the overall estimate has been objectively and quantitatively derived.

Population growth for a harvested (or in this case, potentially entrained) population of fish can be described on annual increments using the Schaeffer Model:

$$N_{t+1} = N_t + r\left(1 - \frac{N_t}{K}\right)N_t - E_t,$$

where

$N_t$ = population size in year t;
K = carrying capacity of population;
$E_t$ = entrainment losses in year t; and
r = discrete population growth rate

If it is assumed the population is depleted relative to the carrying capacity, then this equation simplifies to:

$$N_{t+1} \approx N_t(1 + r) - E_t.$$

If entrainment loss as the fraction of the population lost (PL; $E_t$ = PL x $N_{t,}$) is reparametrized, then:

$N_{t+1} \approx N_t(1 + r - PL).$

Thus, if the entrainment loss rate (PL) is greater than the discrete population growth rate (r), the local population may decline over time.

The discrete population growth rate (r) for each species of concern was derived from information on FishBase (Froese and Pauly 2021), from model-derived resilience factors for the exact or in some cases, a surrogate species. In the FishBase "Estimates based on models" section, the following was used:

1) "K", which is presumed to be the intrinsic population growth rate for depleted populations. The intrinsic growth rate (K) is related to the discrete growth rate as follows:

   $$\exp(K) = (1 + r).$$

   K is not reported for all species; when not reported for a species of concern, surrogates were identified that were primarily based upon taxonomic linkages (Table 2.3).

2) "Population doubling time", which is reported as a categorical range for all species (i.e., three presumed ranges for low resilient, moderate resilient, and high resilient species)[9]. The population doubling time (D) is related to the discrete population growth rate as follows:

   $$(1 + r) = \exp\left(\frac{\ln(2)}{D}\right).$$

Both of these estimates are reported for (1+r) and the most conservative result from each range of values, the lower discrete population growth rate, was used as an estimate for species vulnerability.

## 2.5 Assigning Risk

With quantitative measures estimating the number of fish entrained and the expected number of mortalities, and a quantitative index expressing the relative vulnerability of those species impacted, it is possible to objectively assign risk categories and identify the species most at risk.

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[9] FishBase defines resilience as "the capacity of a system to tolerate impacts without irreversible changes in its outputs or structure. In species or populations, often understood as the capacity to withstand exploitation." (Froese and Pauly 2021). FishBase reports resiliency as very low, low medium, or high. Resiliency ranges for species analyzed within this report were sourced directly from FishBase.

In order to estimate the annual proportion of the population in Lake Jocassee lost to entrainment (PL), an estimate of the local population size of each species (i.e., the denominator of PL) is needed. An annual baseline population estimate of pelagic forage fish (i.e., Blueback Herring, Threadfin Shad) was sourced from pelagic hydroacoustic monitoring surveys conducted by Duke Energy from 1989 to 2020 (A. Stuart, personal communication, October 2021). With 30 years of observations, any evidence of long-term trends was assessed that may indicate Bad Creek Project having an effect on the population. From 2013 to 2015, Duke Energy also conducted complimentary purse seine sampling to characterize the pelagic population of fish and quantify the proportion of the pelagic population comprised of Blueback Herring *vs* Threadfin Shad.

The combined annual population size estimates are skewed with more variance apparent for higher estimates. On the log-scale, there appears to be an approximate 20-year population cycle within Lake Jocassee (Figure 2.1). The median population estimate over the past 20 years (2001-2020) was estimated to capture an expected population size for a random future year. Estimated PL for each species was the annual estimated entrainment mortality divided by this population size estimate.

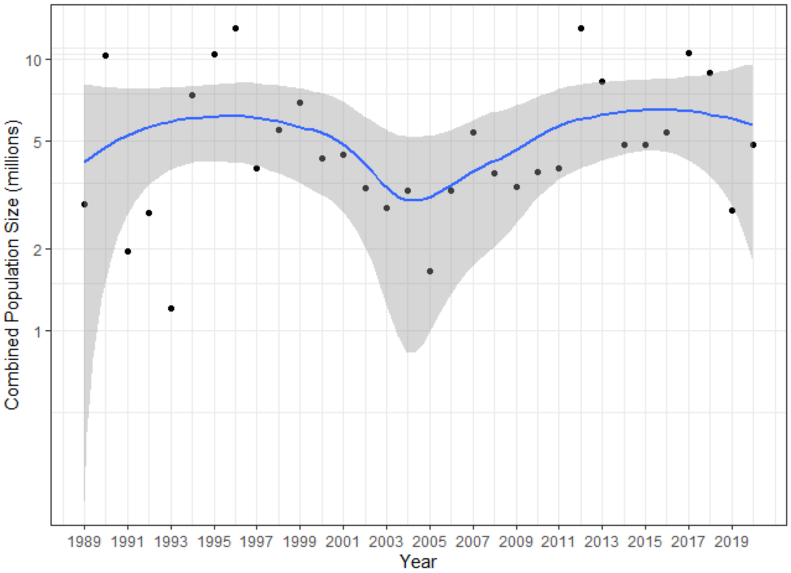

**Figure 2.1 Estimated Local Population Size (Combined Species) 1989-2020, with Local Regression Smoother Trend Estimate Overlaid**

A tabular form of (1+r-PL) is reported for each facility and flow scenario. Values of (1+r-PL) of exactly one would indicate steady population, greater than 1 indicates population growth, and less than 1 would indicate the population is being impacted by entrainment.

# 3.0 RESULTS AND DISCUSSION

## 3.1 Exploratory Data Analysis

### 3.1.1 Analysis of Lake Jocassee Elevation

Elevations remained relatively consistent with an average level of 97.6 feet in 1991, 98.4 feet in 1992, and 92.4 feet in 1993 (Table 3.1). The average forebay elevation across all years was 96.3 feet, with a median of 98.0 feet. The forebay elevation did not exceed 100.0 feet and did not fall below 81.4 feet. The standard deviation of the entire dataset was 4.46, higher than the standard deviation of data from 1991 (0.988) and 1992 (0.771) suggesting 1993 was influential.

**Table 3.1 Statistical summary of Lake Jocassee forebay elevation data from 1990-1993(measured in feet local datum)**

| Time | Minimum | Max | Mean | Standard Deviation | Median |
|---|---|---|---|---|---|
| 1991-1993 | 81.40 | 99.80 | 96.32 | 4.46 | 97.95 |
| 1991 | 92.10 | 99.20 | 97.60 | 0.98 | 97.80 |
| 1992 | 95.00 | 99.80 | 98.51 | 0.77 | 98.60 |
| 1993 | 81.40 | 99.80 | 92.40 | 6.43 | 95.30 |

Histograms confirm the heavy skew of the data with two potential forebay elevation operating modes. Figure 3.1 represents the elevation data from 1991-1993, which was heavily skewed towards the higher elevations with a small cluster at the lower elevations. The cluster of low elevations occurred in 1993. Similar to Figure 3.1, the 1991 elevation data (Figure 3.2) also displays an uneven distribution. A multimodal distribution is evident with cluster of elevations around the 88.6-89.6 values and another cluster in the 97.6-98.6 values. Figure 3.3 contains forebay observations from 1992, and Figure 3.4 from 1993. In 1993, more so than any other year, there was a large proportion of lower elevation observations, suggesting two operational modes (low and high elevation).

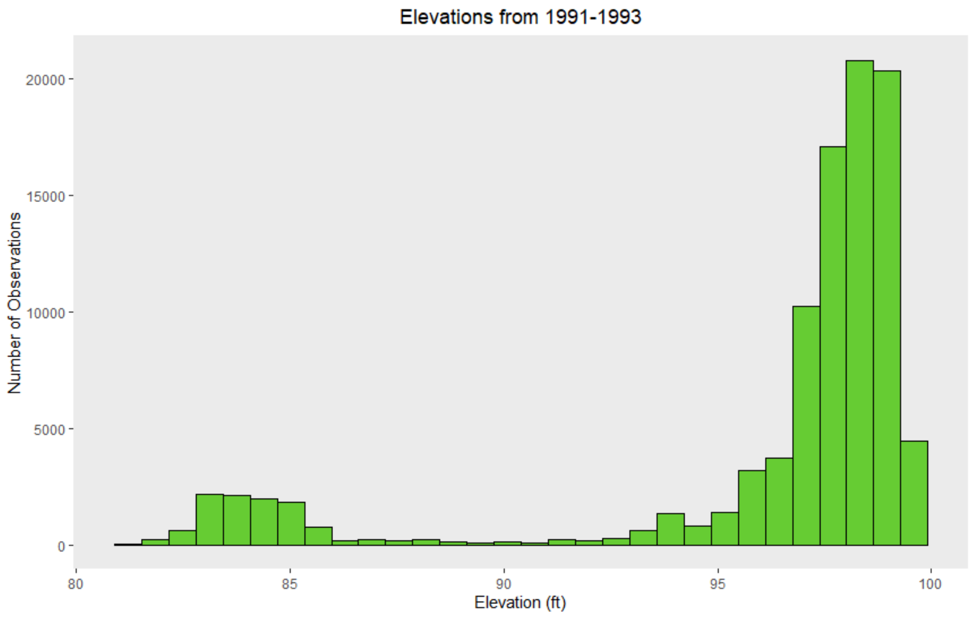

**Figure 3.1** Jocassee Forebay local datum elevation observations from 1991-1993

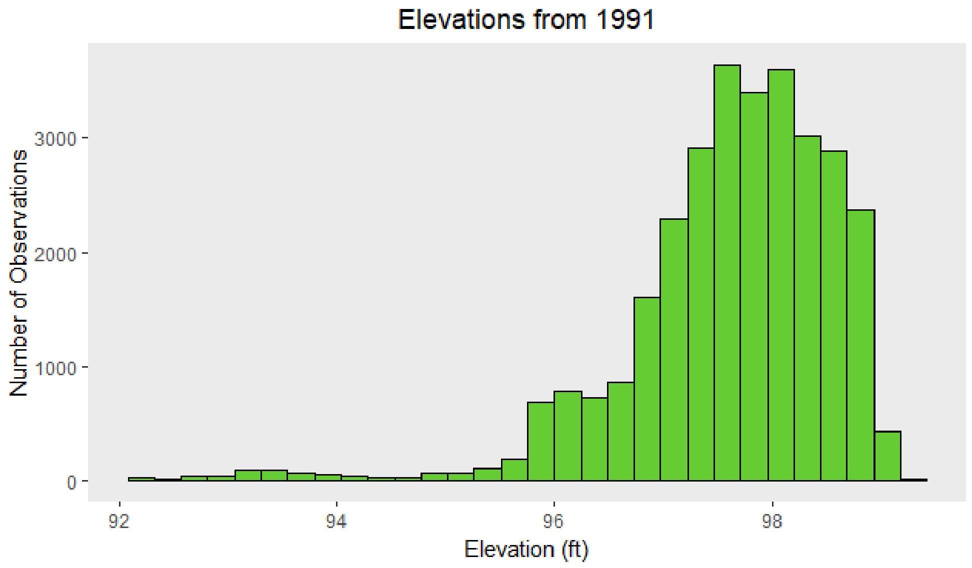

**Figure 3.2** Jocassee Forebay local datum elevation observations in 1991

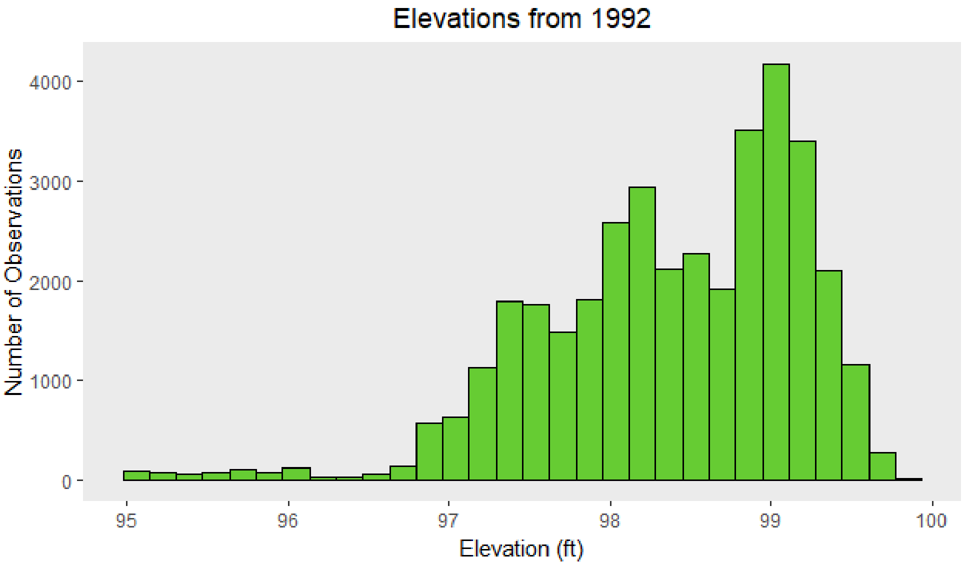

**Figure 3.3 Jocassee Forebay local datum elevation observations in 1992**

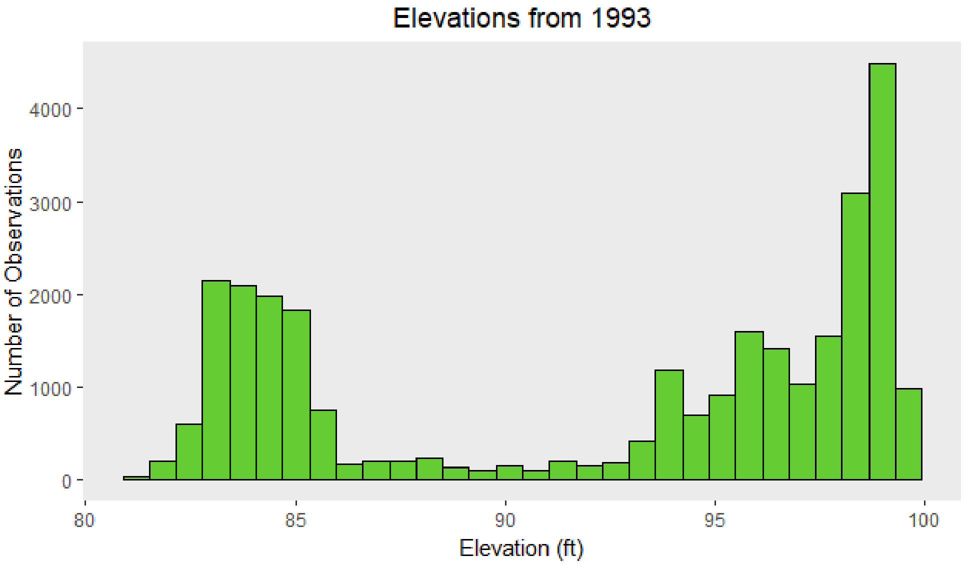

**Figure 3.4 Jocassee Forebay local datum elevation observations in 1993**

### 3.1.2 Analysis of Entrainment Rates

For the entrainment rate analysis, Kleinschmidt computed daily entrainment rates, and then separated the dataset into two categories: entrainment at elevations greater than 89 feet (1,099.0 ft msl) and entrainment at elevations less than or equal to 89 feet (1,099.0 ftmsl). The histogram (Figure 3.6) of the daily max entrainment at elevations below 89 feet (1,099.0 ftmsl) shows a heavy skew to the left, although most observations are greater than 0, indicating a higher entrainment rate than shown in Figure 3.5. This is supported by the statistical summary in Table 3.3, where we see a large difference between the median of 7.5 and the mean of 18.4.

Figure 3.7 contains a histogram of daily entrainment rates at elevations greater than 89.0 feet. Like the trend in Figure 3.5, these data are also heavily skewed to the left, except most observations were 0 fish/Mft$^3$, indicating less entrainment at higher elevations. The median value of 0.7 and mean of 3 (Table 3.3) are closer together than the other elevation group. The standard deviation of entrainment rates at elevations less than or equal to 89 feet was high at 34.6 (Table 3.3) as compared to the standard deviation of 5.73 at elevations greater than 89 feet indicating there were more observations closer together at the lower elevations.

**Table 3.2 Statistical summary of daily entrainment data (fish/Mft$^3$) by year**

| Time | Minimum | Maximum | Average | Standard Deviation | Median |
|---|---|---|---|---|---|
| 1991-1993 | 0.02 | 250.30 | 5.39 | 15.34 | 1.10 |
| 1991 | 0.05 | 44.20 | 7.91 | 6.44 | 8.06 |
| 1992 | 0.04 | 13.20 | 0.90 | 1.46 | 0.45 |
| 1993 | 0.02 | 250.30 | 7.97 | 25.00 | 0.92 |

**Table 3.3 Statistical summary of entrainment rate by forebay elevation operation mode.**

| Operation Mode | Minimum | Maximum | Average | Standard Deviation | Median |
|---|---|---|---|---|---|
| >89 ft | 0 | 44.17 | 3.10 | 5.73 | 0.72 |
| ≤ 89 ft | 0 | 250.27 | 18.41 | 34.59 | 7.54 |

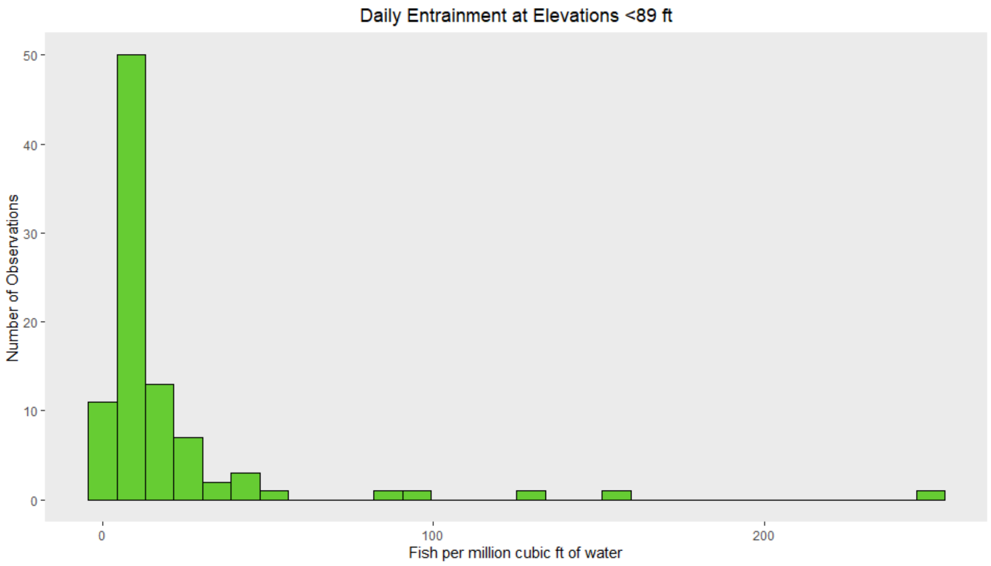

**Figure 3.5 Daily entrainment at elevations less than 89 ft**

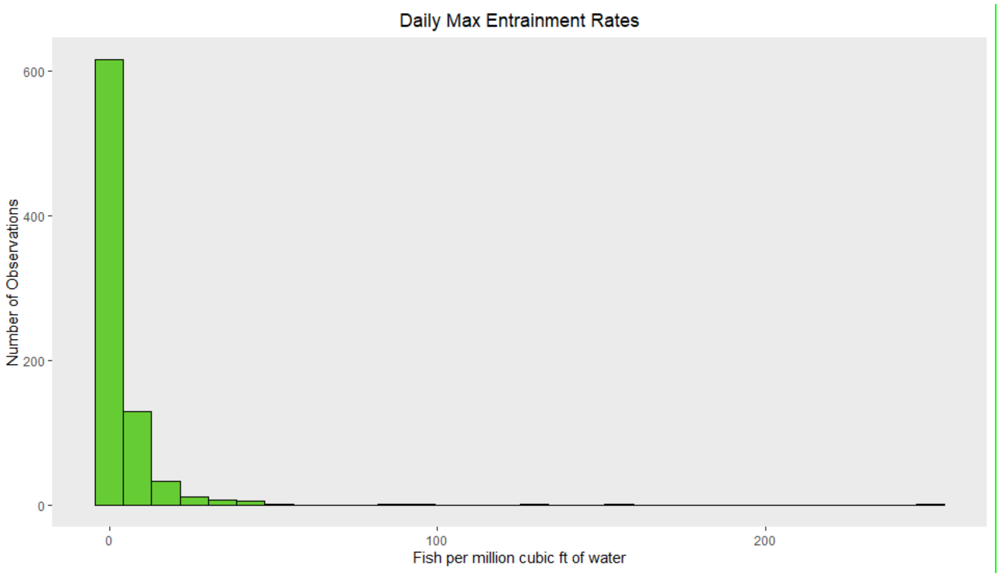

**Figure 3.6 Daily Entrainment Rates from 1991-1993**

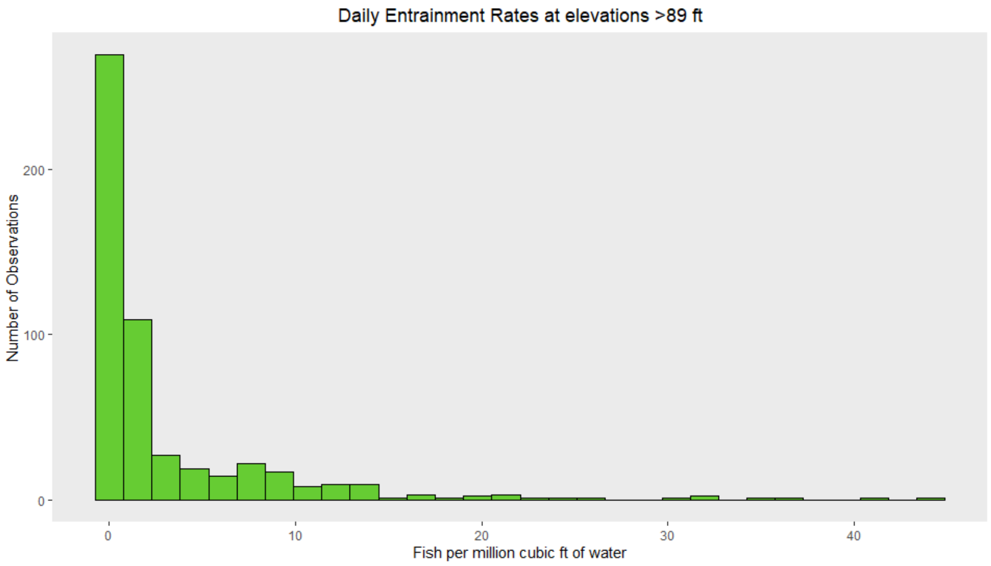

**Figure 3.7 Daily entrainment at elevations greater than 89 ft**

### 3.1.3 Analysis of Temperature Data

For the temperature analysis, the number of values was much lower than the other data sets. However, as seen in Table 3.4, the mean and median temperatures in degrees Celsius (C) were close, meaning there were few outliers, and the distribution of data is symmetrical. Further, temperature did not vary much within a day, meaning imputing temperature values for every entrainment observation proved highly accurate. The highest mean temperature was 24.7 degrees C, with the lowest being 9.1 degrees C. Typical seasonal variation is shown in Figure 3.8 where the highest temperatures are in the summer and lowest in the winter.

**Table 3.4 Statistical summary of temperature data (C)**

| Time | Minimum | Maximum | Mean | Standard Deviation | Median |
|---|---|---|---|---|---|
| 1991-1993 | 9.14 | 24.70 | 16.47 | 5.30 | 16.29 |
| 1991 | 9.14 | 24.70 | 16.80 | 5.53 | 16.64 |
| 1992 | 10.21 | 24.03 | 16.54 | 5.17 | 16.29 |
| 1993 | 9.15 | 24.67 | 16.06 | 5.62 | 15.32 |

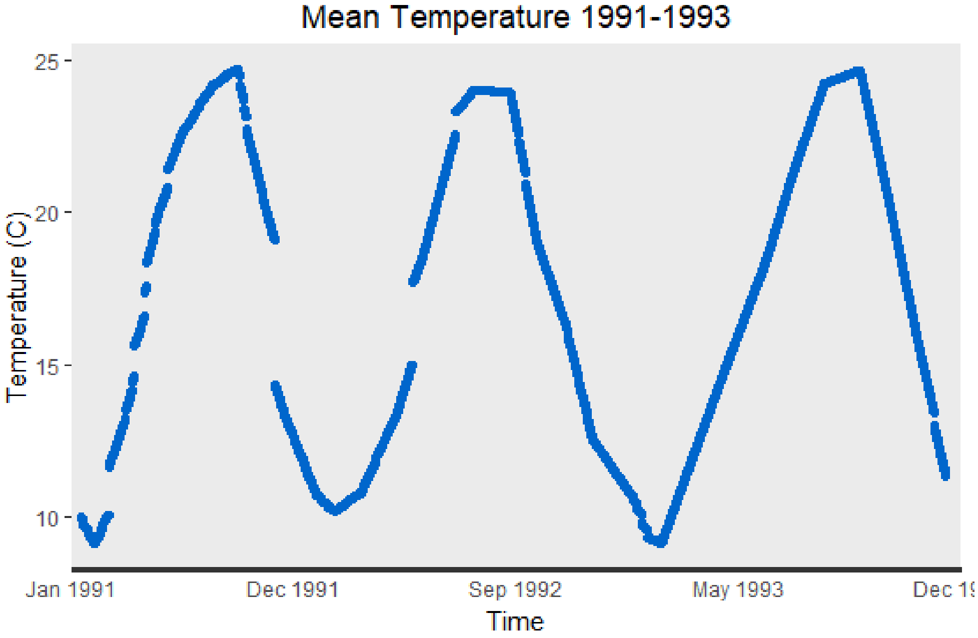

**Figure 3.8 Lake Jocassee Mean daily temperature (C) from 1991-1993**

### 3.1.4 Analysis of Hours Operated Per Unit

Duke Energy provided Bad Creek operations data that reflect the anticipated operations based on the solar market (2014 – 2018). It is assumed that Bad Creek I will continue to operate in this manner, and that operations between units are conditional. Bad Creek I operates on a 'first-on last-off' procedure, where U4 is first, followed by U2, then U3, and finally U1. When Bad Creek II is operational, it will be operated in the same manner as Bad Creek I, but Bad Creek II will run first to optimize use of variable speed pumps. It is assumed that BC2 U4 = BC1 U4, etc. A summary of statistics of hours operated by unit is included in Table 3.5.

**Table 3.5 Bad Creek Unit 1 Hours Operated Summary Statistics (2014– 2018)**

| Season | Minimum | Maximum | Mean | Standard Deviation | Median |
|---|---|---|---|---|---|
| Winter | 0 | 19.00 | 5.34 | 4.09 | 5.25 |
| Spring | 0 | 16.80 | 4.41 | 3.89 | 5.25 |
| Summer | 0 | 13.00 | 7.65 | 2.95 | 8.25 |
| Fall | 0 | 17.80 | 5.13 | 4.12 | 5.75 |

**Table 3.6 Bad Creek Unit 2 Hours Operated Summary Statistics (2014– 2018)**

| Season | Minimum | Maximum | Mean | Standard Deviation | Median |
|---|---|---|---|---|---|
| Winter | 0 | 17.50 | 4.58 | 3.67 | 5.00 |
| Spring | 0 | 16.80 | 3.91 | 3.87 | 5.00 |
| Summer | 0 | 13.00 | 7.65 | 2.99 | 8.25 |
| Fall | 0 | 18.00 | 4.91 | 3.65 | 5.75 |

**Table 3.7 Bad Creek Unit 3 Hours Operated Summary Statistics (2014– 2018)**

| Season | Minimum | Maximum | Mean | Standard Deviation | Median |
|---|---|---|---|---|---|
| Winter | 0 | 16.80 | 4.41 | 3.68 | 4.75 |
| Spring | 0 | 14.20 | 3.79 | 3.67 | 4.50 |
| Summer | 0 | 12.50 | 7.39 | 2.75 | 8.00 |
| Fall | 0 | 16.50 | 5.85 | 3.16 | 6.25 |

**Table 3.8 Bad Creek Unit 4 Hours Operated Summary Statistics (2014– 2018)**

| Season | Minimum | Maximum | Mean | Standard Deviation | Median |
|---|---|---|---|---|---|
| Winter | 0 | 24.00 | 4.83 | 4.20 | 5.00 |
| Spring | 0 | 16.50 | 3.89 | 4.30 | 0.75 |
| Summer | 0 | 13.00 | 7.86 | 2.83 | 8.25 |
| Fall | 0 | 17.20 | 6.18 | 3.23 | 6.25 |

To simulate hours pumping per day, each unit’s observations were fit to a log normal distribution. It was assumed that Bad Creek was operating under the MOU scenario and that the hours a unit operates is conditional on the order of operations. Thus, if U4 is preferred, the number of hours U2 is operated is conditional on the number of hours U4 is operated. The simulation first draws from a log normal distribution fit to U4 hours. Then, U2 hours are filtered to less than or equal to the number of hours U4 is operated. The remaining U2 data are fit to a log normal distribution, and another draw simulates hours operated for U2. This process is repeated for U3 and U1, with the current unit always dependent upon the previous unit’s operation. This type of simulation preserves the first-on last-off operations of preferred units. If the Jocassee Forebay elevation is above 1099 ft MSL, the units could be operated in any order.

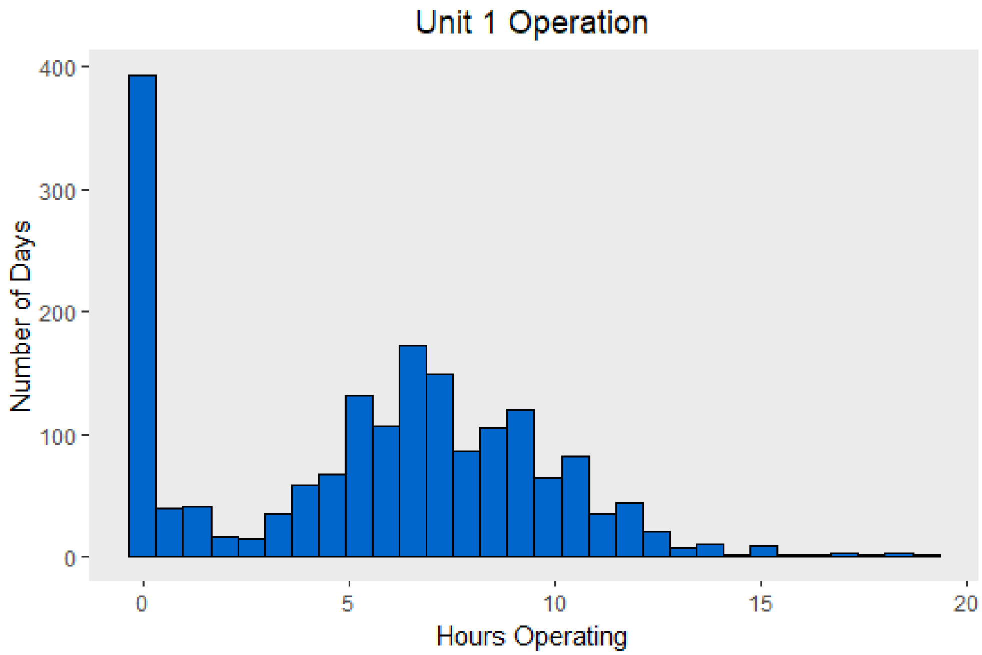

**Figure 3.9 Unit 1 Operation**

Note: the frequency of days with no operations (0 hours) was included in the histogram, but removed when fitting a log normal distribution. There are a considerable number of days (~ 400) where Unit 1 did not run from 2014 – 2018.

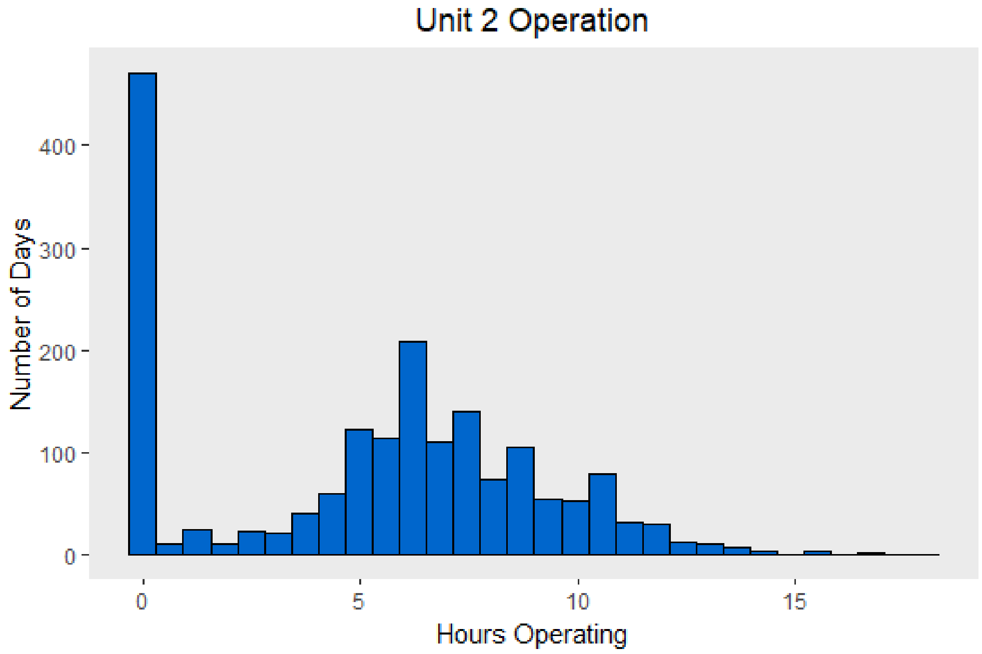

**Figure 3.10 Unit 2 Operation**

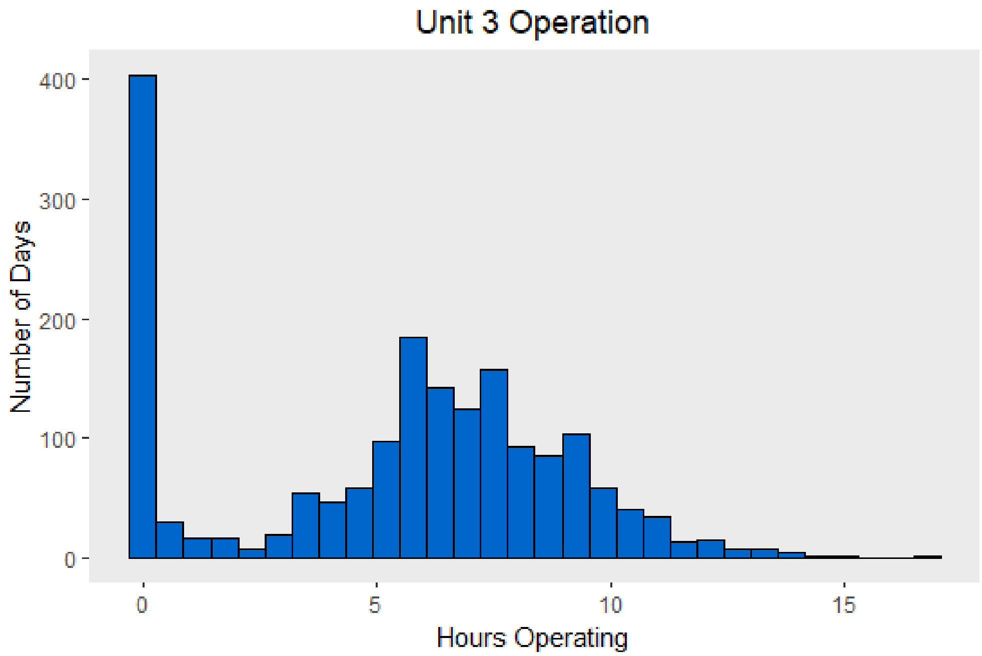

Figure 3.11 Unit 3 Operation

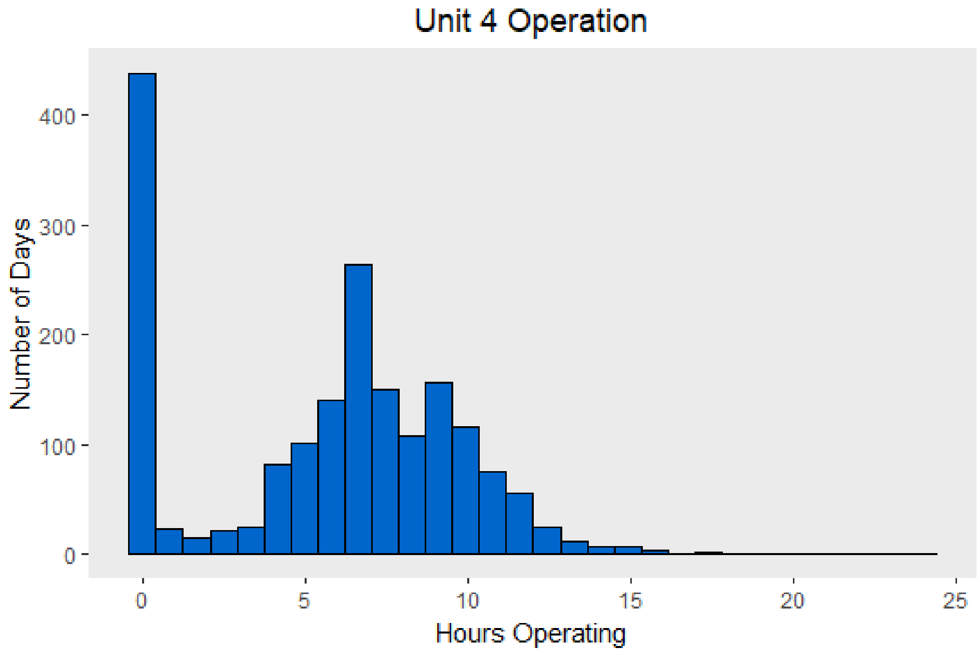

Figure 3.12 Unit 4 Operation

### 3.1.5 Entrainment as a Function of Elevation

Figure 3.13 shows the instantaneous forebay elevation and entrainment rate from 1991-1993. As shown, elevations remained relatively consistent with a mean elevation of 97.6 feet in 1991, 98.5 feet in 1992 and 92.4 feet in 1993. An increase in entrainment is expected as the forebay elevation drops. Overall, the data are highly skewed, with a large gap between the average daily max entrainment and the median values.

In 1991 (Figure 3.14) there was more variation in elevation, and a maximum instantaneous entrainment rate of 20.1 fish/Mft$^3$. Entrainment was high for the first half of the year until July. In 1992, there was no apparent trend with elevation (Figure 3.15). The data from Figure 3.16 show the lowest entrainment values, lowest yearly maximum entrainment rate of 418 fish/Mft$^3$ of water, and the lowest average entrainment at 1.57 fish/Mft$^3$. These values could be attributed to rain because 1992 was the wettest year out of this data set with a yearly total of 28.6 inches of precipitation with an average forebay elevation of 98.5 feet (1108.5 ft msl). The highest daily maximum entrainment at 978 fish/Mft$^3$ occurred in 1993 (Figure 3.16). When comparing elevation to temperature there was no clear trend as the same seasonal temperature pattern was observed regardless of elevation (Figure 3.17).

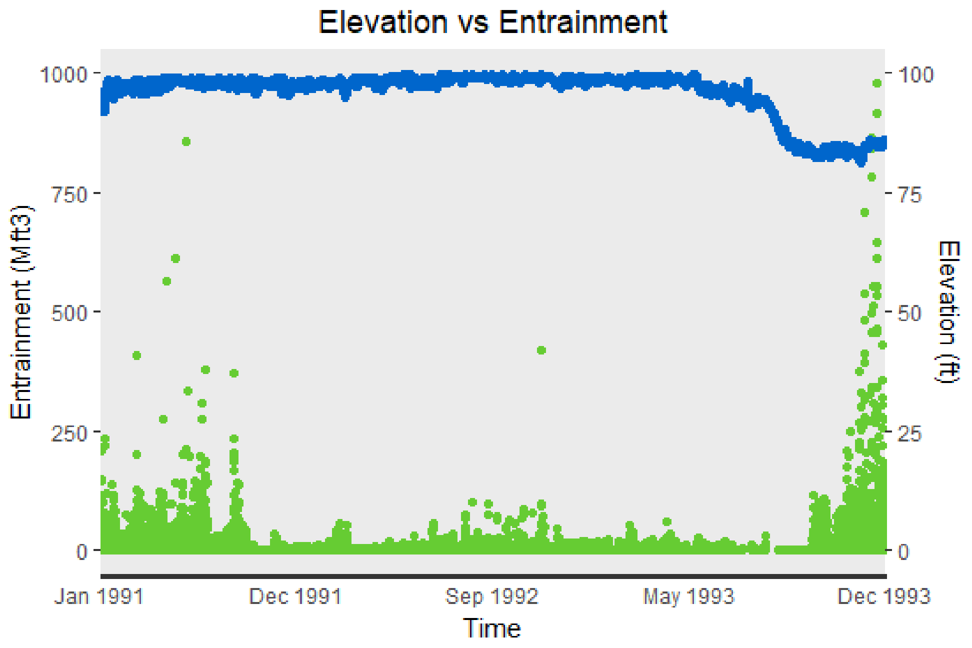

**Figure 3.13** Instantaneous elevation and entrainments rate from 1991-1993, green represents the entrainment observations and blue represents the forebay elevation observations.

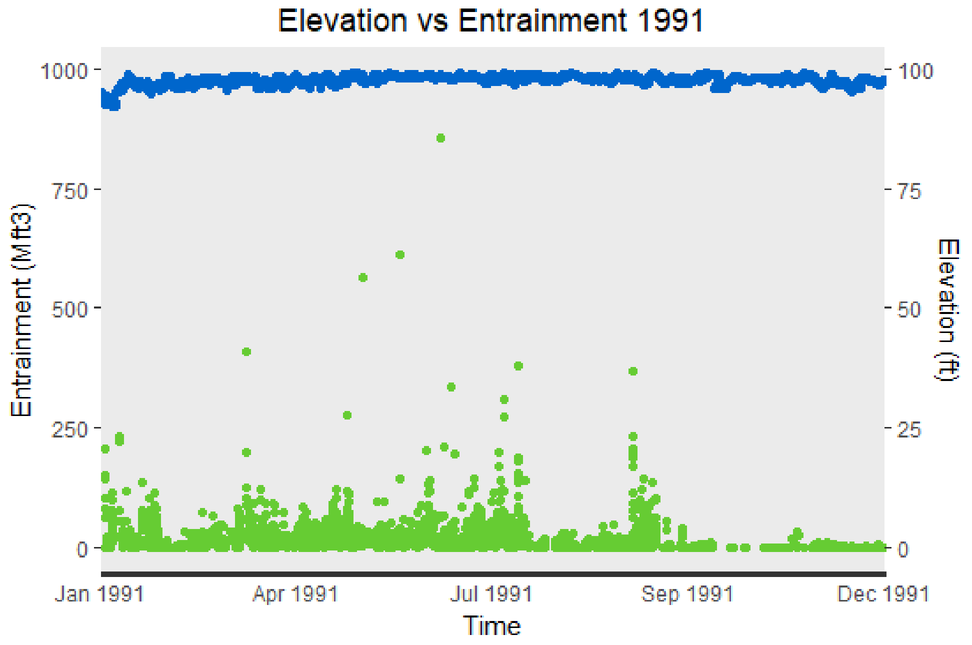

**Figure 3.14** 1991 Instantaneous elevation and entrainment rate, where green represents the entrainment observations and blue represents the forebay elevation observations.

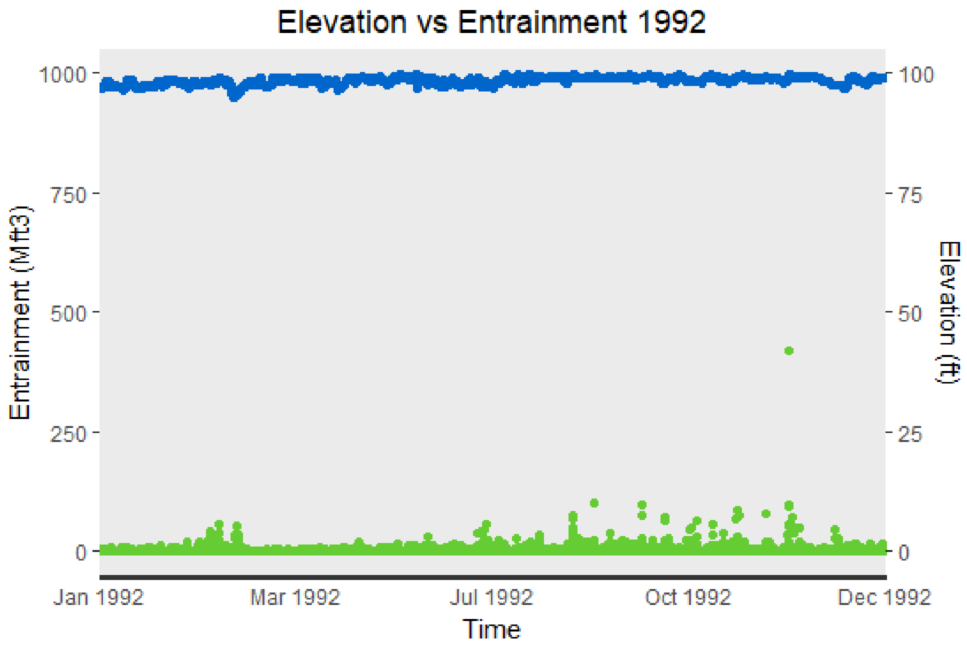

**Figure 3.15** 1992 Instantaneous elevation and entrainments rate, where green represents the entrainment observations and blue represents the forebay elevation observations.

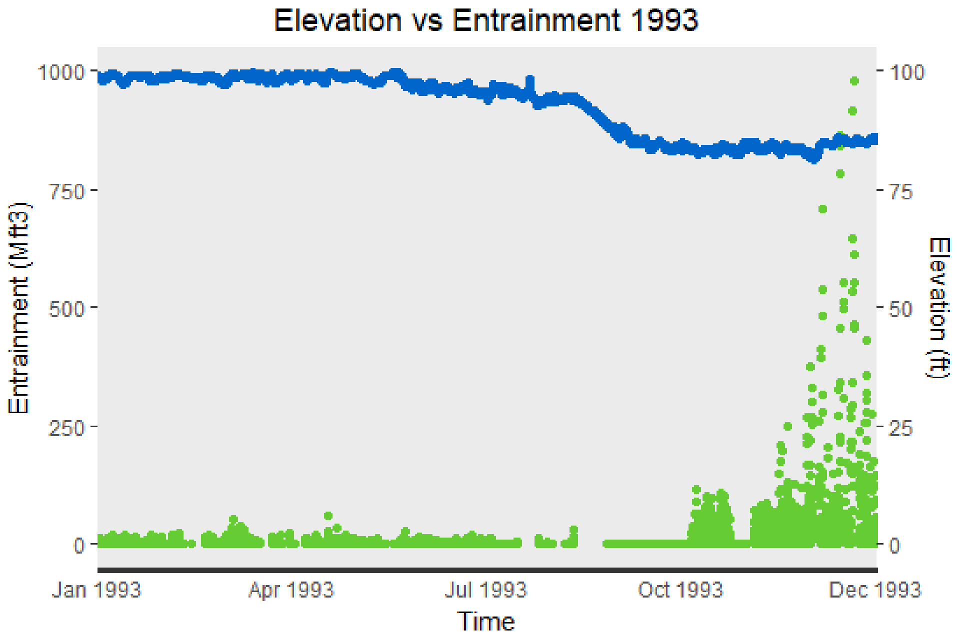

**Figure 3.16** 1993 Instantaneous elevation and entrainments rate, where green represents the entrainment observations and blue represents the forebay elevation observations.

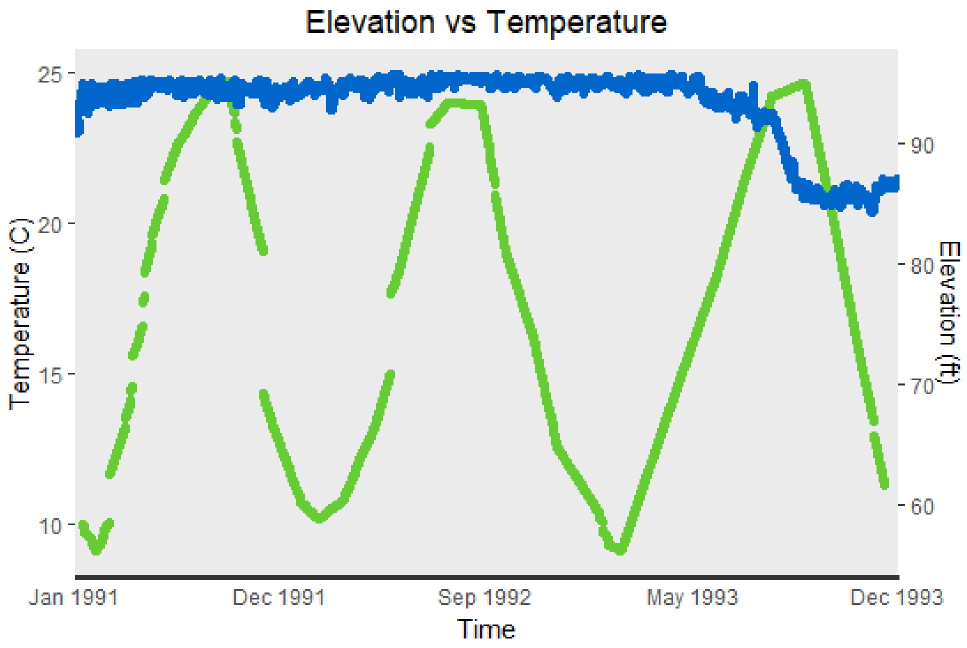

**Figure 3.17 Comparison of elevation and temperature data from 1991-1993, with green being temperature and blue being forebay elevation.**

## 3.2 Entrainment Impact

Simulations of operating scenarios were run at different forebay elevations in different seasons to assess entrainment impact at the Bad Creek Project. Table 3.9 shows the statistical summary of the number of fish entrained per day over the entire simulation dataset. Kleinschmidt began simulations with the forebay elevation at "high" level defined as forebay elevations greater than 89 feet. Then ran simulations when the forebay elevation was at a "low" level defined as forebay elevations less than 89 feet (1099 ftmsl). Table 3.10 contains statistics on the median number of organisms entrained and the likelihood of entraining 10, 100, or 1000 fish in any one event. The probability of 10 fish being entrained at once when elevations are low in the fall was 56.4%, probability of 100 being entrained was 50.6% and probability of 1000 fish being entrained was 44.8%. However, when compared to Fall at high level, when only 16,977 fish are entrained on average, the probabilities are similar. When entrainment is occurring at low elevations, the events are much larger than events at other seasons and high operating levels. The median entrainment of fish was nearly 3x as much during low forebay elevation as it was during high operating elevations in the Fall. The median entrainment in the Fall during normal pond levels was just under 17,000 fish, with a small increase in winter to 18,344 fish, another increase in spring to 23,389 fish, and then summer with 32,684 fish.

**Table 3.9 Statistical Summary of data from all elevation and seasonal scenarios within simulation**

| Minimum | Maximum | Mean | Standard Deviation | Median |
|---|---|---|---|---|
| 0 | 5111 | 149.484 | 316.143 | 27 |

**Table 3.10 Entrainment impact and likelihoods by season.**

| Season | Forebay level | Median Entrained | Probability 10 entrained | Probability 100 entrained | Probability 1000 entrained |
|---|---|---|---|---|---|
| Winter | High | 18,344 | 0.512 | 0.445 | 0.380 |
| Spring | High | 23,389 | 0.19 | 0.09 | 0.04 |
| Summer | High | 32,684 | 0.56 | 0.48 | 0.40 |
| Fall | High | 16,977.5 | 0.54 | 0.43 | 0.33 |
| Fall | Low | 46,052.5 | 0.56 | 0.51 | 0.45 |

**Table 3.11 Statistical summary of daily entrainment by season**

| Season | Forebay | Minimum | Maximum | Mean | Standard Deviation | Median |
|---|---|---|---|---|---|---|
| Winter | High | 0 | 4292 | 100.25 | 252.44 | 20 |
| Spring | High | 0 | 4013 | 127.07 | 294.92 | 22 |
| Summer | High | 0 | 5111 | 178.18 | 396.26 | 39 |
| Fall | High | 0 | 1840 | 91.98 | 171.43 | 29 |
| Fall | Low | 0 | 4480 | 250.30 | 381.35 | 0 |

As shown in Figure 3.18 through Figure 3.22, the highest probability of entraining fish was during the Fall at low forebay levels. Fall season operating at low levels had the highest average entrainment and second highest standard deviation, meaning that there were a higher number of elevated entrainment events during simulations as well as those events being highly variable.

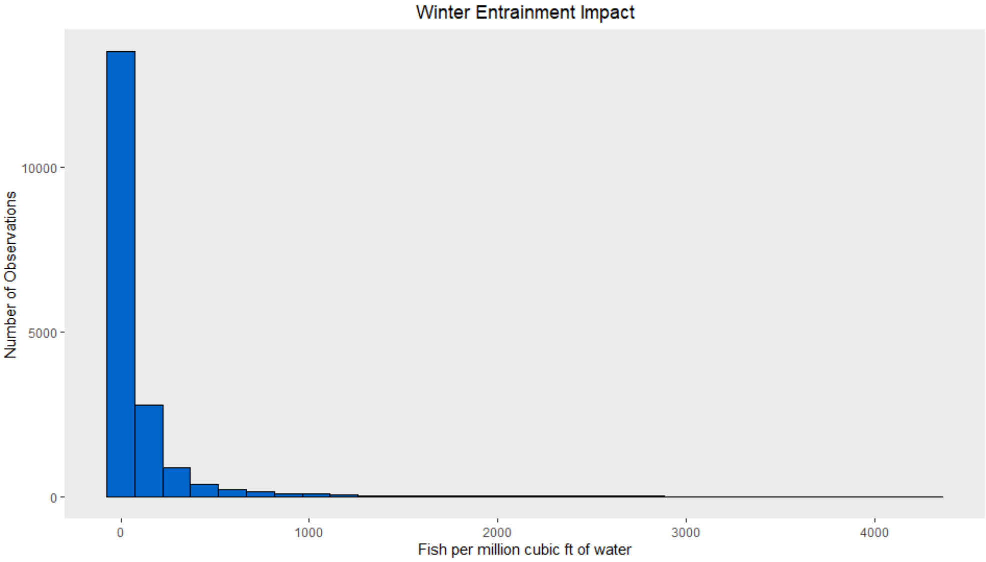

Figure 3.18 Winter Daily Entrainment Impact

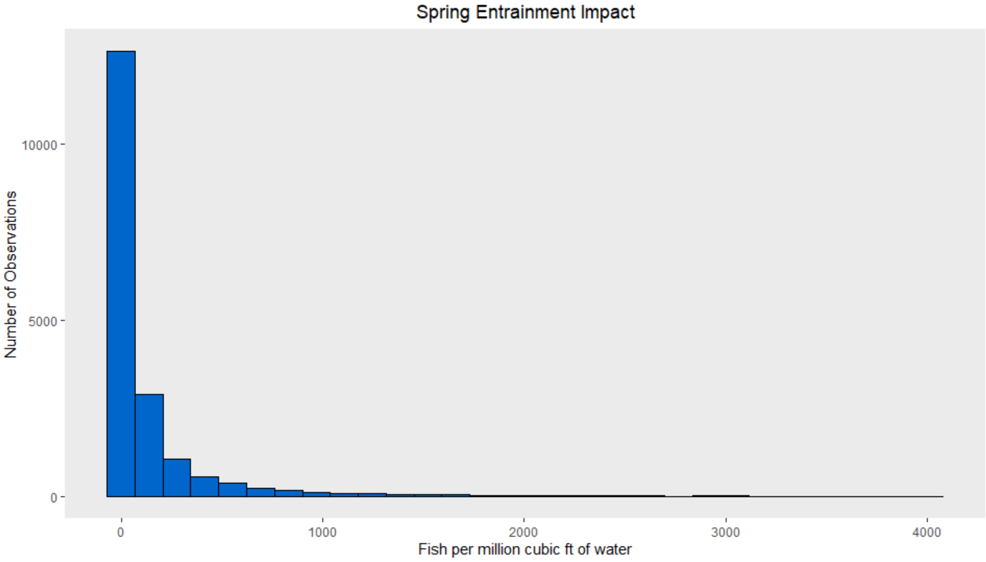

Figure 3.19 Spring Daily Entrainment Impact

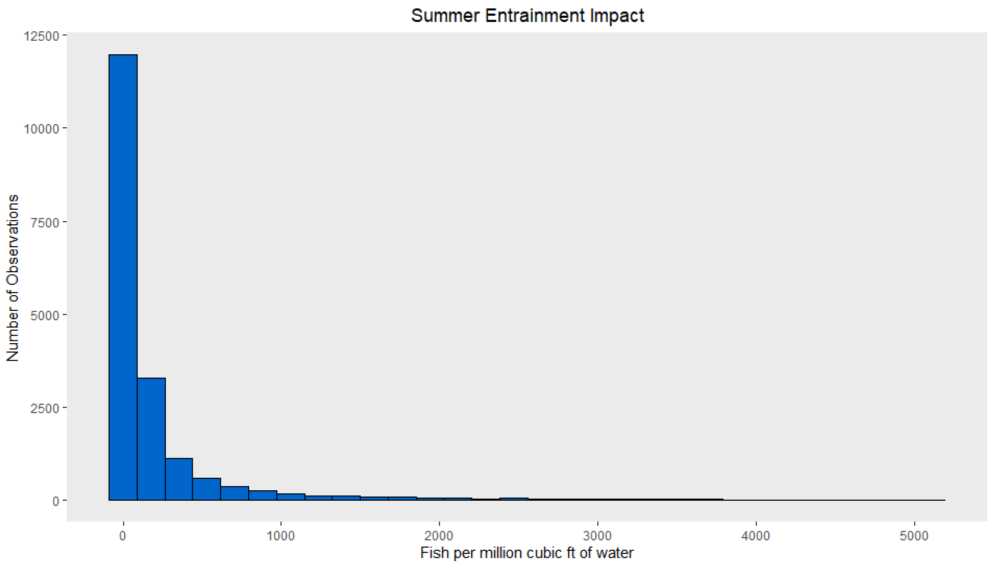

**Figure 3.20 Summer Entrainment Impact**

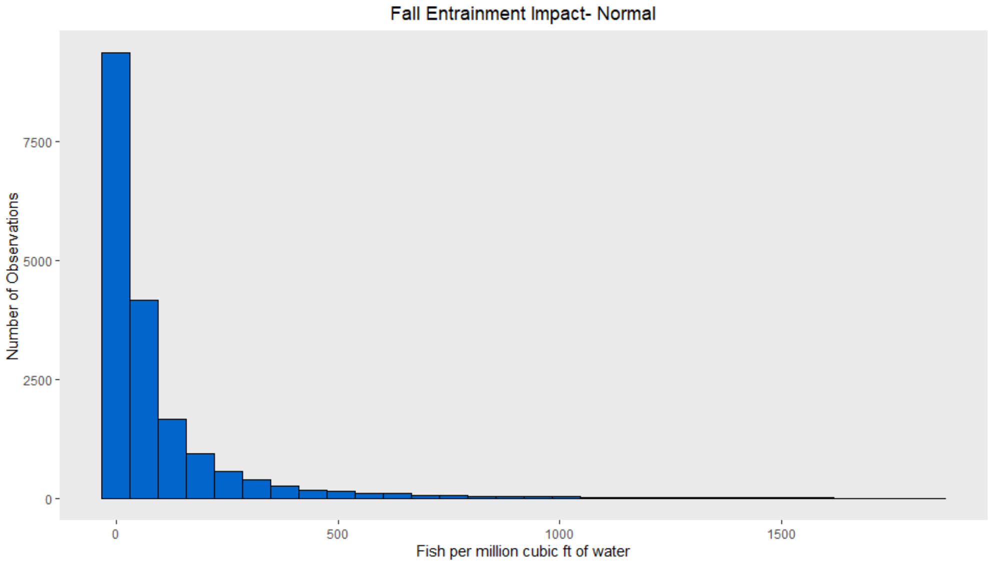

**Figure 3.21 Fall Entrainment Impact-High Operating Level**

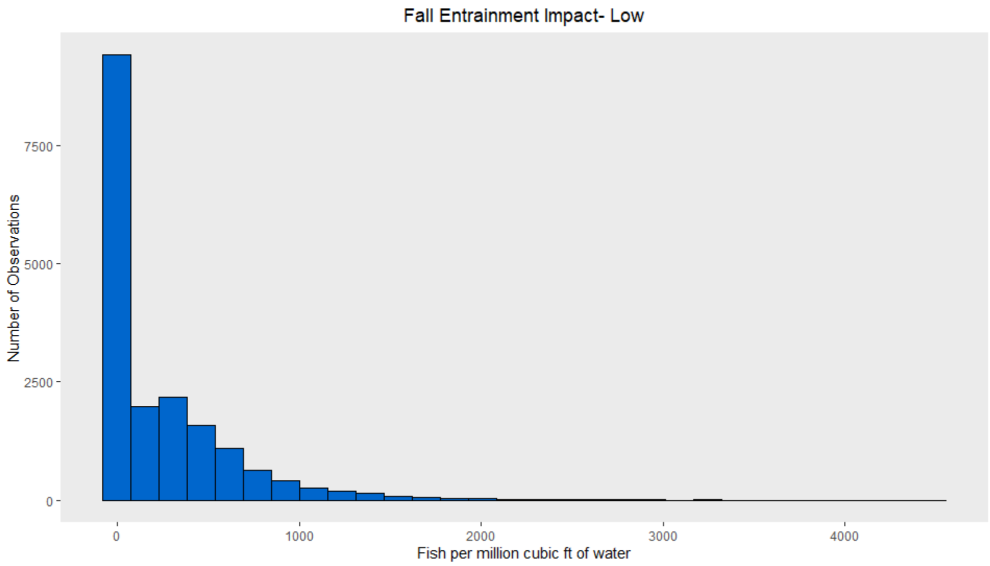

**Figure 3.22 Fall Entrainment Impact-Low Operating Level**

## 3.3 Relative Vulnerability to Entrainment

As there was no substantial increase between entrainment estimates, the previous assessment of vulnerability was used. A summary of FishBase parameters used for the entrainment vulnerability assessment are provided in Table 3.12. Both Blueback Herring and Threadfin Shad are considered moderately vulnerable species with population doubling times in the 1.4-4.4 year range. The intrinsic growth rate estimated for Blueback Herring indicates that this species is moderately vulnerable, with a discrete annual increase of about 20% per year. The intrinsic growth rate was not available for Threadfin Shad, but surrogate Alosines have estimated discrete annual increases of approximately 15-35% per year (Table 3.13).

**Table 3.12 Population Growth Rates Used for Vulnerability Assessment**

| | Parameters from FishBase | | | | Derived discrete growth rate (r) | | | |
|---|---|---|---|---|---|---|---|---|
| | Intrinsic Population Growth Rate (K) | | Categorical population doubling time (D) | | Species-specific | | Categorical | |
| **Species** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** |
| Blueback Herring | 0.18 | 0.18 | 1.40 | 4.40 | 1.20 | 1.20 | 1.17 | 1.64 |
| Threadfin Shad* | | | 1.40 | 4.40 | | | 1.17 | 1.64 |
| American Shad | 0.14 | 0.14 | | | 1.15 | 1.15 | | |
| Alewife | 0.20 | 0.20 | | | 1.22 | 1.22 | | |
| Blueback Herring | 0.18 | 0.18 | | | 1.20 | 1.20 | | |
| Hickory Shad | 0.30 | 0.30 | | | 1.35 | 1.35 | | |

*Intrinsic rate was not available in FishBase for Threadfin Shad but was available for the four North American Freshwater Alosines listed here.

### 3.4 Entrainment Risk

The risk results for Bad Creek Project for Blueback Herring and Threadfin Shad are presented in Table 3.13. The losses to Blueback Herring are relatively small compared to the population numbers, and the risk estimate is low (i.e., discrete population annual growth is estimated to be 16-19% after accounting for entrainment). Threadfin Shad is more heavily impacted, with approximately 12% of the estimated population lost each year to entrainment. According to these estimates, the population should still be sustainable, with estimated discrete annual increases in population ranging from 3% (based on American Shad population growth estimates) to 23% (based on Hickory Shad population growth estimates). The low end of this range, a 3% population growth rate, is low and corresponds to a population doubling rate of more than 20 years.

**Table 3.13 Bad Creek Entrainment Risk to populations of fish inhabiting Lake Jocassee**

| Species | Categorical discrete growth rate (min) | Species-specific discrete growth rate (min) | Estimated Population 2001-2020 (millions) | Annual Entrainment Loss Estimate | Proportion of Annual Population Lost to Entrainment (PL) | Annual population multiplier including entrainment (categorical) | Annual population multiplier including entrainment (species-specific) |
|---|---|---|---|---|---|---|---|
| Blueback Herring | 1.17 | 1.20 | 3.7 | 0.03 | 0.00 | 1.16 | 1.19 |
| Threadfin Shad | 1.17 |  | 0.52 | 0.06 | 0.12 | 1.05 |  |
| American Shad |  | 1.15 |  |  |  |  | 1.03 |
| Alewife |  | 1.22 |  |  |  |  | 1.10 |
| Blueback Herring |  | 1.20 |  |  |  |  | 1.08 |
| Hickory Shad |  | 1.35 |  |  |  |  | 1.23 |

# 4.0 CONCLUSION

Based on the exploratory analysis and simulation, if Lake Jocassee operates at a lower elevation there will be a risk of higher entrainment. Fluctuation in forebay elevations could increase risk of entrainment. Figure 3.17 depicts water temperature on the secondary y-axis. When water temperature and forebay elevation were high in the fall, entrainment was low, but when temperature was high and forebay elevation was low, entrainment was high.

There were numerous differences between this analysis and the previous analysis that have affected the results. The previous analysis (Kleinschmidt 2021) listed annual entrainment at 87,324, while there were 91,394 fish entrained in this analysis during normal operating years and up to 120,469 individuals in years with low operating forebay elevations in the fall. The previous analysis used instantaneous entrainment rates, while the current analysis uses daily entrainment rates. Use of daily entrainment rates provides higher resolution because entrainment is episodic, and high entrainment rates are not expected to occur for an entire pumping cycle. Rather than running for six hours every day, this analysis simulated hours operating per day with a log normal distribution fit to operations data that reflect solar operations. Therefore, days with long duration of operations occur with the same relative frequency in the simulation and actual operations.

The estimated rates of entrainment mortality at the Bad Creek Project are not expected to affect the long-term sustainability of Lake Jocassee fish populations. The species with the largest impact, Blueback Herring and Threadfin Shad, have relatively high fecundity, meaning that population-level compensatory mechanisms would likely offset the entrainment losses in terms of effects on these fish populations. In addition, while some level of entrainment mortality will inevitably occur, many natural populations have excess reproductive capacity that will compensate for some losses of individuals (Sale et al. 1989).

Using a risk assessment framework allows for an objective evaluation of risks to fish populations from entrainment by combining two components, an estimate of entrainment loss and an estimate of population vulnerability to that expected loss for each species impacted. The risk estimate used was the expected population increase in each year after accounting for the entrainment losses. The population increases were based on minimum discrete population growth rates for each species sourced from FishBase.

No expected risk to Blueback Herring was indicated because the estimated entrainment rate of 0.7% per year is substantially below the expected recovery rate of the species. We anticipate a moderate potential risk to Threadfin Shad that is higher when forebay elevations are low with entrainment losses predicted to be approximately 12% of the median population estimate for the past 20 years. Threadfin Shad is considered to be a moderately vulnerable species with moderate population recovery, and this category of fish is expected to have discrete population growth rates of 17-64% per year. Although no species-specific growth rates were found for Threadfin Shad, the estimated rates for the surrogate species ranged from 15% per year for American Shad to 35% per year for Hickory Shad. The expected entrainment rate of 12% for Threadfin Shad is close to the expected annual increase for the slowest recovery surrogate, American Shad, indicating that entrainment mortality may keep the population from substantial increase, but is not likely to cause the population to decrease, unless combined with other impacts.

# 5.0 REFERENCES

Cada G.F. and Schweizer P.E. 2012. The Application of Traits Based Assessment Approaches to Estimate the Effects of Hydroelectric Turbine Passage on Fish Populations. Oak Ridge, TN: Oak Ridge National Laboratory Technical Report. 36 pp.

Cortés, Enric, Freddy Arocha, Lawrence Beerkircher, Felipe Carvalho, Andrés Domingo, Michelle Heupel, Hannes Holtzhausen, Miguel N. Santos, Marta Ribera, and Colin Simpfendorfer. 2010. Ecological risk assessment of pelagic sharks caught in Atlantic pelagic longline fisheries. Aquatic Living Resources (EDP Sciences) 23: 25-34.

Electric Power Research Institute (EPRI). 1997. Turbine entrainment and survival database – field tests. Prepared by Alden Research Laboratory, Inc., Holden, Massachusetts. EPRI Report No. TR-108630. October 1997.

Froese, R. and D. Pauly (Editors). 2021. FishBase. World wide web publication. www.fishbase.org, version (06/2021).

Furlong-Estrada, Emmanuel, Felipe Galván-Magaña, and Javier Tovar-Ávila. 2017. Use of the productivity and susceptibility analysis and a rapid management-risk assessment to evaluate the vulnerability of sharks caught off the west coast of Baja California Sur, Mexico. Fisheries Research 194: 197-208.

Kleinschmidt Associates (Kleinschmidt). 2021. Desktop Entrainment Analysis: Bad Creek Pumped Storage Project (FERC No. P-2740). Prepared for Duke Energy. December 2021.

Patrick, W.S., P. Spencer, O. Ormseth, J. Cope, J. Field, D. Kobayashi, T. Gedamke, E. Cortés, K. Bigelow, W. Overholtz, J. Link, and P. Lawson. 2009. Use of productivity and susceptibility indices to determine stock vulnerability, with example applications to six U.S. fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-101. 90 pp.

Pontón-Cevallos, José F., Stijn Bruneel, Mar\ín and José, R. Jarr\ín, Jorge Ram\írez-González, Jorge R. Bermúdez-Monsalve, and Peter L. M. Goethals. 2020. Vulnerability and decision-making in multispecies fisheries: A risk assessment of bacalao (Mycteroperca olfax) and related species in the Galapagos' handline fishery. Sustainability 12: 6931.

Ramos, Pedro L., Francisco Louzada, Eduardo Ramos, and Sanku Dey. 2020. The Fréchet distribution: Estimation and application-An overview. Journal of Statistics and Management Systems 23: 549-578.

Sale, M.J., S.F. Railsback, S.Y Chang, C.C. Coutant, R.E. Spath, and G.H Taylor. 1989. Balancing hydropower development in the Ohio River basin. US Department of Energy. Report No. CONF-890876-1.

van Treeck, Ruben, Johannes Radinger, Richard A. A. Noble, Franz Geiger, and Christian Wolter. 2021. "The European Fish Hazard Index – An assessment tool for screening hazard of hydropower plants for fish." Sustainable Energy Technologies and Assessments. P. 43.

# BAD CREEK PUMPED STORAGE PROJECT

# (FERC NO. P-2740)

# DESKTOP ENTRAINMENT ANALYSIS

# ADDENDUM 1

## INTRODUCTION

Duke Energy Carolinas, LLC (Duke Energy) retained Kleinschmidt Associates (Kleinschmidt) to conduct fish entrainment analyses in support of the relicensing of the Bad Creek Pumped Storage Project (Project; FERC No. 2740). These analyses were guided by discussions with the Aquatic Resources Committee and are detailed in the Desktop Entrainment Analysis Report (Rev. 2, November 2023) prepared by Kleinschmidt.

The November 2023 report (submitted with the Initial Study Report in January 2024 as Appendix B, Attachment 1) estimated that the Project could entrain between 90,825 and 119,208 fish annually, depending on meteorological conditions. Since the completion of that analysis, new unit technology information was made available regarding updated hydraulic capacities (i.e., increased pumping rates) for the proposed units at Bad Creek II (BCII) (i.e., variable-speed pump turbines). Additionally, unit upgrades to the existing four units at BCI were completed in March 2024, therefore, unit upgrades are reflective of current conditions. This addendum provides an updated assessment of the Project entrainment impact, taking into account the latest information on BCI upgraded and BCII updated pumping rates.

## UPDATED ANALYSIS

Table 1 contains the original and upgraded pumping rates. The time period from 2014 to 2018 was utilized in the analysis as it is indicative of how Duke Energy intends to operate the Project in the future. Kleinschmidt fit a log normal distribution to seasonal operations data (2014 – 2018) to simulate future operations. However, due to the increased pumping rates while pumping the same volume of water, the actual number of hours operated at BCI and BCII will be much lower than previously expected.

To simulate future Project operations utilizing the same volume of water pumped as in 2014 – 2018, we have multiplied simulated hours operated by a coefficient. To derive the coefficient, we first assumed that all new and upgraded units would run for 6 hours each, which resulted in 773,280,000 cubic feet pumped. The original units at BCI would need to run for 14.55 hours each to pump the same volume of water. The upgraded units at BCI and the proposed units at BCII would reduce operational times by 58.8%. Therefore, the coefficient applied to the simulated hours was 1 – 0.588 or 0.412.

**Table 1. Original (as-constructed), upgraded (BCI), and updated (BCII) pumping rates at the Bad Creek Pumped Storage Project.**

| Unit | Original Pumping Rate (cfs) | Previously Modeled Pumping Rate (cfs) (Kleinschmidt 2023) | Upgraded Pumping Rate (cfs) |
|---|---|---|---|
| BCI Unit 1 | 3690 | 3690 | 4060 |
| BCI Unit 2 | 3690 | 3690 | 4060 |
| BCI Unit 3 | 3690 | 3690 | 4060 |
| BCI Unit 4 | 3690 | 3690 | 4060 |
| BCII Unit 5 | N/A | 3690 | 4890 |
| BCII Unit 6 | N/A | 3690 | 4890 |
| BCII Unit 7 | N/A | 3690 | 4890 |
| BCII Unit 8 | N/A | 3690 | 4890 |

The calculated entrainment estimate (Table 2) aligns with previous assessments for the Project since the volume of water pumped remains the same.

**Table 2. Seasonal entrainment estimates at the Bad Creek Pumped Storage Project using upgraded BCI and updated BCII pumping rates.**

| Species | Scenario | Median Number Entrained |
|---|---|---|
| Fish | Bad Creek Fall Low Pond | 45,574.5 |
| Fish | Bad Creek Fall Normal Pond | 17,192.5 |
| Fish | Bad Creek Spring Normal Pond | 22,702.5 |
| Fish | Bad Creek Summer Normal Pond | 32,511.5 |
| Fish | Bad Creek Winter Normal Pond | 18,419 |

Under normal operational conditions, the annual entrainment estimate remains at 90,825 fish. During a drought year with a reduced forebay elevation, the annual entrainment estimate remains at 119,208 fish.

## REFERENCES

Kleinschmidt. (2023). Revised Desktop Entrainment Analyses: Bad Creek Pumped Storage Project (FERC No. P-2740). Pittsfield, ME: Kleinschmidt Associates.

# BAD CREEK PUMPED STORAGE PROJECT

# (FERC NO. P-2740)

# DESKTOP ENTRAINMENT ANALYSIS

# ADDENDUM 2

## INTRODUCTION

Duke Energy Carolinas, LLC (Duke Energy) retained Kleinschmidt Associates (Kleinschmidt) to perform fish entrainment analyses in support of the relicensing of the Bad Creek Pumped Storage Project (Project; FERC No. 2740). These analyses were guided by discussions with the Aquatic Resources Committee and are detailed in the revised Desktop Entrainment Analysis Report (November 2023) prepared by Kleinschmidt and included with the Initial Study Report (ISR).

The November 2023 report estimated that the Project could entrain between 90,825 and 119,208 fish annually, depending on meteorological conditions. Drought conditions were identified as contributing to higher entrainment rates (Kleinschmidt 2023). It was estimated that Threadfin Shad account for approximately 71% of the entrained organisms, totaling 64,485 to 83,445 fish per year, while Blueback Herring account for 14%, or approximately 12,715 to 16,688 fish per year.

In comments dated March 1, 2024, the Federal Energy Regulatory Commission (FERC) staff requested additional information regarding the revised Desktop Entrainment Analysis Report. Specifically, they noted:

*"Section 2.4, Vulnerability to Entrainment, states that information on FishBase1 was used to derive discrete population growth rate (r) parameters for each species of concern. While FishBase can be used for this information, that information may be out of date and may not always be reflective of current literature. For the USR, please conduct a broader literature review (including both peer reviewed and gray/agency literature) to ensure the best available scientific data is being used for each species of interest to derive accurate population growth rate estimates for the entrainment analysis."*

This addendum addresses FERC staff concerns by incorporating a more comprehensive literature review to ensure the best available data are used. It also provides additional insights into the effects of entrainment on the Threadfin Shad and Blueback Herring populations in Lake Jocassee.

# SPECIES' LIFE HISTORY INFORMATION

## THREADFIN SHAD

Threadfin Shad is a small, planktivorous pelagic fish common in rivers and reservoirs throughout the southeast U.S. that serves as forage prey for predator fish species. Although Threadfin Shad may mature during its first year, maturity typically occurs during its second year of life with a maximum age of four years (Jenkins and Burkhead, 1994; Rohde et al., 2009). Fecundity ranges from 6,700 to 36,509 eggs per female dependent on size and age of reproduction (LWB Environmental Services, 2012). Spawning typically occurs from April through July. Life history parameters for Threadfin Shad are presented in Table 1.

**Table 1. Life history parameters for Threadfin Shad (LWB Environmental Services, 2012).**

| Stage | Daily Mortality | Duration (d) | Cumulative Mortality | % Mature | % Female | Start Weight (g) |
|---|---|---|---|---|---|---|
| Eggs | 0.222 | 3 | 0.67 | 0 | 50 | $5.68 \times 10^{-5}$ |
| Larvae | 0.178 | 27 | 4.79 | 0 | 50 | $5.68 \times 10^{-5}$ |
| Juveniles | 0.0099 | 335 | 3.30 | 0 | 50 | 0.0612 |
| Age 1 | 0.0082 | 365 | 3.0 | 50 | 50 | 8.8 |
| Age 2 | -* | 365 | -* | 100 | 50 | 27.6 |

*All fish are assumed to die before age 3 (EPRI 2012)

## BLUEBACK HERRING

Blueback Herring is a small, planktivorous pelagic fish with a range extending from Nova Scotia south to northern Florida; abundance is greater in the southern portion of its range (USEPA, 2004). Although anadromous, landlocked populations of the species exist in inland reservoirs. Blueback Herring can live to 8 years old (USEPA, 2004; Rohde et al., 2009), although Jessop et al. 1983 reported a maximum age of 11 years. Males mature at ages 3 to 4 and females mature at ages 4 to 5 (USEPA, 2004). Fecundity ranges from 45,800 to 349,700 eggs per female dependent on size (USEPA, 2004). Life history parameters for Blueback Herring are presented in Table 2.

**Table 2. Life history parameters for Blueback Herring (EPRI 2012).**

| Stage | Daily Mortality | Duration (d) | Cumulative Mortality | % Mature | % Female | Start Weight (g) |
|---|---|---|---|---|---|---|
| Eggs | 0.0942 | 6 | 0.58 | 0 | 50 | $9.43 \times 10^{-4}$ |
| Yolk-sac Larvae | 0.143 | 13 | 1.90 | 0 | 50 | $9.43 \times 10^{-4}$ |
| Post Yolk-sac Larvae | 0.044 | 40 | 1.80 | 0 | 50 | $9.43 \times 10^{-4}$ |
| Juveniles | 0.0207 | 306 | 6.50 | 0 | 50 | 0.0612 |
| Age 1 | $8.22 \times 10^{-4}$ | 365 | 0.3 | 0 | 50 | 7 |
| Age 2 | $8.22 \times 10^{-4}$ | 365 | 0.3 | 0 | 50 | 41 |
| Age 3 | $8.22 \times 10^{-4}$ | 365 | 0.3 | 0 | 50 | 92 |
| Age 4 | 0.0041 | 365 | 0.73 | 50 | 50 | 144 |
| Age 5 | 0.0041 | 365 | 1.5 | 100 | 50 | 188 |

## METHODS

Methods used for additional entrainment analyses, as described below, have been derived from the information presented within the Introduction to this Addendum 2, as well as the life history parameters presented in Table 1 and Table 2.

To convert the daily mortality rates (see Table 1 and Table 2) to lifestage-specific survival rates, we can use the following relationship (equation 1):

$$S_i = e^{-Z_i}$$

Where $S_i$ is the survival rate for life stage $j$, and $Z_j$ is the stage-based instantaneous mortality rate for life stage $i$. $Z_i$ can be calculated using the relationship:

$$Z_i = -\log_e(S_i) = d_i z_i$$

Where $d_i$ is the duration of the stage $i$ in days, and $z_i$ is the daily instantaneous mortality rate for stage $i$. Given the daily mortality rate ($z_i$) and duration of each stage ($d_i$) we can calculate the lifestage specific instantaneous mortality rate $Z_i$. After calculating $Z_i$ for each lifestage, we can then derive the survival rate ($S_i$) for each lifestage using equation 1.
The intrinsic population growth rate ($r$) is the rate at which a population grows or decreases under ideal conditions with no migration. Table 1 has 4 lifestages with a lifestage specific survival rate $S_i$ from stage $i$ to $i + 1$, and Table 2 has 9 life stages. With

$b_i$ representing the per capita birth rate (fecundity) for individuals in lifestage $i$, we constructed a Leslie matrix for each species to derive growth rate $r$ :

$$L = \begin{bmatrix} b_1 & b_2 & b_3 & \cdots & b_n \\ S_1 & 0 & 0 & \cdots & 0 \\ 0 & S_2 & 0 & \cdots & 0 \\ 0 & 0 & S_3 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & S_{n-1} \end{bmatrix}$$

The square matrix is used to model the population growth of age-structured populations ($b_1$= egg, $b_2$= larvae, $b_3$= juvenile, $b_4$= adult year 1, $b_5$= adult year 2, etc.). The largest eigenvalue ($\lambda$) of the Leslie matrix is used to define the long-term growth rate $r$ of the population with:

$$r = \ln(\lambda)$$

With the intrinsic population growth rate ($r$) known, we can use the Schaeffer model for estimating the population growth of a harvested (or entrained) population of fish to understand if entrainment loss is greater than the number of individuals entering the population. The Schaeffer model is given with:

$$N_{t+1} \sim N_t(1 + K) - E_t$$

Where $N_{t+1}$ is the population in the next year, $N_t$ is the population in Lake Jocassee in the current year, $K$ is the discrete growth rate, and $E_t$ represents the entrainment losses in year $t$. To translate the continuous growth rate $r$ into the discrete growth rate $K$, we can use the relationship:

$$e^K = (1 + r)$$

To assess the risk of population decline in Lake Jocassee, we performed a sensitivity analysis that altered fecundity in normal and dry years and among different reproductive scenarios. For Threadfin Shad, the three scenarios analyzed included 1) the conservative population estimate that fish spawn at year 1 and die before year 2; 2) where 5% of the population survives until year 2; and 3) where 4% of the population reaches maturity, spawn in year 0, and then again at year 1. For Blueback Herring, two reproductive scenarios were analyzed, a low and high fecundity model where 50% spawn at year 4 and 50% spawn at year 5.

## RESULTS

The only difference between normal and dry years is the number of organisms entrained. The Leslie matrices of a fecundity scenario in a normal year will equal that of a fecundity scenario in a dry year. Results of the Leslie matrices are presented below, followed by the water year scenario population estimates.

### LESLIE MATRICES

#### *THREADFIN SHAD*

The conservative low fecundity scenario produced the Leslie matrix found in Table 3A-F. The dominant eigenvalue ($\lambda$) was 1.005 suggesting that fecundity is adequate to provide a modest population growth rate ($r$) of 0.0053. The model that depicts 5% of the population surviving to spawn until year 2 produced the Leslie matrix in Table 3B. The dominant eigenvalue ($\lambda$) was 1.006, similarly suggesting that fecundity can adequately provide a modest population growth rate ($r$) of 0.0059. The low fecundity model that simulates 4% of the population spawning before year 0 and during year 1 produced the Leslie matrix in Table 3C. The dominant eigenvalue ($\lambda$) was 1.248 suggesting relatively high population growth rate ($r$) of 0.22.

The conservative high fecundity model produced the Leslie matrix provided in Table 3D. The dominant eigenvalue ($\lambda$) was 1.53 suggesting a relatively high population growth rate ($r$) of 0.429. The model that depicts 5% of the population surviving to spawn in year 2 with high fecundity produced the Leslie matrix in Table 3E. The dominant eigenvalue ($\lambda$) was 1.536 suggesting another high population growth rate ($r$) of 0.429. If 4% of juvenile Threadfin Shad mature and spawn within year 0, the representative Leslie matrix is provided in Table 3F. The dominant eigenvalue ($\lambda$) was 2.067 suggesting another high population growth rate ($r$) of 0.726.

### **Table 3. Threadfin Shad Fecundity Model**

<table>
<tr><th></th><th>Low Fecundity</th><th>High Fecundity</th></tr>
<tr><td>Conservative life history</td><td>A:<table>
<tr><td>0</td><td>0</td><td>0</td><td>6,700</td></tr>
<tr><td>0.513</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0.008</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0.036</td><td>0</td></tr>
</table></td><td>D:<table>
<tr><td>0</td><td>0</td><td>0</td><td>36,509</td></tr>
<tr><td>0.513</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0.008</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0.036</td><td>0</td></tr>
</table></td></tr>
<tr><td>5% survive to spawn in year 2</td><td>B:<table>
<tr><td>0</td><td>0</td><td>0</td><td>6,700</td><td>355</td></tr>
<tr><td>0.513</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0.008</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0.036</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0.050</td><td>0</td></tr>
</table></td><td>E:<table>
<tr><td>0</td><td>0</td><td>0</td><td>36,509</td><td>1,825</td></tr>
<tr><td>0.513</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0.008</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0.036</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0.050</td><td>0</td></tr>
</table></td></tr>
<tr><td>4% mature and spawn in year 0</td><td>C:<table>
<tr><td>0</td><td>0</td><td>268</td><td>6,700</td></tr>
<tr><td>0.513</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0.008</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0.036</td><td>0</td></tr>
</table></td><td>F:<table>
<tr><td>0</td><td>0</td><td>1,825</td><td>36,509</td></tr>
<tr><td>0.513</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0.008</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0.036</td><td>0</td></tr>
</table></td></tr>
</table>

### *BLUEBACK HERRING*

The low fecundity scenario produced the Leslie matrix provided in Table 4. The dominant eigenvalue (λ) was 1.005 suggesting there is just enough fecundity to provide a modest growth rate (r) of 0.0053. The high fecundity model produced the Leslie matrix shown in Table 5. The dominant eigenvalue (λ) was 1.48 suggesting a relatively high growth rate (r) of 0.392.

### **Table 4. Low Fecundity Leslie Matrix for Blueback Herring**

| **0** | **0** | **0** | **0** | **0** | **0** | **0** | **22,900** | **22,900** |
|---|---|---|---|---|---|---|---|---|
| 0.568 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0.156 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.172 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.002 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.741 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0.741 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0.741 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.224 | 0 |

**Table 5. High Fecundity Leslie Matrix for Blueback Herring**

| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 174,850 | 175,850 |
|---|---|---|---|---|---|---|---|---|
| 0.568 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0.156 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.172 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0.002 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0.741 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0.741 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0.741 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.224 | 0 |

## POPULATION RESILIENCY

### *THREADFIN SHAD*

In a normal water year, an estimated 64,485 Threadfin Shad would be entrained ($E_t$) while 84,636 would be entrained in a dry year. The estimated population of pelagic fish within Lake Jocassee is 5,430,000 fish (Personal Communication, Alan Stuart, 2021), while Threadfin Shad was found to contribute 12% of the pelagic population on average (Personal Communication, Alan Stuart, 2021). Using the best estimates available, 651,600 Threadfin Shad inhabit Lake Jocassee on an annual basis.

Table 6 presents the population in year 2 ($N_{t+1}$) for each life history and fecundity scenario in a normal water year. For this scenario, a population with low fecundity will decline, while a highly fecund population will still increase given the estimated entrainment impact at the Project.

**Table 6. Threadfin Shad Population at Year 2 Fecundity Normal Water Year**

| Scenario | Low Fecundity | High Fecundity |
|---|---|---|
| Conservative life history | 590,584 | 819,811 |
| 5% survive to and spawn in year 2 | 590,988 | 819,997 |
| 4% mature and spawn in year 0 | 717,602 | 942,793 |

Table 7 presents the population in year 2 ($N_{t+1}$) for each life history and fecundity scenario in a dry water year. As with a normal water year, populations with low fecundity will decline, while those with high fecundity will still increase given the estimated entrainment impact at the Project.

**Table 7. Threadfin Shad Population at Year 2 Fecundity Dry Water Year**

| Scenario | Low Fecundity | High Fecundity |
|---|---|---|
| Conservative life history | 570,433 | 799,660 |
| 5% survive to and spawn in year 2 | 570,836 | 799,846 |
| 4% mature and spawn in year 0 | 697,451 | 922,641 |

### *BLUEBACK HERRING*

In a normal water year, an estimated 12,715 Blueback Herring are entrained ($E_t$) while 16,688 would be entrained in a dry year. The estimated population of pelagic fish within Lake Jocassee is 5,430,000 fish (Personal Communication, Alan Stuart, 2021), with Blueback Herring accounting for 88% of the pelagic population on average (Personal Communication, Alan Stuart, 2021). Using the best estimates available, 4,778,400 Blueback Herring inhabit Lake Jocassee on an annual basis.

Table 8 contains the population in year 2 ($N_{t+1}$) for each fecundity scenario in normal and dry water years. Under both scenarios, the population is expected to increase despite the estimated entrainment impact at the Project.

**Table 8. Blueback Herring Population at Year 2 for Low and High Fecundity, and Normal and Dry Year scenarios**

| Scenario | Low Fecundity | High Fecundity |
|---|---|---|
| Normal Water Year | 4,736,248 | 5,582,275 |
| Dry Water Year | 4,732,274 | 5,578,302 |

## DISCUSSION AND CONCLUSION

For each life history and water year scenario analyzed for Threadfin Shad, the low fecundity model resulted in a declining population, while the high fecundity model demonstrated modest to substantial growth. Considering that Kleinschmidt (2021) found there to be a self-sustaining population with an approximate 20-year cycle, the actual fecundity measure for the Lake Jocassee population of Threadfin Shad is likely between 6,700 and 36,509 per female.

For Blueback Herring, both high and low fecundity models resulted in increasing population estimates for normal and dry water year scenarios. Our analysis suggests that the actual fecundity measure for Lake Jocassee Blueback Herring is likely between 22,900 and 175,850 per female, and the population of Blueback Herring would continue to increase despite entrainment impacts due to Bad Creek operations. While the life history parameters used in this model were associated with anadromous populations that have a longer life expectancy, landlocked populations are expected to mature earlier and not live as long. A secondary model was constructed that shortened the life expectancy and found a growth rate of 1.32 rather than 1.48. However, the population is still expected to grow after entrainment.

Kleinschmidt also described uncertainty around the annual entrainment estimate (Kleinschmidt 2021, 2023, 2024), suggesting that there is a possibility that very large (but infrequent) entrainment events could lead to a population decline in a particular year, especially during dry years. However, with such a large natural variation in fecundity (Kuklinski, 2006; Pablico, 2017) and compensatory density-dependence mechanisms, the population of pelagic fishes in Lake Jocassee is likely to rebound. Compensatory mechanisms occur when a population declines because there is less competition for resources, such as food and habitat. This leads to improved individual growth, survival, and greater reproductive success among the survivors. Improved individual growth means increased fecundity, and increased fecundity allows for an increase in population growth rates. This concept of maximum sustainable yield has been used to manage fisheries resources since the enactment of the Magnuson-Stevens Fisheries Conservation and Management Act in 1976. With an observed stable long-term population of pelagic fishes in Lake Jocassee, we are likely at or below maximum sustainable entrainment for Threadfin Shad and no noticeable population level impacts to Blueback Herring.

In 2024, Kleinschmidt concluded that the added operations of Bad Creek II would not substantially increase the number of entrained organisms because the overall volume of water pumped would remain the same. However, should future operations require a larger volume of water, additional population monitoring may be warranted.

## REFERENCES

Electric Power Research Institute (EPRI). (2012). Fish Life History Parameter Values for Equivalent Adult and Production Foregone Models: Comprehensive Update. EPRI, Palo Alto, CA: 2012. Technical Report 1023103.

Jenkins, R.E. and N.M. Burkhead. (1994). Freshwater Fishes of Virginia. American Fisheries Society. Bethesda, MD.

Jessop, B. M., Anderson, W. E., and Vromans, A. H. (1983). Life history data on alewife and blueback herring of the Saint Johns River, New Brunswick. Canadian Data Report of Fisheries and Aquatic Sciences No. 426.

Kleinschmidt. (2021). Updated Desktop Entrainment Analyses: Bad Creek Pumped Storage Project (FERC No. P-2740). Pittsfield, ME: Kleinschmidt Associates.

Kleinschmidt. (2023). Revised Desktop Entrainment Analyses: Bad Creek Pumped Storage Project (FERC No. P-2740). Pittsfield, ME: Kleinschmidt Associates.

Kleinschmidt. (2024). Bad Creek Pumped Storage Fish Entrainment Analysis: Addendum 1. Pittsfield, ME: Kleinschmidt Associates.

Kuklinski, K. E. (2006). Prolonged Spawing of Adult Threadfin Shad and Contribution of Age-0 Threadfin Shad as a Brood Source of Summer Larval Presence in Hugo Reservoir, Oklahoma. Proceedings of the annual Conference of the Southeast Association of Fish and Wildlife Agencies. 60, pp. 194-199. SEAFWA.

LWB Environmental Services, Inc. (2012). Fish Life History Parameter Values for Equivalent Adult and Production Foregone Models: Comprehensive update. Palo Alto, CA: Electric Power Research Institute. Retrieved June 17, 2024.

Pablico, G. T. (2017). Fecundity for *Dorosoma petenense*. Retrieved June 4, 2024, from fishbase: https://fishbase.se/Reproduction/FecundityList.php?ID=1606&GenusName=Dorosoma&SpeciesName=petenense&fc=794&StockCode=1799.

Rohde, F.C., Arndt, R.G., Foltz, J.W., and Quattro, J.M. (2009). Freshwater Fishes of South Carolina. The University of South Carolina Press. Columbia, SC.

U.S. Environmental Protection Agency (USEPA). (2004). Section 316(b) Phase II Final Rule - Regional Studies, Part D: Mid-Atlantic Region. Washington, D.C.: U.S. Environmental Protection Agency .

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# Attachment 2

## Effects of Bad Creek II Complex and Expanded Weir on Aquatic Habitat Final Report

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# 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*

# 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.

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[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.

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[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).

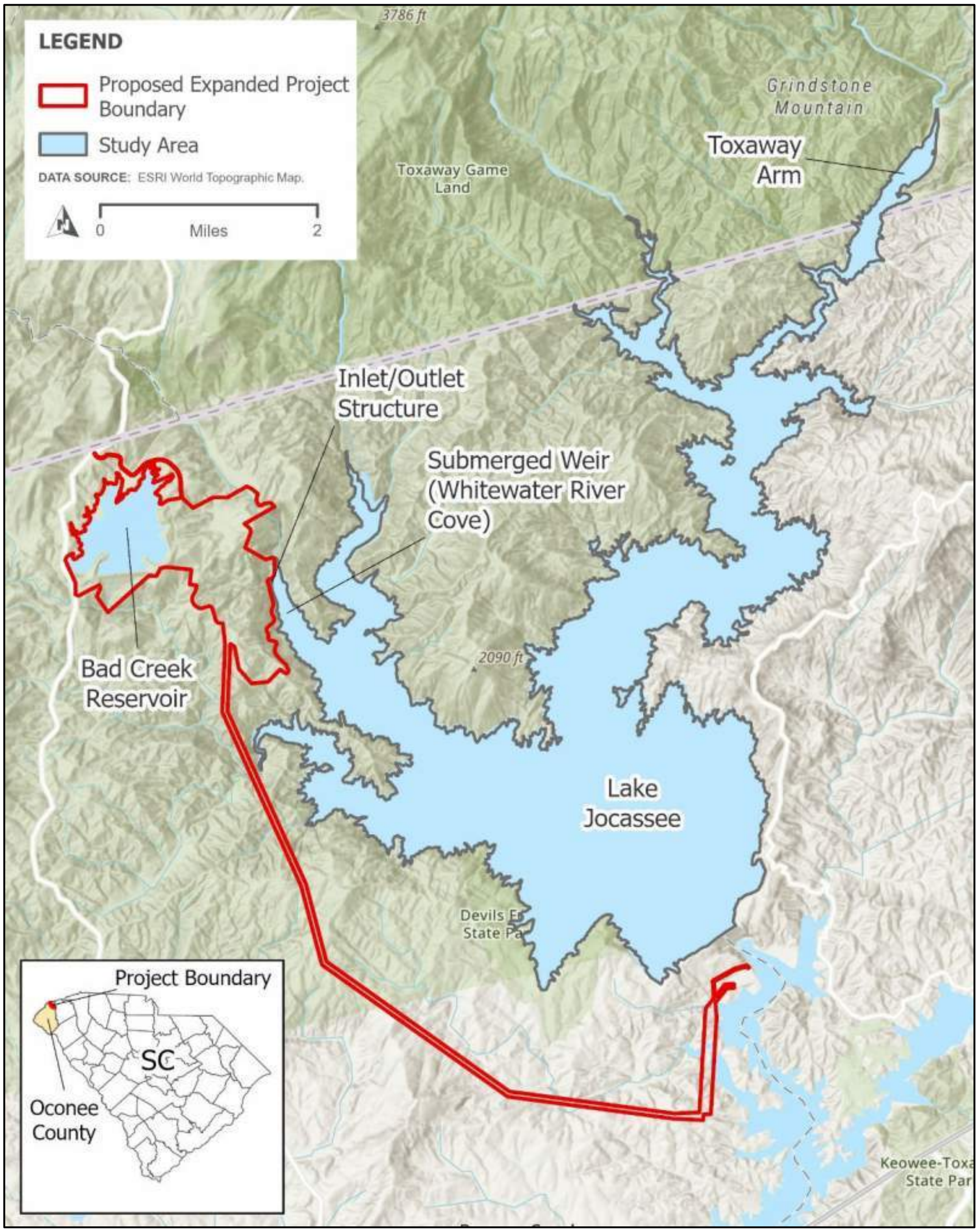

Figure 3-1. Aquatic Resources Study Task 2 Study Area

# 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

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[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).

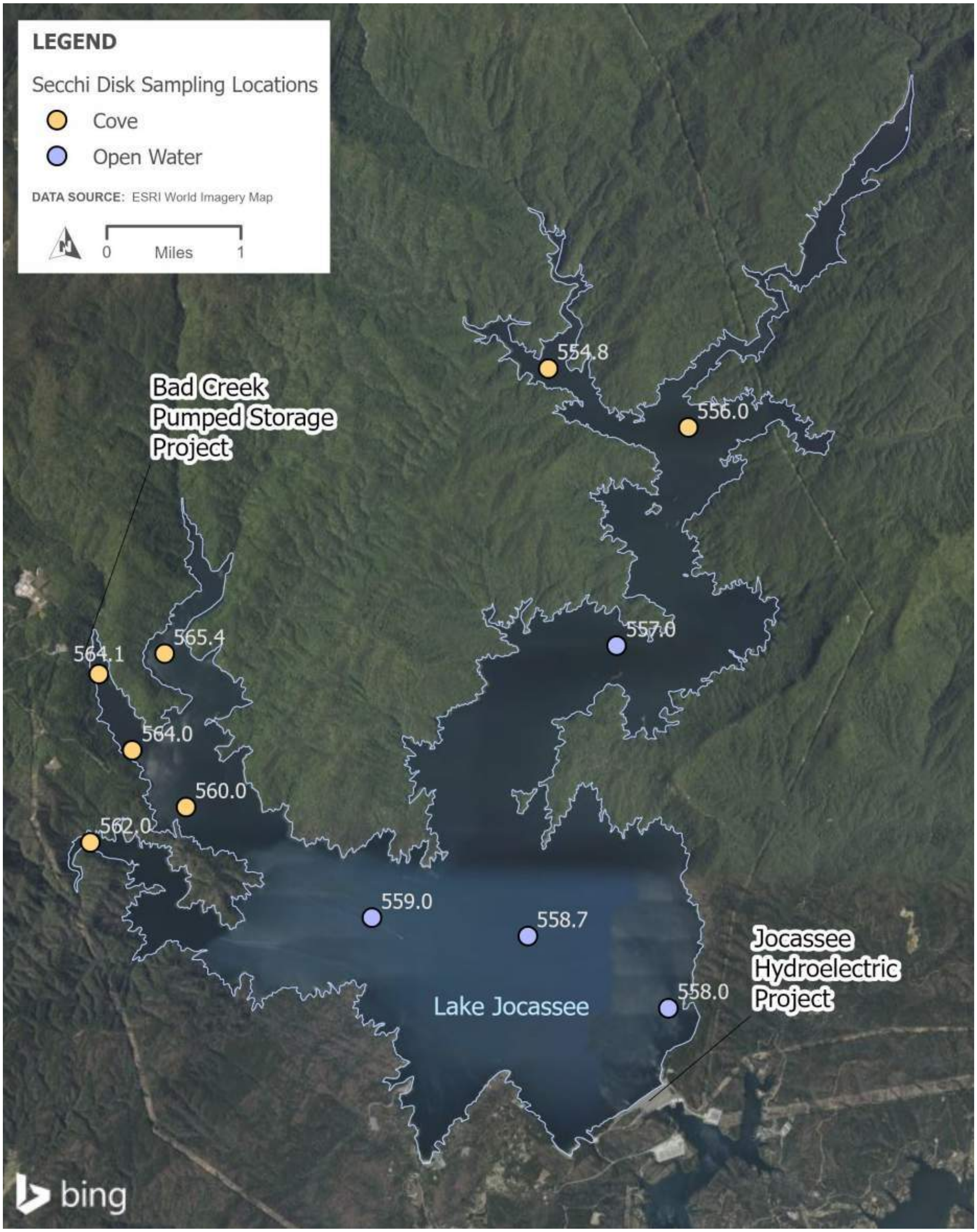


Figure 4-1. Secchi Depth Sampling Locations

### 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 ($\eta$), 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:

| | |
|---|---|
| $\eta$ | 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).

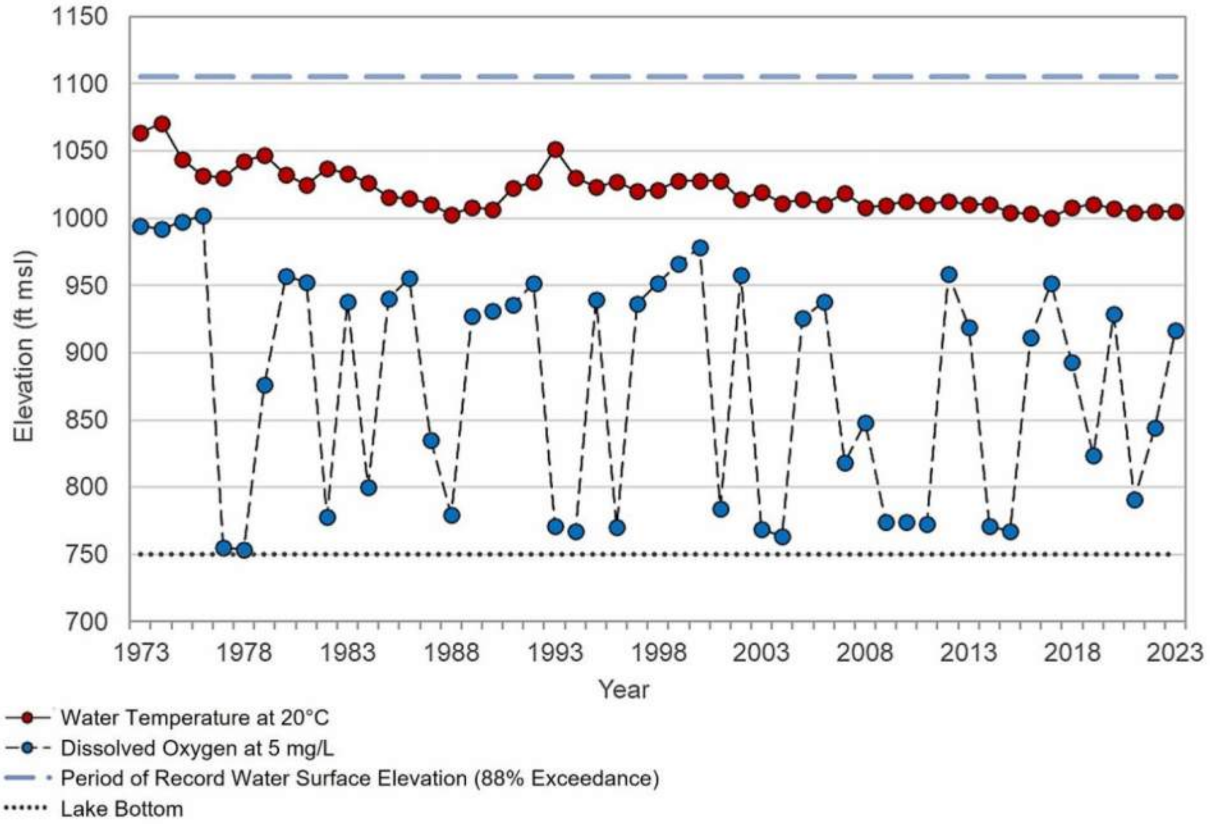
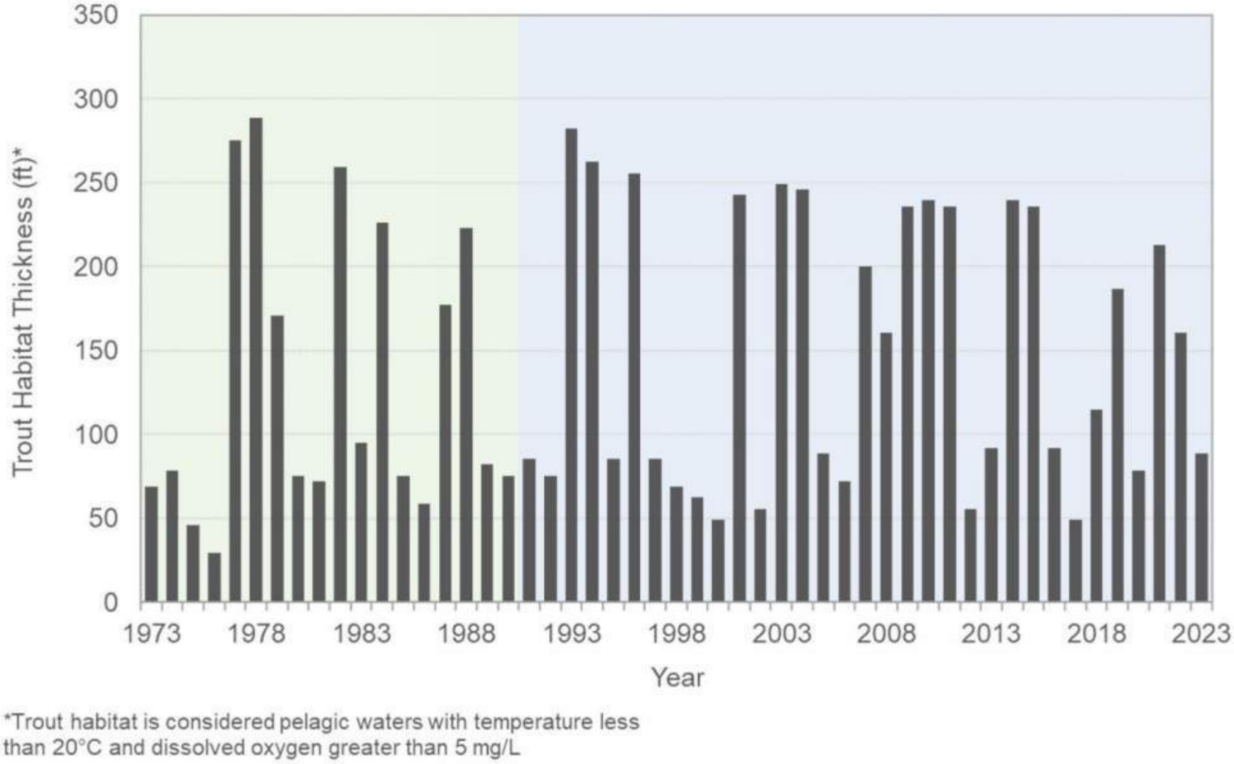


**Figure 5-1. Pelagic Trout Habitat Thresholds from 1973-2023**

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.



*Trout habitat is considered pelagic waters with temperature less than 20°C and dissolved oxygen greater than 5 mg/L

**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).

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[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).

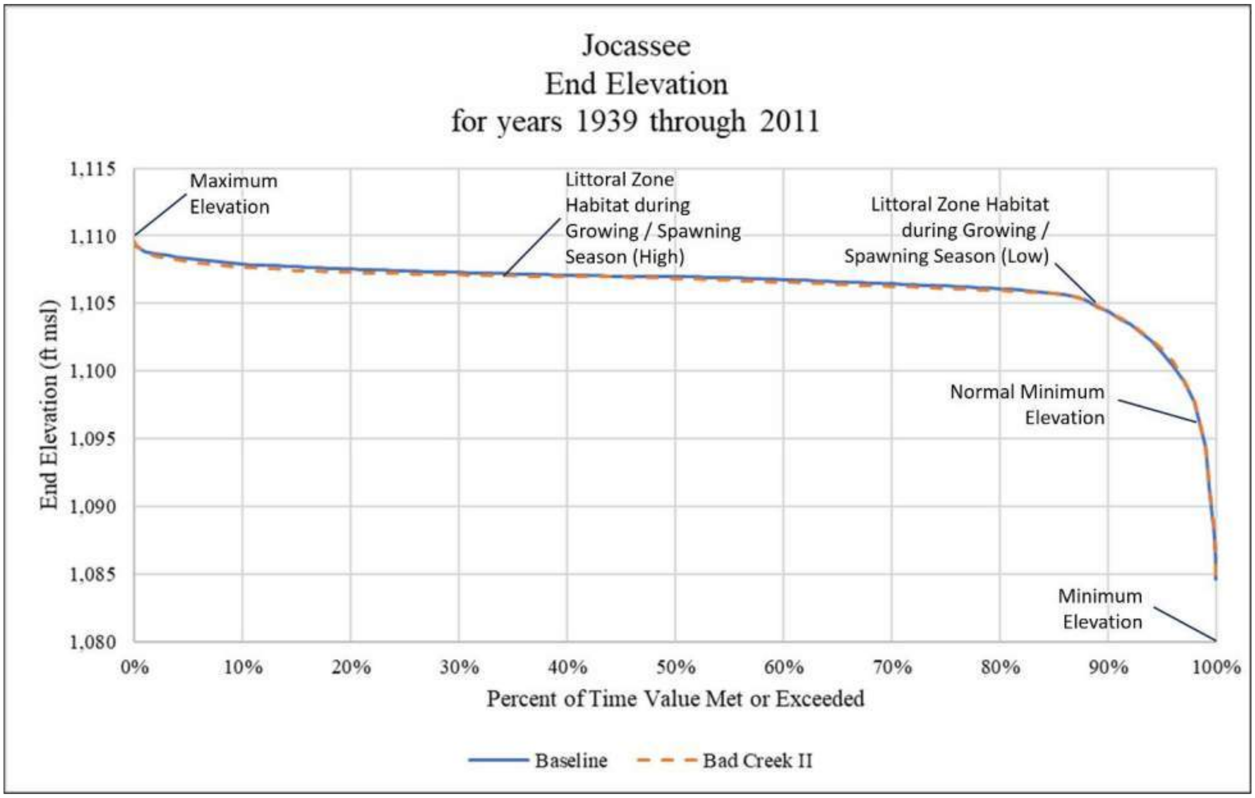

**Figure 5-3. Normal Hydrology Jocassee 24-hour Reservoir Fluctuation for 1939-2011 (HDR 2024)**

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 | Performance measure has improved vs. the Baseline scenario |
| Background | 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).

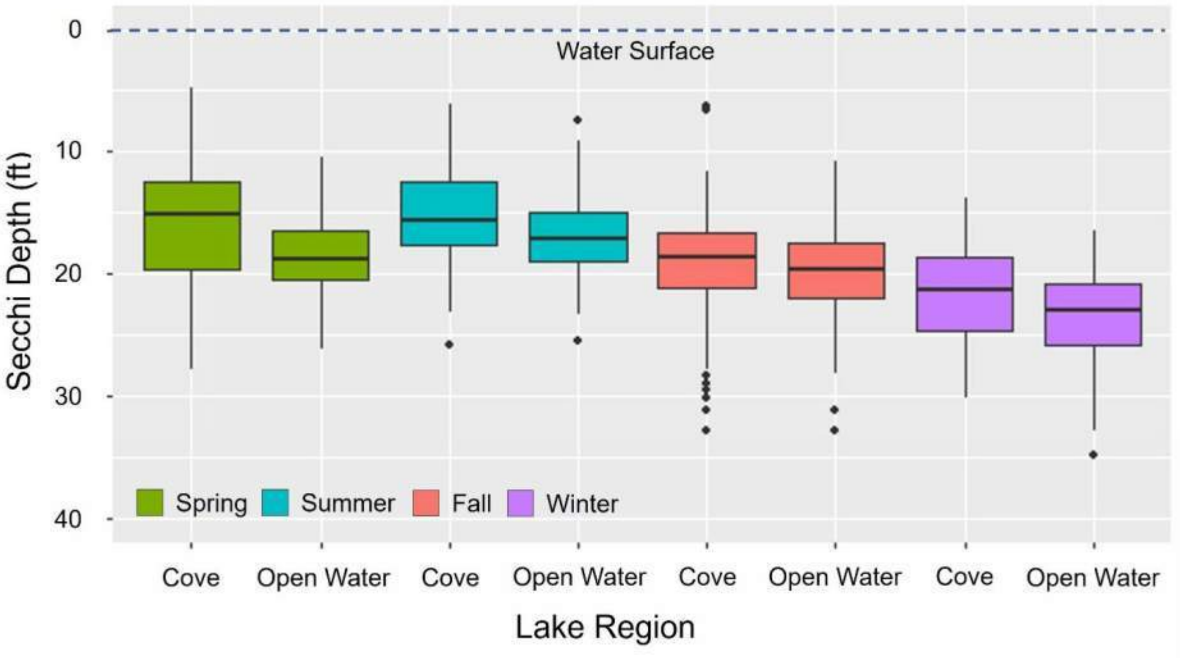

**Figure 5-4. Box Plot of Secchi Depth Data (Duke Energy 2024) for Cove and Open Water Locations**

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

Aho, J.M, C.S. Anderson, and J.W. Terrell. 1986. Habitat suitability index models and instream flow suitability curves: redbreast sunfish. U.S. Fish and Wildlife Service Biological Report 82(10.119). 23 pp.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22(2): 361-369.

Cole, G.A. 1994. Textbook of Limnology, 4th ed. Waveland Press, Inc.

Duke Energy Carolinas, LLC (Duke Energy). 2022. Pre-application Document. Bad Creek Pumped Storage Project FERC Project No. 2740. February 23, 2022.

______. 2024. Secchi disk data, Microsoft Excel workbook format. Transmitted via email from Nick Wahl on March 1, 2024.

Edwards, E.A., G. Gebhart, and O.E. Meughan. 1983. Habitat suitability information: Smallmouth bass. U.S. Fish and Wildlife Service FWS/OBS-82/10.36. 47 pp.

Flow Science, Inc. (Flow Science). 2023. User Manual: FLOW-3D Documentation, release 23.1.0.12. Albuquerque: Flow Science, Inc.

Foris, W.J. 1991. Temporal and spatial variability in pelagic trout habitat in a southeastern pumped-storage reservoir. Paper presented at NALMS, November 1991. Denver, CO.

_____. Jocassee Reservoir Pelagic Trout Habitat: Year 2013. Duke Energy, Huntersville, NC. November 2014.

HDR Engineering, Inc. of the Carolinas (HDR). 2010. Keowee-Toxaway Hydroelectric Project (FERC No. 2503) Lake Jocassee Bathymetry Study Report. October 2010.

_____. 2023. Velocity effects and vertical mixing in Lake Jocassee due to a second powerhouse. Final Report. Bad Creek Pumped Storage Project FERC Project No. 2740. Prepared for Duke Energy Carolinas, LLC, October 27, 2023.

_____. 2024. Water Exchange Rates and Lake Jocassee Reservoir Levels – Final Report. Bad Creek Pumped Storage Project, FERC Project No. 2740. Prepared for Duke Energy Carolinas, LLC, March 2024.

Lee, R.W. and W. Rast. 1997. Light attenuation in a shallow, turbid reservoir, Lake Houston, Texas. U.S. Geological Survey Water-Resources Investigations Report 97-4064. Austin, TX.

Oliver, J.L., P.L. Hudson, and J.P. Clugston. 1978. Effects of a pumped-storage hydroelectric plant on reservoir trout habitat. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 31: 449-457.

Poole, H.H., and W.R.G. Atkins. 1929. Photo-electric measurements of submarine illumination throughout the year. Journal of Marine Biological Association of the United Kingdom 16(1): 297-324.

Rohde, F.C., Rudolf, G.A., Foltz, J.W., and J.M. Quattro. 2009. Freshwater Fishes of South Carolina. University of South Carolina Press, Columbia, SC.

Seekell, D., B. Cae, S. Norman, and P. Bystrom. 2021. Patterns and variation of littoral habitat size among lakes. Geophysical Research Letters 48: e2021GL095046.

Stuber, R.J., G. Gebhart, and O.E. Maughan. 1982a. Habitat suitability index models: Largemouth bass. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-82/10.16. 32 pp.

_____. 1982b. Habitat suitability index models: Bluegill. U.S. Fish and Wildlife Service. FWS/OBS-82/10.8. 26 pp.

Wernand, M.R. 2010. On the history of the Secchi disc. Journal of the European Optical Society-Rapid publications, Europe, v. 5, April 2010. ISSN 1990-2573.

# Attachment A

## Attachment A – Pelagic Trout Habitat Figures (Foris 2014)

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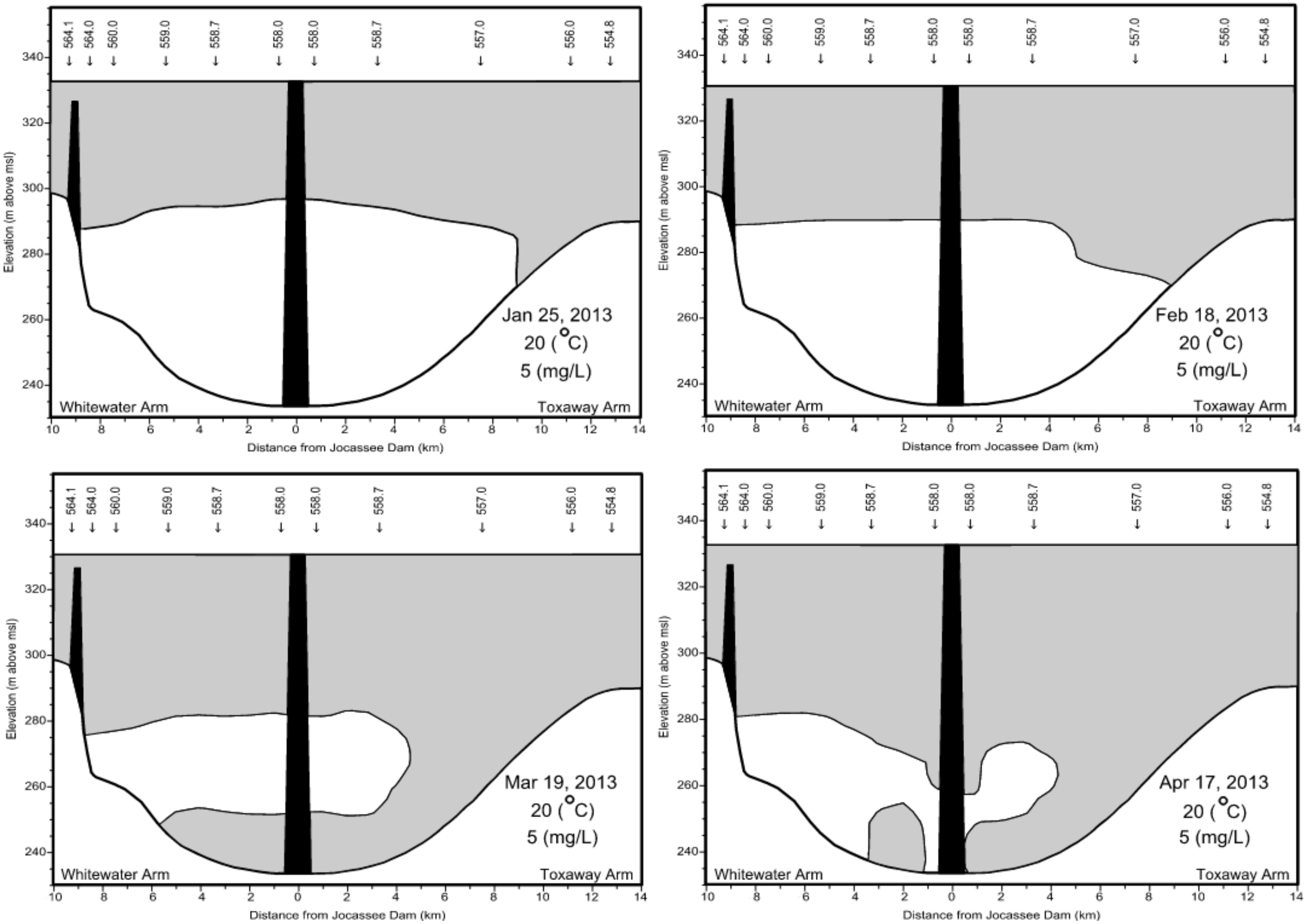

**Figure 1. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, January – April 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from Jocassee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

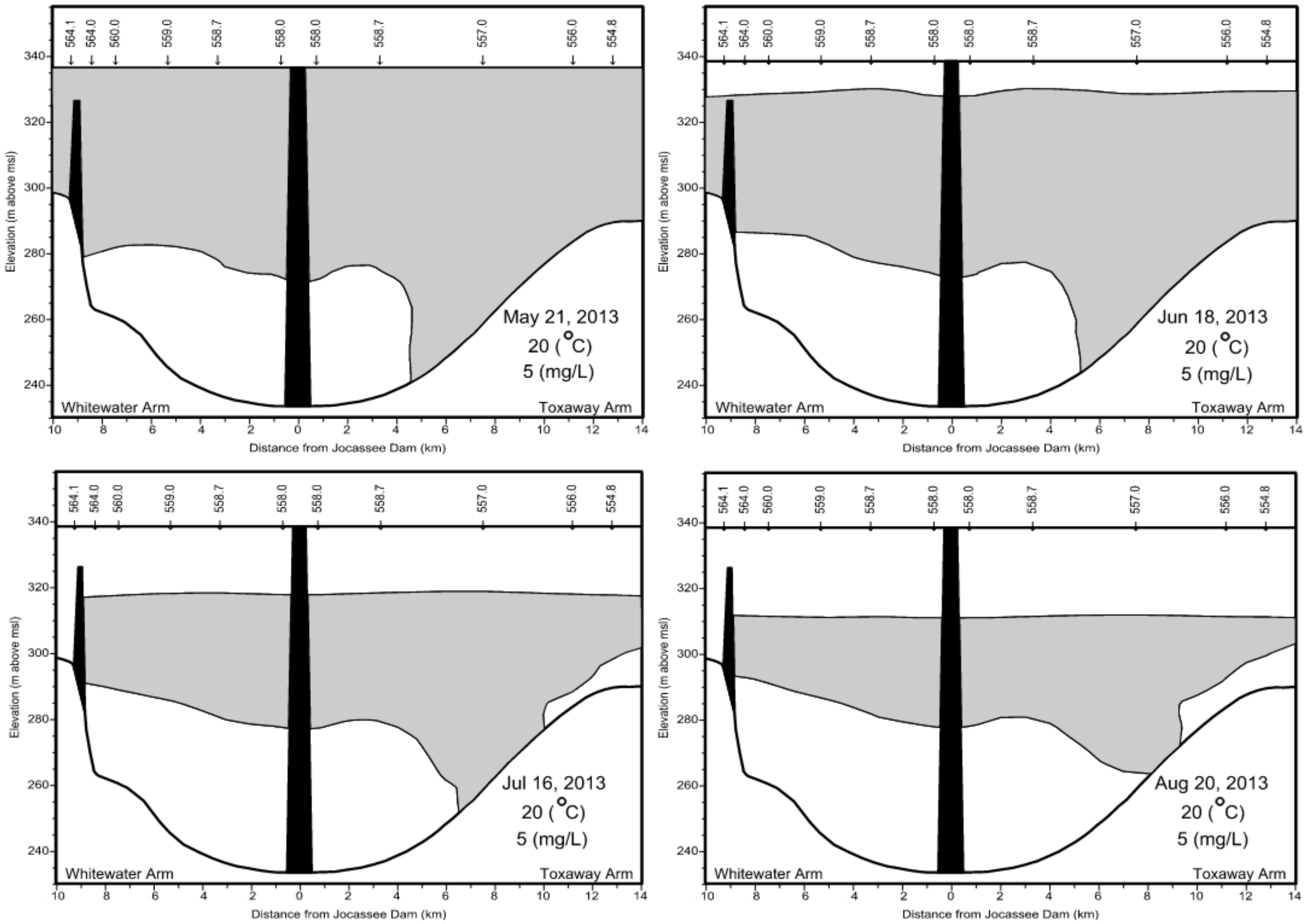

**Figure 2. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, May – August 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from Jocassee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

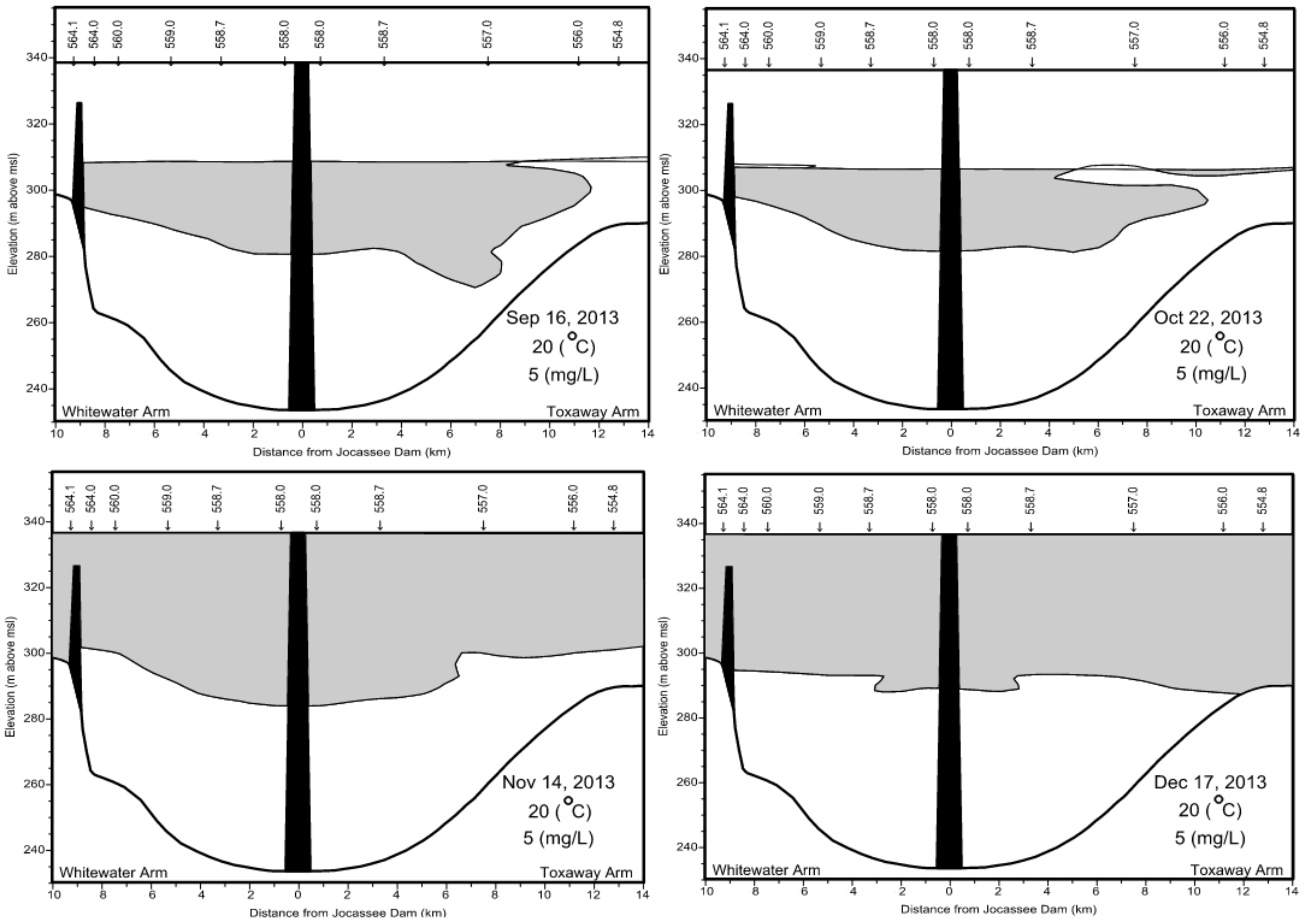

**Figure 3. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, September – December 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from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

# Attachment B

## Attachment B – CFD Modeling Figures

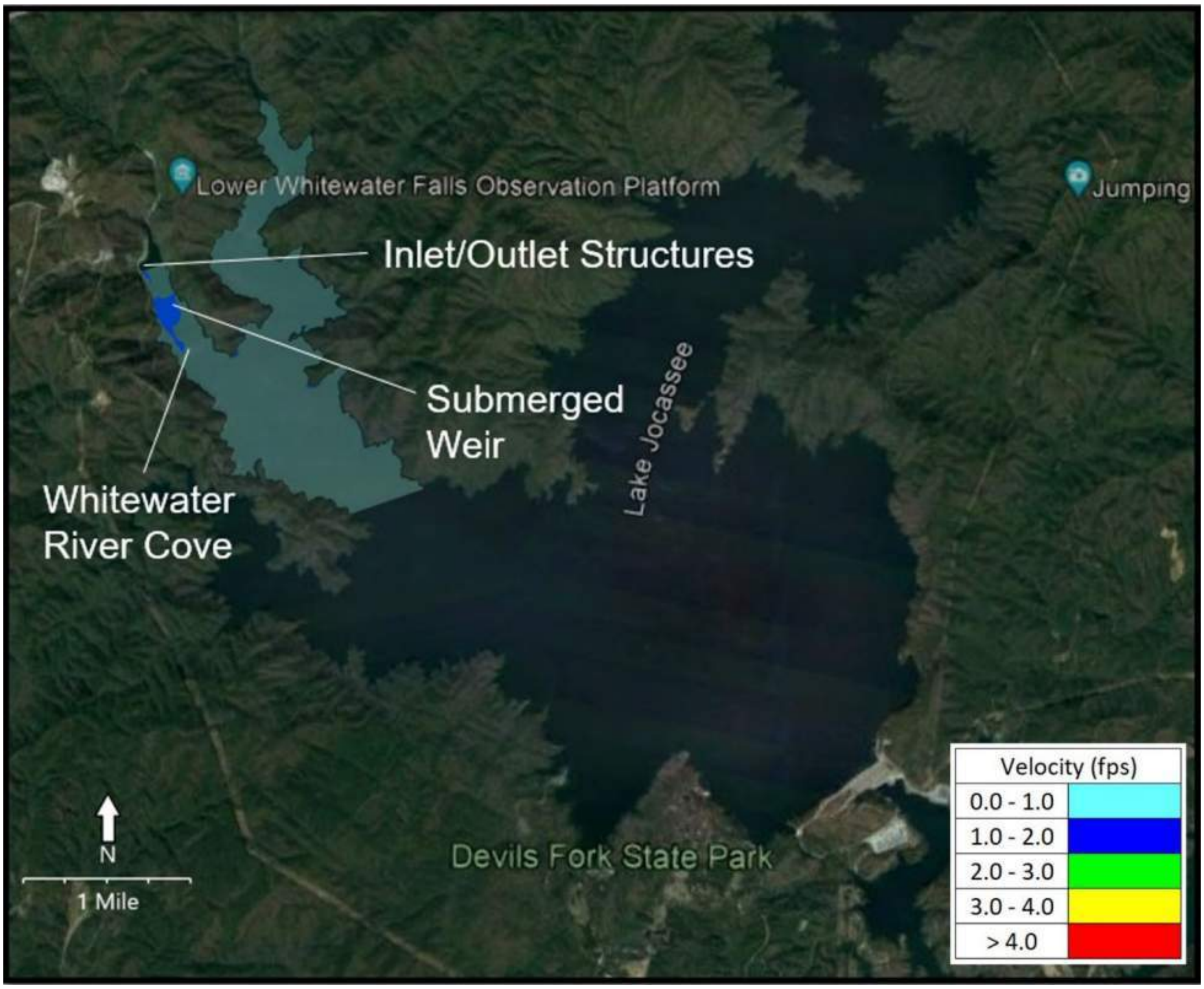

**Figure 1. Proposed Generation with Expanded Weir at Full Pond (1,110 ft msl) – Velocity Contours (HDR 2023)**

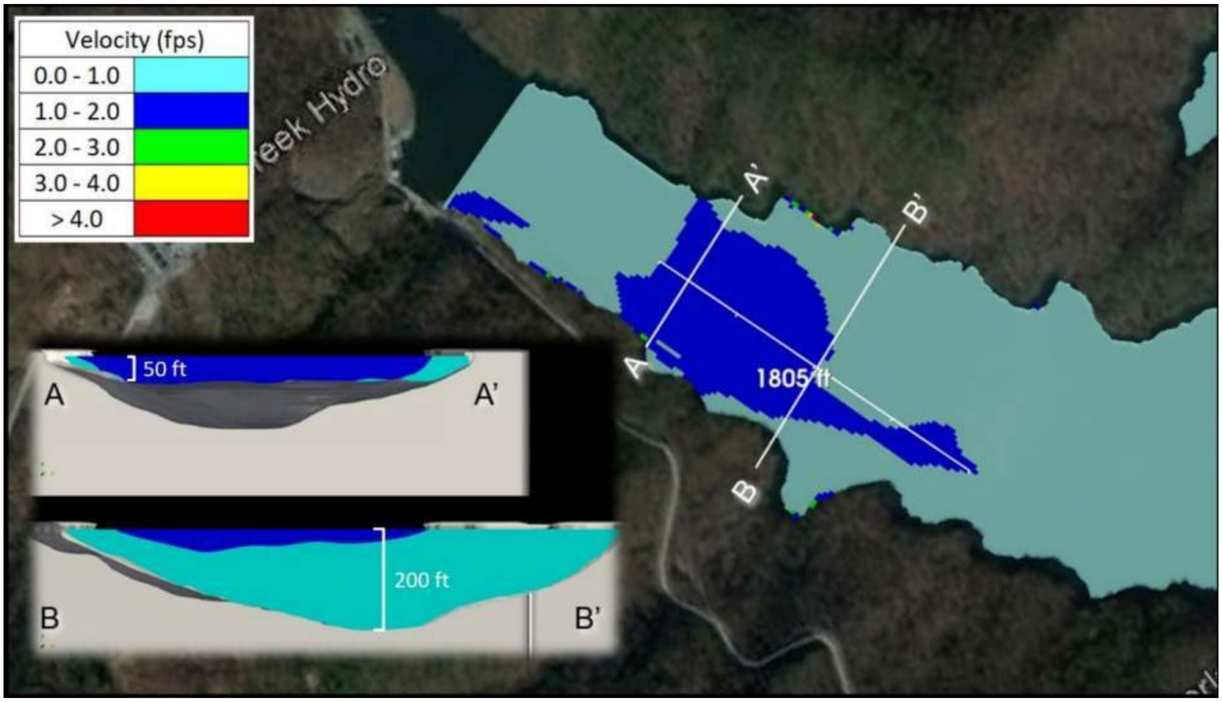

**Figure 2. Proposed Generation (Expanded Weir) at Full Pond (1,110 ft msl) – Velocity Contours in Submerged Weir Vicinity (Flow is Left to Right) (HDR 2023)**

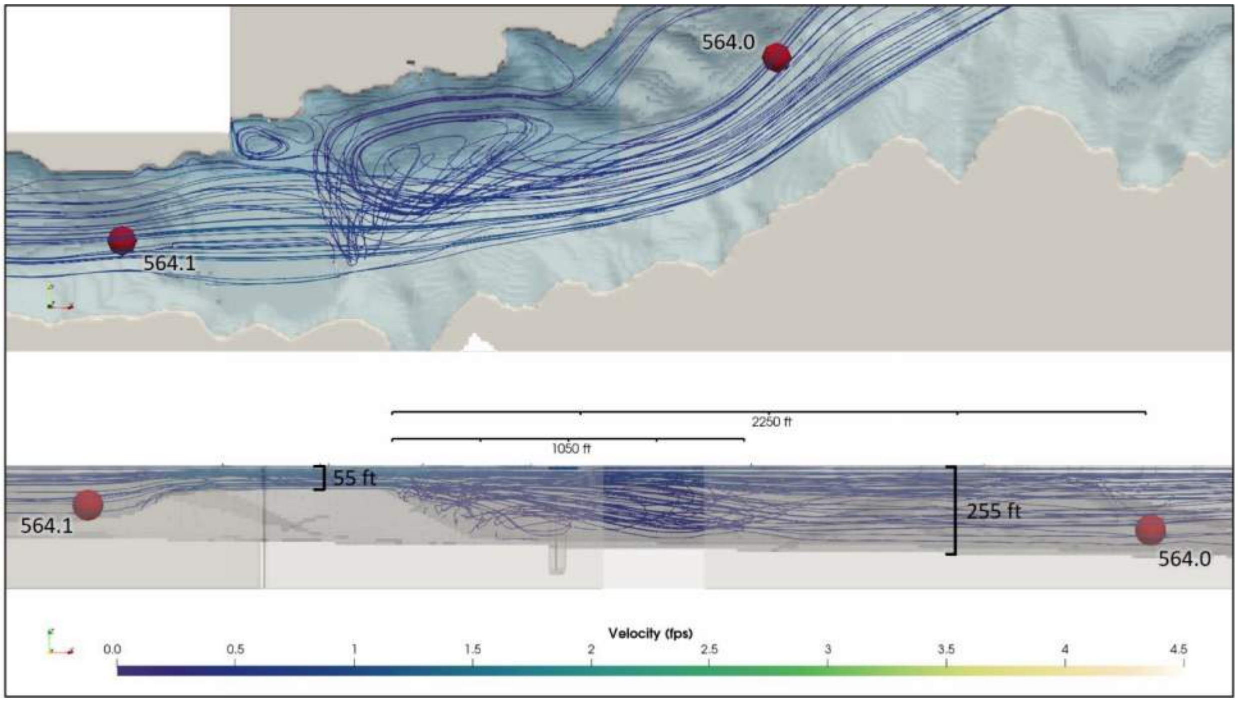

**Figure 3. Proposed Generation (Expanded Weir) at Full Pond (1,110 ft msl) – Whitewater River Cove Streamlines (flow is left to right, red circles represent water quality sampling locations) (HDR 2023)**

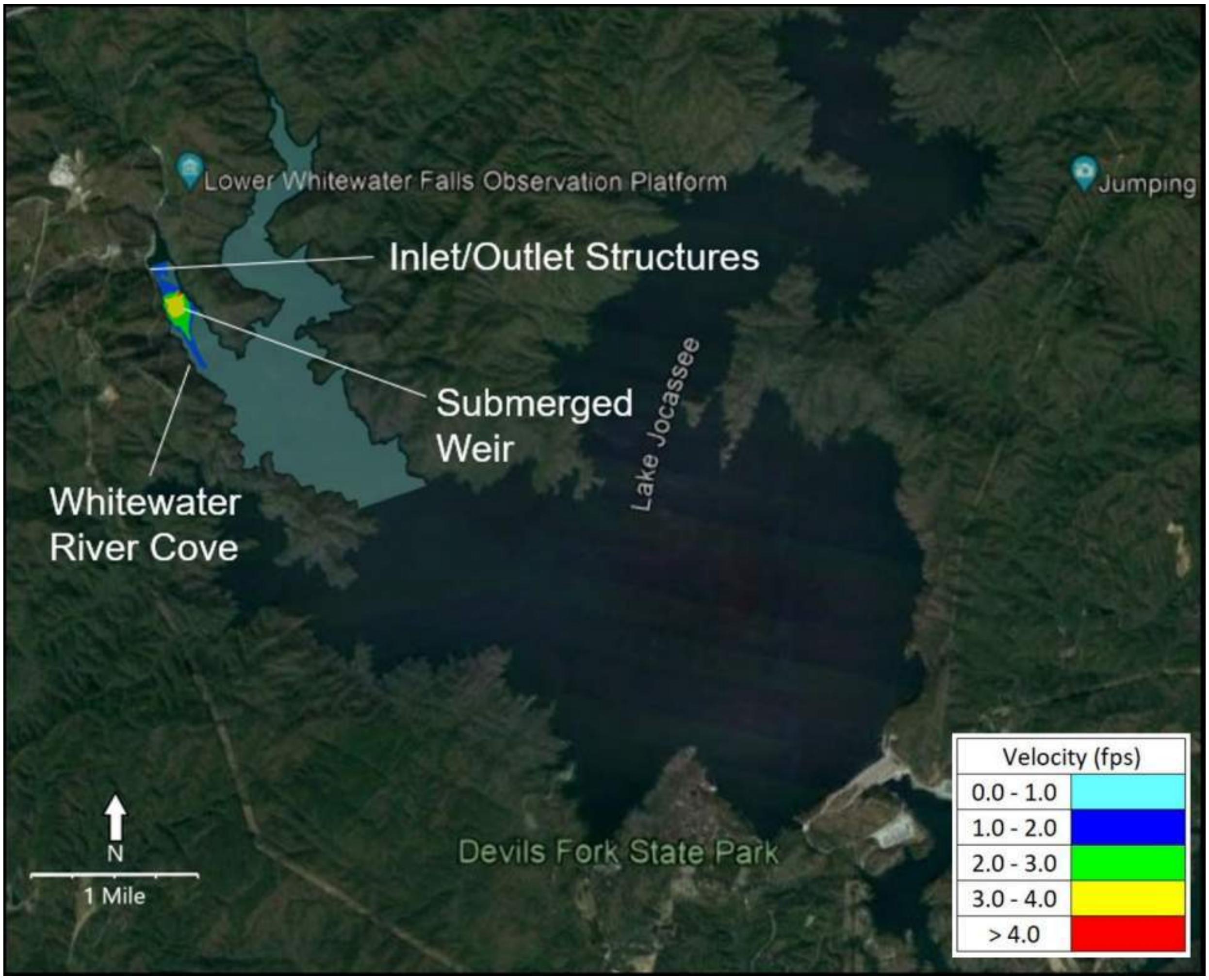

**Figure 4. Proposed Generation with Expanded Weir at Maximum Drawdown (1,080 ft msl – Velocity Contours (HDR 2023)**

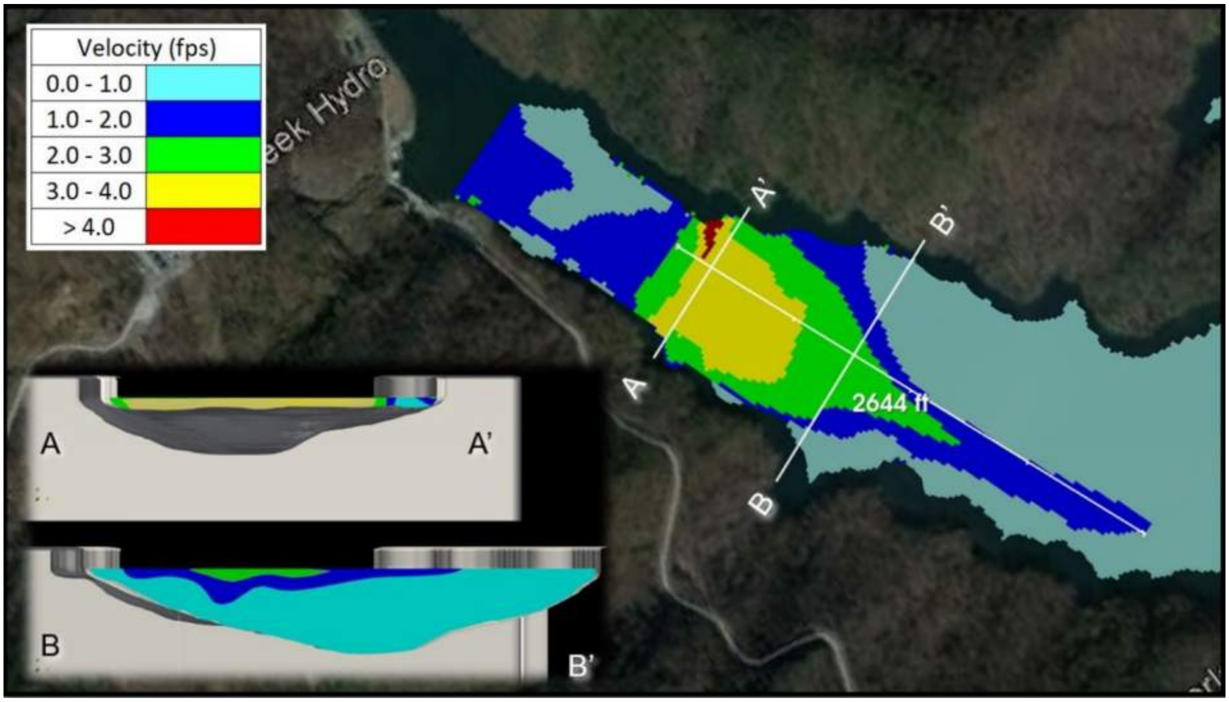

**Figure 5. Proposed Generation (Expanded Weir) at Maximum Drawdown (1,080 ft msl) – Velocity Contours in Submerged Weir Vicinity (Flow is Left to Right) (HDR 2023)**

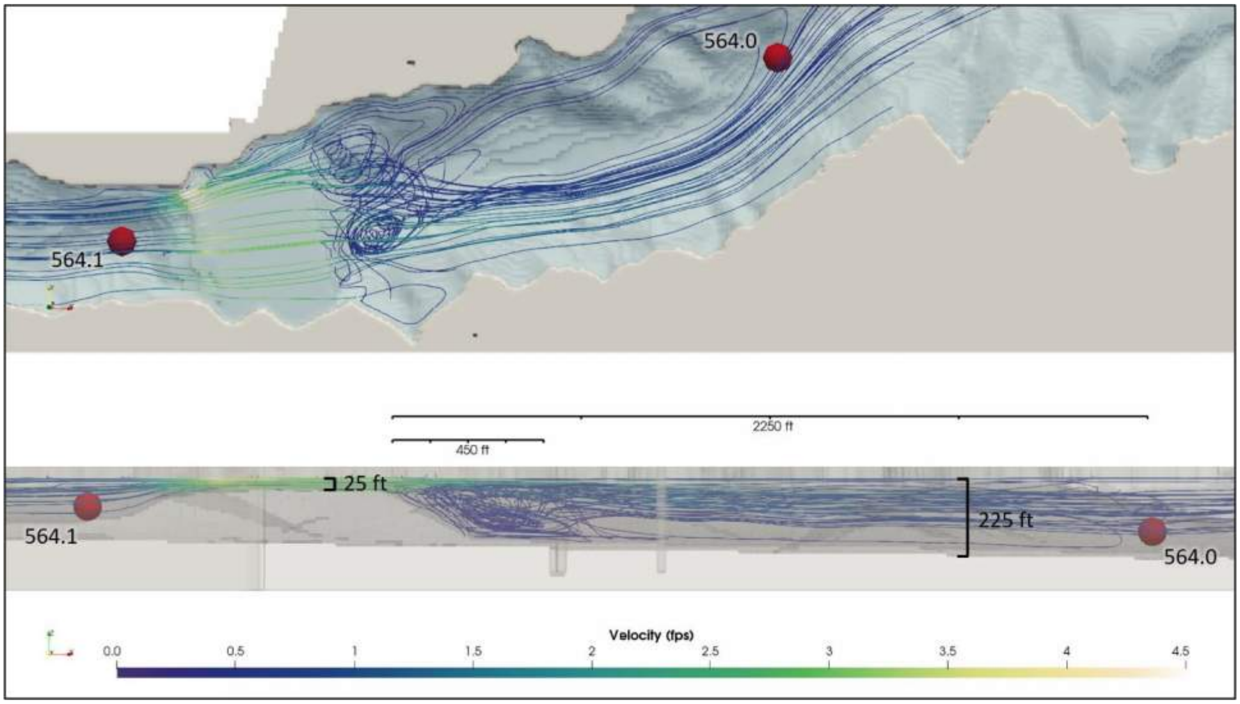

**Figure 6. Proposed Generation (Expanded Weir) at Maximum Drawdown (1,080 ft msl) – Whitewater River Cove Streamlines (flow is left to right, red circles represent water quality sampling locations) (HDR 2023)**

# Attachment C

## Attachment C – Littoral Habitat Figures

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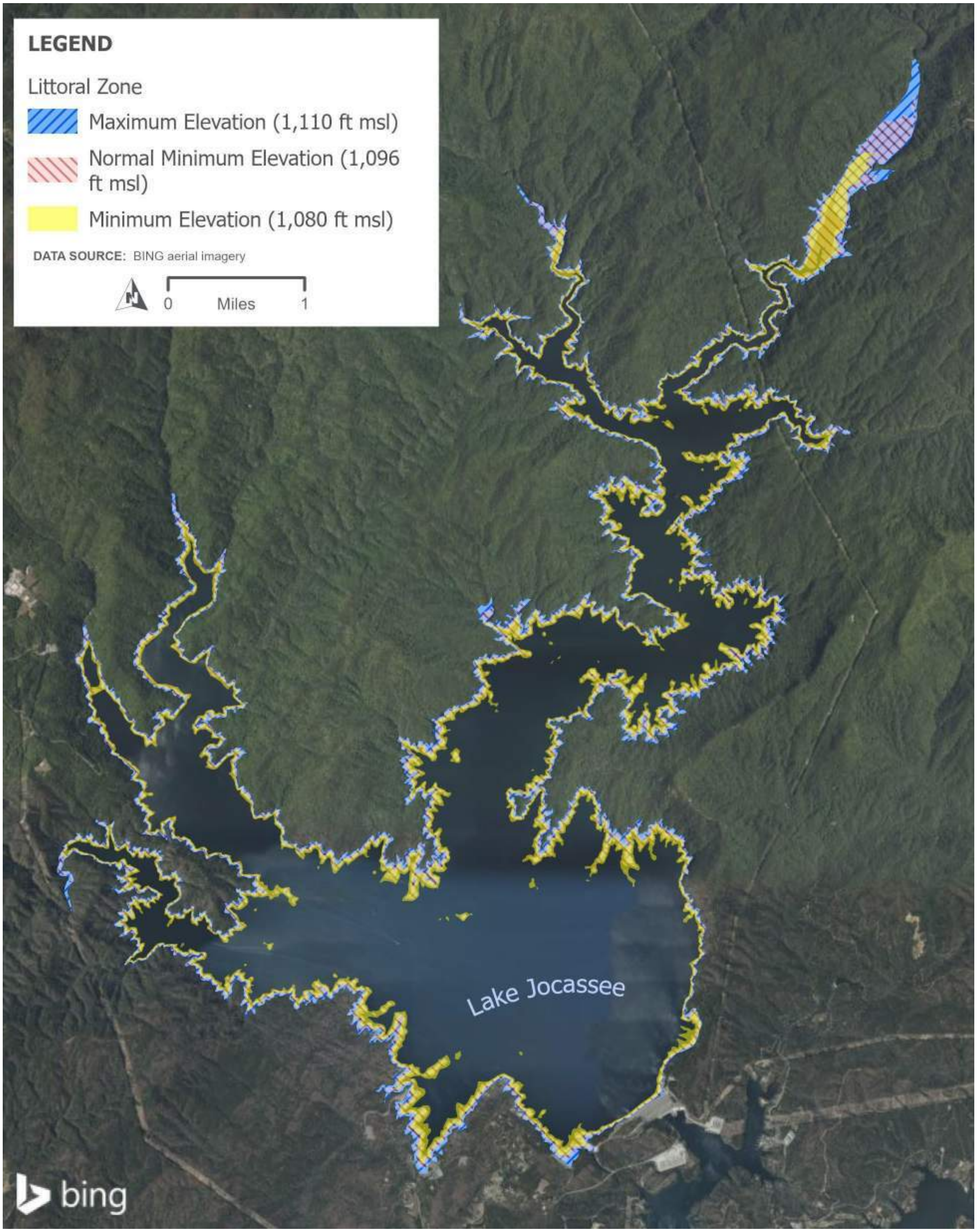
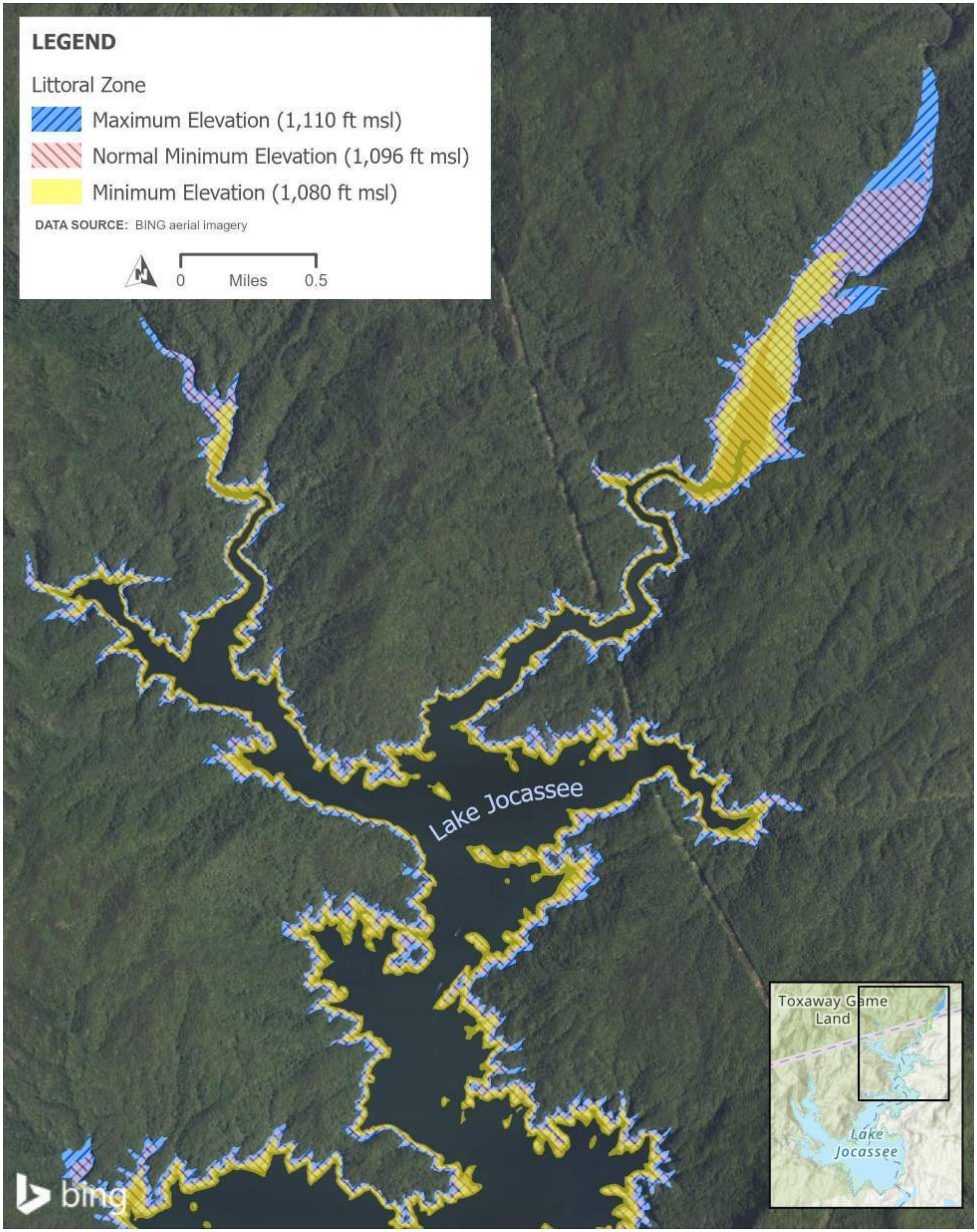
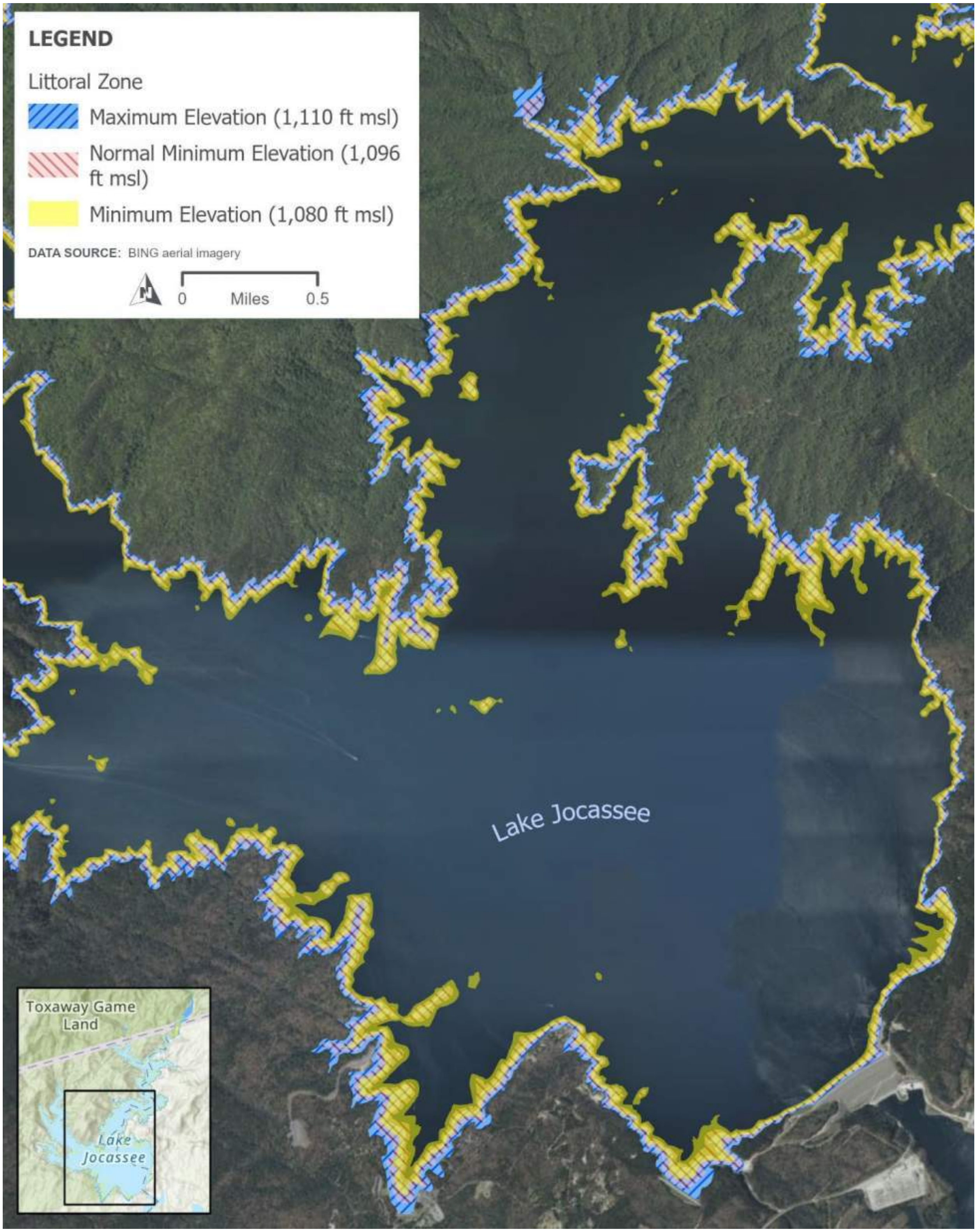

LEGEND
Littoral Zone
Maximum Elevation (1,110 ft msl)
Normal Minimum Elevation (1,096 ft msl)
Minimum Elevation (1,080 ft msl)
DATA SOURCE: BING aerial imagery
0
Miles
1
Lake Jocassee
bing


LEGEND
Littoral Zone
Maximum Elevation (1,110 ft msl)
Normal Minimum Elevation (1,096 ft msl)
Minimum Elevation (1,080 ft msl)
DATA SOURCE: BING aerial imagery
0
Miles
0.5
Lake Jocassee
bing
Toxaway Game Land
Lake Jocassee


LEGEND
Littoral Zone
Maximum Elevation (1,110 ft msl)
Normal Minimum Elevation (1,096 ft msl)
Minimum Elevation (1,080 ft msl)
DATA SOURCE: BING aerial imagery
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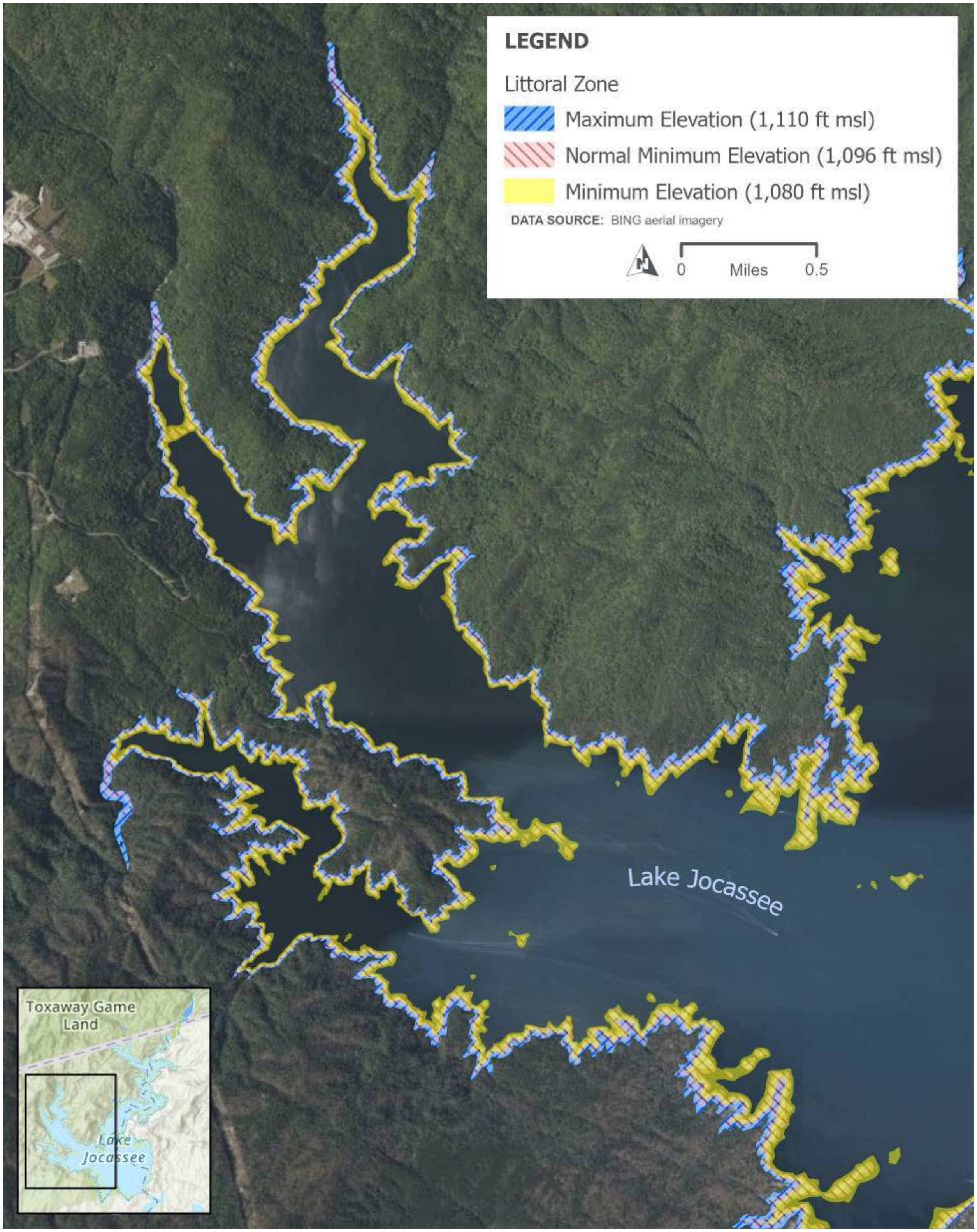
Lake Jocassee
Toxaway Game Land
Lake Jocassee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Maximum Elevation (1,110 ft msl)
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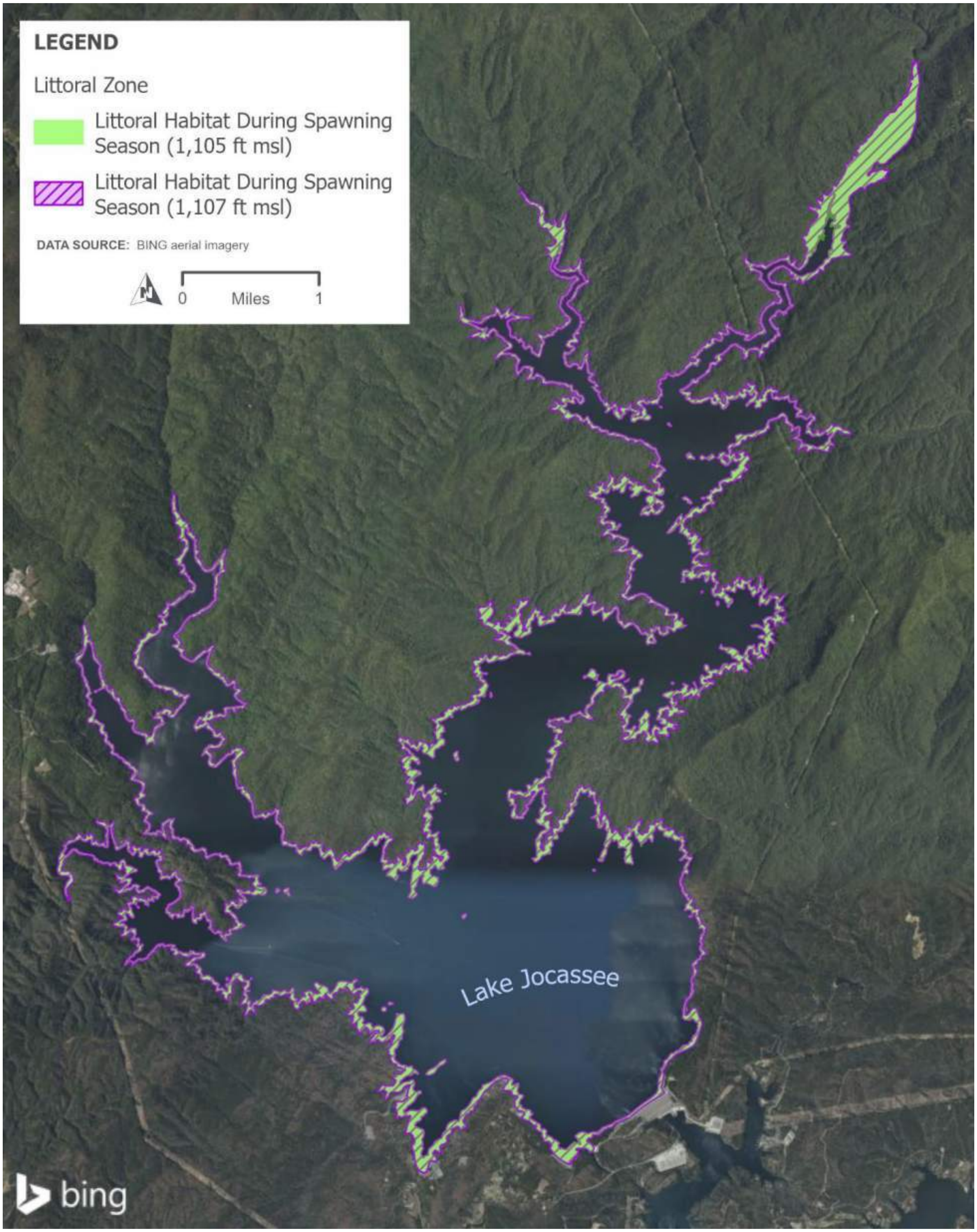
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Littoral Zone
Littoral Habitat During Spawning Season (1,105 ft msl)
Littoral Habitat During Spawning Season (1,107 ft msl)
DATA SOURCE: BING aerial imagery
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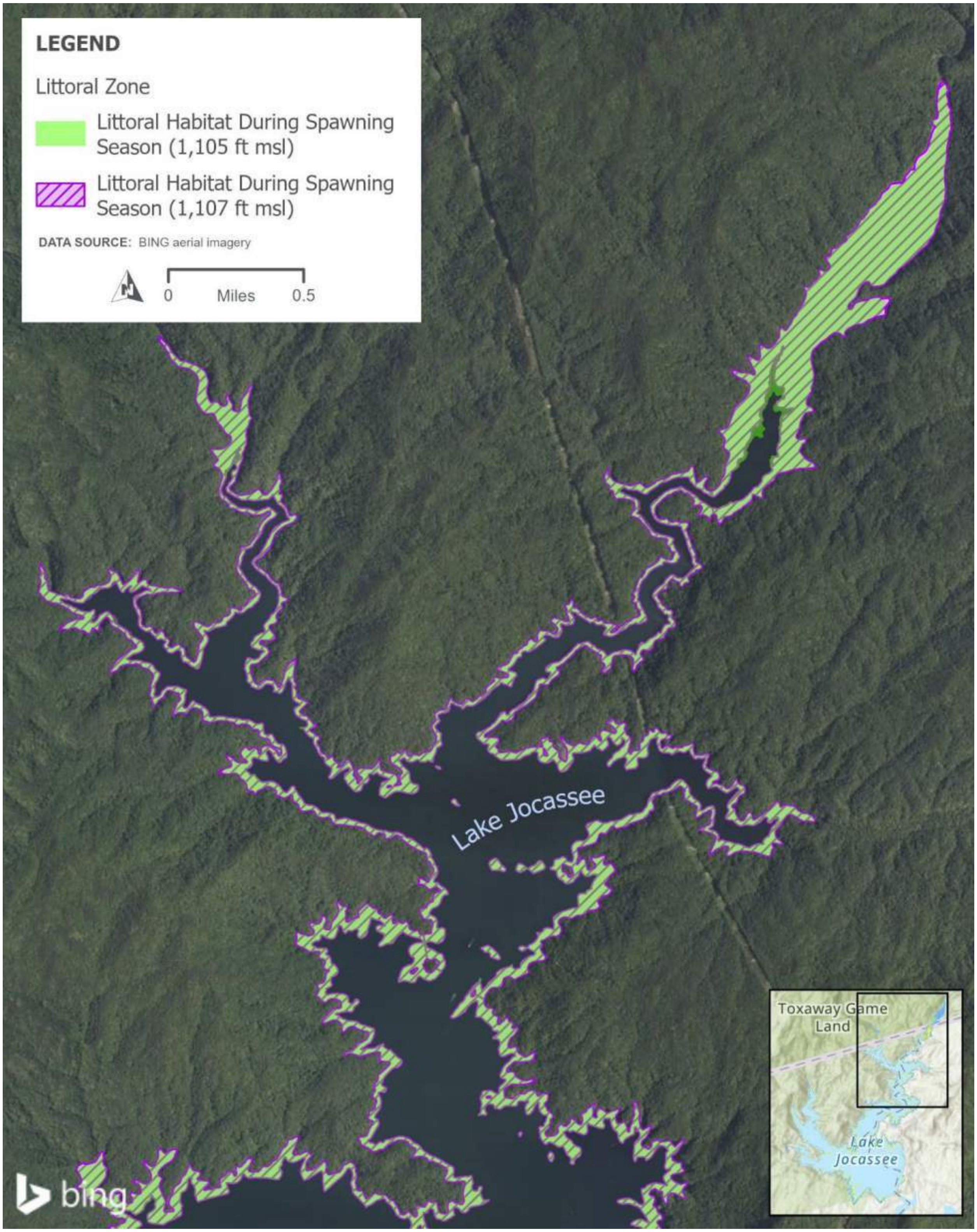
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▨ Littoral Habitat During Spawning Season (1,107 ft msl)
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LEGEND
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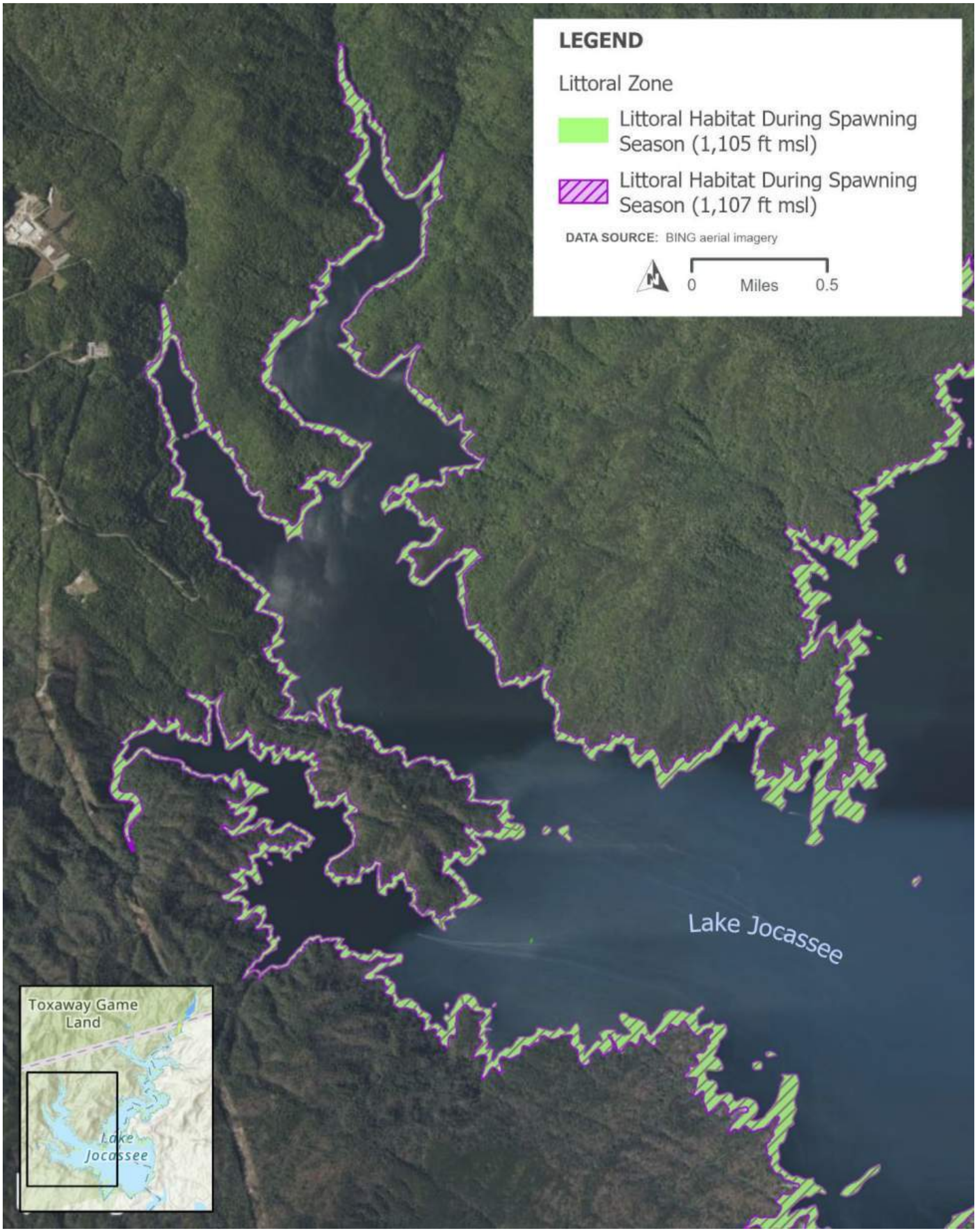
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🟩 Littoral Habitat During Spawning Season (1,105 ft msl)
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Toxaway Game Land
Lake Jocassee

# Attachment 3

## Impacts to Surface Waters and Associated Aquatic Fauna Final Report

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# IMPACTS TO SURFACE WATERS AND ASSOCIATED AQUATIC FAUNA

# FINAL REPORT

## AQUATIC RESOURCES STUDY

**Bad Creek Pumped Storage Project**
**FERC Project No. 2740**

*Oconee County, South Carolina*

*February 14, 2023*

# IMPACTS TO SURFACE WATERS AND ASSOCIATED AQUATIC FAUNA
# BAD CREEK PUMPED STORAGE PROJECT
# FERC PROJECT NO. 2740
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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| °C | degrees Celsius |
| Bad Creek (or Project) | Bad Creek Pumped Storage Project |
| Bad Creek II Complex | Bad Creek II Power Complex |
| BEHI | bank erosion hazard index |
| CFR | Code of Federal Regulations |
| CPUE | catch per unit effort |
| DBH | diameter at breast height |
| Duke Energy or Licensee | Duke Energy Carolinas, LLC |
| EPT | Ephemeroptera, Plecoptera, and Trichoptera |
| FERC or Commission | Federal Energy Regulatory Commission |
| KT Project | Keowee-Toxaway Hydroelectric Project |
| mg/L | milligrams per liter |
| NBS | near-bank stress |
| NCDWQ | North Carolina Division of Water Quality |
| NCSAM | North Carolina Stream Assessment Method |
| Protocol | SCDNR Fish Collection Protocols for Streams |
| RBP | Rapid Bioassessment Protocol |
| RSP | Revised Study Plan |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| SCDNR | South Carolina Department of Natural Resources |
| SQT | Stream Quantification Tool |
| USACE | U.S. Army Corps of Engineers |
| USEPA | U.S. Environmental Protection Agency |

# 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 (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 final report includes the methods and results from Task 3 (Impacts to Surface Waters and Associated Aquatic Fauna) 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.

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

# 2 Goals and Objectives

Tasks carried out for the Bad Creek Aquatic Resources Study employed standard methodologies that are consistent with the scope and level of effort described in the RSP filed with the Commission on December 5, 2022 (Duke Energy 2022). 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 Power Complex (Bad Creek II Complex).

This report was developed in support of Task 3 of the Aquatic Resources Study (Impacts to Surface Waters and Associated Aquatic Fauna). The main objective of this task is as follows:

- Evaluating potential direct impacts to aquatic habitat (including wetlands) related to Bad Creek II Complex construction activities and weir expansion by quantifying and characterizing surface waters, including resource quality.

This objective was met through a combination of activities, including desktop description of impacted surface waters, previously conducted Natural Resource Assessments of areas of potential impact, and presence/absence of mussels and characterization of habitat quality through surveys of streams in the potential spoil deposition areas.

Duke Energy is proposing the development of a temporary access road to provide an alternate route to the Fisher Knob community during Bad Creek II Complex construction. The potential 3.7-mile-long predominantly gravel road was not proposed at the time of RSP filing. Therefore, in addition to assessing surface waters that have the potential to be impacted by construction as described in the RSP, Duke Energy evaluated surface waters that would be crossed by the access road, with the same goals and objectives as those established in the RSP.

# 3 Study Area

The study area includes the shoreline of Lake Jocassee, streams within potential upload spoil locations, and streams and creeks that would be crossed by the potential temporary access road as described in the June 28, 2023, Relicensing Study Progress Report No. 2 filed with FERC (Figure 3-1).

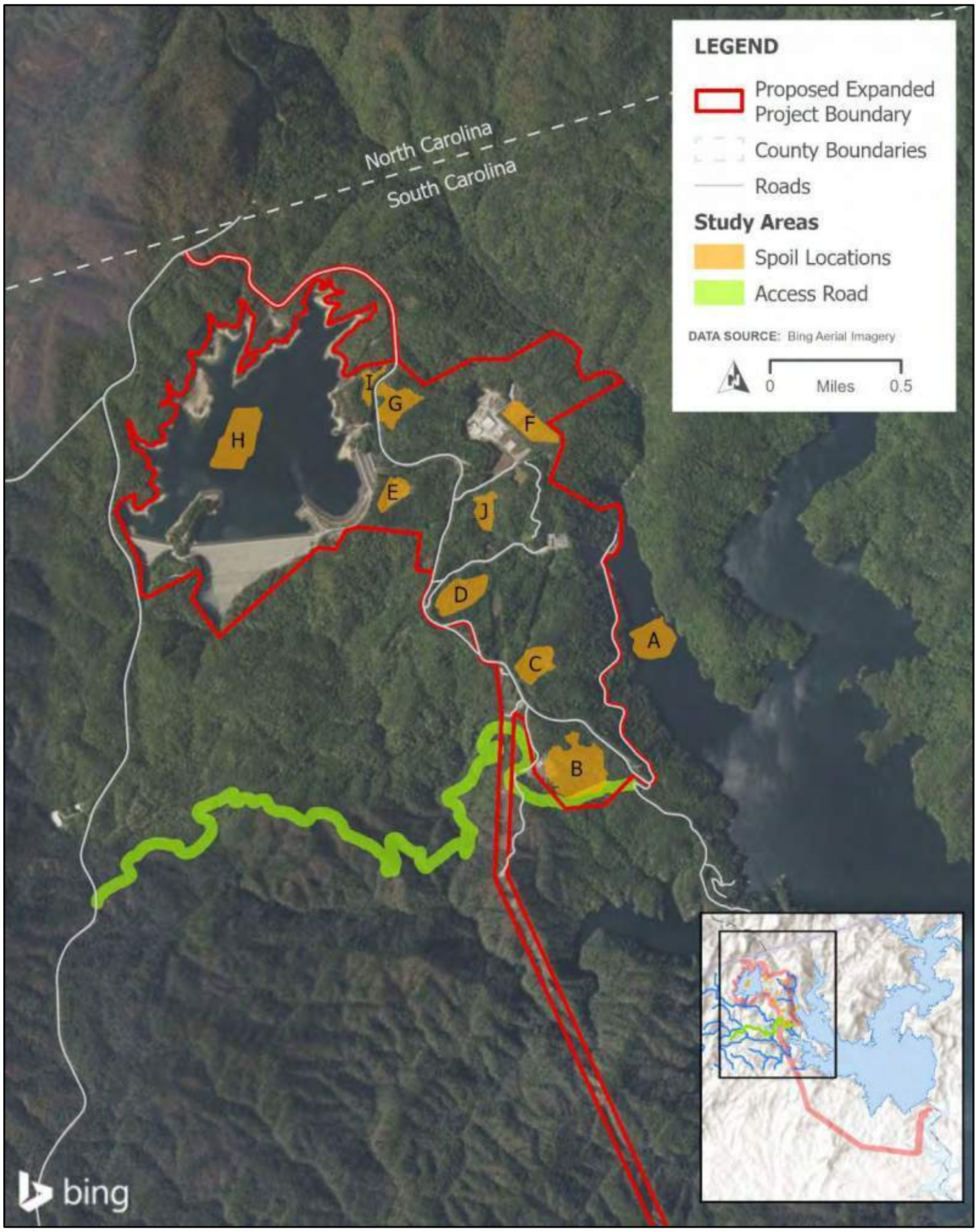

**Figure 3-1. Potential Spoil Locations and Proposed Temporary Access Road Study Area**

# 4 Overview

Construction of the Bad Creek II Complex would impact existing streams and waterbodies, including wetlands. Overburden (i.e., soil and rock) material from the construction activities are proposed to be deposited in spoil locations throughout the site. Siting for spoil location alternatives is ongoing by Duke Energy, with consideration of existing natural resources that are identified during site investigations, existing topography, and quantity of material used to expand the submerged weir in Lake Jocassee (if pursued). Although Duke Energy will avoid and minimize impacts to surface waters and wetlands to the extent practicable, it is likely that impacts to streams and wetlands will occur as a result of spoil placement.

Duke Energy is also proposing the development of a temporary access road to provide an alternate route to the Fisher Knob community and Project during the period of Bad Creek II Complex construction. The access road would be decommissioned following Project construction completion.

Duke Energy proposed to evaluate the aquatic resources (streams, wetlands, and Lake Jocassee) that may experience direct impacts from spoil placement or other construction activities. This included a characterization of aquatic resources with respect to stream types as indicated from natural resources assessments, habitat quality, and potential fauna (mussels) presence. Field activities in support of this study task are outlined below.

# 5 Methods

General methods for stream habitat quality surveys and mussel surveys were provided in the Aquatic Resources RSP and are detailed further below. With the addition of the proposed temporary access road and through consultation with the South Carolina Department of Natural Resources (SCDNR), additional methodologies (described below) related to the South Carolina Stream Quantification Tool (SQT) were adapted by Duke Energy into the study. A memo developed as a summary of stream survey approach methods prepared in consultation with SCDNR and filed with the Commission with the September 28, 2023, Relicensing Study Progress Report No. 3 is provided as Attachment A (HDR 2023).

## 5.1 Natural Resources Assessments

Natural resources assessments of the potential upland spoil locations were conducted using a combination of desktop and field assessments while applying methodologies and guidance described in the U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual (USACE 1987), the 2012 USACE Eastern Mountains and Piedmont Regional Supplement (Version 2.0) (USACE 2012),  USACE Regulatory Guidance Letter 05-05 Ordinary High Water Mark Identification, and the North Carolina Division of Water Quality (NCDWQ) Methodology for Identification of Intermittent and Perennial Streams and Their Origins (Version 4.11) (NCDWQ 2010).

A delineation of surface waters and wetlands crossed by the temporary access road was completed following the same USACE and NCDWQ guidance, including flagging in the field and recording with a sub-meter accuracy GPS. The delineation was completed for a 100-foot buffer around the potential temporary access road.

## 5.2 Stream Habitat Quality Surveys

As stated in Section 4, the disposal of overburden material in upland locations would result in impacts to streams and wetlands and will require an individual permit from the USACE and water quality certification from South Carolina Department of Health and Environmental Control (SCDHEC) under the authorities of Sections 404 and 401 of the Clean Water Act. In preparation for these expected regulatory processes (if Bad Creek II Complex is pursued), stream habitat quality surveys were completed to provide a physical assessment of the existing conditions of streams that have the potential to be impacted.

### 5.2.1 Rapid Bioassessment Protocol

In accordance with the FERC-approved Aquatic Resources RSP, the stream habitat assessment portion of the U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocol (RBP) was completed for streams within potential spoil locations. Streams and creeks crossed by the temporary access road were also assessed, as described in the Relicensing Study Progress Report No. 3 filed with FERC on September 28, 2023, and the Aquatic Resources Study Approach to Stream Surveys technical memo, which has undergone stakeholder review. These assessments provide information regarding stream functionality and condition, which in turn can indicate the value of aquatic habitat to aquatic and terrestrial life, and ecosystem services such as nutrient reduction and support of watershed health. The USEPA RBP includes an evaluation of the variety and quality of (1) stream substrate, (2) channel morphology, (3) bank structure, and (4) riparian vegetation (Barbour et al. 1999). Ten parameters across four condition categories (e.g., poor, marginal, suboptimal, or optimal) were rated on a numerical scale of zero to twenty for each sampled reach, with higher scores indicating supportive conditions. Total scores were then compared to reference reach conditions for an overall index. Reference reaches are stable segments of streams against which streams can be compared for optimal condition.

### 5.2.2 North Carolina Stream Assessment Method

The North Carolina Stream Assessment Method (NCSAM) was completed for streams within potential spoil locations and streams or creeks crossed by the temporary access road. The NCSAM rates streams for three Class 1 functions: hydrology, water quality, and habitat. Within each Class 1 function, streams are rated for up to eight Class 2 functions, which may include Class 3 and Class 4 functions. The functions provided by a stream are a product of the hydrologic, geologic, morphologic, and vegetational setting of the stream and its drainage area (Gordon et al. 1992 as cited by N.C. Stream Functional Assessment Team 2013). Alterations and/or stressors can contribute to the degradation of a stream, either naturally or anthropogenically, including storm damage, excessive vegetation, beaver impoundment, stream migration, and sedimentation, which can lead to lower stream function. Parameters evaluated with NCSAM protocol include flow restrictions; streambank erosion; buffer size and type; water quality stressors; substrate composition; in-stream habitat; visual and dip netting assessments for aquatic life; presence of wetlands; shade; and others.

The NCSAM utilizes a Boolean logic chain of reasoning to convert metric evaluation results into qualitative functional ratings for individual metrics, function classes, and an overall functional rating.

### 5.2.3 South Carolina Stream Quantification Tool

The SC SQT was developed in a collaborative effort between federal and state representatives to provide a tool for assessing and quantifying functional lift and loss of streams in South Carolina. In May 2023, the SCDNR requested that Duke Energy apply the SQT methods to streams within potential spoil locations and streams crossed by the temporary access road. Duke Energy consulted with the SCDNR in May and June 2023 regarding the applicability and methodology of the SQT for stream assessments. In July 2023, Duke Energy and the SCDNR conducted a site visit to two potential spoil locations representative of conditions across the site. It was agreed among the SCDNR staff and Duke Energy personnel that streams within potential spoil locations are generally high functioning with limited (if any) anthropogenically caused degradation, and that field data collection to support SQT analysis for streams in these areas were not likely to produce significantly different results (i.e., lower functionality scores) than an assumption of fully functional. Therefore, Duke Energy proposed to field survey streams potentially crossed by the temporary access road, only. Documentation of all consultation for the Aquatic Resources study is included in Attachment 4 of Appendix B of the Initial Study Report.

Reach lengths for SQT assessments were 100 linear feet upstream and downstream at each potential temporary access road stream crossing based on the results of the stream and wetland delineation completed in September 2023 (see Section 5.1). Each stream was segmented into "upstream" and "downstream" reaches to facilitate comparison of stream conditions before (i.e., baseline) and after construction of the temporary access road and to provide a means for considering natural events which may influence the condition of the streams. For example, a major storm event resulting in high flows and movement of large woody debris could influence stream geomorphology and overall condition. To determine how natural events may affect the stream, the upstream reach will function as a control comparison during the period in which the road crossing is installed.

Stream surveys consisted of assessment of five functional categories including hydrology, hydraulics, geomorphology, physiochemical, and biology (South Carolina Steering Committee 2022a). Depending on the anticipated type of impact or lift, physiochemical and biology categories are optional. Guidance from the SQT suggests physiochemical parameters be measured for stream projects with "goals or objectives related to physiochemical functions or where watershed conditions suggest that uplift is possible." Construction of the proposed Fisher Knob access road would be conducted from upland locations and no in-water work would occur. Best management practices to prevent sedimentation, such as silt fencing, would be installed to prevent water quality impacts at stream crossings. Given that impacts to water quality are not anticipated and appropriate stream protection measures will be taken, no physiochemical monitoring was conducted.

#### 5.2.3.1 Hydrology, Hydraulics, and Geomorphology

All streams crossed by the proposed access road were surveyed for the first three functional categories of the SQT (hydrology, hydraulics, and geomorphology). Stream geomorphic measurements were made using tapes, stadia rod, and a line level per the Rapid Method approach described in the SQT Data Collection and Analysis Manual[2] (South Carolina Steering Committee 2022a).

The field team identified bankfull indicators along the 100-foot reach and selected a stable riffle for the dimension survey. The channel was surveyed by stretching the tape between bankfull indicators on each bank and leveled via line level. The depth from bankfull was measured across the channel bottom and recorded. The field team used these data to compare to regional curves (SCDNR 2020) for bankfull verification.

Riffle and pool data (e.g., bankfull depth, bankfull width, low bank height, flood prone width, maximum pool depth, etc.) were collected at each feature along the reach. Due to difficulty in the field with dense vegetative cover and limited line-of-sight, stream and valley slope was measured via GIS with 2-foot topography. Stream sinuosity was also measured via GIS using the stream boundaries delineated during the natural resources assessment.

Assessments of large woody debris and bank erosion/near bank stress were made for each stream reach. Large woody debris (defined as dead and fallen wood over 1 meter in length and at least 10 centimeters in diameter at its largest end, within the channel or touching the top of streambank) was noted for each stream reach. Bank erosion was documented where present and bank erosion hazard index (BEHI) and near-bank stress (NBS) calculated.

As part of the geomorphology assessment, one 10-meter-by-10-meter vegetation plot was established on either side of channel for each stream reach and the vegetation community observed was documented in accordance with the Carolina Vegetation Survey level 2 method

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[2] https://www.dnr.sc.gov/sqt/docs/SC_SQT_Data_Collection_and_Analysis_Manual.pdf

(Lee et al. 2008). Diameter at breast height (DBH) was measured for all woody vegetation greater than 1.37 meters tall and the number of stems counted.

#### 5.2.3.2 Stream Quantification Tool Analysis

The SQT was implemented at each 100-foot stream reach. Index values (from 0.00 to 1.00) were calculated from the metrics entered for each of the functional categories described above. For parameters incorporating more than one metric, index values were averaged. Parameter scores were then averaged to calculate total functional category scores, and scores weighted and summed by the tool for an overall existing condition score.

**Table 5-1. Summary of Parameters and Metrics used in the Stream Quantification Tool**

| Functional Category | Function-Based Parameters | Metrics |
|---|---|---|
| Hydrology | Reach Runoff | Land Use Coefficient |
| | | Concentrated Flow Points (No./1,000 ft) |
| Hydraulics | Floodplain Connectivity | Bank Height Ratio (ft/ft) |
| | | Entrenchment Ratio (ft/ft) |
| | Flow Dynamics | Width/Depth Ratio State (observed/expected) |
| Geomorphology | Large Woody Debris (LWD) | LWD Piece Count (No./100 m) |
| | Lateral Migration | Dominant BEHI/NBS |
| | | Percent Streambank Erosion (%) |
| | Riparian Vegetation | Buffer Width (ft) |
| | | Average DBH (inches) |
| | | Tree Density (No./acre) |
| | Bed Form Diversity | Pool Spacing Ratio (ft/ft) |
| | | Pool Depth Ratio (ft/ft) |
| | | Percent Riffle (ft/ft) |

Source: South Carolina Steering Committee 2022a; ft= feet/foot; No.= number

## 5.3 Fish Community Sampling

Fish community sampling was completed in Limber Pole and Howard creeks following the Fish Collection Protocols for Streams (Protocol) as described in the SCDNR Fish Sampling Guidance (SCDNR 2022) for the Blue Ridge ecoregion. Electrofishing reach lengths were determined based on the mean width of the reach with a minimum of 100 meters consistent with the Protocol. Natural obstructions (e.g., riffles, log jams, or falls) were also utilized to define sampling reach boundaries when possible. A calibrated multiparameter water quality data sonde was used to record existing water quality conditions during sampling events, including temperature, dissolved oxygen, conductivity, pH, salinity, and turbidity.

The number of electrofishing units and netters varied based on stream width and followed the Protocol. Electrofishing crews worked in an upstream direction, and all stunned fish were collected along with any reptiles or amphibians incidentally encountered. Immediately after capture, fish were placed in an aerated five-gallon bucket and processed at the mid-point and/or end of sampling depending on the reach length. All fish were identified to species and a subset of each species was measured for total length to the nearest millimeter.

## 5.4 Macroinvertebrate Sampling

Aquatic macroinvertebrates are good indicators of water quality due to their sensitivity to changes in physical, chemical, and biological conditions(USEPA 2023). Organisms within the Ephemeroptera, Plecoptera, and Trichoptera (EPT) genera are particularly sensitive to poor water quality and intolerant to pollution, therefore the presence of species within these groups indicate good water quality. Macroinvertebrate surveys were completed following the *SCDHEC Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling* (SCDHEC 2017). This method includes a timed-qualitative multiple habitat sampling protocol to collect macroinvertebrates, which allows for sampling representative macroinvertebrate taxa from the variety of natural habitats within a stream.

Procedures included sampling with kick nets, D-shaped dip nets, and sieves with the goal to collect as many different macroinvertebrate taxa as possible during a specified amount of time in multiple habitat types. More details on sampling methods are included in the following sections. Samples collected from all three sampling methods were combined into a sieve bucket. Organisms are separated or “picked” from the rest of the sample in the field using forceps and picking trays and preserved in glass vials containing 85 percent ethyl alcohol. Organisms were picked in approximate proportion of their abundance and no attempt was made to remove all specimens encountered. Organisms collected and preserved in vials in the field were shipped to a certified taxonomist Pennington & Associates Inc, for identification to the lowest taxonomic level to calculate species taxa richness which is of the number of different kinds of organisms (taxa) in a collection and biotic index score for each site.

### 5.4.1 Kick Net Collection

A 1.0-meter-square 500-1000-micron mesh net attached between poles was used for kick net sampling in riffles. The kick net was placed downstream of the riffle area sampled and held in place on either side by two biologists to catch macroinvertebrates and debris that drift into the net. The third biologist perturbed the substrate from upstream, including dislodging cobble and small boulders, moving downstream towards the net. Contents collected in the kick net were rinsed into a sieve bucket.

### 5.4.2 D-frame Dip Net Collection

D-frame dip nets were used to sample root wad habitats, generally located along stream margins, as well as aquatic vegetation, if present. Root wads were sampled by repeatedly thrusting a 500-micron D-frame dip net upwardly into the roots along a stretch of bank until the net was approximately one-quarter full of detritus and root debris. Several randomly selected root wads were also washed down by hand into the dip net to remove firmly attached macroinvertebrates. Aquatic vegetation was sampled by sweeping the dip net through the vegetation. Contents of the dip net sampling were rinsed into the same sieve bucket with the kick net sample for a wholly representative sample of the stream.

### 5.4.3 Leaf Pack Collection

Mature leaf packs were collected at areas with swift moving water and placed in the sieve bucket and discarded after elutriation. The macroinvertebrates remaining in the sieve bucket were included with those from the kick net and D-frame dip net. Samples from the sieve bucket were transferred to picking trays and macroinvertebrates were removed using forceps and preserved in glass vials containing 85 percent ethyl alcohol.

### 5.4.4 Visual Collection

The intent of visual collections was to specifically target microhabitats that were not sampled using the aforementioned collection methods. Stream habitat components including large-grained substrate, recessed rock crevices, woody debris, mature leaf packs, roots, and other debris were searched for macroinvertebrates, which were collected directly with forceps and placed in the glass vials containing 85 percent ethyl alcohol.

## 5.5 Mussel Surveys

Mussel surveys consisted of an assessment for supportive habitat, followed by timed searches where suitable habitat was identified. Suitable habitat was defined as areas with appropriate substrate (sand and gravel), presence of fish hosts for glochidia, and potentially, evidence of live mussels or shells. Mussel habitat was evaluated for streams within potential spoil locations, streams and creeks crossed by the potential temporary access road, and along the portion of Lake Jocassee's shoreline included in the study area.

Mussel surveys followed methods adapted from the USEPA Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys for the Development of Site-specific Water Quality Criteria for Ammonia (USEPA 2013). The survey consisted of timed visual and tactile searches for mussels in areas identified with suitable habitat. Timed searches were a minimum of four person-hours in Lake Jocassee and one person-hour in creeks. Habitat conditions at each sampling location were recorded including substrate conditions, shoreline composition, and basic water quality parameters (water temperature, dissolved oxygen).

# 6 Results

## 6.1 Natural Resource Assessments

The natural resources assessment to identify surface waters and wetlands within potential spoil locations was completed in September 2021 and along the proposed temporary access road in September 2023. The 2021 natural resources assessment report was attached as Appendix E to the Pre-Application Document filed with FERC in February 2022 (HDR 2021). The surface waters and wetlands within the potential spoil locations are summarized in Table 6-1 and depicted on figures provided in Attachment B. Resources identified include nine streams, three wetlands, and one open waterbody.

**Table 6-1. Summary of Surface Waters and Wetlands estimated[1] within Potential Spoil Locations**

| Name | Type | Spoil Location | Extent (linear feet or acres) |
|---|---|---|---|
| **Streams (linear feet)** | | | |
| Stream 4 | Intermittent | G | 942 |
| Stream 4a | Perennial | G | 542 |
| Stream 11 | Unknown | J | 148 |
| Stream 13 | Intermittent | D | 227 |
| Stream 14 | Perennial | D | 770 |
| Stream 17 | Perennial | C | 286 |
| Stream 19 (Devils Fork) | Perennial | B | 1,129 |
| Stream 20 | Perennial | B | 577 |
| Stream 21 | Unknown | B | 172 |
| | | *Total* | *4,793* |
| **Wetlands (acres)** | | | |
| Wetland 4 (isolated) | Emergent | F | 0.37 |
| Wetland 7 (isolated) | Forested | F | 1.15 |
| Wetland 10 (isolated) | Emergent | E | 2.96 |
| | | *Total* | *4.48* |
| **Open Waterbodies (acres)** | | | |
| Lake Jocassee | Freshwater | A | 12.7 |

[1] Extent of surface waters and wetlands was estimated using desktop resources and field investigations. A delineation of surface waters is planned to be completed in 2024.

[2] Spoil location J was added after filing the Pre-Application Document, however the area was evaluated during the 2021 Natural Resources Assessment.

The 2023 natural resources assessment identified six streams or creeks crossed by the access road if the Bad Creek II Complex is pursued and the Fisher Knob access road is constructed. Streams include Limber Pole Creek, Howard Creek, Devils Fork, and three unnamed tributaries. Additional unnamed tributaries and wetlands were identified and delineated within the 100-foot buffer of the potential temporary access road, however stream habitat quality surveys and mussel surveys completed for this study considered only those crossed by the potential temporary access road. Streams and wetlands estimated or delineated along the temporary access road route are summarized in Table 6-2 and depicted on figures provided in Attachment B. Note that Devils Fork was surveyed at both locations; the survey location of “Stream 19” denoted in Table 6-1 was several hundred feet upstream of the survey location of “Stream 17”, where the potential temporary access road would cross this feature.

**Table 6-2. Streams and Wetlands identified along the Temporary Access Road**

| **Name** | **Type** | **Extent (linear feet or acres)** | **Potentially Crossed by Access Road (Y/N)** |
|---|---|---|---|
| **Streams (linear feet)** | | | |
| Stream 1 (Limber Pole Creek) | Perennial | 397 | Y |
| Stream 2 | Perennial | 273 | N |
| Stream 3 | Perennial | 62 | N |
| Stream 4 | Intermittent | 314 | N |
| Stream 5 | Perennial | 48 | N |
| Stream 6 | Intermittent | 621 | N |
| Stream 7 (Howard Creek) | Perennial | 516 | Y |
| Stream 8 | Intermittent | 69 | N |
| Stream 9 | Perennial | 180 | N |
| Stream 10 | Intermittent | 95 | N |
| Stream 11 | Perennial | 166 | N |
| Stream 12 | Intermittent | 763 | Y |
| Stream 13 | Intermittent | 208 | N |
| Stream 15 | Perennial | 397 | Y |
| Stream 16 | Perennial | 717 | Y |
| Stream 17 (Devils Fork at road crossing) | Perennial | 295 | Y |
| Stream 18 | Intermittent | 87 | N |
| **Wetlands (acres)** | | | |
| Wetland 1 | Emergent | 0.02 | N |
| Wetland 2 | Emergent | 0.01 | N |
| Wetland 3 | Emergent | 0.00 | N |
| Wetland 4 | Emergent | 0.02 | N |
| Wetland 5 | Emergent | 0.02 | N |
| Wetland 6 | Forested | 0.16 | N |

## 6.2 Stream Habitat Quality Surveys

Stream habitat quality surveys were completed for streams within potential spoil areas and those potentially crossed by the temporary access road as identified during the Natural Resources Assessment (see Section 6.1); however, USEPA RPB and NCSAM forms were not completed for Stream 11 (spoil location J), Streams 13 and 14 (spoil location D), or 20 and 21 (spoil location B) due to inclement weather which presented a safety concern at the time staff was on site.

### 6.2.1 Rapid Bioassessment Protocol

USEPA RBP data forms were completed in September 2023 for streams within potential spoil locations and potentially crossed by the temporary access road. All streams scored above 100 in the "optimal" or "suboptimal" range (Table 6-3). Some streams had reduced scores related to limited baseflow conditions (less aquatic habitat) and/or microhabitat characteristics (e.g., presence of epifaunal substrate, level of embeddedness, velocity/depth regime, etc.). USEPA RBP data forms for the assessed streams are provided in Attachment C.

**Table 6-3. Summary of USEPA Rapid Bioassessment Protocol Stream Habitat Assessments**

| Stream Name / Location | Stream Type | Total Score | Condition Category |
|---|---|---|---|
| **Streams within Potential Spoil Locations** | | | |
| Stream 4 - Spoil Location G | Intermittent | 117 | Suboptimal |
| Stream 4a - Spoil Location G | Perennial | 137 | Suboptimal |
| Stream 17 - Spoil Location C | Perennial | 143 | Suboptimal |
| Stream 19 (Devils Fork) - Spoil Location B | Perennial | 155 | Optimal |
| **Streams potentially crossed by the Temporary Access Road** | | | |
| Stream 1 (Limber Pole Creek) | Perennial | 170 | Optimal |
| Stream 7 (Howard Creek) | Perennial | 185 | Optimal |
| Stream 12 | Intermittent | 126 | Suboptimal |
| Stream 15 | Perennial | 133 | Suboptimal |
| Stream 16 | Intermittent | 127 | Suboptimal |
| Stream 17 (Devils Fork) | Perennial | 144 | Suboptimal |

[1] Condition categories include Poor, Marginal, Suboptimal, and Optimal.

### 6.2.2 North Carolina Stream Assessment Method

NCSAM data forms were completed for streams within potential spoil locations and those potentially crossed by the temporary access road in September 2023. All streams were rated as high functioning with the exception of Streams 4 and 4a within spoil location G, and Stream 12 along the proposed temporary access road, which were rated as "medium" primarily due to limited baseflow conditions or, for Stream 4a, related to suboptimal streamside conditions (limited buffer). A summary is provided in Table 6-4 and complete data forms and rating sheets for each stream are included in Attachment D.

**Table 6-4. Summary of NC Stream Assessment Method Ratings**

| Stream Name | Stream Type | NCSAM Overall Functional Rating |
|---|---|---|
| **Streams within Potential Spoil Locations** | | |
| Stream 4 - Spoil Location G | Intermittent | Medium |
| Stream 4a - Spoil Location G | Perennial | Medium |
| Stream 17 - Spoil Location C | Perennial | High |
| Stream 19 (Devils Fork) - Spoil Location B | Perennial | High |
| **Streams Potentially Crossed by Temporary Access Road** | | |
| Stream 1 (Limber Pole Creek) | Perennial | High |
| Stream 7 (Howard Creek) | Perennial | High |
| Stream 12 | Intermittent | Medium |
| Stream 15 | Perennial | High |
| Stream 16 | Intermittent | High |
| Stream 17 (Devils Fork) | Perennial | High |

## 6.2.3 Stream Quantification Tool

### 6.2.3.1 Hydrology, Hydraulics, and Geomorphology

Stream surveys of hydrology, hydraulics, and geomorphology in support of the SQT were performed October 2-3, 2023. Streams appeared to be typical of those common to the Blue Ridge ecoregion, with limited hydraulic access to the floodplain (i.e., entrenched or moderately entrenched), low sinuosity, and moderate to high stream slopes. Streams were in good condition representative of those absent of anthropogenic influence. Riparian buffers were well vegetated with mature trees, and some areas also contained dense shrubs. Vegetation plots were placed such that each plot was representative of the plant community, structure, and age throughout the reach. Average DBH across reaches ranged from 8.2 to 18.6, with tree density up to 405 trees per acre (Table 6-5). Most streams contained coarse substrate (usually gravel), although bedrock cascades were present in one location. The smaller streams including Stream 12, Stream 16, and Devils Fork contained flow that went subsurface in several areas throughout upstream and/or downstream reaches. Areas where water re-emerged appeared to support relatively high abundance of salamanders. All streams were in stable condition throughout with limited streambank erosion. Vegetation data by plot and representative photographs are provided in Attachment E. Rapid Method forms completed for each stream reach are provided in Attachment F, and representative photographs of surveyed stream reaches are provided in Attachment G.

**Table 6-5. Summary of Vegetation Plot Data**

| Stream/Creek | Reach | Average DBH (inches) | Average Tree Density (No. of trees per acre) |
|---|---|---|---|
| Stream 1<br>(Limber Pole Creek) | Upstream | 9.5 | 405 |
| | Downstream | 10.5 | 223 |
| Stream 7<br>(Howard Creek) | Upstream | 12.3 | 142 |
| | Downstream | 8.5 | 121 |
| Stream 12<br>(UT to Howard Creek) | Upstream | 18.6 | 243 |
| | Downstream | 14.7 | 162 |
| Stream 15<br>(UT to Devils Fork) | Upstream | 8.2 | 101 |
| | Downstream | 9.6 | 223 |
| Stream 16<br>(UT to Devils Fork) | Upstream | 8.6 | 263 |
| | Downstream | 10.3 | 142 |
| Stream 17<br>(Devils Fork) | Upstream | 9.6 | 202 |
| | Downstream | 10.9 | 263 |

UT = unnamed tributary

#### 6.2.3.2 Stream Quantification Tool Analysis

Information gathered during stream surveys of the lower-level functional categories (hydrology, hydraulics, geomorphology [including riparian vegetation]) were used for Rosgen classification and input to the SC SQT to develop an overall Existing Condition Score for each stream reach. Higher-level functions (physiochemical and biology) were not included. The maximum potential Existing Condition Score the streams could receive was 0.6 (0.2 per functional category) (South Carolina Steering Committee 2022b).

Most streams surveyed exhibited entrenched or moderately entrenched conditions, low sinuosity, and coarse bed material. Width-depth ratios and slope were variable. The majority of streams were classified as Rosgen B-type streams, with G-type streams noted in areas exhibiting streambank erosion, and one A-type stream. B-type streams exhibit moderate gradient with moderate entrenchment and width/depth ratios, dominated by riffle features with infrequently spaced pools. A-type streams are entrenched and confined, high-gradient streams with frequently spaced pools associated with step/pool morphology. Both A and B type streams have stable plan and profile, and stable banks. G-type streams are more unstable, entrenched streams exhibiting low width/depth ratio, moderate gradients, and high bank erosion rates.

All reaches were rated to have a “good” catchment assessment due to the limited development of the upstream drainage areas. Although typical of A, B, and G-type streams, entrenched and moderately entrenched streams were rated poorly by the SQT under the hydraulics functional category due to these streams’ limited access to the floodplain. Other factors which reduced existing condition scores include streams with streambank erosion (such as the upstream reach of Stream 15 or downstream reach of Stream 16) or a limited large woody debris present (such as the upstream reach of Stream 12, and upstream and downstream reaches of Stream 15).

Stream 15 was the only stream with bedrock cascades, classified as a Rosgen A1a+ type stream with high gradient, entrenchment, no large woody debris and no streambank erosion noted. Riffles were uncommon, though small pools at the base of cascades were present. Although this reach would be considered stable, its limited access to the floodplain, constrained floodplain extent (i.e., flood prone width), lack of large woody debris, and low bedform diversity resulted in a low and moderate score for hydraulics and geomorphology functional categories.

Overall, the streams surveyed along the temporary access road generally exhibited stable, high-quality, potential reference reach-type conditions (Table 6-6). The SQT catchment assessments and existing condition matrix summaries for each stream reach are provided in Attachment J.

### Table 6-6. Summary of Stream Characteristics

| Stream/Creek | Reach | Entrenchment Ratio | Width/ Depth Ratio | Sinuosity | Slope | Bed Material (D50) | Rosgen Classification | Catchment Assessment | SQT Existing Condition Score | Maximum SQT Existing Condition Score | Percent Stream Functionality | Reach Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream 1 (Limber Pole Creek) | Upstream | Moderately entrenched to entrenched | Moderate | Low | Moderate | 11.30 (medium gravel) | B4 | Good | 0.48 | 0.6 | 80% | The upstream reach of Limber Pole Creek was densely covered with mountain laurel along the riparian zone. A small amount of active streambank erosion was present comprising approximately 6% of the reach. A small (low-discharge) tributary entered the creek at station 50. |
| | Downstream | Moderately entrenched to entrenched | High | Low | Low | 14.55 (medium gravel) | B4c | Good | 0.50 | 0.6 | 83% | The downstream reach of Limber Pole Creek was similar to the upstream reach and also densely vegetated with mountain laurel. All streambanks were stable. |
| Stream 7 (Howard Creek) | Upstream | Moderately entrenched to entrenched | High | Low | Low | 34.60 (very coarse gravel) | B4c | Good | 0.45 | 0.6 | 75% | The upstream reach of Howard Creek exhibited conditions typical of B-type streams in the Blue Ridge ecoregion. Some bank erosion was noted comprising 16.5% of the reach, primarily attributable to lateral drainage (i.e., a swale input) or in-channel woody debris influences. |
| | Downstream | Moderately entrenched to entrenched | High | Low | Moderate to high | 56.69 (very coarse gravel) | B4a | Good | 0.44 | 0.6 | 73% | The downstream reach of Howard Creek exhibited entrenchment and moderate width-to-depth ratio typical of B-type streams in the Blue Ridge ecoregion. A cascade approximately 20 inches high was present at station 96.5. |
| Stream 12 (UT to Howard Creek) | Upstream | Entrenched | Moderate | Low | High | 14.29 (medium gravel) | B4a | Good | 0.39 | 0.6 | 65% | Stream 12 was an intermittent stream covered in many areas with dense in vegetation, primarily mountain laurel. Some water was present at the time of survey. The channel had high gradient with step-pools. No streambank erosion was noted. |
| | Downstream | Moderately entrenched | Moderate | Moderate | Moderate to high | 3.13 (very fine gravel) | B4a | Good | 0.48 | 0.6 | 80% | The downstream reach of Stream 12 contained a small amount water at the time of survey. Step-pool features were observed for the most upstream portion of the stream before the flow went subsurface between station 49 and 54.2. A small amount of streambank erosion was present on an outside meander (5% of channel). |
| Stream 15 (UT to Devils Fork) | Upstream | Entrenched | Low | Low | Moderate | 1.36 (very coarse sand) | G5 | Good | 0.37 | 0.6 | 62% | The upstream reach of Stream 15 was adjacent to a 0.16-acre forested wetland area. The stream contained limited flow at the time of survey, however a moderate amount of streambank erosion was present (approximately 26.5 percent). The stream diverged around a "forested island" in the upstream end of the reach. |
| | Downstream | Entrenched | Low | Low | Very high | -- (bedrock) | A1a+ | Good | 0.36 | 0.6 | 60% | The downstream reach of Stream 15 exhibited very high gradient with bedrock cascades. Limited stream flow resulted in sheetflow across the bedrock. Small pools |

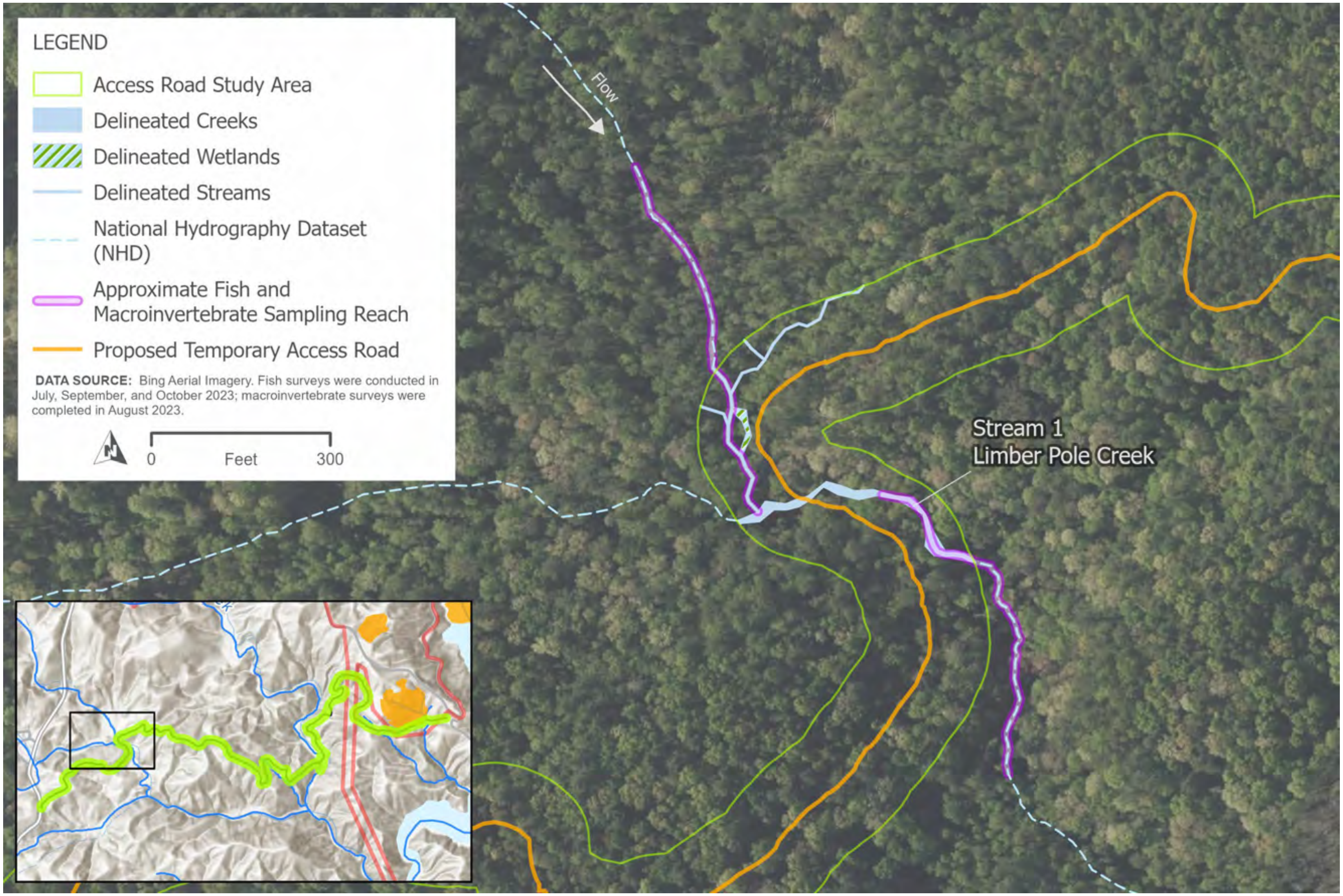
| Stream/Creek | Reach | Entrenchment Ratio | Width/ Depth Ratio | Sinuosity | Slope | Bed Material (D50) | Rosgen Classification | Catchment Assessment | SQT Existing Condition Score | Maximum SQT Existing Condition Score | Percent Stream Functionality | Reach Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | were present at the base of cascades. No bank eroding in this reach was noted. |
| Stream 16 (UT to Devils Fork) | Upstream | Moderately entrenched to entrenched | Moderate | Low | Moderate to high | 10.20 (medium gravel) | B4a | Good | 0.45 | 0.6 | 75% | The upstream reach of Stream 16 exhibited a riffle-pool pattern with stable banks and a moderate to high gradient. The stream originated at station 3.5 (subsurface from 0.0 to 3.5). |
| | Downstream | Entrenched | Low | Low | Moderate | 20.13 (coarse gravel) | G4 | Good | 0.37 | 0.6 | 62% | The downstream reach of Stream 16 exhibited a moderate to high gradient and a moderate amount of streambank erosion comprising 23.5% of the reach. The lower 17 feet of the reach (station 83 to 100) was subsurface. |
| Stream 17 (Devils Fork) | Upstream | Moderately entrenched to entrenched | Low to moderate | Low to moderate | Moderate to high | 9.32 mm (medium gravel) | B4a | Good | 0.40 | 0.6 | 67% | The upstream reach of Devils Fork was a perennial feature that flowed subsurface periodically throughout the reach; approximately 27.5% of the stream channel was dry due to the disappearance of flow underground. The upstream reach exhibited high grade with step-pool features and little bank erosion present. |
| | Downstream | Moderately entrenched to entrenched | High | Low to moderate | Moderate | 0.45 (medium sand) | B5 | Good | 0.37 | 0.6 | 62% | The downstream reach of Devils Fork was similar to the upstream reach in that approximately 20% of the surface water flow would disappear underground periodically through the reach. No areas of bank erosion were identified. |

[1] Rosgen classification was based on an overall stream reach metrics with consideration of the “continuum of physical variables” (Rosgen 1994, 1996) and best professional judgement of Rosgen-trained scientists.

## 6.3 Fish Community Sampling

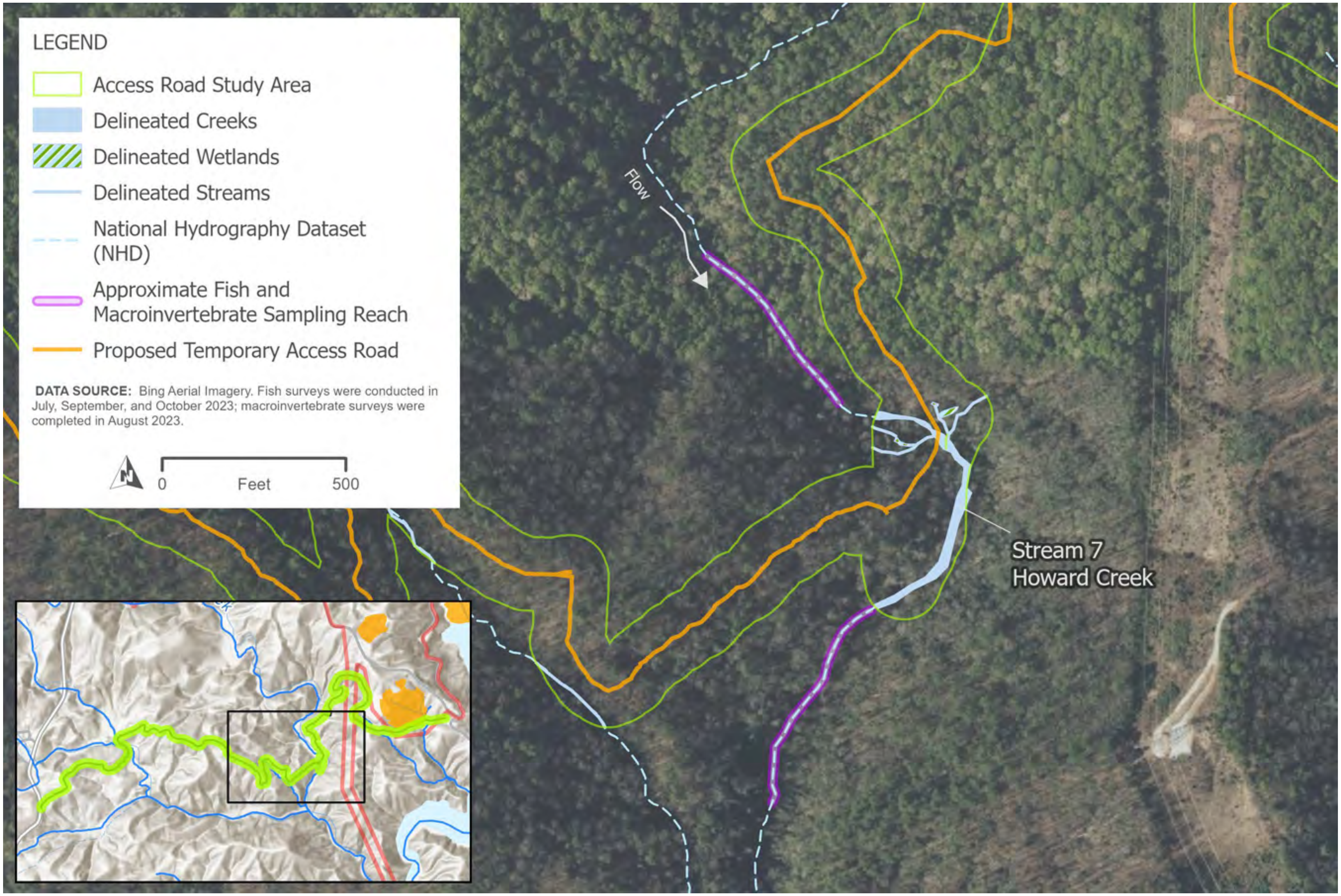
In accordance with the Protocol, one electrofishing unit and one netter was used for the upstream reach of Stream 1, and two electrofishing units and two netters were used at all other reaches. Surveys were completed upstream and downstream of the road crossings on July 25 and 26, September 5 and 6, and October 9 and 10, 2023. The four stream reaches maintained consistent species diversity over the three sampling events. No fish were collected in either reach of Stream 1 during 2023. Two species of fish, Rainbow Trout (*Oncorhynchus mykiss)* and Western Blacknose Dace (*Rhinichthys obtusus)*, were collected in both reaches of Stream 7 during all sampling events. Fish survey details including stream characteristics, sampling effort, water quality data, number of fish collected, catch rate, and fish density is provided in Attachment H.

In addition to the two species of fish collected, numerous aquatic salamanders from the genus *Desmognathus* were captured in both Stream 1 and Stream 7. The salamanders were captured in every reach during each sampling event, ranging from two to 15 individuals.



**DATA SOURCE:** Bing Aerial Imagery. Fish surveys were conducted in July, September, and October 2023; macroinvertebrate surveys were completed in August 2023.

**Figure 6-1. Fish and Macroinvertebrate Sampling Reaches on Stream 1 (Limber Pole Creek)**



**DATA SOURCE:** Bing Aerial Imagery. Fish surveys were conducted in July, September, and October 2023; macroinvertebrate surveys were completed in August 2023.

Figure 6-2. Fish and Macroinvertebrate Sampling Reaches on Stream 7 (Howard Creek)

## 6.4 Macroinvertebrate Sampling

Macroinvertebrate sampling was completed in Streams 1 and 7. One survey per stream reach was conducted on August 1 and 2, 2023, which is within the recommended index period (June 15, 2023, to September 15, 2023, for the Blue Ridge ecoregion). Stream reach lengths were the same as those sampled during fish community sampling conducted in July 2023 (see Figure 6-1, Figure 6-2, and Attachment H).

Biotic and EPT indices and scores were developed from the laboratory-identified taxa in accordance with the SCDHEC (2017) SOP (Table 6-7). The biotic index (BI) for a sample is a weighted average of the tolerance values referenced in SCDHEC's SOP Appendix 5 for organisms collected in sample with respect to their relative abundance. The BI value is scaled from 0.0 to 10.0, with 10 representing relative tolerance to general stressors, with lower values representing more pristine conditions.

The EPT taxa are a subset of benthic macroinvertebrate species belonging to the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which are highly sensitive and intolerant to pollution. The EPT index represents the total number of EPT taxa collected at a site with higher values indicating higher water quality.

The BI and EPT scores are weighted based on ecoregion. The BI and EPT scores are averaged to produce a combined score to determine the bioclassification of streams in South Carolina with the highest value equaling 5.0 and the lowest 1.0. The scores are rounded to show a single decimal and are rated as follows: 1 = Poor, 2 = Fair, 3 = Good-Fair, 4 = Good, and 5 = Excellent.

Full taxonomic identification results are provided in Attachment I.

**Table 6-7. Stream Bioclassification Scores[1] for Stream 1 (Limber Pole Creek) and Stream 7 (Howard Creek)**

| Metrics | Limber Pole Creek | | Howard Creek | |
|---|---|---|---|---|
| | Upstream | Downstream | Upstream | Downstream |
| Total No. of Organisms | 163 | 161 | 319 | 246 |
| Total No. of Taxa | 35 | 29 | 39 | 39 |
| EPT Index | 27 | 21 | 30 | 28 |
| Biotic Index Assigned Values | 1.68 | 2.04 | 2.98 | 2.25 |
| EPT Score | 3.93 | 3.19 | 4.31 | 4.06 |
| Biotic Index Score | 9.04 | 8.57 | 7.31 | 8.29 |
| | 6.49 | 5.88 | 5.81 | 6.17 |

| **Metrics** | **Limber Pole Creek** | | **Howard Creek** | |
|---|---|---|---|---|
| | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| South Carolina Bioclassification | Excellent/Fully Supporting | | | |

[1] See SCDHEC (2017) for details on EPT, Biotic Index, and Biotic Index Assigned Value scores for the Blue Ridge ecoregion.

Water quality parameters were collected in conjunction with the macroinvertebrate sampling (see Table 6-8). A water quality meter (YSI Sonde) was calibrated and used to record ambient stream temperature, pH, dissolved oxygen, and conductivity. Stream 1 and Stream 7 are classified by the SCDHEC as Natural Trout (TN) waters. The results recorded in the field met the SCDHEC's surface water quality standards for TN classification (SCDHEC 2023).

**Table 6-8. Water Quality Results Summary during Macroinvertebrate Sampling**

| **Water Quality Parameter** | **Limber Pole Creek** | | **Howard Creek** | |
|---|---|---|---|---|
| | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| Water Temperature (°C) | 19.5 | 20.2 | 19.2 | 19.2 |
| Dissolved Oxygen (mg/L) | 8.31 | 8.24 | 8.77 | 8.87 |
| Dissolved Oxygen (%) | N/A | 91.0 | 94.9 | 96.0 |
| pH (SU) | 6.10 | 6.89 | 7.42 | 7.44 |
| Conductivity (µmhos/cm) | 94.9 | 92.4 | 99.5 | 100.7 |

Macroinvertebrate sampling also included a review of the abundance and diversity of microhabitat types and conditions. Most habitat types or characteristics scored good to excellent with the exception of mature leaf packs, aquatic vegetation, presence of braided channels, and pine needles in streams. The forests surrounding the creeks were dominated by deciduous species and therefore limited, if any pine needles were present. The streams were also well shaded, which limits aquatic vegetation (or algae) growth. The high position (i.e., headwaters) in the watershed also limits the amount of nutrient input needed for aquatic plant growth, as well as the type of stream morphology, i.e., braided channels – the streams assessed are not conducive to braided channel formation due to steeper slopes (Table 6-9).

**Table 6-9. SCDHEC Aquatic Biology Section Habitat Assessment Summary**

| **Habitat Type** | **Limber Pole Creek** | | **Howard Creek** | |
|---|---|---|---|---|
| | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| Root Banks | Good | Good-Fair | Good-Fair | Good |
| Logs, Sticks, Snags | Good | Good-Fair | Good-Fair | Good-Fair |

| **Habitat Type** | **Limber Pole Creek** | | **Howard Creek** | |
|---|---|---|---|---|
| | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| Rock/Gravel Riffle | Good | Excellent | Excellent | Excellent |
| Mature Leaf Pack | Poor | Poor | Poor | Poor |
| Aquatic Vegetation | Good-Fair | Nonexistent | Poor | Poor |
| Braided Channel | Nonexistent | Nonexistent | Nonexistent | Nonexistent |
| Amount of Pine Needles in Stream | Nonexistent | Nonexistent | Nonexistent | Nonexistent |
| Velocity/Flow | Good | Good | Good | Good |
| Sedimentation | Little or none | Moderate | Little or none | Little or none |

The SCDHEC SOP adopted the USEPA’s Revisions to Rapid Bioassessment Protocols for Use in Streams and Rivers and also developed a simplified form to meet the specific needs of the SCDHEC’s Aquatic Biology Section. Other species observed but not collected included fish, crayfish, and salamanders, were recorded on the Macroinvertebrate Habitat Assessment Forms. Completed habitat assessment forms are located in Appendix I and a summary of the Aquatic Biology Section Habitat Assessment results are presented above in Table 6-9.

## 6.5 Mussel Surveys

Freshwater mussel habitat assessments were conducted in July and August, 2023. Consistent with the RSP, Duke Energy biologists surveyed potential upland spoil locations for mussel habitat and determined that no supportive habitat is present for mussel assemblages due to an absence of fish hosts necessary for mussel reproduction. SCDNR concurred with this assessment during the July 12, 2023, site visit to two potential spoil locations with streams representative of those in the area. With this conclusion, no mussel searches were completed at these locations.

Stream 1 and Stream 7 contained suitable habitat for mussels consisting of diverse substrates and creek shoreline complexity, although no fish were captured during electrofishing in Limber Pole Creek. Searches in these two streams totaling one person-hour each yielded no freshwater mussels or shells. Mussel searches were again conducted during electrofishing surveys in September and October, yielding no direct mussel observations or evidence of past or present mussel presence (shells). During the three searches in each of these two creeks, water temperature ranged from 11.6°Celsius (°C) to 20.8°C, and dissolved oxygen ranged from 7.9 milligrams per liter (mg/L) to 9.9 mg/L.

A length of approximately 600 meters of shoreline along the western shore of the Whitewater River arm of Lake Jocassee near the Bad Creek inlet/outlet structure and proposed location of the Bad Creek II Complex inlet/outlet structure was surveyed for suitable freshwater mussel habitat. This survey found a band of suitable sand habitat which stretched approximately 200 meters from the base of Whitewater Falls to the proposed location of the Bad Creek II Complex inlet/outlet structure (Figure 6-3). Three other small coves in the Whitewater River arm also exhibited suitable sand habitat to support freshwater mussels. Four total person-hours of searching these areas in Lake Jocassee yielded no freshwater mussels or shells. Non-native Asian clams (*Corbicula fluminea*) were identified, although their distribution was uncommon and patchy. During the survey, the water temperature was 27.5°C with 7.9 mg/L dissolved oxygen.

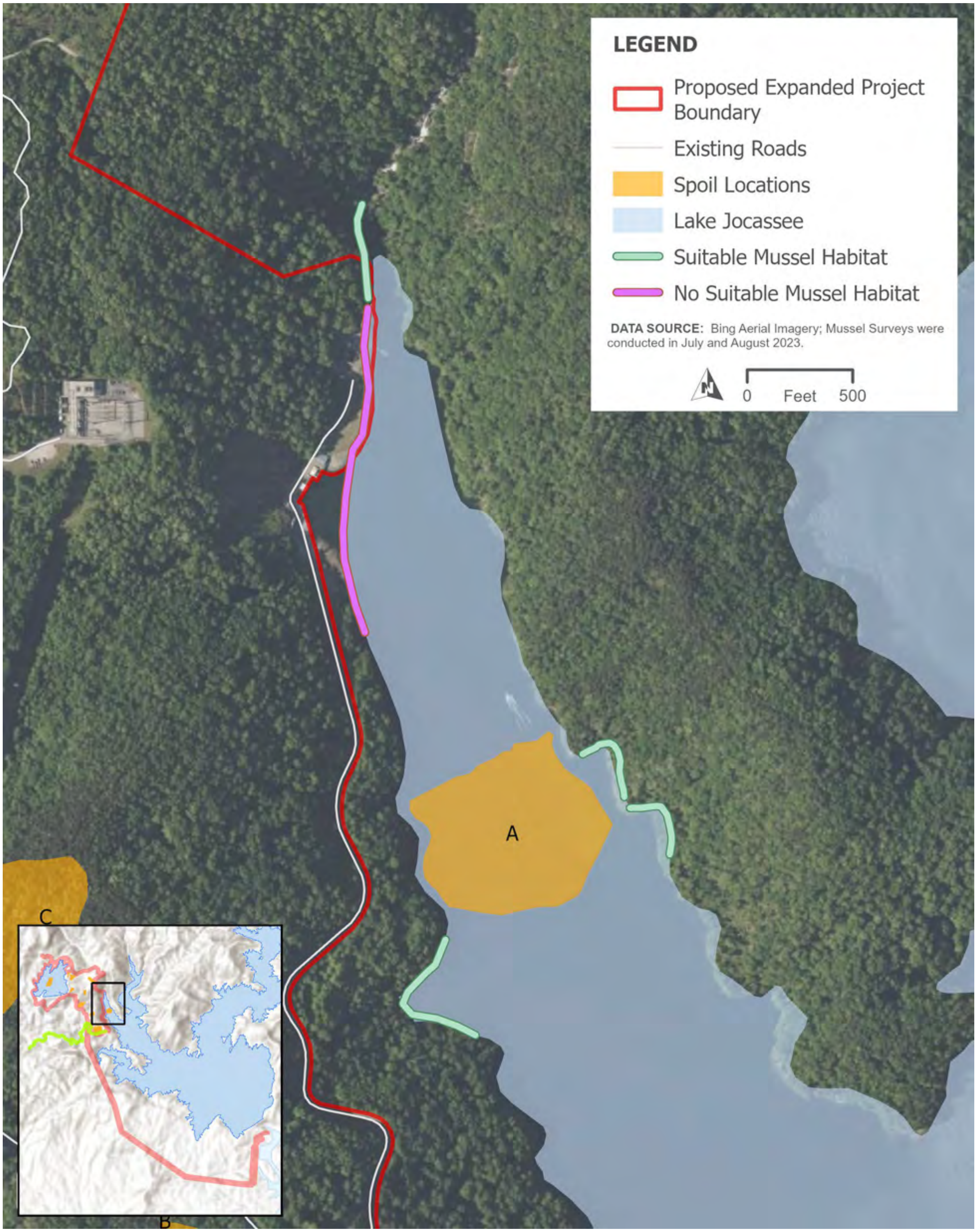


Figure 6-3. Mussel Habitat Survey Areas along Lake Jocassee Shoreline

# 7 Conclusions

The USEPA RBP and NCSAM methods of stream habitat quality assessments indicate that the streams within potential spoil locations and those potentially crossed by the proposed temporary access road are in fully functioning condition. Although the SQT rated streams along the temporary access road relatively low, the streams are generally in stable, functioning condition for the stream classification and characteristics which they exhibit (e.g., entrenchment). While field crews were unable to complete USEPA RBP and NCSAM forms for streams 13, 14, 20, or 21 (within potential spoil locations B and D), consistent with SCDNR determination during the July 2023 site visit (see Section 6.2.3), it is likely that these streams also present fully functioning conditions.

Macroinvertebrate surveys of Stream 1 and Stream 7 found abundant EPT taxa and habitat conditions, resulting in a high bioclassification score indicating a fully supporting system. While fish community sampling resulted in limited fish species collected from Stream 7 and none from Stream 1, this is typical of streams high in the watershed where flow may be limited in areas and high gradient sections of stream may include natural barriers to upstream movement.

No mussel habitat was identified in streams within potential spoil locations. Although suitable mussel habitat was present in Stream 1, Stream 7, and areas of shoreline in Lake Jocassee, no native mussels were observed during any of the surveys.

## 7.1 Impacts Assessment

Impacts to streams and wetlands within potential spoil areas would consist of fill due to the placement of French drains, followed by placement of overburden (rock) generated by the construction of the Bad Creek II Complex. French drains would be used to maintain connection of flow to downstream waters, however the surface waters and wetlands within the potential spoil locations would no longer be available as habitat to the organisms currently utilizing them. Additional evaluations are currently underway to determine natural resource impacts for the different potential spoil areas, and these evaluations are expected to inform eventual spoil site selection.

If the Bad Creek II Complex is pursued and the temporary access road is constructed, limited, if any impacts to streams crossed by the access road are expected. Streams would be spanned by bridges to avoid direct impact to streams, and best management practices, such as silt fencing, would be installed to prevent any incidental water quality impacts caused by temporary land disturbance. The road would be decommissioned following the construction completion of the Bad Creek II Complex and bridges removed.

No impacts to mussels are expected, as no native mussels were observed in the vicinity of the current or future inlet/outlet structure, or in the vicinity of the expanded underwater weir. A minor portion of suitable mussel habitat located immediately upstream of the proposed inlet/outlet structure for the Bad Creek II Complex could be impacted due to construction activities, however, as stated, no mussels were identified in this area during surveys. Aquatic organisms in Lake Jocassee would experience short-term water quality effects due to expansion of the weir (i.e., placement of rock/overburden on and in the vicinity of the existing weir) and construction of the Bad Creek II Complex inlet/outlet structure. Per the Water Resources RSP, a Water Quality Monitoring Plan will be developed in consultation with stakeholders and focused on the pre-construction, construction, and post-construction of the Bad Creek II Complex, with key components including 1) the construction of the inlet/outlet structure and expansion of the submerged weir; 2) construction in upland areas; and 3) potential upland spoil disposal.

Compensatory mitigation will be required for unavoidable impacts to surface waters (including wetlands) that are regulated under Section 404 of the Clean Water Act to ensure that impacts to aquatic resources are avoided or minimized to the greatest extent possible. Mitigation options may include on-site restoration and/or purchase credits from an approved in-lieu fee mitigation bank to offset unavoidable adverse impacts.

# 8 Variances from FERC-approved Study Plan

The USEPA RBP and NCSAM forms for five streams within potential spoil locations B, D, and J were not completed as required by the RSP due to safety concerns related to inclement weather. As with other streams within potential spoil locations or observed along the proposed temporary access road, and consistent with SCDNR determination during the July 2023 site visit (see Section 6.2.3), it is likely that these streams also present fully functioning conditions.

Additional acreage was included in the study area originally presented in the RSP to assess potential impacts to natural resources associated with construction of a temporary access road to the south of the Project. The temporary access road would provide ingress and egress to homeowners of the Fisher Knob community during construction, which requires public closure of Bad Creek Road. Additionally, methods for determining stream quality were expanded to include the SQT methodology, which was completed in collaboration with the SCDNR.

# 9 Germane Correspondence and Consultation

Germane correspondence and consultation documentation related to Task 3 of the Aquatic Resources Study is summarized in Table 10-1 and included in Attachment 4 of the Aquatic Resources Draft Study Report.

**Table 10-1. Summary of Germane Correspondence and Consultation related to Task 3 of the Aquatic Resources Study**

| Date | Correspondents | Topic |
|---|---|---|
| April 19, 2023 (e-mail) | Duke Energy to Aquatic Resources RC | Transmittal of April 6, 2023, entrainment meeting summary and proposal to use the NCSAM (request for comment) |
| May 8, 2023 (e-mail) | SCDNR to Duke Energy | Request to use the SC SQT to evaluate streams to be assessed under Task 3 of the Aquatic Resources Study |
| May 9, 2023 (e-mail) | Duke Energy to SCDNR | Acknowledgement of request receipt |
| May 24, 2023 (virtual meeting) | Duke Energy and SCDNR | Virtual meeting with SCDNR to discuss methodology and applicability of the SQT to streams within spoil locations and along the proposed temporary access road |
| June 9, 2023 (e-mail) | Duke Energy to SCDNR | Transmittal of meeting minutes summary from May 24, 2023, discussion and Stream Survey Approach Memo with request for comment |
| June 16, 2023 (e-mail) | SCDNR to Duke Energy | Comments on Stream Survey Approach Memo |
| June 21, 2023 (virtual meeting) | Duke Energy and SCDNR | Virtual meeting with SCDNR to discuss SQT methodology and applicability to streams within spoil locations and along the proposed temporary access road, as well as the SQT debit calculator |
| June 23, 2023 (e-mail) | Duke Energy to SCDNR | Transmittal of meeting minutes summary from May 24, 2023, discussion |

| Date | Correspondents | Topic |
|---|---|---|
| June 23, 2023 (e-mail) | SCDNR to Duke Energy | Comments on May 24, 2023, meeting summary |
| July 12, 2023 (in-person) | Duke Energy and SCDNR | Site visit to Spoil Locations B and G on the Bad Creek II Complex project site |
| August 3, 2023 (e-mail) | Duke Energy to the Aquatic Resources RC | Transmittal of the revised Stream Survey Approach Memo |
| September 18, 2023 (e-mail) | Duke Energy to SCDNR | Question regarding number of riparian vegetation survey plots required for survey in support of the SQT |
| September 23, 2023 (e-mail) | SCDNR to Duke Energy | Response to question regarding the number of riparian vegetation survey plots required |
| November 17, 2023 | Duke Energy to the Aquatic Resources RC | Distribution of the Task 3 Aquatic Resources Impacts to Surface Waters and Associated Aquatic Fauna Draft Report |
| December 18, 2023 (virtual meeting) | Duke Energy and SCDNR | Virtual meeting with SCDNR to discuss comments on the Aquatic Resources Impacts to Surface Waters and Associated Aquatic Fauna Draft Report |
| December 21, 2023 | Duke Energy to SCDNR | Transmittal of meeting minutes summary from December 18, 2023, discussion |
| December 21, 2023 | SCDNR to Duke Energy | Comment on meeting summary from December 18, 2023 |
| December 21, 2023 | SCDNR to Duke Energy | Transmittal of comments on Aquatic Resources Impacts to Surface Waters and Associated Aquatic Fauna Draft Report |
| December 22, 2023 | Duke Energy to SCDNR | Transmittal of Natural Resources Assessment report and spatial file for streams located along the temporary access road |
| December 31, 2023 | SCDNR to Duke Energy | Comments on the meeting summary from December 18, 2023 |
| January 9, 2024 | Duke Energy to SCDNR | Transmittal of revised meeting minutes summary from the December 18, 2023, meeting |

# 10 References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Duke Energy Carolinas, LLC (Duke Energy). 2022. Appendix D Aquatic Resources Revised Study Plan, Bad Creek Pumped Storage Project FERC Project No. 2740. Prepared by HDR Engineering, Inc. December 2022.

Gordon, N.D., T.A. McMahon, and B.L. Finlayson. 1992. Stream Hydrology: An Introduction for Ecologists. John Wiley & Sons, New York. 526 pp.

HDR Engineering of the Carolinas, Inc. (HDR). 2021. Bad Creek II Power Complex Project Natural Resources Assessment. Prepared for Duke Energy Carolinas, LLC. November 2021.

______. 2023. Aquatic Resources Study Approach to Stream Surveys - Revised Post-Consultation. Memo provided to South Carolina Department of Natural Resources on behalf of Duke Energy Carolinas, LLC. July 2023.

Lee, M.T., Peet, R.K., Roberts, S.D., & Wentworth, T.R. 2008. CVS-EEP Protocol for Recording Vegetation All Levels of Plot Sampling, Version 4.2.

North Carolina Division of Water Quality (NCDWQ). 2010. Methodology for Identification of Intermittent and Perennial Streams and Their Origins (Version 4.11).

North Carolina Stream Functional Assessment Team. 2013. N.C. Stream Assessment Method (NCSAM) Draft User Manual. March 2013. Accessed October 2023. [URL]: https://www.saw.usace.army.mil/Portals/59/docs/regulatory/publicnotices/2013/NCSAM_Draft_User_Manual_130318.pdf.

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22(3): 169-199.

Rosgen, D.L.1996. Applied River Morphology, 2nd Edition. Wildland Hydrology, October 1, 1996. 378 pp.

South Carolina Department of Health and Environmental Control (SCDHEC). 2017. Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling. Technical Report No. 0914-17. Bureau of Water. Columbia, South Carolina.

_____. 2023. Regulations 61-68 Water Classifications and Standards. S.C. Code Sections 48-1-10 et seq. Available at: https://scdhec.gov/sites/default/files/Library/Regulations/R.61-68.pdf#page=30.

South Carolina Department of Natural Resources (SCDNR). 2020. Stream Geomorphology Data Collection and Analysis South Carolina Ecoregions 66, 45, 65, 63. Prepared by Jennings Environmental, PLLC.

______. 2022. Fish Sampling Guidance - Fish Collection Protocols for Streams. Dated August 11, 2022.

South Carolina Steering Committee. 2022. South Carolina Stream Quantification Tool: Data Collection and Analysis Manual, SC SQT v1.1. South Carolina Department of Natural Resources, Columbia, SC.

U.S. Army Corps of Engineers (USACE). 1987. Corps of Engineers Wetlands Delineation Manual. Wetlands Research Program Technical Report Y-87-1. January 1987.

______. 2012. Regional Supplement of the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region (Version 2.0). U.S. Vicksburg, Mississippi. April 2012.

U.S. Environmental Protection Agency (USEPA). 2013. Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys for the Development of Site-specific Water Quality Criteria for Ammonia. EPA 800-R-13-003. August 2013.

_____. 2023. Indicators: Benthic Macroinvertebrates. Accessed January 18, 2024. [URL]: https://www.epa.gov/national-aquatic-resource-surveys/indicators-benthic-macroinvertebrates.

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# Attachment A

## Attachment A - Aquatic Resources Study Approach to Stream Surveys Memo

# Memo

Date: Wednesday, July 26, 2023

Project: Bad Creek Pumped Storage Project Relicensing

To: South Carolina Department of Natural Resources

From: HDR Engineering of the Carolinas, Inc.

Subject: Aquatic Resources Study Approach to Stream Surveys – Revised Post-Consultation

## Project Understanding

Duke Energy Carolinas, LLC (Duke Energy or Licensee) 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. Duke Energy is pursuing a new license for the Project and in accordance with 18 Code of Federal Regulations §5.11, developed a Revised Study Plan (RSP) which proposed six studies for Project relicensing, including an Aquatic Resources Study. The goal of the Aquatic Resources Study is to evaluate potential impacts to fish and aquatic life populations, communities, and habitats due to the potential construction and operation of an additional power complex (Bad Creek II Power Complex [Bad Creek II Complex]) adjacent to the existing Project. The Aquatic Resources Study is ongoing.

As additional information, Duke Energy is proposing the development of an access road to provide an alternate route to the Fisher Knob community, for use during Bad Creek II construction. The access road is not presently included in the proposed expanded FERC Project Boundary and was not yet planned at the time of preparation of the RSP. Consistent with the objective of the Aquatic Resources Study to "evaluate the aquatic resources (streams, wetlands, and Lake Jocassee) that may experience direct impacts from spoil placement or other construction activities", Duke Energy plans to evaluate surface waters that may be crossed by the access road in addition to waters within potential spoil locations as described in the RSP.

## Approach to Streams within Potential Spoil Locations

According to preliminary studies and estimates for proposed material removed from underground excavations for the Bad Creek II Complex, approximately 4 million cubic yards of overburden material for the project infrastructure will need to be deposited at upland spoil locations or along the submerged weir in Lake Jocassee (Attachment 1). An additional spoil area related to the construction of a proposed transformer yard, potential spoil location J, adds an approximately 0.4 million cubic yards to the overburden amount, for a total of 4.4 million cubic yards. Nine potential streams are present within the proposed on-site spoil locations (see Table 1 and Attachment 1). Surface waters (including wetlands) in these locations were evaluated in the field during the Natural Resources Assessment completed by HDR in September 2021 (HDR 2021; Appendix E of the Pre-Application Document filed with FERC on February 23, 2022).

Consistent with the RSP, Duke Energy will complete U.S. Environmental Protection Agency (USEPA) Rapid Bioassessment Protocol (USEPA RBP; Barbour et al. 1999) stream habitat assessments for all streams within potential spoil locations. During the Joint Resource

Committee Meeting on February 22, 2023, and the Aquatic Resources Study Resource Committee Meeting held on April 6, 2023, committee members expressed interest in biological assessments. In follow-up correspondence with the Aquatic Resources Committee, Duke Energy proposed to complete stream assessments using the North Carolina Stream Assessment Method (NCSAM; N.C. Stream Functional Assessment Team 2013) in addition to the USEPA RBP.

The South Carolina Department of Natural Resources (SCDNR) also requested that Duke Energy use the SCDNR Stream Quantification Tool (SQT)[1] (South Carolina Steering Committee 2022) for stream assessments. Duke Energy consulted with the SCDNR on May 24 and June 21, 2023, to discuss the applicability and methodology of the SQT. Duke Energy, HDR, and SCDNR also participated in a site visit to Bad Creek on July 12, 2023. The site visit included Alan Stuart (Duke Energy), Allan Boggs (Duke Energy), Nick Wahl (Duke Energy), Eric Mularski (HDR), Erin Settevendemio (HDR), and Lorianne Riggin (SCDNR). The group visited spoil locations B and D (see figures in Attachment 1), which were considered locations with representative conditions of stream and riparian habitat. During the site visit, SCDNR and Duke Energy agreed that the streams within spoil locations are generally high functioning with limited (if any) anthropogenically caused degradation, and that field data collection to support SQT analysis for streams within spoil locations was not likely to produce significantly different results (i.e., lower functionality scores) than an assumption of fully functional. Therefore, field surveys of the streams within potential spoil locations applying the SQT methodology are not required.

## Approach to Streams Crossed by the Access Road to the Fisher Knob Community

The potential access road would require crossings at three named streams (Limber Pole Creek, Howard Creek, and Devils Fork) and potentially other unidentified streams (see figures provided in Attachment 2). Currently, two access road routes are being considered, however only one would be developed. The routes diverge just west of Howard Creek, where Option 1 crosses Howard Creek and heads north across a ridge. Option 2 crosses Howard Creek and heads south along the left bank of Howard Creek before directing northeast. The road options converge east of the transmission line corridor west of Devils Fork. It is anticipated that Option 1 would result in fewer riparian buffer impacts and therefore this is the preferred route.

Based on review of two-foot topography contour maps, an additional three streams may be present along the access road, though the flow of these streams is currently unknown. A surface waters delineation is scheduled for mid-late August to identify stream conditions/flow of these unnamed features. If Duke Energy develops the access road, streams and creeks along the alignment will likely be spanned by [temporary] bridges. Duke Energy will conduct field assessments using the SCDNR SQT to evaluate stream function as a baseline prior to construction activities to document any changes that may occur, though none are anticipated.

Streams crossed by the access road will be assessed with the USEPA RBP and NCSAM. Stream assessments will be conducted upstream and downstream of each road crossing. The intent is to document a baseline, existing condition of the stream before the construction of the access road. When and if the road is decommissioned, the streams would be re-assessed to compare to the baseline condition. Additionally, evaluating the streams at upstream and downstream locations

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[1] SCDNR Stream Quantification Tool

allows an opportunity to document changes that may have happened elsewhere (i.e., upstream) in the watershed or as a result of other factors, such as storm events.

## Proposed Field Methods

Numerous methods for stream habitat and biological assessments will be used for evaluating streams in the vicinity of the Project. Field methods to be implemented at each stream are based on consultation with the Aquatic Resources Study Resource Committee (RC) and SCDNR, as discussed above. The following summary provides an overview of planned field methods for streams within spoil locations and those crossed by the potential access road.

### USEPA Rapid Bioassessment Protocol

In accordance with the RSP, the USEPA RBP stream habitat assessment will be completed at all streams within spoil locations. Barbour et al. (1999) states, "an evaluation of habitat quality is critical to any assessment of ecological integrity". Stream habitat assessments are defined as the "evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community" (Barbour et al. 1999). These assessments provide information regarding stream functionality and condition, which in turn can indicate the value of aquatic habitat to aquatic and terrestrial life, and ecosystem services such as nutrient reduction and support of watershed health. The USEPA RBP includes an evaluation of the variety and quality of (1) stream substrate, (2) channel morphology, (3) bank structure, and (4) riparian vegetation. Ten parameters within the four categories are rated on a numerical scale for each sampled reach.

### NC Stream Assessment Method

The NCSAM provides "an accurate, reproducible, rapid, observational, and science-based field method to determine the level of stream function relative to a reference condition" (N.C. Stream Functional Assessment Team 2013). While the NCSAM was developed for use in North Carolina, the Project is just a few miles from the North-South Carolina border and stream categories identified for the method include those in the Blue Ridge ecoregion, where the Project is located. Similarities between topography and streams in the Carolinas allow this method to provide valuable information regarding the overall function of streams with a simple and efficient tool.

The NCSAM rates streams for three Class 1 functions: hydrology, water quality, and habitat. Within each Class 1 function, streams are rated for up to eight Class 2 functions, which may include Class 3 and Class 4 functions. The functions provided by a stream are a product of the hydrologic, geologic, morphologic, and vegetational setting of the stream and its drainage area (Gordon et al. 1992 as cited by N.C. Stream Functional Assessment Team 2013). Alterations and/or stressors can contribute to the degradation of a stream, either naturally or anthropogenically, including storm damage, excessive vegetation, beaver impoundment, stream migration, and sedimentation, which can lead to lower stream function. Parameters evaluated with NCSAM protocol include flow restrictions; streambank erosion; buffer size and type; water quality stressors; substrate composition; in-stream habitat; visual and dip netting assessments for aquatic life; presence of wetlands; shade; and others.

## SCDNR Stream Quantification Tool Approach

As stated above, six or more streams could be crossed by the access road and Duke Energy proposes to use the SQT field methodology for stream assessments in this area. The SCDNR SQT was developed in a collaborative effort between federal and state representatives to provide a tool for assessing and quantifying functional lift and loss of streams in South Carolina. The SQT can be used to determine the functional condition of a stream, with the SQT Debit Calculator as a means of calculating credits or debits resulting from reach-scale activities typically encountered in the Clean Water Act 404 program.

The SQT requires the assessment of five functional categories: hydrology, hydraulics, geomorphology, physiochemical, and biology (South Carolina Steering Committee 2022). Depending on the anticipated type of impacts or lift, physiochemical and biology categories are optional. Guidance from the SQT suggests physiochemical parameters be measured for stream projects with "goals or objectives related to physiochemical functions or where watershed conditions suggest that uplift is possible." Work would be conducted from upland locations and no in-water work would occur. Best management practices to prevent sedimentation such as silt fencing would be installed to prevent water quality impacts at stream crossings. The future Water Quality Management Plan (developed under the Water Resources Study) will also consider water quality in the areas of the new access road. Given that impacts to water quality are not anticipated and appropriate protection measures will be taken, Duke Energy is not proposing physiochemical monitoring.

At prior meetings with Duke Energy, Aquatic Resources RC members have expressed interest in the biological community of streams in the vicinity of the proposed Bad Creek II Complex. Duke Energy therefore proposes to conduct fish and macroinvertebrate sampling supporting the SQT assessment.

### Hydrology, Hydraulics, and Geomorphology

Duke Energy will survey all streams crossed by both access road options using the first three functional categories of the SQT, which comprise hydrology, hydraulics, and geomorphology, using the Rapid Method outlined in the SQT Data Collection and Analysis Manual (South Carolina Steering Committee 2022). Parameters evaluated under these categories include reach runoff, floodplain connectivity, flow dynamics, large woody debris, lateral migration, riparian vegetation, and bed form diversity. Up to 17 metrics will be taken for the parameters evaluated; metrics selection, instruction, and applicability is provided in the SQT Data Collection and Analysis Manual (South Carolina Steering Committee 2022).

### Fish Surveys

Fish surveys for use with the SQT are only applicable to perennial streams with drainage areas between 1.5 and 63 square miles (South Carolina Steering Committee 2022), which includes Limber Pole Creek and Howard Creek. As outlined by the SQT Data Collection and Analysis Manual, fish surveys will follow Fish Collection Protocols for Streams as described in the SCDNR Fish Sampling Guidance[2] (SCDNR 2022). For streams in the Blue Ridge ecoregion, sample reaches will be 30 times the average wetted width, or a minimum 100 meters with one electrofishing pass. Surveys will be completed upstream and downstream of the road crossings

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[2] SCDNR Fish Sampling Guidance

three times between July and October 2023. A calibrated multiparameter water quality data sonde will be used to record existing water quality conditions during sampling events, including temperature, dissolved oxygen, conductivity, pH, salinity, and turbidity.

### Macroinvertebrate Surveys

Macroinvertebrate surveys under the SQT are limited to perennial streams with a minimum three-square mile drainage area (South Carolina Steering Committee 2022), which includes Limber Pole Creek and Howard Creek. As outlined in the SQT Data Collection and Analysis Manual, macroinvertebrate surveys will be completed following the Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling[3] (SCDHEC 2017). This method uses a qualitative multiple habitat sampling protocol with kick nets, D-shaped dip nets, and sieves to collect as many different macroinvertebrate taxa as possible during a specified amount of time. One survey per stream reach will be conducted during the recommended index period (June 15, 2023 to September 15, 2023 for the Blue Ridge ecoregion). Stream reach lengths will be determined on a site-by-site basis consistent with guidance provided in SCDHEC (2017), which is typically 100 meters of stream. Water quality conditions at the time of sampling will be recorded with a multiparameter data sonde. Collected samples will be preserved in 85 percent ethanol and labeled with the station number and collection date. Samples will be transported to a qualified laboratory for identification and analysis under chain-of-custody. Identified taxa and relative abundance will be used to calculate biotic indices to assess stream conditions.

### Mussel Surveys

Consistent with the RSP, Duke Energy biologists surveyed upland spoil locations for mussel habitat and determined that no supportive habitat is present for mussel assemblages. SCDNR concurred with this assessment during the July 12, 2023 site visit to two representative spoil locations with streams characteristics of those throughout the Aquatic Resources study area.

Mussel surveys of Limber Pole Creek and Howard Creek will be conducted in late July 2023 following methods adapted from the USEPA Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys for the Development of Site-specific Water Quality Criteria for Ammonia (USEPA 2013). The survey will include visual and tactile collection of mussels, identification to species, and enumeration. Habitat conditions will be documented, including substrate and water quality, through stream habitat assessments and fish surveys.

### Summary of Proposed Field Methods

Field surveys of streams within spoil locations were proposed in the RSP. Since the proposed access road was not planned at the time of the filing of the RSP, the stream crossings were not included in Aquatic Resources Study; however, for completeness, field surveys will also be performed at potential stream crossing locations. The field methods proposed for each stream were developed in consultation with the Aquatic Resources RC and SCDNR. A summary of the proposed field methods is provided in Table 1, with brief descriptions of methods provided in Table 2.

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[3] SCDHEC Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling

## Results and Conclusions

An overview of results of field studies will be discussed in a future meeting to be scheduled for late October or early November 2023. Results and conclusions of the stream habitat assessments and SQT will be summarized in a draft report, which will be provided to the Aquatic Resources RC in November 2023 for comment and in the Initial Study Report (to be filed with FERC by January 4, 2024).

## Table 1. Proposed Field Survey Approach for Streams within Potential Spoil Locations and Road Crossings

| Potential Impact | Stream Name/No. | Flow | Drainage Area (sq. mi) | Stream Habitat Assessment | Fish Survey | Macroinvertebrate Survey | Mussel Survey[1] |
|---|---|---|---|---|---|---|---|
| **Potential Spoil Locations** | | | | | | | |
| B | 20 | Perennial | 0.05 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | USEPA qualitative presence survey |
| B | 21 | Perennial | 0.05 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | USEPA qualitative presence survey |
| C | 17 | Perennial | 0.05 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | USEPA qualitative presence survey |
| D | 13 | Intermittent | 0.04 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | N/A |
| D | 14 | Perennial | 0.04 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | USEPA qualitative presence survey |
| G | 4 | Intermittent | 0.06 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | N/A |
| G | 4a | Perennial | 0.06 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | USEPA qualitative presence survey |
| J | 11 | Perennial | 0.11 | USEPA RBP & NCSAM | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | USEPA qualitative presence survey |
| **Potential Access Road Crossings** | | | | | | | |
| 1 | Limber Pole Creek | Perennial | 1.8 | USEPA RBP, NCSAM, & SCDNR SQT | SCDNR Fish Collection Protocol | SCDHEC Standard Operating and Quality Control Procedures | USEPA qualitative presence survey |
| 2 | UT Howard Creek | Unknown[2] | 0.03 | USEPA RBP & NCSAM | Unknown[2] | Unknown[2] | Unknown[2] |
| 3a/b | Howard Creek | Perennial | 4.16 | USEPA RBP, NCSAM, & SCDNR SQT | SCDNR Fish Collection Protocol | SCDHEC Standard Operating and Quality Control Procedures | USEPA qualitative presence survey |
| 4 | UT Howard Creek | Unknown[2] | 0.01 | USEPA RBP & NCSAM | Unknown[2] | Unknown[2] | Unknown[2] |
| 5 | UT Devils Fork | Unknown[2] | 0.03 | USEPA RBP & NCSAM | Unknown[2] | Unknown[2] | Unknown[2] |
| 6 | Devils Fork (Stream 19) | Perennial | 0.09 | USEPA RBP, NCSAM, & SCDNR SQT | NCSAM visual/dipnet assessment | NCSAM presence/absence assessment | USEPA qualitative presence survey |

UT: unnamed tributary

[1] Mussel surveys will only be completed in waters determined to provide supportive mussel habitat.

[2] Aquatic life surveys would only be conducted in intermittent or perennial streams.

## Table 2. Descriptions of Field Survey Protocols

| Survey Type | Survey Method | Brief Summary of Methods |
|---|---|---|
| Stream Habitat Assessment | USEPA Rapid Bioassessment Protocol Stream Assessment | Scored condition parameters including epifaunal substrate/available cover, substrate embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, frequency of riffles or bends, bank stability, vegetative protection, and riparian vegetative zone width. |
| | NC Stream Assessment Method (NCSAM) | Documentation of in-stream habitat types including aquatic macrophytes and mosses; sticks, leaf packs, or emergent vegetation; snags and logs; undercut banks and root mats; and bedform and substrate types. Observations of stream instability or stressors. |
| | SCDNR Stream Quantification Tool (SQT) | Hydrology, hydraulics, and geomorphology will be assessed across seven functional parameters, including reach runoff, floodplain connectivity, flow dynamics, large woody debris, lateral migration, riparian vegetation, and bed form diversity. Metrics will be taken applying the Rapid Method, using tapes and stadia rods. |
| Fish Surveys | NC Stream Assessment Method (NCSAM) | Visual assessment for fish and semi-aquatic life such as reptiles and amphibians. |
| | SCDNR Stream Quantification Tool (SQT)/ SCDNR Fish Collection Protocols for Streams | Fish surveys completed for the SCDNR SQT will follow the SCDNR Fish Collection Protocols for Streams. For streams in the Blue Ridge Ecoregion, the survey reach will encompass 30 times the average wetted width of the stream or a minimum of 100 meters with one survey pass. Two to three electrofishers, two netters, and one to two buckets will be used. Water quality parameters and photo vouchers will be taken. |
| Macroinvertebrate Surveys | NC Stream Assessment Method (NCSAM) | Presence/absence survey of macroinvertebrates in all available habitats, including riffles, pools, snags and logs, leaf packs, macrophytes, root mats, hard substrates, and banks. Macroinvertebrates sampled via dipnet with mesh size between 0.5-0.8 mm. |
| | SCDNR Stream Quantification Tool (SQT)/ SCDHEC Standard Operating and Quality Control Procedures | Macroinvertebrate surveys completed for the SCDNR SQT will follow the SCDHEC Standard Operating and Quality Control Procedures. This includes a qualitative, multiple habitat sampling protocol with kick nets, D-shaped dip nets, and sieves to collect as many different macroinvertebrate taxa as possible during a specified amount of time. Stream reach lengths are typically 100 meters. Collected samples will be preserved in 85 percent ethanol and labeled with the station number and collection date. Samples will be transported to a qualified laboratory for identification and analysis under chain-of-custody. Macroinvertebrate surveys under the SQT are limited to waters with a minimum 3-square-mile drainage area. |
| Mussel Surveys | Adapted from USEPA Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys | Visual sampling approach to determine mussel presence, richness, and relative density. Mussels collected visually and tactilely (grubbing) during timed searches within well-defined areas. |

# References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

North Carolina Stream Functional Assessment Team. 2013. N.C. Stream Assessment Method (NC SAM) Draft User Manual. Accessed June 2023. [URL]: https://www.saw.usace.army.mil/Portals/59/docs/regulatory/publicnotices/2013/NCSAM_Draft_User_Manual_130318.pdf

South Carolina Department of Health and Environmental Control. 2017. Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling. Technical Report No. 0914-17. Bureau of Water. Columbia, South Carolina.

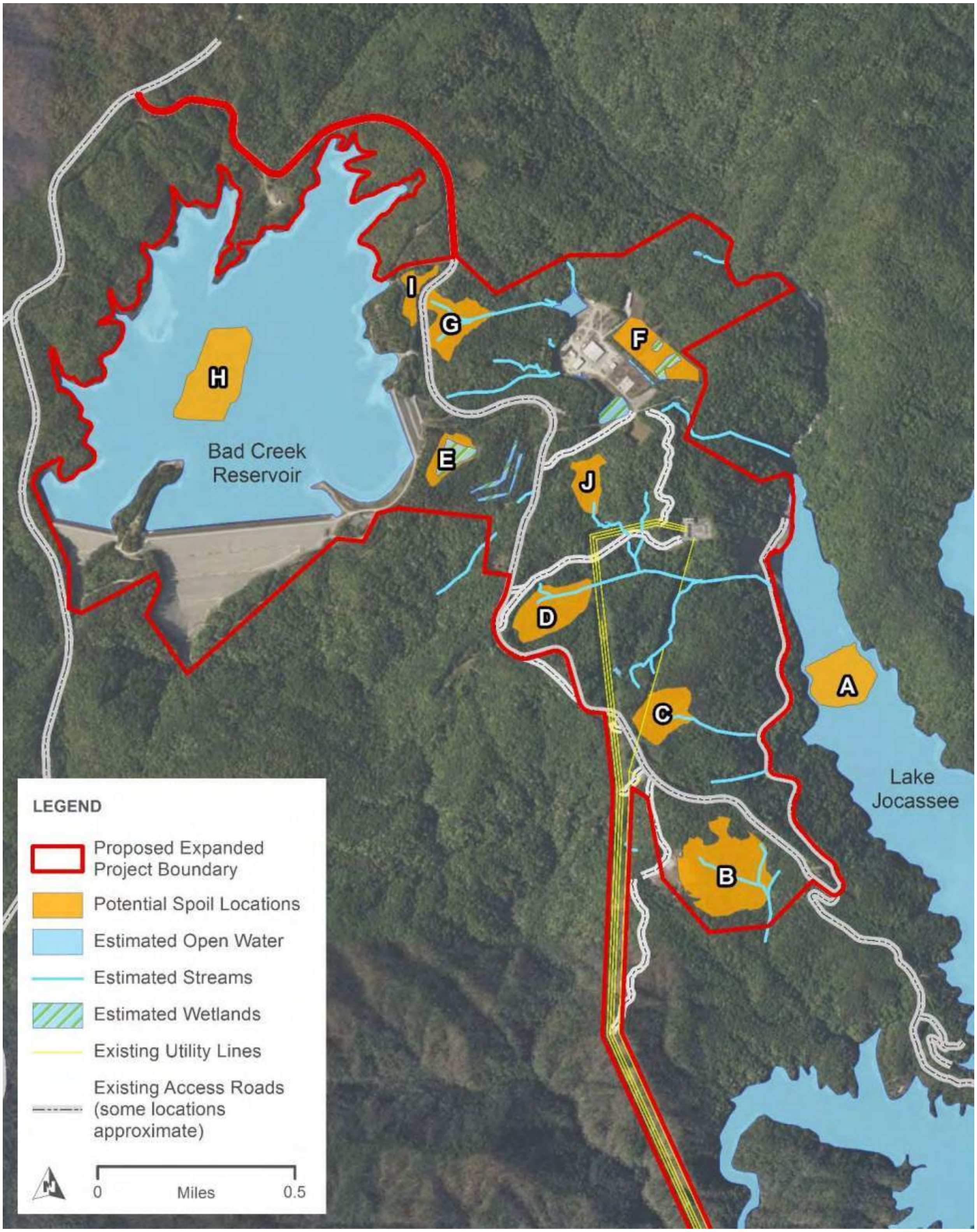
South Carolina Department of Natural Resources. 2022. Fish Sampling Guidance: Fish Collection Protocols for Streams. Accessed July 2023. [URL]: https://www.dnr.sc.gov/environmental/SCDNRSamplingProcedureFishes.pdf.

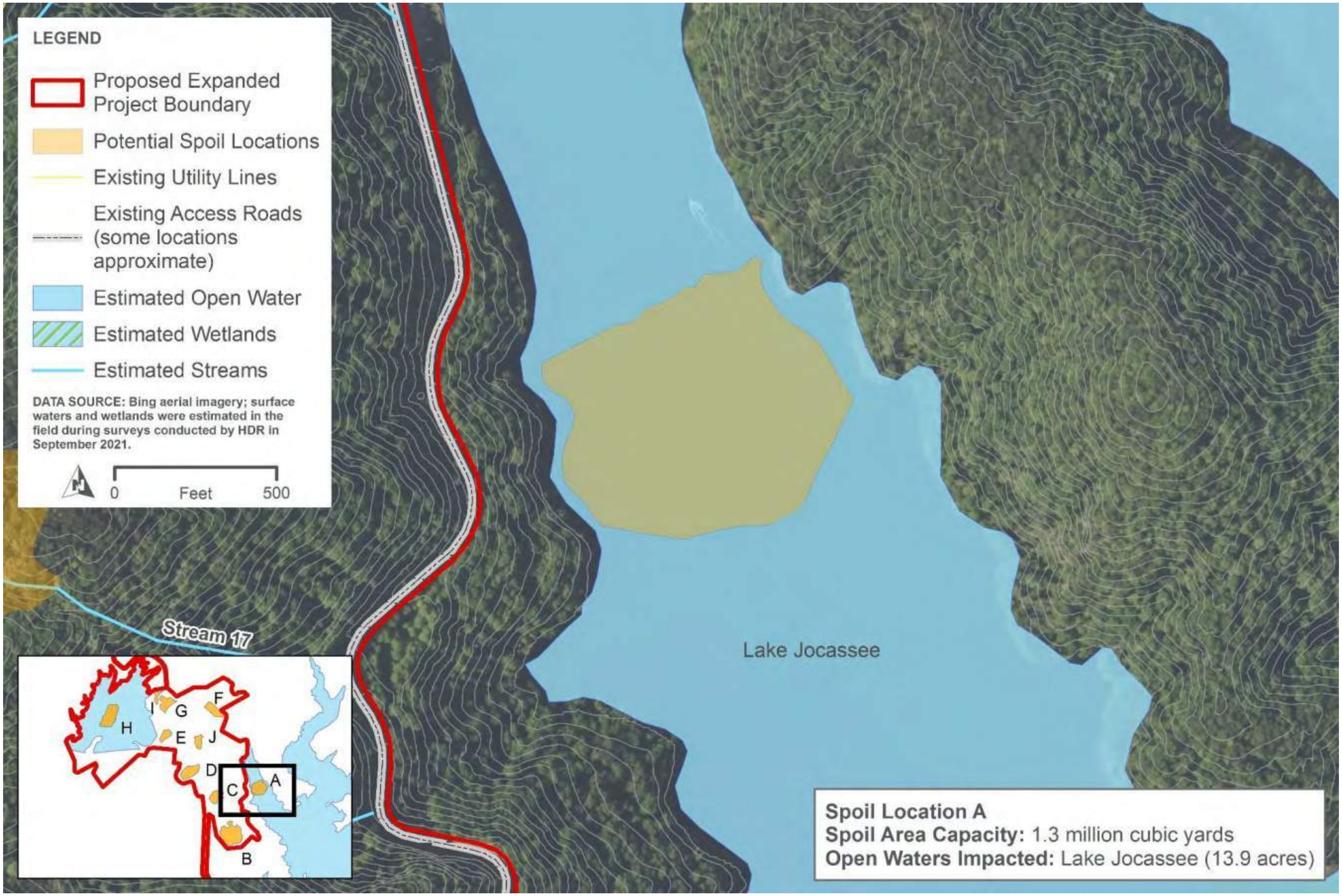
South Carolina Steering Committee. 2022. South Carolina Stream Quantification Tool: Data Collection and Analysis Manual, SC SQT v1.1. South Carolina Department of Natural Resources, Columbia, SC.

U.S. Environmental Protection Agency (USEPA). 2013. Technical Support Document for Conducting and Reviewing Freshwater Mussel Occurrence Surveys for the Development of Site-specific Water Quality Criteria for Ammonia. EPA 800-R-13-003. Office of Water. Washington, DC. Accessed June 2023. [URL]: https://www.epa.gov/sites/default/files/2015-08/documents/tsd_for_conducting_and_reviewing_freshwater_mussel_occurrence_surveys_for_the_development_of_site-specific_wqc_for_ammonia.pdf.

# Attachment 1

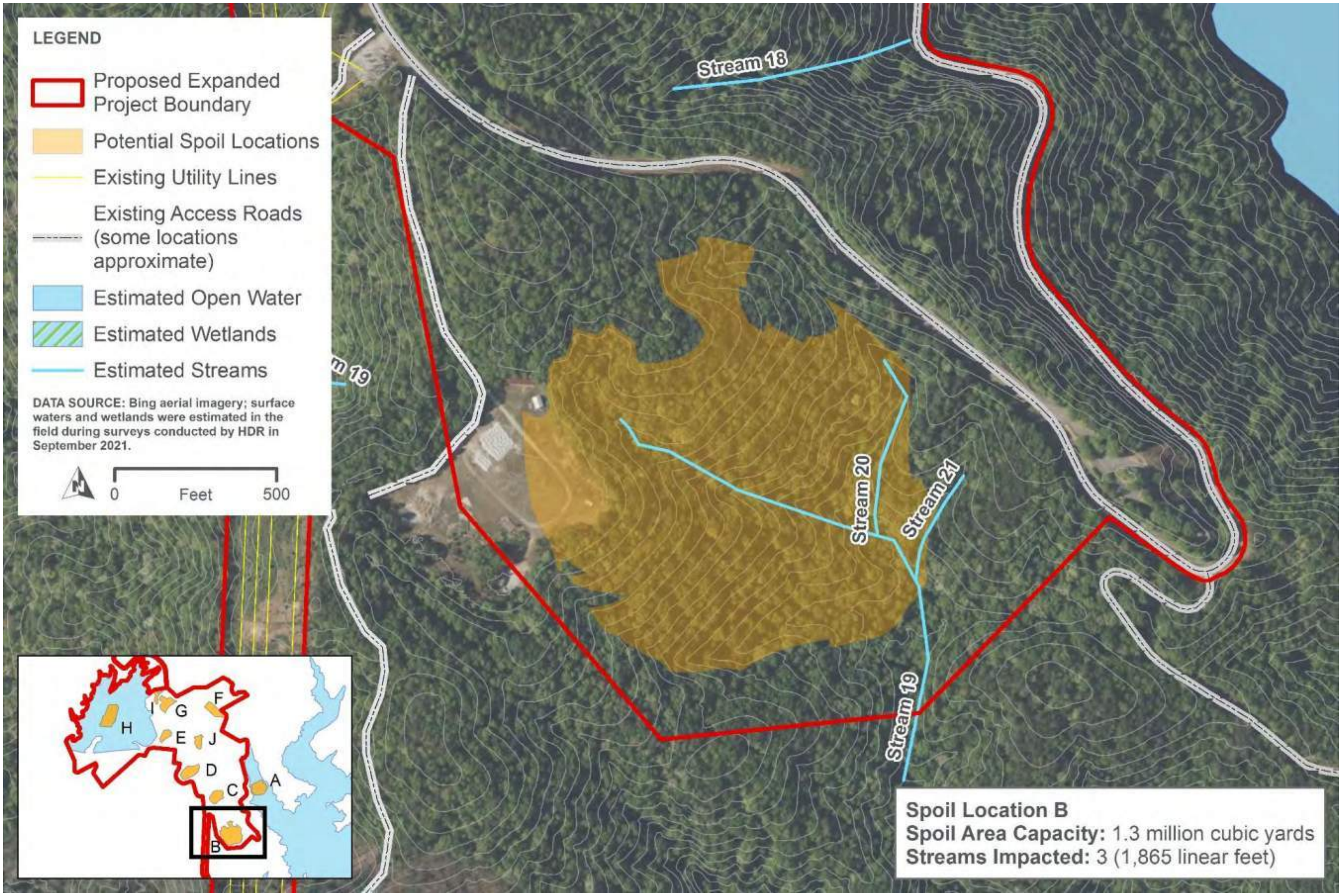
## Attachment 1 – Streams and Wetlands within Potential Spoil Locations


Bad Creek Reservoir
Lake Jocassee
A
B
C
D
E
F
G
H
I
J
LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Estimated Open Water
Estimated Streams
Estimated Wetlands
Existing Utility Lines
Existing Access Roads (some locations approximate)
0
Miles
0.5



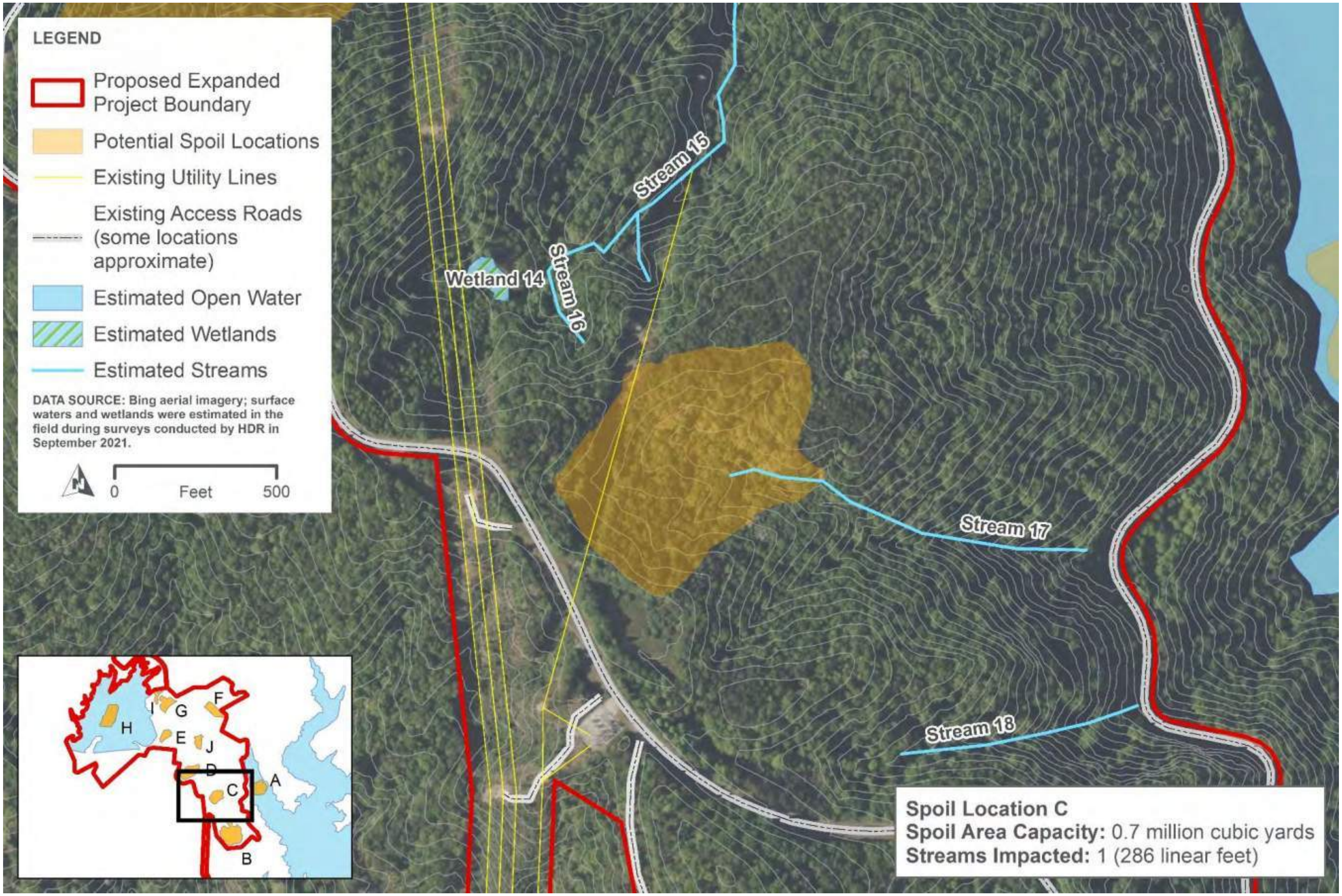
**DATA SOURCE:** Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

**Spoil Location A**
**Spoil Area Capacity:** 1.3 million cubic yards
**Open Waters Impacted:** Lake Jocassee (13.9 acres)

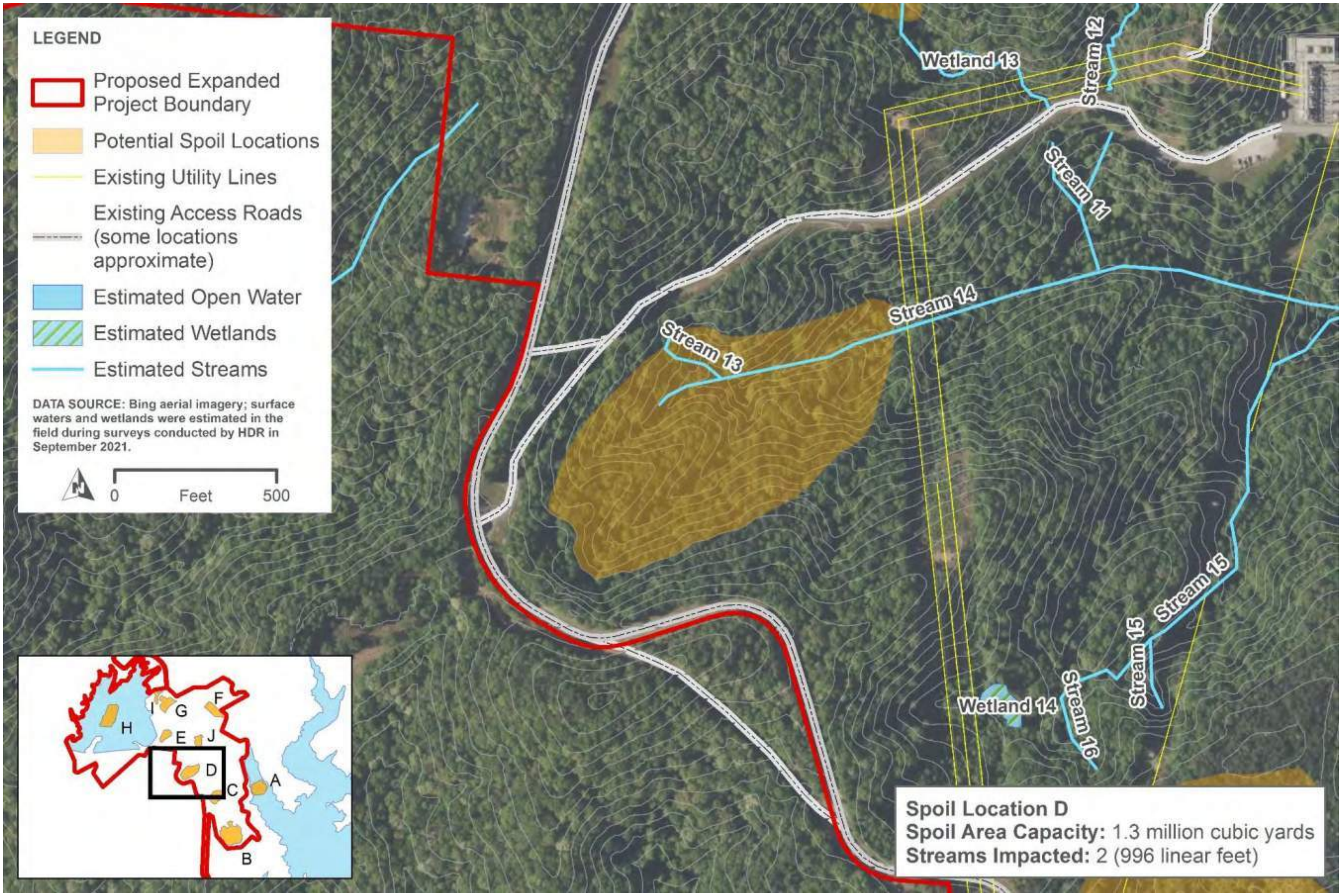


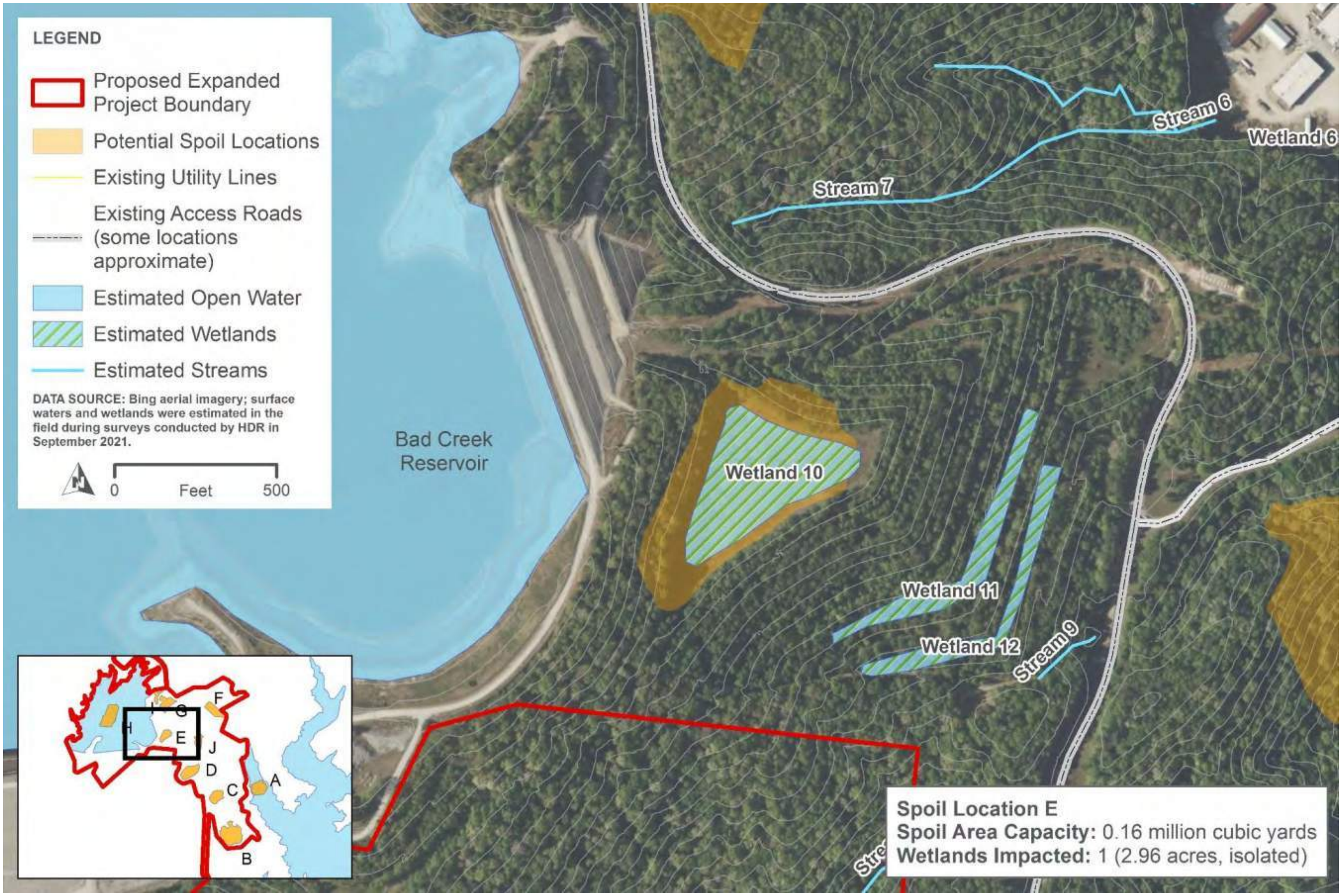
**DATA SOURCE:** Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

**Spoil Location B**
**Spoil Area Capacity:** 1.3 million cubic yards
**Streams Impacted:** 3 (1,865 linear feet)



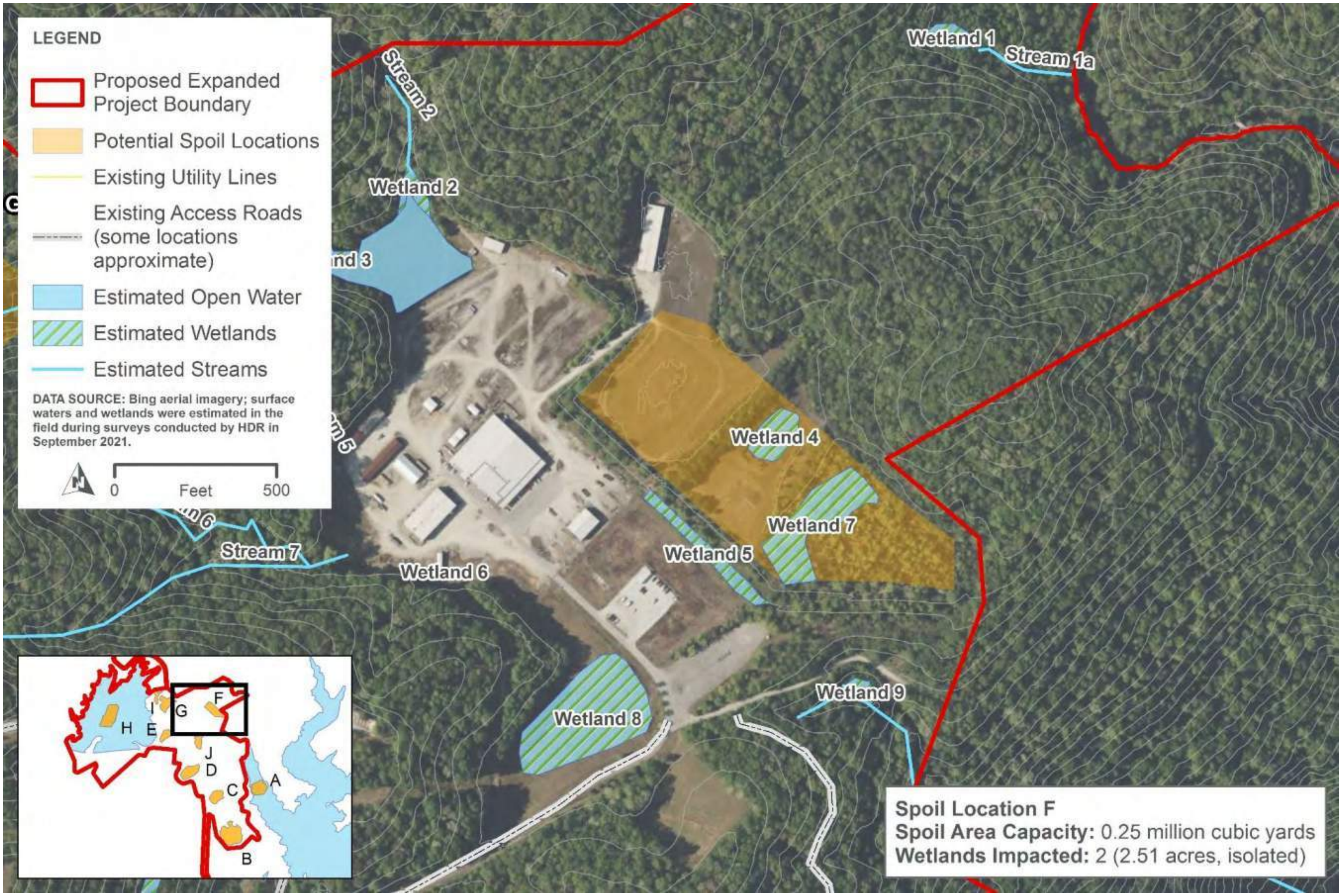
**Spoil Location C**
**Spoil Area Capacity:** 0.7 million cubic yards
**Streams Impacted:** 1 (286 linear feet)


LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Utility Lines
Existing Access Roads (some locations approximate)
Estimated Open Water
Estimated Wetlands
Estimated Streams
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.
0
Feet
500
Wetland 13
Stream 12
Stream 11
Stream 14
Stream 13
Stream 15
Wetland 14
Stream 16
H
I
G
F
E
J
D
C
A
B
Spoil Location D
Spoil Area Capacity: 1.3 million cubic yards
Streams Impacted: 2 (996 linear feet)



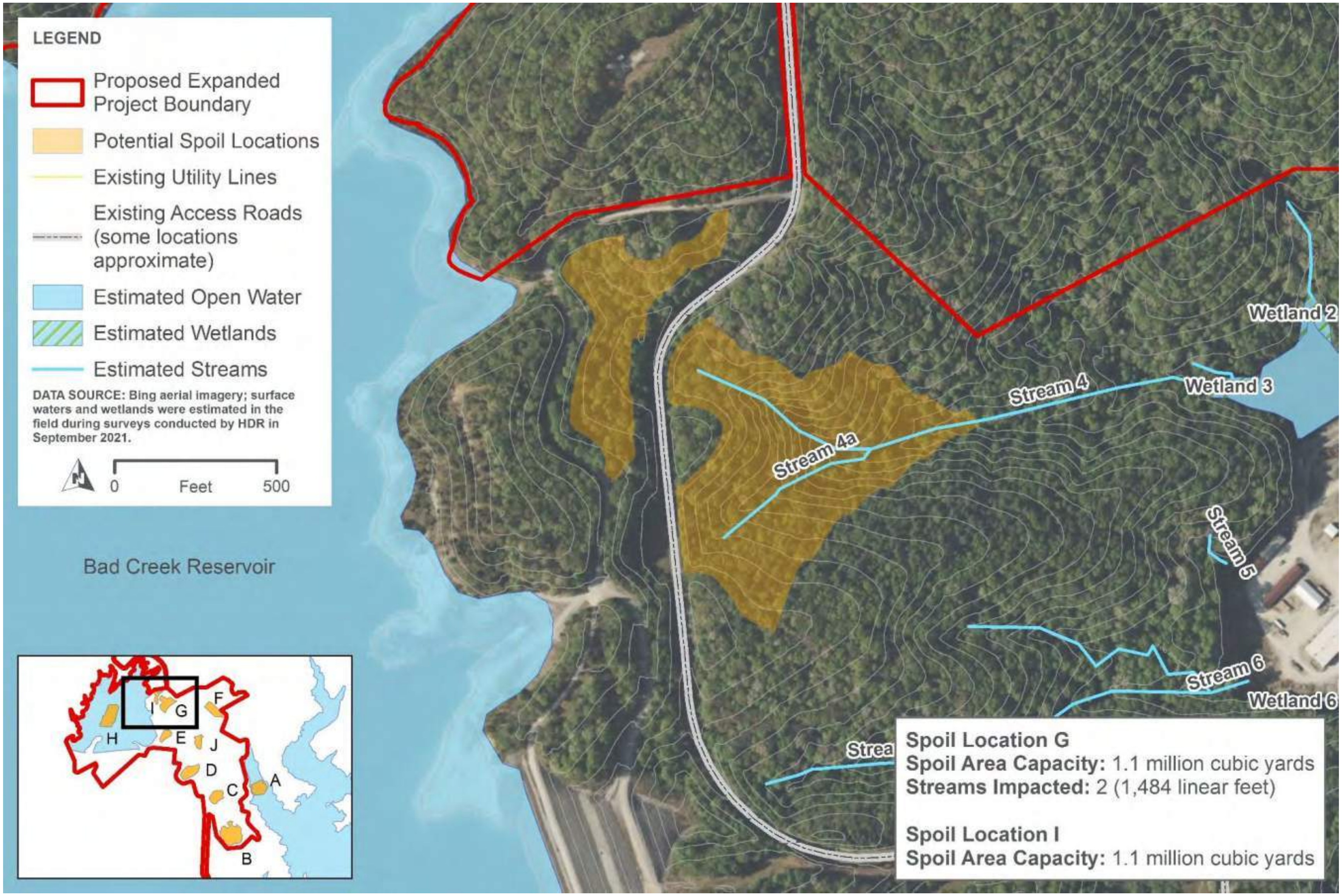
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

**Spoil Location E**
**Spoil Area Capacity:** 0.16 million cubic yards
**Wetlands Impacted:** 1 (2.96 acres, isolated)



**DATA SOURCE:** Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

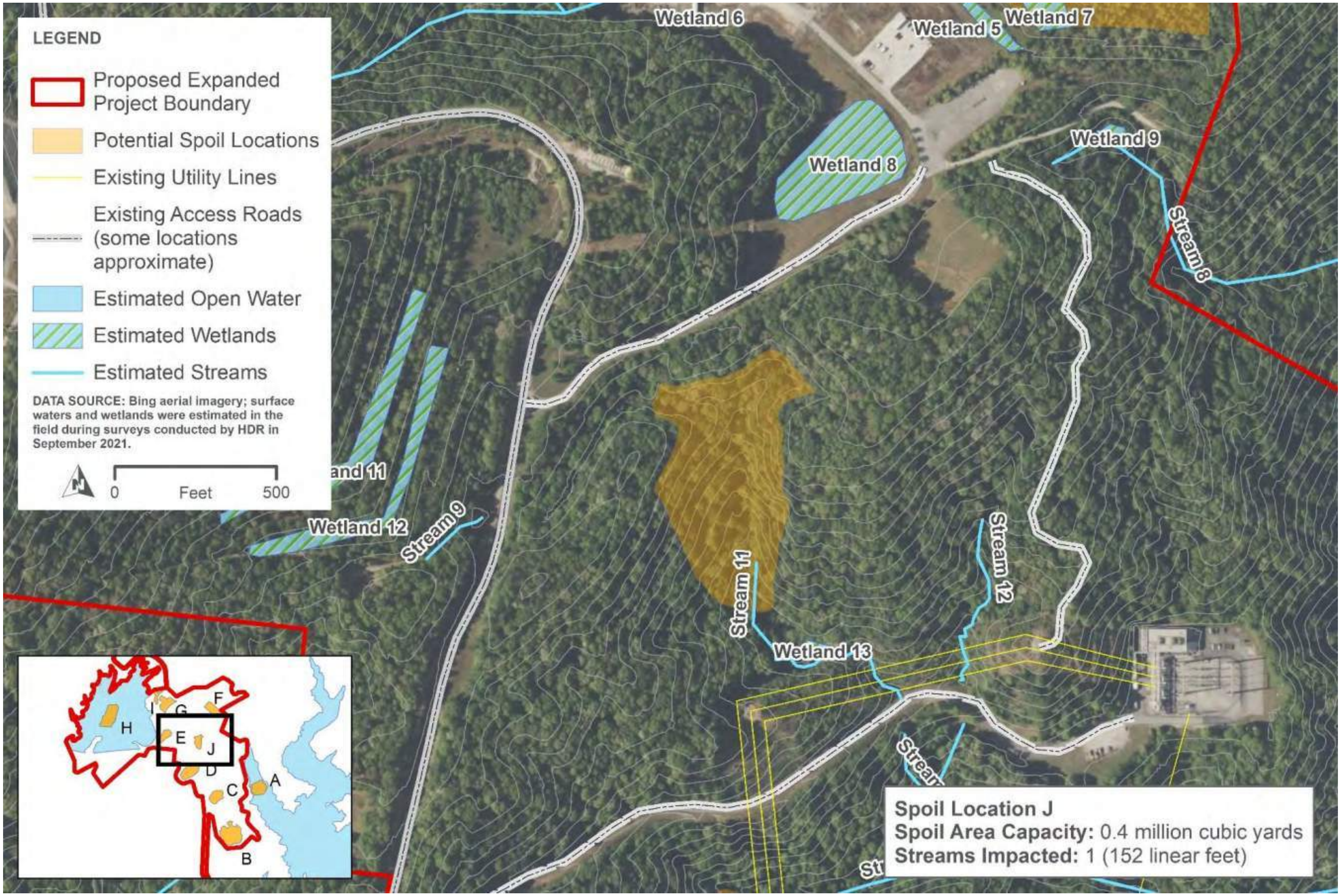
**Spoil Location F**
**Spoil Area Capacity:** 0.25 million cubic yards
**Wetlands Impacted:** 2 (2.51 acres, isolated)



**Spoil Location G**
**Spoil Area Capacity:** 1.1 million cubic yards
**Streams Impacted:** 2 (1,484 linear feet)

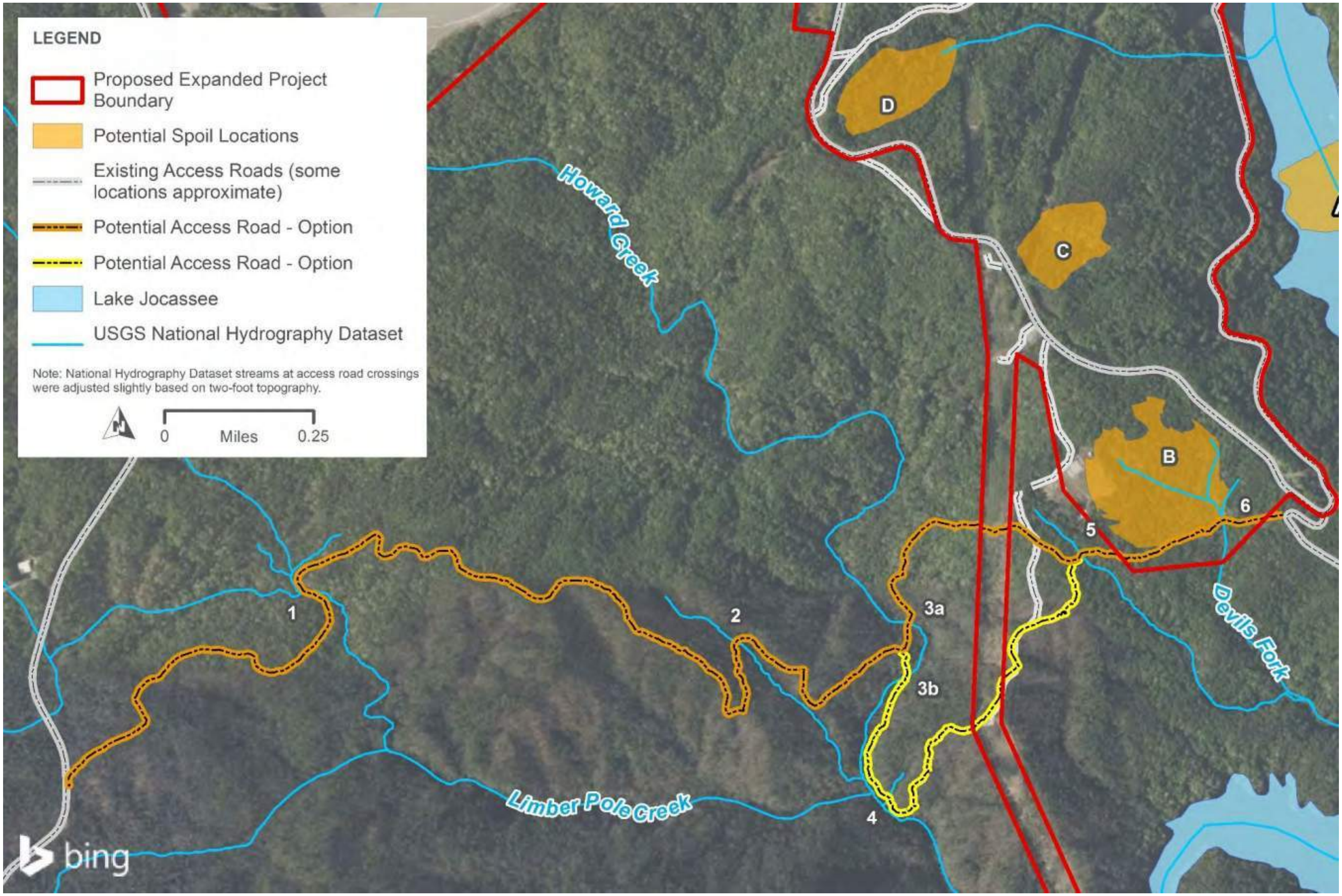
**Spoil Location I**
**Spoil Area Capacity:** 1.1 million cubic yards

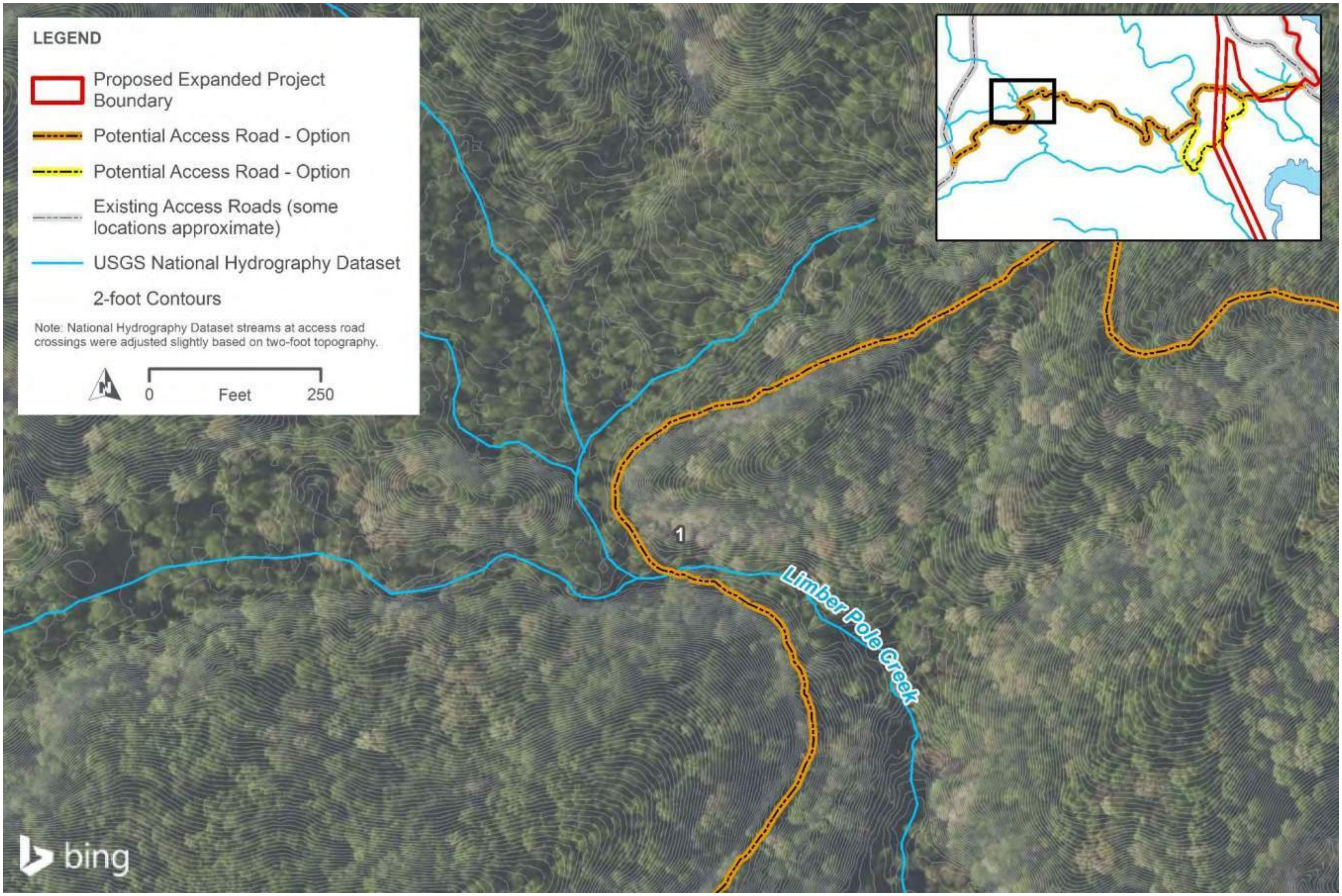

LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Utility Lines
Existing Access Roads (some locations approximate)
Estimated Open Water
Estimated Wetlands
Estimated Streams
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.
0
Feet
500
Bad Creek Reservoir
I
G
F
H
E
J
D
C
A
B
Spoil Location H
Spoil Area Capacity: 1.5 million cubic yards
Open Waters Impacted: Bad Creek Reservoir (19.3 acres)

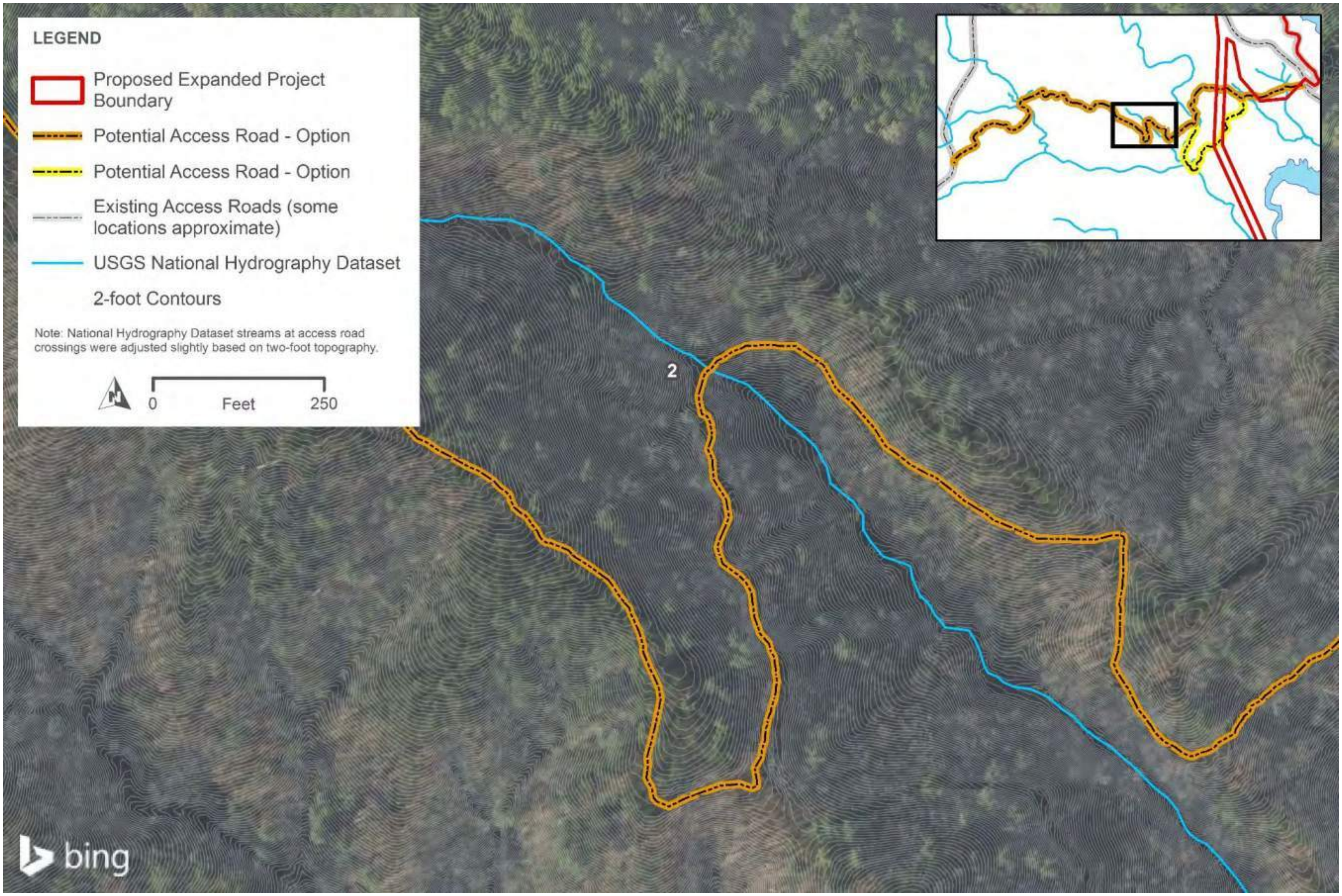

LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Utility Lines
Existing Access Roads (some locations approximate)
Estimated Open Water
Estimated Wetlands
Estimated Streams
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.
N
0
Feet
500
Wetland 6
Wetland 5
Wetland 7
Wetland 8
Wetland 9
Stream 8
and 11
Wetland 12
Stream 9
Stream 11
Stream 12
Wetland 13
Strean
St
H
I
G
F
E
J
D
C
A
B
Spoil Location J
Spoil Area Capacity: 0.4 million cubic yards
Streams Impacted: 1 (152 linear feet)

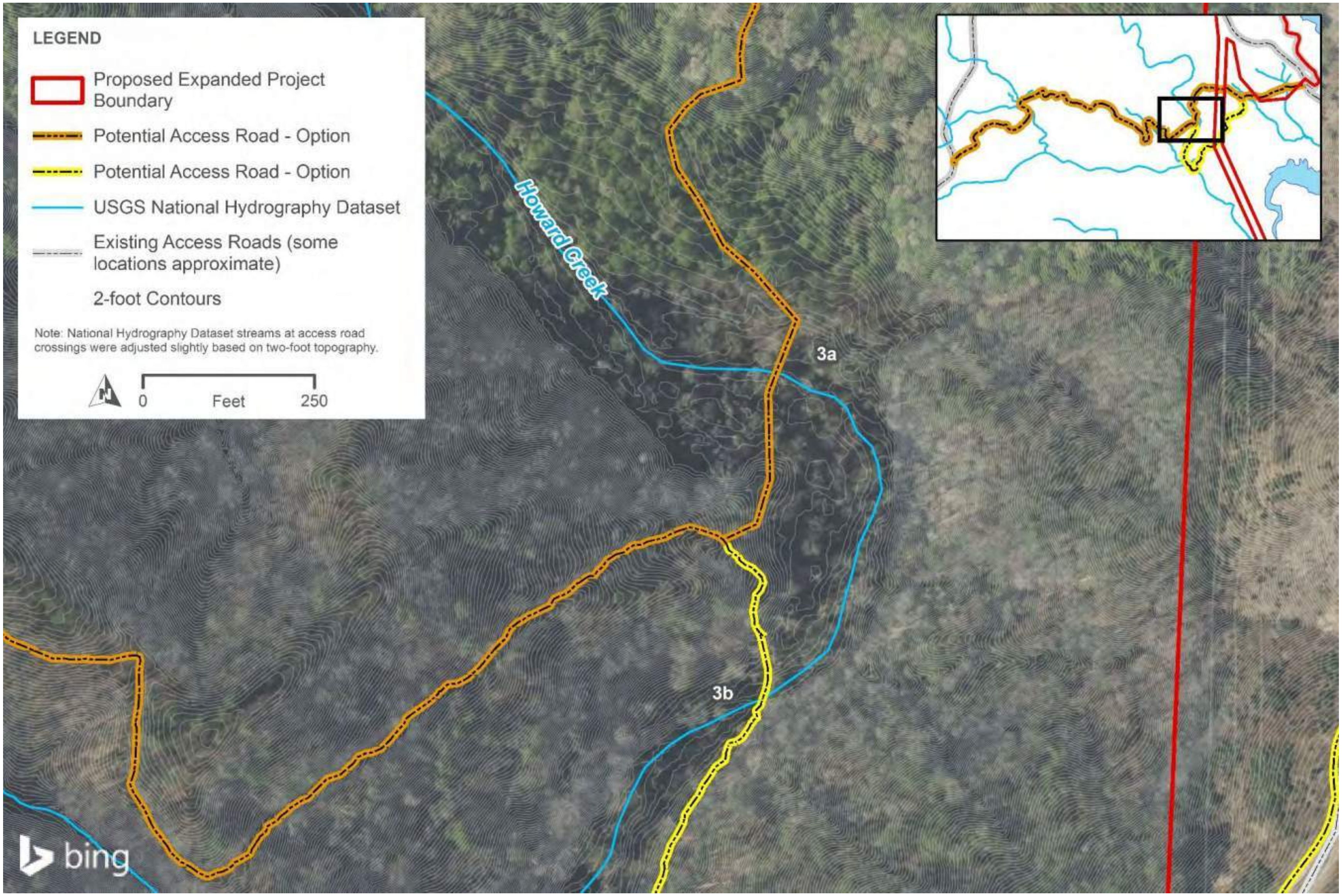
# Attachment 2

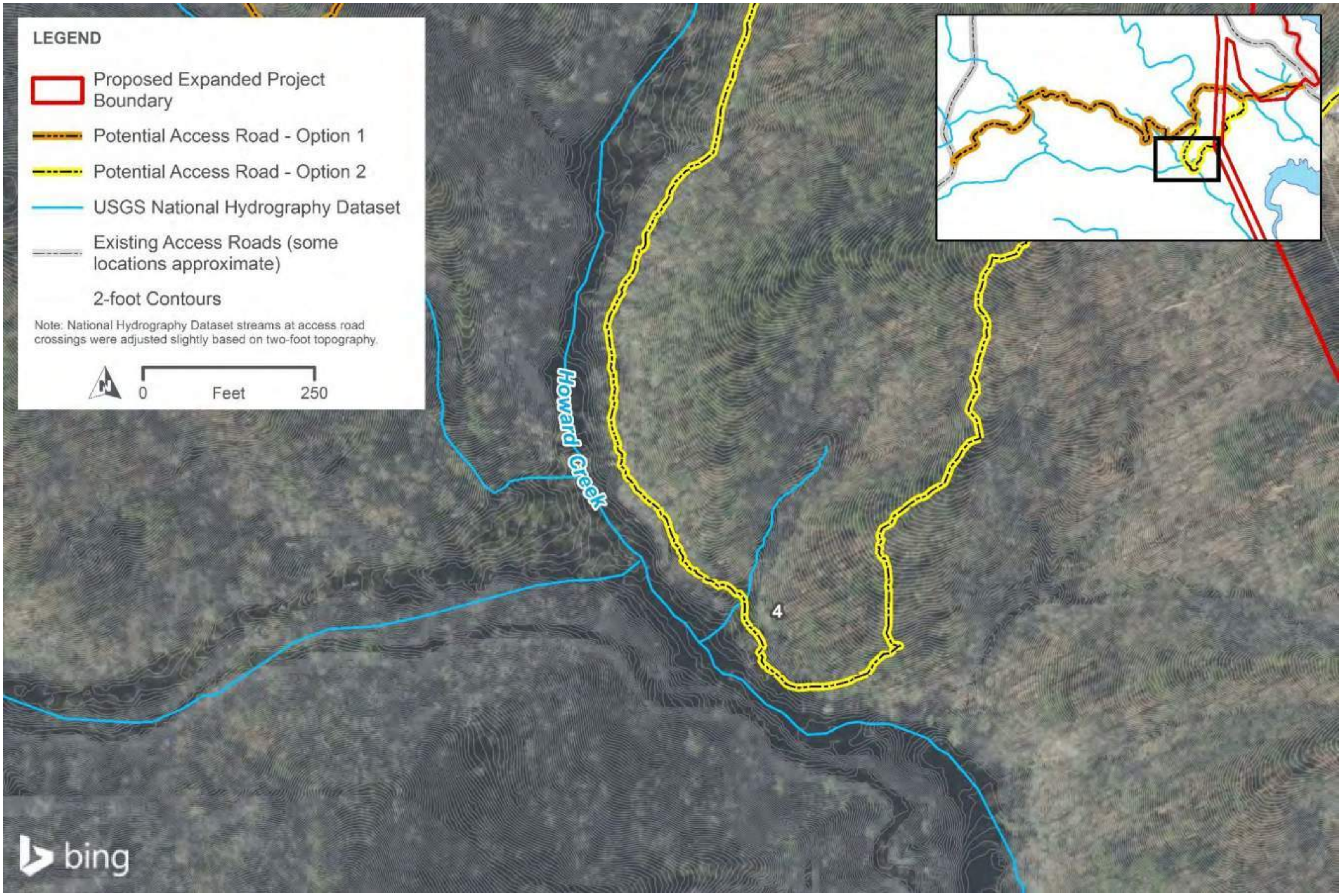
## Attachment 2 – Potential Access Road Stream Crossings

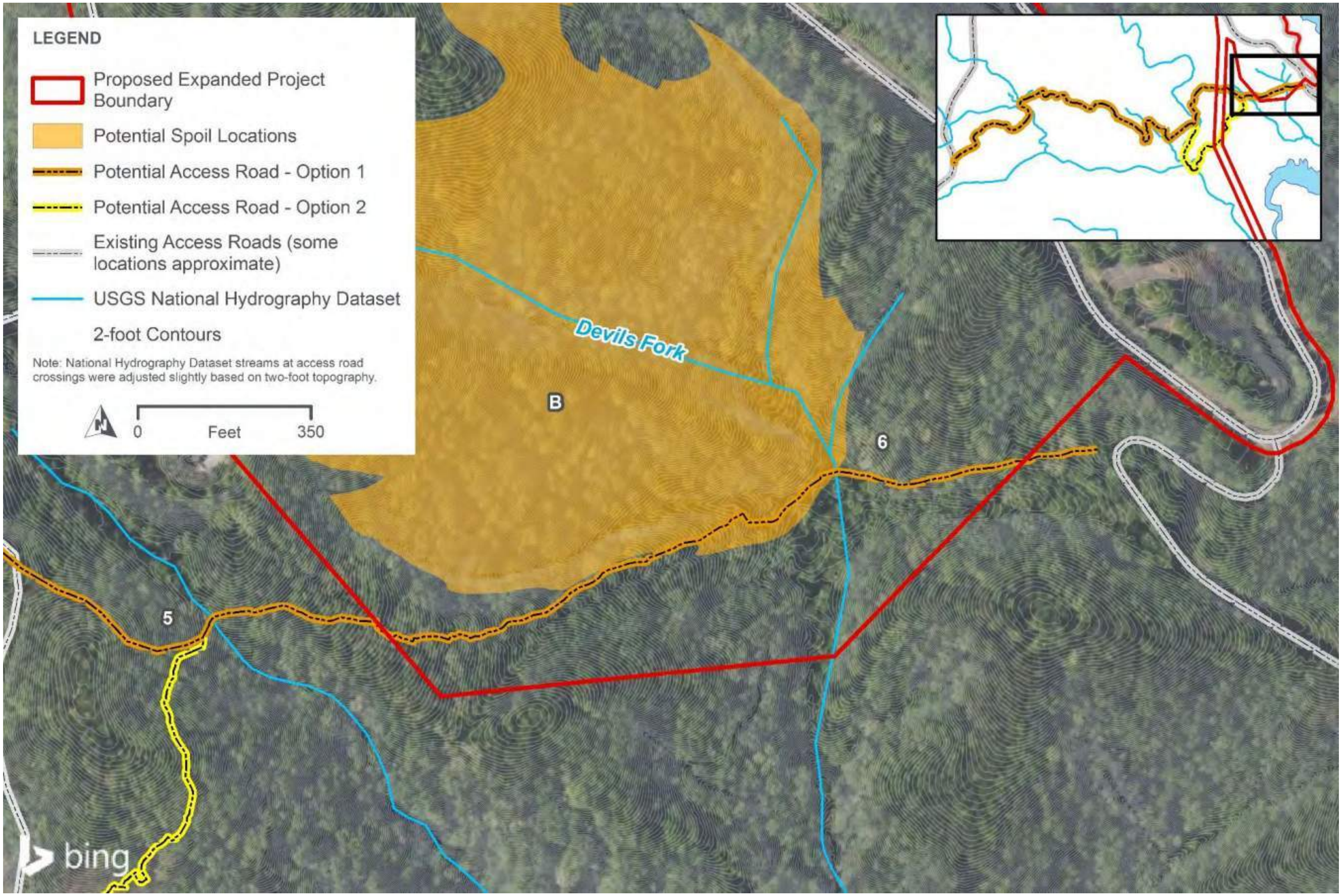

LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Access Roads (some locations approximate)
Potential Access Road - Option
Potential Access Road - Option
Lake Jocassee
USGS National Hydrography Dataset
Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based on two-foot topography.
0
Miles
0.25
Howard Creek
Limber Pole Creek
Devils Fork
D
C
B
1
2
3a
3b
4
5
6
bing


LEGEND
Proposed Expanded Project Boundary
Potential Access Road - Option
Potential Access Road - Option
Existing Access Roads (some locations approximate)
USGS National Hydrography Dataset
2-foot Contours
Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based on two-foot topography.
N
0
Feet
250
1
Limber Pole Creek
bing


LEGEND
Proposed Expanded Project Boundary
Potential Access Road - Option
Potential Access Road - Option
Existing Access Roads (some locations approximate)
USGS National Hydrography Dataset
2-foot Contours
Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based on two-foot topography.
N
0
Feet
250
2
bing


LEGEND
Proposed Expanded Project Boundary
Potential Access Road - Option
Potential Access Road - Option
USGS National Hydrography Dataset
Existing Access Roads (some locations approximate)
2-foot Contours
Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based on two-foot topography.
N
0
Feet
250
Howard Creek
3a
3b
bing


LEGEND
Proposed Expanded Project Boundary
Potential Access Road - Option 1
Potential Access Road - Option 2
USGS National Hydrography Dataset
Existing Access Roads (some locations approximate)
2-foot Contours
Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based on two-foot topography.
N
0
Feet
250
Howard Creek
4
bing


LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Potential Access Road - Option 1
Potential Access Road - Option 2
Existing Access Roads (some locations approximate)
USGS National Hydrography Dataset
2-foot Contours
Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based on two-foot topography.
0
Feet
350
Devils Fork
B
5
6
bing

# Attachment B

## Attachment B - Natural Resources Assessment Figures

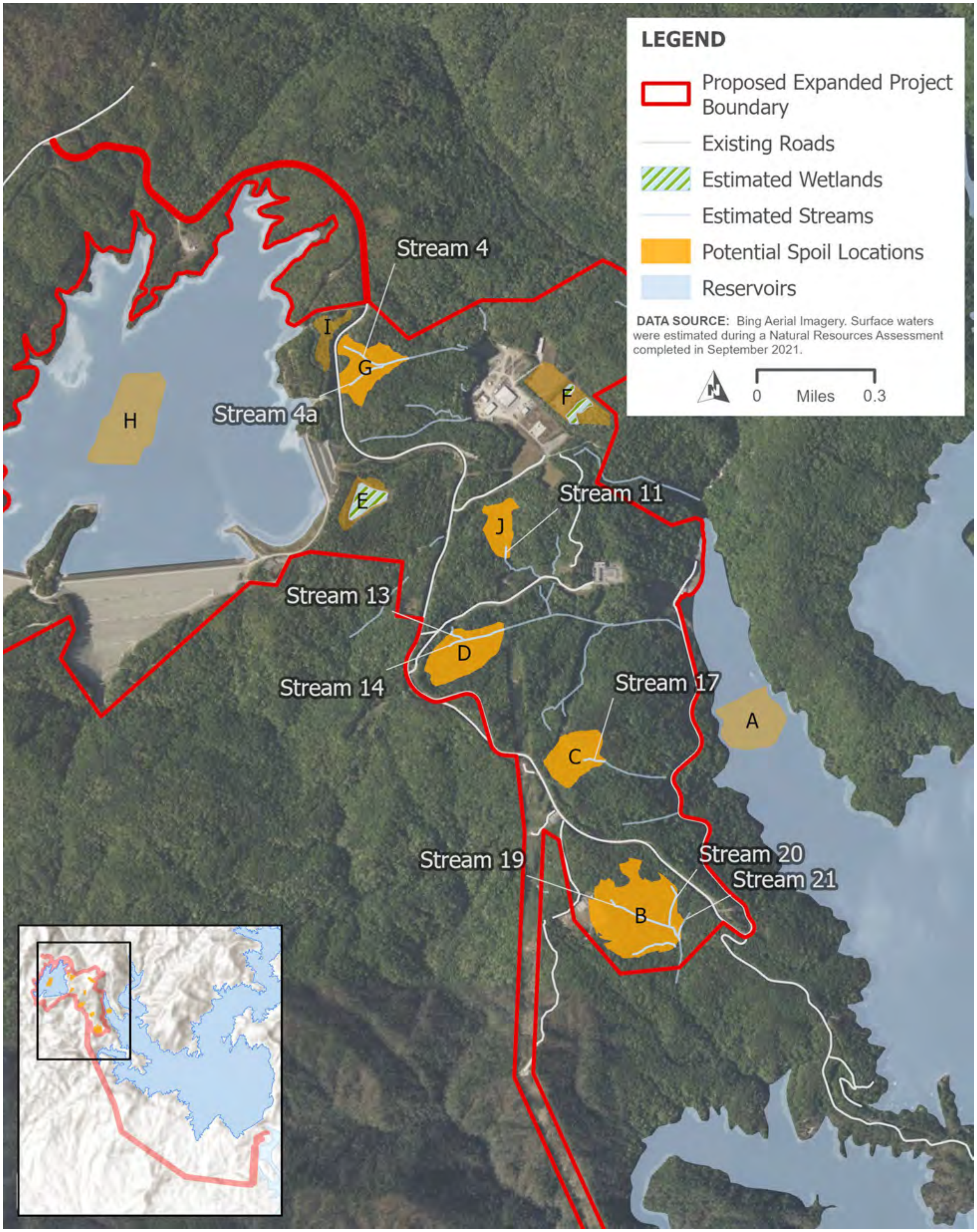


Figure 1. Estimated surface waters and wetlands within spoil locations

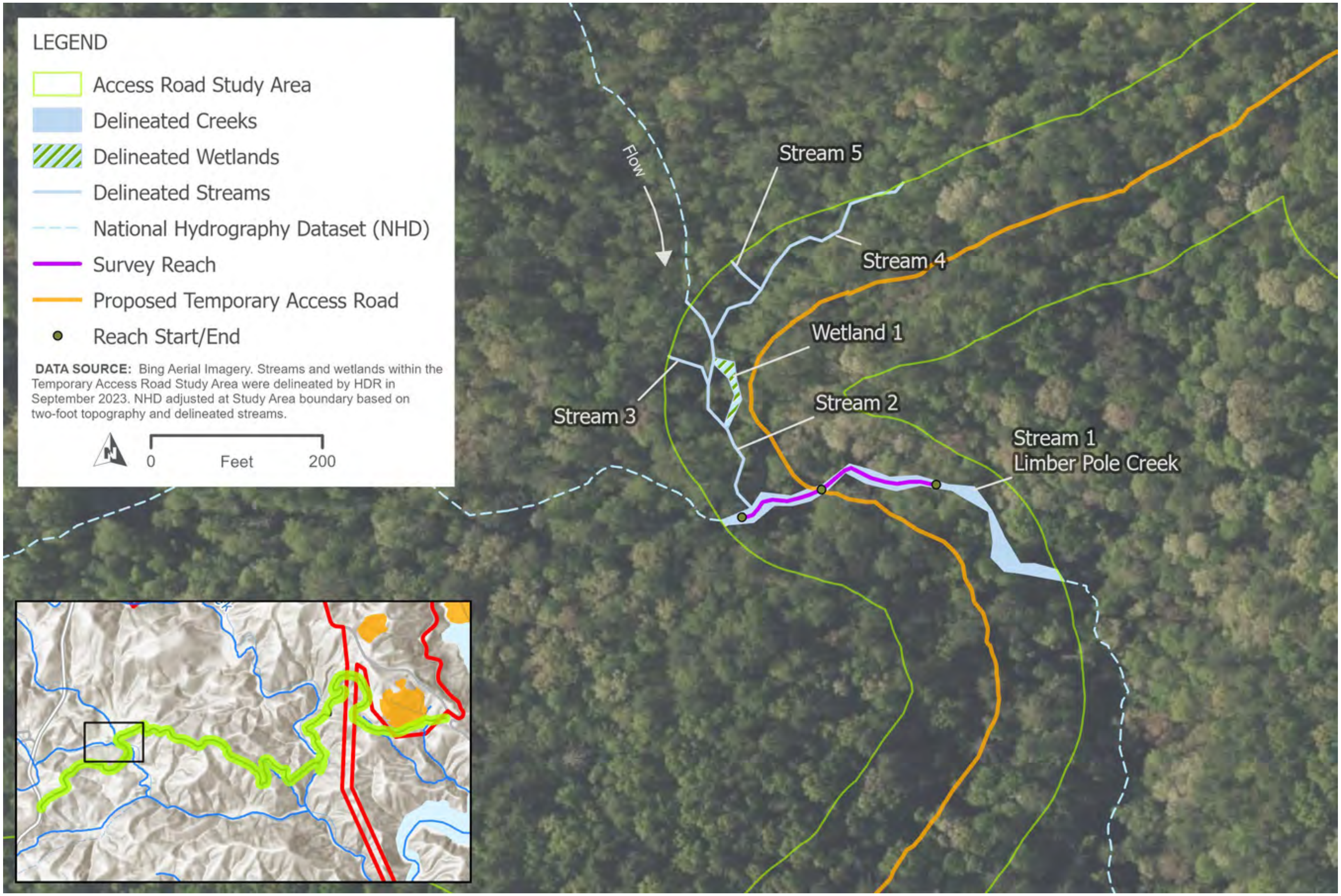
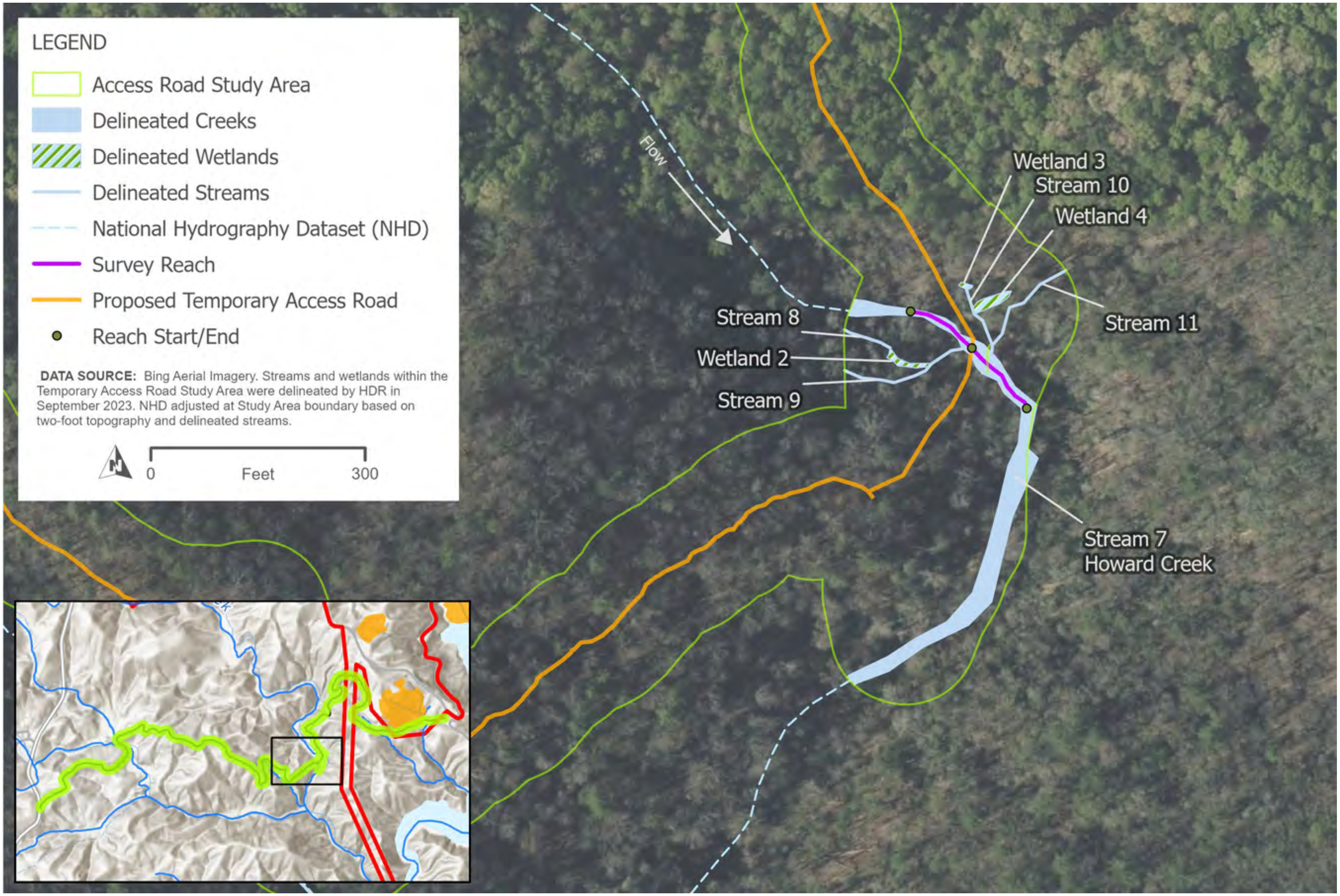


Figure 2. Streams and wetlands surveyed along the proposed temporary access road at the Stream 1 (Limber Pole Creek) crossing

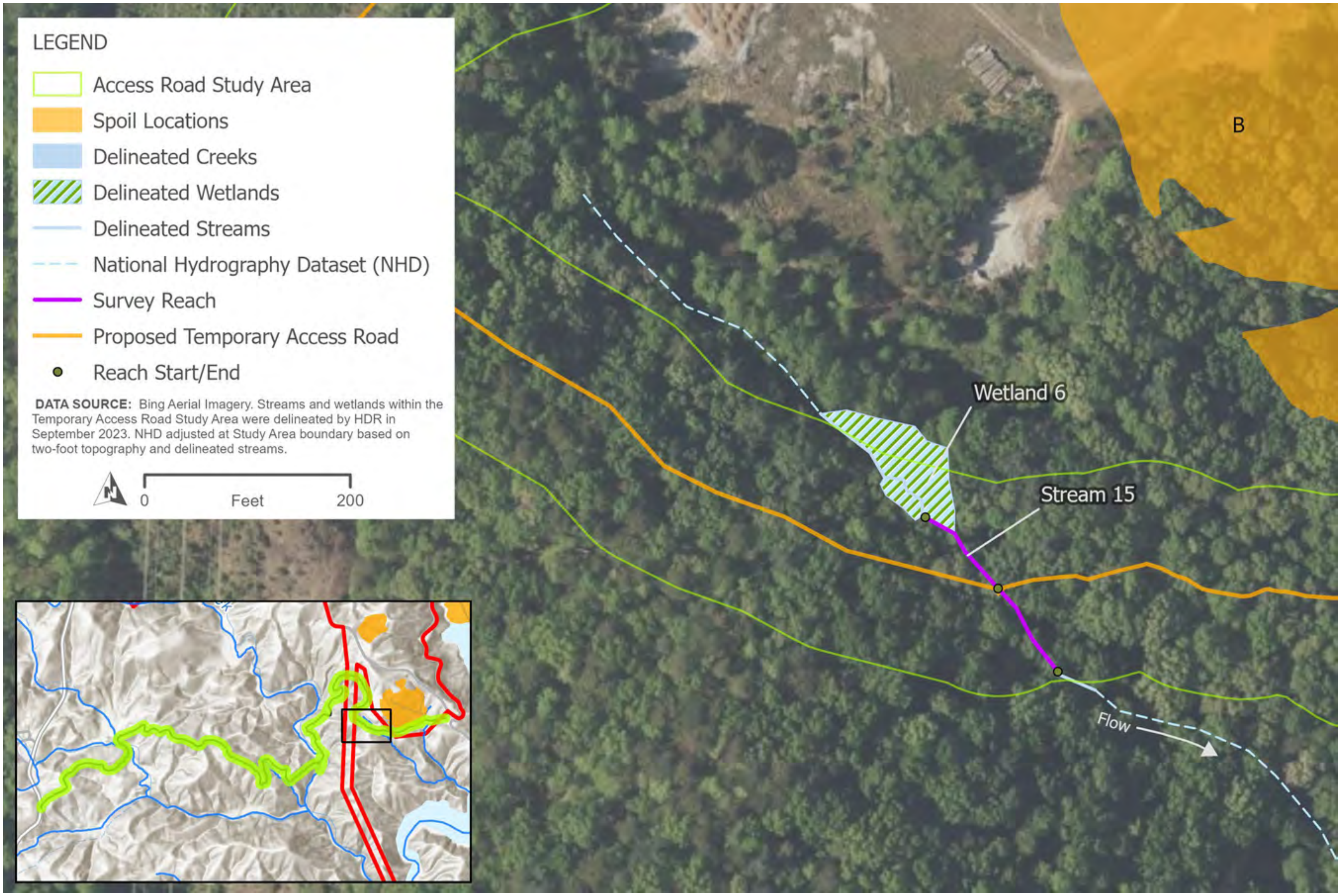


**DATA SOURCE:** Bing Aerial Imagery. Streams and wetlands within the Temporary Access Road Study Area were delineated by HDR in September 2023. NHD adjusted at Study Area boundary based on two-foot topography and delineated streams.

Figure 3. Streams and wetlands surveyed along the proposed temporary access road at the Stream 7 (Howard Creek) crossing

**DATA SOURCE:** Bing Aerial Imagery. Streams and wetlands within the Temporary Access Road Study Area were delineated by HDR in September 2023. NHD adjusted at Study Area boundary based on two-foot topography and delineated streams.

Figure 4. Streams and wetlands surveyed along the proposed temporary access road at the Stream 12 crossing



**DATA SOURCE:** Bing Aerial Imagery. Streams and wetlands within the Temporary Access Road Study Area were delineated by HDR in September 2023. NHD adjusted at Study Area boundary based on two-foot topography and delineated streams.

Figure 5. Streams and wetlands surveyed along the proposed temporary access road at the Stream 15 crossing

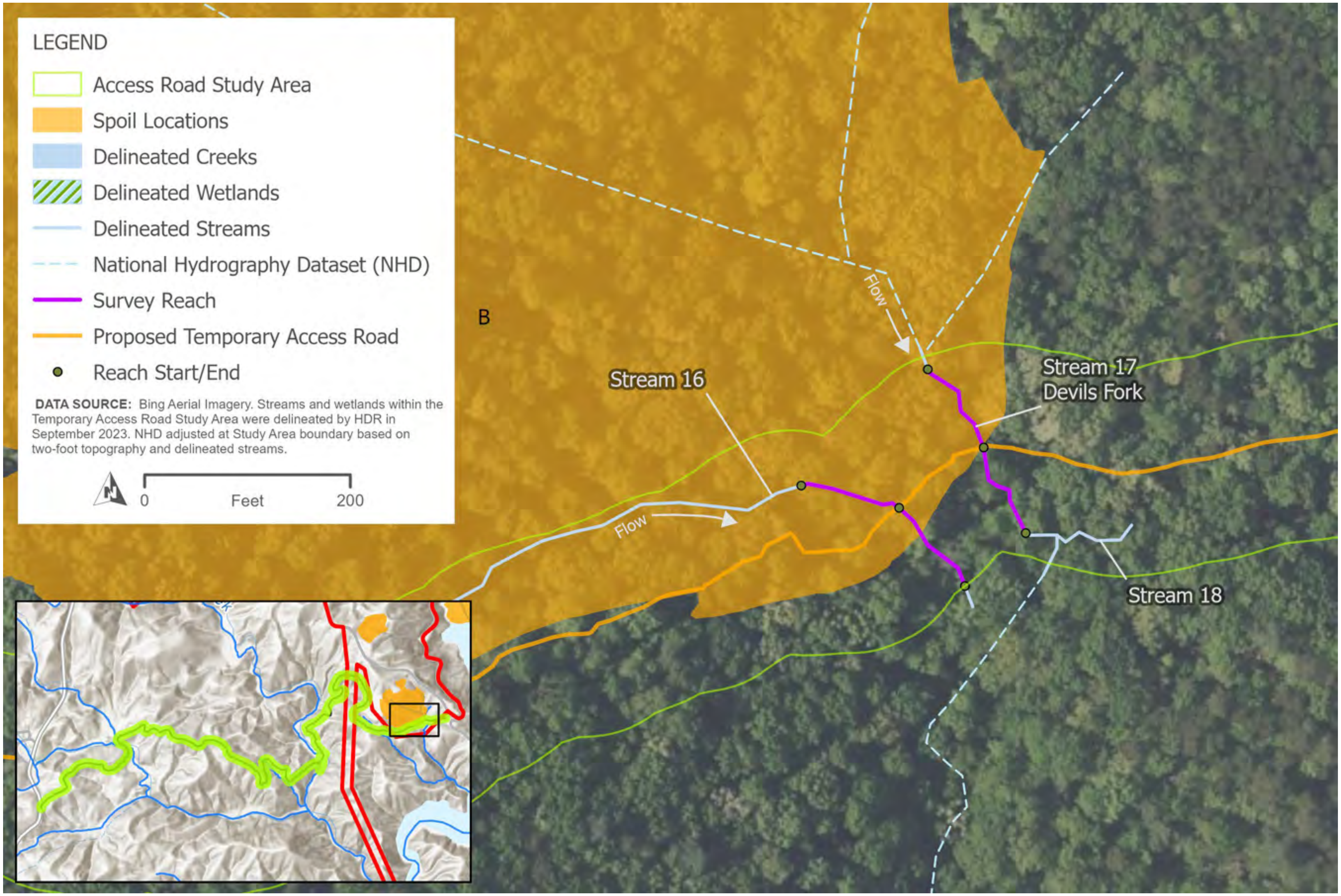


Figure 6. Streams and wetlands surveyed along the proposed temporary access road at the Stream 15 and 17 crossings

# Attachment C

## Attachment C - U.S. Environmental Protection Agency Rapid Bioassessment Protocol Data Forms

Temporary Access Road

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | | |
|---|---|---|
| STREAM NAME Stream 1 (Limber Pole) | LOCATION Bad Creek Pumped Storage Project | |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Perennial | |
| LAT _______________ LONG _______________ | RIVER BASIN Savannah | |
| STORET # | AGENCY | |
| INVESTIGATORS EBS | | |
| FORM COMPLETED BY | DATE 10/2/2023<br>TIME ________ AM PM | REASON FOR SURVEY |

| | Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|---|
| | | Optimal | Suboptimal | Marginal | Poor |
| Parameters to be evaluated in sampling reach | **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| | **SCORE** 18 | 20 19 [✓ 18] 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| | **SCORE** 18 | 20 19 [✓ 18] 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| | **SCORE** 20 | [✓ 20] 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| | **SCORE** 13 | 20 19 18 17 16 | 15 14 [✓ 13] 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| | **SCORE** 14 | 20 19 18 17 16 | 15 [✓ 14] 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

**Parameters to be evaluated broader than sampling reach**

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| **SCORE** 20 | [✓ 20] 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| **SCORE** 19 | 20 [✓ 19] 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| SCORE 8 (LB) | Left Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| SCORE 10 (LB) | Left Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| SCORE 10 (LB) | Left Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 170

Temporary Access Road

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | |
|---|---|
| STREAM NAME Stream 7 (Howard Creek) | LOCATION Oconee County, South Carolina |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Perennial |
| LAT 34.990481 LONG -83.00247 | RIVER BASIN Savannah |
| STORET # | AGENCY |
| INVESTIGATORS Paul Bright / Brett Boone | |
| FORM COMPLETED BY Paul Bright | DATE 10/18/23<br>TIME 9:00 [✓ AM] PM |
| REASON FOR SURVEY Environmental survey | |

**Parameters to be evaluated in sampling reach**

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | Optimal | Suboptimal | Marginal | Poor |
| **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **SCORE** 19 | 20 [✓ 19] 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| **SCORE** 18 | 20 19 [✓ 18] 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| **SCORE** 19 | 20 [✓ 19] 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| **SCORE** 17 | 20 19 18 [✓ 17] 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **SCORE** 19 | 20 [✓ 19] 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

| | Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|---|
| | | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **Parameters to be evaluated broader than sampling reach** | **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| | **SCORE** 19 | 20 [✓ 19] 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| | **SCORE** 18 | 20 19 [✓ 18] 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| | SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| | SCORE 10 (LB) | Left Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| | **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| | SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 185

Temporary Access Road

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | |
|---|---|
| STREAM NAME Stream 12 | LOCATION Oconee County, South Carolina |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Intermittent |
| LAT 34.995451 LONG -83.001330 | RIVER BASIN Savannah |
| STOREET # | AGENCY |
| INVESTIGATORS Paul Bright / Brett Boone | |
| FORM COMPLETED BY<br>Paul Bright | DATE 10/18/23<br>TIME 4:00 AM [✓ PM] |
| | REASON FOR SURVEY<br>Environmental survey |

Parameters to be evaluated in sampling reach

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | Optimal | Suboptimal | Marginal | Poor |
| **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| **SCORE** 8 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 [✓ 8] 7 6 | 5 4 3 2 1 0 |
| **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| **SCORE** 13 | 20 19 18 17 16 | 15 14 [✓ 13] 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **SCORE** 6 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 [✓ 6] | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | Optimal | Suboptimal | Marginal | Poor |
| **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| **SCORE** 13 | 20 19 18 17 16 | 15 14 [✓ 13] 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| **SCORE** 13 | 20 19 18 17 16 | 15 14 [✓ 13] 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| SCORE 8 (LB) | Left Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| SCORE 8 (RB) | Right Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 126

Temporary Access Road

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | | |
|---|---|---|
| STREAM NAME Stream 15 | LOCATION Oconee County, South Carolina | |
| STATION #_________ RIVERMILE__________ | STREAM CLASS Perennial | |
| LAT 34.993024 LONG -82.997765 | RIVER BASIN Savannah | |
| STORET # | AGENCY | |
| INVESTIGATORS Paul Bright / Brett Boone | | |
| FORM COMPLETED BY<br>Paul Bright | DATE 10/19/23<br>TIME 10:00 [✓ AM] PM | REASON FOR SURVEY<br>Environmental survey |

| | Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|---|
| | | Optimal | Suboptimal | Marginal | Poor |
| **Parameters to be evaluated in sampling reach** | **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| | **SCORE** 8 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 [✓ 8] 7 6 | 5 4 3 2 1 0 |
| | **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| | **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| | **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| | **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| | **SCORE** 16 | 20 19 18 17 [✓ 16] | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| | **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

**Parameters to be evaluated broader than sampling reach**

| **Habitat Parameter** | **Condition Category** | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| **SCORE** 17 | 20 19 18 [✓ 17] 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| SCORE 7 (LB) | Left Bank 10 9 | 8 [✓ 7] 6 | 5 4 3 | 2 1 0 |
| SCORE 7 (RB) | Right Bank 10 9 | 8 [✓ 7] 6 | 5 4 3 | 2 1 0 |
| **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 133

Temporary Access Road

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | | |
|---|---|---|
| STREAM NAME Stream 16 | LOCATION Oconee County, South Carolina | |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Perennial | |
| LAT 34.993518 LONG -82.994454 | RIVER BASIN Savannah | |
| STORET # | AGENCY | |
| INVESTIGATORS Paul Bright / Brett Boone | | |
| FORM COMPLETED BY<br>Paul Bright | DATE 10/19/23<br>TIME 3:00 AM [✓ PM] | REASON FOR SURVEY<br>Environmental survey |

Parameters to be evaluated in sampling reach

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| **SCORE** 8 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 [✓ 8] 7 6 | 5 4 3 2 1 0 |
| **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **SCORE** 6 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 [✓ 6] | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | Optimal | Suboptimal | Marginal | Poor |
| **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| **SCORE** 18 | 20 19 [✓ 18] 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| SCORE 8 (LB) | Left Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| SCORE 8 (RB) | Right Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 127

Temporary Access Road

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME Stream 17 (Devils Fork)

LOCATION Oconee County, South Carolina

STATION #__________ RIVERMILE__________

STREAM CLASS Perennial

LAT 34.993745 LONG -82.993409

RIVER BASIN Savannah

STORET #

AGENCY

INVESTIGATORS Paul Bright / Brett Boone

FORM COMPLETED BY Paul Bright

DATE 10/19/23

TIME 12:00 AM [✓ PM]

REASON FOR SURVEY Environmental survey

| | Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|---|
| | | Optimal | Suboptimal | Marginal | Poor |
| Parameters to be evaluated in sampling reach | **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| | **SCORE** 16 | 20 19 18 17 [✓ 16] | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| | **SCORE** 12 | 20 19 18 17 16 | 15 14 13 [✓ 12] 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| | **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| | **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| | **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| | **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| | **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

**Parameters to be evaluated broader than sampling reach**

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **6. Channel Alteration**<br>15 | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| **SCORE** | 20 19 18 17 16 | [✓ 15] 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **7. Frequency of Riffles (or bends)**<br>19 | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| **SCORE** | 20 [✓ 19] 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| SCORE 8 (LB) | Left Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| SCORE 8 (RB) | Right Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 144

Spoil Location G

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | | |
|---|---|---|
| STREAM NAME Stream 4a | LOCATION Bad Creek Pumped Storage Project - Spoil Location G | |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Intermittent | |
| LAT _______________ LONG _______________ | RIVER BASIN Savannah | |
| STORET # | AGENCY | |
| INVESTIGATORS JK, MI | | |
| FORM COMPLETED BY | DATE 09/12/203<br>TIME ________ AM PM | REASON FOR SURVEY |

**Parameters to be evaluated in sampling reach**

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | Optimal | Suboptimal | Marginal | Poor |
| **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **SCORE** 12 | 20 19 18 17 16 | 15 14 13 [✓ 12] 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| **SCORE** 8 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 [✓ 8] 7 6 | 5 4 3 2 1 0 |
| **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| **SCORE** 13 | 20 19 18 17 16 | 15 14 [✓ 13] 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

| | **Habitat Parameter** | **Condition Category** | | | |
|---|---|---|---|---|---|
| | | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **Parameters to be evaluated broader than sampling reach** | **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| | **SCORE** 19 | 20 [✓ 19] 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| | **SCORE** 12 | 20 19 18 17 16 | 15 14 13 [✓ 12] 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| | SCORE 7 (LB) | Left Bank 10 9 | 8 [✓ 7] 6 | 5 4 3 | 2 1 0 |
| | SCORE 7 (RB) | Right Bank 10 9 | 8 [✓ 7] 6 | 5 4 3 | 2 1 0 |
| | **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| | SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| | SCORE 10 (LB) | Left Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 137

Spoil Location G

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | | |
|---|---|---|
| STREAM NAME Stream 4 | LOCATION Bad Creek Pumped Storage Project - Spoil Location G | |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Perennial | |
| LAT _______________ LONG _______________ | RIVER BASIN Savannah | |
| STORET # | AGENCY | |
| INVESTIGATORS JK, MI | | |
| FORM COMPLETED BY | DATE 09/12/203<br>TIME ________ AM PM | REASON FOR SURVEY |

Parameters to be evaluated in sampling reach

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **SCORE** 8 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 [✓ 8] 7 6 | 5 4 3 2 1 0 |
| **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| **SCORE** 15 | 20 19 18 17 16 | [✓ 15] 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| **SCORE** 6 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 [✓ 6] | 5 4 3 2 1 0 |
| **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| **SCORE** 9 | 20 19 18 17 16 | 15 14 13 12 11 | 10 [✓ 9] 8 7 6 | 5 4 3 2 1 0 |
| **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **SCORE** 4 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 [✓ 4] 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

| | Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|---|
| | | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **Parameters to be evaluated broader than sampling reach** | **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| | **SCORE** 16 | 20 19 18 17 [✓ 16] | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| | **SCORE** 3 | 20 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 [✓ 3] 2 1 0 |
| | **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| | SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| | SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| | **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| | SCORE 10 (LB) | Left Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| | SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 117

Spoil Location C

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | |
|---|---|
| STREAM NAME Stream 17 | LOCATION Bad Creek Pumped Storage Project - Spoil Location C |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Perennial |
| LAT _______________ LONG _______________ | RIVER BASIN Savannah |
| STORET # | AGENCY |
| INVESTIGATORS JK, MI | |
| FORM COMPLETED BY | DATE 09/12/203<br>TIME ________ AM PM |
| | REASON FOR SURVEY |

| | Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|---|
| | | Optimal | Suboptimal | Marginal | Poor |
| Parameters to be evaluated in sampling reach | **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| | **SCORE** 14 | 20 19 18 17 16 | 15 [✓ 14] 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| | **SCORE** 11 | 20 19 18 17 16 | 15 14 13 12 [✓ 11] | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| | **SCORE** 9 | 20 19 18 17 16 | 15 14 13 12 11 | 10 [✓ 9] 8 7 6 | 5 4 3 2 1 0 |
| | **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| | **SCORE** 13 | 20 19 18 17 16 | 15 14 [✓ 13] 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| | **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| | **SCORE** 12 | 20 19 18 17 16 | 15 14 13 [✓ 12] 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

**Parameters to be evaluated broader than sampling reach**

| **Habitat Parameter** | **Condition Category** | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| **SCORE** 20 | [✓ 20] 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| **SCORE** 12 | 20 19 18 17 16 | 15 14 13 [✓ 12] 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| SCORE 7 (LB) | Left Bank 10 9 | 8 [✓ 7] 6 | 5 4 3 | 2 1 0 |
| SCORE 7 (RB) | Right Bank 10 9 | 8 [✓ 7] 6 | 5 4 3 | 2 1 0 |
| **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| SCORE 10 (LB) | Left Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 143

Spoil Location B

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

| | |
|---|---|
| STREAM NAME Stream 19 (Devils Fork) | LOCATION Bad Creek Pumped Storage Project - Spoil Location B |
| STATION #__________ RIVERMILE__________ | STREAM CLASS Perennial |
| LAT _______________ LONG _______________ | RIVER BASIN Savannah |
| STORET # | AGENCY |
| INVESTIGATORS JK, MI | |
| FORM COMPLETED BY | DATE 09/12/203<br>TIME ________ AM PM<br>REASON FOR SURVEY |

**Parameters to be evaluated in sampling reach**

| Habitat Parameter | Condition Category | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **1. Epifaunal Substrate/ Available Cover** | Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient). | 40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale). | 20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed. | Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking. |
| **SCORE** 15 | 20 19 18 17 16 | [✓ 15] 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **2. Embeddedness** | Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space. | Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment. | Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment. | Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment. |
| **SCORE** 16 | 20 19 18 17 [✓ 16] | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **3. Velocity/Depth Regime** | All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.) | Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes). | Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low). | Dominated by 1 velocity/ depth regime (usually slow-deep). |
| **SCORE** 14 | 20 19 18 17 16 | 15 [✓ 14] 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **4. Sediment Deposition** | Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition. | Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools. | Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent. | Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition. |
| **SCORE** 10 | 20 19 18 17 16 | 15 14 13 12 11 | [✓ 10] 9 8 7 6 | 5 4 3 2 1 0 |
| **5. Channel Flow Status** | Water reaches base of both lower banks, and minimal amount of channel substrate is exposed. | Water fills >75% of the available channel; or <25% of channel substrate is exposed. | Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed. | Very little water in channel and mostly present as standing pools. |
| **SCORE** 9 | 20 19 18 17 16 | 15 14 13 12 11 | 10 [✓ 9] 8 7 6 | 5 4 3 2 1 0 |

# HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

**Parameters to be evaluated broader than sampling reach**

| **Habitat Parameter** | **Condition Category** | | | |
|---|---|---|---|---|
| | **Optimal** | **Suboptimal** | **Marginal** | **Poor** |
| **6. Channel Alteration** | Channelization or dredging absent or minimal; stream with normal pattern. | Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present. | Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted. | Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely. |
| **SCORE** 20 | [✓ 20] 19 18 17 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **7. Frequency of Riffles (or bends)** | Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. | Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15. | Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25. | Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. |
| **SCORE** 17 | 20 19 18 [✓ 17] 16 | 15 14 13 12 11 | 10 9 8 7 6 | 5 4 3 2 1 0 |
| **8. Bank Stability (score each bank)**<br>Note: determine left or right side by facing downstream. | Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected. | Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion. | Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods. | Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars. |
| SCORE 8 (LB) | Left Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| SCORE 8 (RB) | Right Bank 10 9 | [✓ 8] 7 6 | 5 4 3 | 2 1 0 |
| **9. Vegetative Protection** (score each bank) | More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally. | 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining. | 50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining. | Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height. |
| SCORE 9 (LB) | Left Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 9 (RB) | Right Bank 10 [✓ 9] | 8 7 6 | 5 4 3 | 2 1 0 |
| **10. Riparian Vegetative Zone Width** (score each bank riparian zone) | Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone. | Width of riparian zone 12-18 meters; human activities have impacted zone only minimally. | Width of riparian zone 6-12 meters; human activities have impacted zone a great deal. | Width of riparian zone <6 meters: little or no riparian vegetation due to human activities. |
| SCORE 10 (LB) | Left Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |
| SCORE 10 (RB) | Right Bank [✓ 10] 9 | 8 7 6 | 5 4 3 | 2 1 0 |

**Total Score** 155

# Attachment D

## Attachment D - North Carolina Stream Assessment Method Data Forms

# NC SAM FIELD ASSESSMENT FORM
## Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek Pumped Storage Project 2. Date of evaluation: 9/12/2023
3. Applicant/owner name: Duke Energy 4. Assessor name/organization: JK, MI (HDR)
5. County: 6. Nearest named water body
7. River basin: Savannah on USGS 7.5-minute quad: Whitewater River
8. Site coordinates (decimal degrees, at lower end of assessment reach): 35.0150578, -83.0064250

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): Stream 4 10. Length of assessment reach evaluated (feet): 100
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 1.5 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 5 13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☐Perennial flow ☒Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A 
(more sinuous stream, flatter valley slope)

☒B 
(less sinuous stream, steeper valley slope)

17. Watershed size: **(skip for Tidal Marsh Stream)** ☒Size 1 (< 0.1 mi²) ☐Size 2 (0.1 to < 0.5 mi²) ☐Size 3 (0.5 to < 5 mi²) ☐Size 4 (≥ 5 mi²)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☐Yes ☒No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☐Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☒No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction <u>or</u> fill to the point of obstructing flow <u>or</u> a channel choked with aquatic macrophytes <u>or</u> ponded water <u>or</u> impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☒B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**
   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

6. **Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

LB RB
☒A ☒A Little or no evidence of conditions that adversely affect reference interaction
☐B ☐B Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching])
☐C ☐C Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] or too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) or floodplain/intertidal zone unnaturally absent or assessment reach is a man-made feature on an interstream divide

7. **Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B Excessive sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach and causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☐I Other: ____________________ (explain in “Notes/Sketch” section)
☒J Little to no stressors

8. **Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

☐A Drought conditions and no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions and rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

9. **Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

10. **Natural In-stream Habitat Types – assessment reach metric**
10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☒B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only
☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

**********************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*****************************

11. **Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☒ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☐ | ☒ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☐ | ☐ | ☐ | ☒ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☒Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☐ | Beetles |
| ☐ | ☐ | Caddisfly larvae (T) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☐ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☐ | Damselfly and dragonfly larvae |
| ☐ | ☐ | Dipterans |
| ☐ | ☐ | Mayfly larvae (E) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*) |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☐ | Other fish |
| ☒ | ☐ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☐ | Stonefly larvae (P) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☐ | Worms/leeches |

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☐B | ☐B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☐B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☒C | ☒C | Majority of streamside area with depressions able to pond water < 3 inches deep |

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☐Y | ☐Y | Are wetlands present in the streamside area? |
| ☒N | ☒N | |

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**

**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☐A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☒F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**

**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☒B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☐F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**

Consider aspect. Consider "leaf-on" condition.

☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**
**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide or no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation or modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer or predominantly herbaceous species or bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☒No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ______________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Stream 4

| | | | |
|---|---|---|---|
| Stream Site Name | Bad Creek Pumped Storage Project | Date of Assessment | 9/12/2023 |
| Stream Category | Mb1 | Assessor Name/Organization | JK, MI (HDR) |

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | NO |
| Presence of regulatory considerations (Y/N) | NO |
| Additional stream information/supplementary measurements included (Y/N) | NO |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Intermittent |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **MEDIUM** | **MEDIUM** |
| (2) Baseflow | **LOW** | **LOW** |
| (2) Flood Flow | **HIGH** | **HIGH** |
| (3) Streamside Area Attenuation | **HIGH** | **HIGH** |
| (4) Floodplain Access | **HIGH** | **HIGH** |
| (4) Wooded Riparian Buffer | **HIGH** | **HIGH** |
| (4) Microtopography | NA | NA |
| (3) Stream Stability | **HIGH** | **HIGH** |
| (4) Channel Stability | **HIGH** | **HIGH** |
| (4) Sediment Transport | **HIGH** | **HIGH** |
| (4) Stream Geomorphology | **HIGH** | **HIGH** |
| (2) Stream/Intertidal Zone Interaction | NA | NA |
| (2) Longitudinal Tidal Flow | NA | NA |
| (2) Tidal Marsh Stream Stability | NA | NA |
| (3) Tidal Marsh Channel Stability | NA | NA |
| (3) Tidal Marsh Stream Geomorphology | NA | NA |
| (1) Water Quality | **LOW** | **LOW** |
| (2) Baseflow | **LOW** | **LOW** |
| (2) Streamside Area Vegetation | **HIGH** | **HIGH** |
| (3) Upland Pollutant Filtration | **HIGH** | **HIGH** |
| (3) Thermoregulation | **HIGH** | **HIGH** |
| (2) Indicators of Stressors | **NO** | **NO** |
| (2) Aquatic Life Tolerance | **LOW** | **NA** |
| (2) Intertidal Zone Filtration | NA | NA |
| (1) Habitat | **MEDIUM** | **MEDIUM** |
| (2) In-stream Habitat | **LOW** | **LOW** |
| (3) Baseflow | **LOW** | **LOW** |
| (3) Substrate | **LOW** | **LOW** |
| (3) Stream Stability | **HIGH** | **HIGH** |
| (3) In-stream Habitat | **HIGH** | **HIGH** |
| (2) Stream-side Habitat | **HIGH** | **HIGH** |
| (3) Stream-side Habitat | **HIGH** | **HIGH** |
| (3) Thermoregulation | **HIGH** | **HIGH** |
| (2) Tidal Marsh In-stream Habitat | NA | NA |
| (3) Flow Restriction | NA | NA |
| (3) Tidal Marsh Stream Stability | NA | NA |
| (4) Tidal Marsh Channel Stability | NA | NA |
| (4) Tidal Marsh Stream Geomorphology | NA | NA |
| (3) Tidal Marsh In-stream Habitat | NA | NA |
| (2) Intertidal Zone | NA | NA |
| Overall | **MEDIUM** | **MEDIUM** |

# NC SAM FIELD ASSESSMENT FORM
## Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek Pumped Storage Project
2. Date of evaluation: 9/12/2023
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: JK / HDR
5. County:
6. Nearest named water body on USGS 7.5-minute quad: Lake Jocassee
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 35.0145516, -83.0080285

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): Stream 4a - spoil G
10. Length of assessment reach evaluated (feet): 100
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 4 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 8
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☒Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A

(more sinuous stream, flatter valley slope)

☒B

(less sinuous stream, steeper valley slope)

17. Watershed size: (**skip for Tidal Marsh Stream**) ☒Size 1 (< 0.1 mi²) ☐Size 2 (0.1 to < 0.5 mi²) ☐Size 3 (0.5 to < 5 mi²) ☐Size 4 (≥ 5 mi²)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☐Yes ☒No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☐Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☒No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☒A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction or fill to the point of obstructing flow or a channel choked with aquatic macrophytes or ponded water or impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☐B Not A

3. **Feature Pattern – assessment reach metric**
   - ☒A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☐B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☒A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☐B Not A

5. **Signs of Active Instability – assessment reach metric**

   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

**6. Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no evidence of conditions that adversely affect reference interaction |
| ☒B | ☒B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

**7. Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B <u>Excessive</u> sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach <u>and</u> causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☐I Other: ____________________ (explain in “Notes/Sketch” section)
☒J Little to no stressors

**8. Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

☐A Drought conditions <u>and</u> no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions <u>and</u> rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

**9. Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

**10. Natural In-stream Habitat Types – assessment reach metric**
10a. ☒Yes ☐No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

☒A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☒B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only

☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

************************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS********************************

**11. Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☒ | ☐ | ☐ | Bedrock/saprolite |
| ☐ | ☒ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Detritus |
| ☐ | ☐ | ☒ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ______

12b. ☒Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☐ | Beetles |
| ☐ | ☐ | Caddisfly larvae (T) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☐ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☐ | Damselfly and dragonfly larvae |
| ☐ | ☐ | Dipterans |
| ☐ | ☐ | Mayfly larvae (E) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*) |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☐ | Other fish |
| ☐ | ☒ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☒ | Stonefly larvae (P) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☐ | Worms/leeches |

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☒B | ☒B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☒B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☒C | ☐C | Majority of streamside area with depressions able to pond water < 3 inches deep |

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☐Y | ☐Y | Are wetlands present in the streamside area? |
| ☒N | ☒N | |

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**

**Check all contributors within the assessment reach or within view of and draining to the assessment reach.**

☐A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☒F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**

**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☒B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☐F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**

Consider aspect. Consider "leaf-on" condition.

☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**
**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| | | | | |
|---|---|---|---|---|
| Vegetated | | Wooded | | |
| LB | RB | LB | RB | |
| ☐A | ☐A | ☒A | ☒A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☒E | ☒E | ☐E | ☐E | < 10 feet wide or no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| | | |
|---|---|---|
| LB | RB | |
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation or modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| | | | | | | |
|---|---|---|---|---|---|---|
| Abuts | | < 30 feet | | 30-50 feet | | |
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| | | |
|---|---|---|
| LB | RB | |
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer or predominantly herbaceous species or bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| | | |
|---|---|---|
| LB | RB | |
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| | | |
|---|---|---|
| LB | RB | |
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☒No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ______________________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Stream 4a

Stream Site Name: Bad Creek Pumped Storage Project
Date of Assessment: 9/12/2023
Stream Category: Mb1
Assessor Name/Organization: JK / HDR

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | NO |
| Presence of regulatory considerations (Y/N) | NO |
| Additional stream information/supplementary measurements included (Y/N) | NO |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Perennial |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **LOW** | |
| (2) Baseflow | **LOW** | |
| (2) Flood Flow | **MEDIUM** | |
| (3) Streamside Area Attenuation | **MEDIUM** | |
| (4) Floodplain Access | **MEDIUM** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | |
| (3) Stream Stability | **MEDIUM** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **HIGH** | |
| (4) Stream Geomorphology | **LOW** | |
| (2) Stream/Intertidal Zone Interaction | NA | |
| (2) Longitudinal Tidal Flow | NA | |
| (2) Tidal Marsh Stream Stability | NA | |
| (3) Tidal Marsh Channel Stability | NA | |
| (3) Tidal Marsh Stream Geomorphology | NA | |
| (1) Water Quality | **MEDIUM** | |
| (2) Baseflow | **LOW** | |
| (2) Streamside Area Vegetation | **MEDIUM** | |
| (3) Upland Pollutant Filtration | **LOW** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **MEDIUM** | |
| (2) Intertidal Zone Filtration | NA | |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **MEDIUM** | |
| (3) Baseflow | **LOW** | |
| (3) Substrate | **HIGH** | |
| (3) Stream Stability | **MEDIUM** | |
| (3) In-stream Habitat | **MEDIUM** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Tidal Marsh In-stream Habitat | NA | |
| (3) Flow Restriction | NA | |
| (3) Tidal Marsh Stream Stability | NA | |
| (4) Tidal Marsh Channel Stability | NA | |
| (4) Tidal Marsh Stream Geomorphology | NA | |
| (3) Tidal Marsh In-stream Habitat | NA | |
| (2) Intertidal Zone | NA | |
| Overall | **MEDIUM** | |

## NC SAM FIELD ASSESSMENT FORM
## Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek Pumped Storage Project
2. Date of evaluation: 9/12/2023
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: JK, MI (HDR)
5. County:
6. Nearest named water body on USGS 7.5-minute quad: Howard Creek
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.9999817, -82.9961129

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): Stream 17 spoil C
10. Length of assessment reach evaluated (feet): 100
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 3 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 5
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☒Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A

(more sinuous stream, flatter valley slope)

☒B

(less sinuous stream, steeper valley slope)

17. Watershed size: (**skip for Tidal Marsh Stream**) ☒Size 1 (< 0.1 mi$^2$) ☐Size 2 (0.1 to < 0.5 mi$^2$) ☐Size 3 (0.5 to < 5 mi$^2$) ☐Size 4 (≥ 5 mi$^2$)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☐Yes ☒No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☐Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☒No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction or fill to the point of obstructing flow or a channel choked with aquatic macrophytes or ponded water or impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☒B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**

   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

**6. Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Little or no evidence of conditions that adversely affect reference interaction |
| ☐B | ☐B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

**7. Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**
☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B <u>Excessive</u> sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach <u>and</u> causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☐I Other: ____________________ (explain in “Notes/Sketch” section)
☒J Little to no stressors

**8. Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.
☐A Drought conditions <u>and</u> no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions <u>and</u> rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

**9. Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

**10. Natural In-stream Habitat Types – assessment reach metric**
10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**
☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☒B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only
☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

**************************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*******************************

**11. Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☒ | ☐ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☒ | ☐ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________________________

12b. ☒Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

1 >1 Numbers over columns refer to “individuals” for Size 1 and 2 streams and “taxa” for Size 3 and 4 streams.
☐ ☐Adult frogs
☐ ☐Aquatic reptiles
☐ ☐Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☐ ☐Beetles
☐ ☐Caddisfly larvae (T)
☐ ☐Asian clam (*Corbicula*)
☐ ☐Crustacean (isopod/amphipod/crayfish/shrimp)
☐ ☐Damselfly and dragonfly larvae
☐ ☐Dipterans
☐ ☐Mayfly larvae (E)
☐ ☐Megaloptera (alderfly, fishfly, dobsonfly larvae)
☐ ☐Midges/mosquito larvae
☐ ☐Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*)
☐ ☐Mussels/Clams (not *Corbicula*)
☐ ☐Other fish
☐ ☒Salamanders/tadpoles
☐ ☐Snails
☐ ☐Stonefly larvae (P)
☐ ☐Tipulid larvae
☐ ☐Worms/leeches

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

LB RB
☒A ☒A Little or no alteration to water storage capacity over a majority of the streamside area
☐B ☐B Moderate alteration to water storage capacity over a majority of the streamside area
☐C ☐C Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes)

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

LB RB
☐A ☐A Majority of streamside area with depressions able to pond water ≥ 6 inches deep
☐B ☐B Majority of streamside area with depressions able to pond water 3 to 6 inches deep
☒C ☒C Majority of streamside area with depressions able to pond water < 3 inches deep

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

LB RB
☐Y ☐Y Are wetlands present in the streamside area?
☒N ☒N

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**

**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☐A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☒F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**

**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**

Consider aspect. Consider “leaf-on” condition.

☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**
**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide or no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation or modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer or predominantly herbaceous species or bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☒No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ______________________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Stream 17

| | | | |
|---|---|---|---|
| Stream Site Name | Bad Creek Pumped Storage Project | Date of Assessment | 9/12/2023 |
| Stream Category | Mb1 | Assessor Name/Organization | JK, MI (HDR) |

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | NO |
| Presence of regulatory considerations (Y/N) | NO |
| Additional stream information/supplementary measurements included (Y/N) | NO |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Perennial |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **HIGH** | |
| (2) Baseflow | **HIGH** | |
| (2) Flood Flow | **HIGH** | |
| (3) Streamside Area Attenuation | **HIGH** | |
| (4) Floodplain Access | **HIGH** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | |
| (3) Stream Stability | **HIGH** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **MEDIUM** | |
| (4) Stream Geomorphology | **HIGH** | |
| (2) Stream/Intertidal Zone Interaction | NA | |
| (2) Longitudinal Tidal Flow | NA | |
| (2) Tidal Marsh Stream Stability | NA | |
| (3) Tidal Marsh Channel Stability | NA | |
| (3) Tidal Marsh Stream Geomorphology | NA | |
| (1) Water Quality | **MEDIUM** | |
| (2) Baseflow | **HIGH** | |
| (2) Streamside Area Vegetation | **HIGH** | |
| (3) Upland Pollutant Filtration | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **LOW** | |
| (2) Intertidal Zone Filtration | NA | |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **HIGH** | |
| (3) Baseflow | **HIGH** | |
| (3) Substrate | **MEDIUM** | |
| (3) Stream Stability | **HIGH** | |
| (3) In-stream Habitat | **HIGH** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Tidal Marsh In-stream Habitat | NA | |
| (3) Flow Restriction | NA | |
| (3) Tidal Marsh Stream Stability | NA | |
| (4) Tidal Marsh Channel Stability | NA | |
| (4) Tidal Marsh Stream Geomorphology | NA | |
| (3) Tidal Marsh In-stream Habitat | NA | |
| (2) Intertidal Zone | NA | |
| Overall | **HIGH** | |

# NC SAM FIELD ASSESSMENT FORM
## Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek Pumped Storage Project
2. Date of evaluation: 9/12/2023
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: JK, MI
5. County:
6. Nearest named water body on USGS 7.5-minute quad: Howard Creek
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.9945859, -82.9951158

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): Devils Fork
10. Length of assessment reach evaluated (feet): 100
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 3 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 5
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☒Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A 
(more sinuous stream, flatter valley slope)

☒B 
(less sinuous stream, steeper valley slope)

17. Watershed size: (**skip for Tidal Marsh Stream**) ☒Size 1 (< 0.1 mi$^2$) ☐Size 2 (0.1 to < 0.5 mi$^2$) ☐Size 3 (0.5 to < 5 mi$^2$) ☐Size 4 (≥ 5 mi$^2$)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☐Yes ☒No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☐Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☒No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction <u>or</u> fill to the point of obstructing flow <u>or</u> a channel choked with aquatic macrophytes <u>or</u> ponded water <u>or</u> impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☒B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**
   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

**6. Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Little or no evidence of conditions that adversely affect reference interaction |
| ☐B | ☐B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

**7. Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B <u>Excessive</u> sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach <u>and</u> causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☐I Other: ____________________ (explain in “Notes/Sketch” section)
☒J Little to no stressors

**8. Recent Weather – watershed metric (skip for Tidal Marsh Streams)**

For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

☐A Drought conditions <u>and</u> no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions <u>and</u> rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

**9. Large or Dangerous Stream – assessment reach metric**

☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

**10. Natural In-stream Habitat Types – assessment reach metric**

10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☐B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only

☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

**********************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*****************************

**11. Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**

☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☒ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☐ | ☒ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☐Yes ☒No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☐ | Beetles |
| ☐ | ☐ | Caddisfly larvae (T) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☐ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☐ | Damselfly and dragonfly larvae |
| ☐ | ☐ | Dipterans |
| ☐ | ☐ | Mayfly larvae (E) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*) |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☐ | Other fish |
| ☐ | ☐ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☐ | Stonefly larvae (P) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☐ | Worms/leeches |

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☐B | ☐B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☐B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☒C | ☒C | Majority of streamside area with depressions able to pond water < 3 inches deep |

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☐Y | ☐Y | Are wetlands present in the streamside area? |
| ☒N | ☒N | |

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**

**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☐A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☒F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**

**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**

Consider aspect. Consider "leaf-on" condition.

☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**

**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide <u>or</u> extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide <u>or</u> no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation <u>or</u> modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**

**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).

**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer <u>or</u> predominantly herbaceous species <u>or</u> bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**

Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**

Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing <u>or</u> communities with non-native invasive species present, but not dominant, over a large portion of the expected strata <u>or</u> communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent <u>or</u> communities with non-native invasive species dominant over a large portion of expected strata <u>or</u> communities composed of planted stands of non-characteristic species <u>or</u> communities inappropriately composed of a single species <u>or</u> no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☒No Was conductivity measurement recorded?

If No, select one of the following reasons. ☐No Water ☐Other: ________________________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).

☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Devils Fork

| | | | |
|---|---|---|---|
| Stream Site Name | Bad Creek Pumped Storage Project | Date of Assessment | 9/12/2023 |
| Stream Category | Mb1 | Assessor Name/Organization | JK, MI |

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | NO |
| Presence of regulatory considerations (Y/N) | NO |
| Additional stream information/supplementary measurements included (Y/N) | NO |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Perennial |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **HIGH** | |
| (2) Baseflow | **HIGH** | |
| (2) Flood Flow | **HIGH** | |
| (3) Streamside Area Attenuation | **HIGH** | |
| (4) Floodplain Access | **HIGH** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | |
| (3) Stream Stability | **HIGH** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **MEDIUM** | |
| (4) Stream Geomorphology | **HIGH** | |
| (2) Stream/Intertidal Zone Interaction | NA | |
| (2) Longitudinal Tidal Flow | NA | |
| (2) Tidal Marsh Stream Stability | NA | |
| (3) Tidal Marsh Channel Stability | NA | |
| (3) Tidal Marsh Stream Geomorphology | NA | |
| (1) Water Quality | **MEDIUM** | |
| (2) Baseflow | **HIGH** | |
| (2) Streamside Area Vegetation | **HIGH** | |
| (3) Upland Pollutant Filtration | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **LOW** | |
| (2) Intertidal Zone Filtration | NA | |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **MEDIUM** | |
| (3) Baseflow | **HIGH** | |
| (3) Substrate | **MEDIUM** | |
| (3) Stream Stability | **HIGH** | |
| (3) In-stream Habitat | **MEDIUM** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Tidal Marsh In-stream Habitat | NA | |
| (3) Flow Restriction | NA | |
| (3) Tidal Marsh Stream Stability | NA | |
| (4) Tidal Marsh Channel Stability | NA | |
| (4) Tidal Marsh Stream Geomorphology | NA | |
| (3) Tidal Marsh In-stream Habitat | NA | |
| (2) Intertidal Zone | NA | |
| Overall | **HIGH** | |

## NC SAM FIELD ASSESSMENT FORM
### Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek Pumped Storage Project
2. Date of evaluation: 10/2/2023
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: EBS / HDR
5. County:
6. Nearest named water body on USGS 7.5-minute quad: Howard Creek
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.991628, -83.0200869

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): Limber Pole
10. Length of assessment reach evaluated (feet): 200
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 4 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 20
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☒Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A

(more sinuous stream, flatter valley slope)

☒B

(less sinuous stream, steeper valley slope)

17. Watershed size: (**skip for Tidal Marsh Stream**) ☐Size 1 (< 0.1 mi$^2$) ☐Size 2 (0.1 to < 0.5 mi$^2$) ☒Size 3 (0.5 to < 5 mi$^2$) ☐Size 4 (≥ 5 mi$^2$)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☐Yes ☒No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☐Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☒No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction <u>or</u> fill to the point of obstructing flow <u>or</u> a channel choked with aquatic macrophytes <u>or</u> ponded water <u>or</u> impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☒B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**

   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

6. **Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Little or no evidence of conditions that adversely affect reference interaction |
| ☐B | ☐B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

7. **Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B <u>Excessive</u> sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach <u>and</u> causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in "Notes/Sketch" section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☐I Other: ____________________ (explain in "Notes/Sketch" section)
☒J Little to no stressors

8. **Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

☐A Drought conditions <u>and</u> no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions <u>and</u> rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

9. **Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

10. **Natural In-stream Habitat Types – assessment reach metric**

10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☒B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only

☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

**************************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*****************************

11. **Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☒ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☒ | ☐ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☐ | ☒ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☒ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ______________________

12b. ☒Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

1 >1 Numbers over columns refer to “individuals” for Size 1 and 2 streams and “taxa” for Size 3 and 4 streams.
☐ ☐Adult frogs
☐ ☐Aquatic reptiles
☐ ☐Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☐ ☒Beetles
☐ ☒Caddisfly larvae (T)
☐ ☐Asian clam (*Corbicula*)
☐ ☒Crustacean (isopod/amphipod/crayfish/shrimp)
☐ ☒Damselfly and dragonfly larvae
☐ ☒Dipterans
☐ ☒Mayfly larvae (E)
☐ ☐Megaloptera (alderfly, fishfly, dobsonfly larvae)
☐ ☐Midges/mosquito larvae
☐ ☐Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*)
☐ ☐Mussels/Clams (not *Corbicula*)
☐ ☐Other fish
☐ ☒Salamanders/tadpoles
☐ ☐Snails
☐ ☒Stonefly larvae (P)
☐ ☐Tipulid larvae
☐ ☐Worms/leeches

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

LB RB
☒A ☒A Little or no alteration to water storage capacity over a majority of the streamside area
☐B ☐B Moderate alteration to water storage capacity over a majority of the streamside area
☐C ☐C Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes)

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

LB RB
☒A ☒A Majority of streamside area with depressions able to pond water ≥ 6 inches deep
☐B ☐B Majority of streamside area with depressions able to pond water 3 to 6 inches deep
☐C ☐C Majority of streamside area with depressions able to pond water < 3 inches deep

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

LB RB
☐Y ☐Y Are wetlands present in the streamside area?
☒N ☒N

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**
**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☒A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☒E Stream bed or bank soil reduced (dig through deposited sediment if present)
☐F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**
**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**
Consider aspect. Consider “leaf-on” condition.

☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**
**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide <u>or</u> extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide <u>or</u> no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation <u>or</u> modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer <u>or</u> predominantly herbaceous species <u>or</u> bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing <u>or</u> communities with non-native invasive species present, but not dominant, over a large portion of the expected strata <u>or</u> communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent <u>or</u> communities with non-native invasive species dominant over a large portion of expected strata <u>or</u> communities composed of planted stands of non-characteristic species <u>or</u> communities inappropriately composed of a single species <u>or</u> no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☒No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ______________________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Limber Pole

| | | | |
|---|---|---|---|
| Stream Site Name | Bad Creek Pumped Storage Project | Date of Assessment | 10/2/2023 |
| Stream Category | Mb3 | Assessor Name/Organization | EBS / HDR |

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | NO |
| Presence of regulatory considerations (Y/N) | NO |
| Additional stream information/supplementary measurements included (Y/N) | NO |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Perennial |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **HIGH** | |
| (2) Baseflow | **HIGH** | |
| (2) Flood Flow | **HIGH** | |
| (3) Streamside Area Attenuation | **HIGH** | |
| (4) Floodplain Access | **HIGH** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | |
| (3) Stream Stability | **HIGH** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **HIGH** | |
| (4) Stream Geomorphology | **HIGH** | |
| (2) Stream/Intertidal Zone Interaction | NA | |
| (2) Longitudinal Tidal Flow | NA | |
| (2) Tidal Marsh Stream Stability | NA | |
| (3) Tidal Marsh Channel Stability | NA | |
| (3) Tidal Marsh Stream Geomorphology | NA | |
| (1) Water Quality | **HIGH** | |
| (2) Baseflow | **HIGH** | |
| (2) Streamside Area Vegetation | **HIGH** | |
| (3) Upland Pollutant Filtration | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **HIGH** | |
| (2) Intertidal Zone Filtration | NA | |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **HIGH** | |
| (3) Baseflow | **HIGH** | |
| (3) Substrate | **HIGH** | |
| (3) Stream Stability | **HIGH** | |
| (3) In-stream Habitat | **HIGH** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Tidal Marsh In-stream Habitat | NA | |
| (3) Flow Restriction | NA | |
| (3) Tidal Marsh Stream Stability | NA | |
| (4) Tidal Marsh Channel Stability | NA | |
| (4) Tidal Marsh Stream Geomorphology | NA | |
| (3) Tidal Marsh In-stream Habitat | NA | |
| (2) Intertidal Zone | NA | |
| Overall | **HIGH** | |

## NC SAM FIELD ASSESSMENT FORM
**Accompanies User Manual Version 2.1**

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**
1. Project name (if any): Bad Creek Pumped Storage Project
2. Date of evaluation: 10/2/2023
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: EBS / HDR
5. County:
6. Nearest named water body on USGS 7.5-minute quad: Howard Creek
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.991628, -83.0200869

**STREAM INFORMATION: (depth and width can be approximations)**
9. Site number (show on attached map): Howard Creek
10. Length of assessment reach evaluated (feet): 200
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 3 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 28
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☒Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**
15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A

(more sinuous stream, flatter valley slope)

☒B

(less sinuous stream, steeper valley slope)

17. Watershed size: **(skip for Tidal Marsh Stream)** ☐Size 1 (< 0.1 mi²) ☐Size 2 (0.1 to < 0.5 mi²) ☒Size 3 (0.5 to < 5 mi²) ☐Size 4 (≥ 5 mi²)

**ADDITIONAL INFORMATION:**
18. Were regulatory considerations evaluated? ☐Yes ☒No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☐Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☒No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction or fill to the point of obstructing flow or a channel choked with aquatic macrophytes or ponded water or impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☒B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**
   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

**6. Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

LB RB
☒A ☒A Little or no evidence of conditions that adversely affect reference interaction
☐B ☐B Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching])
☐C ☐C Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] or too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) or floodplain/intertidal zone unnaturally absent or assessment reach is a man-made feature on an interstream divide

**7. Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B Excessive sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach and causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☐I Other: ____________________ (explain in “Notes/Sketch” section)
☒J Little to no stressors

**8. Recent Weather – watershed metric (skip for Tidal Marsh Streams)**

For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.
☐A Drought conditions and no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions and rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

**9. Large or Dangerous Stream – assessment reach metric**

☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

**10. Natural In-stream Habitat Types – assessment reach metric**

10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**
☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☒B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only
☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

**********************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*****************************

**11. Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☒ | ☐ | ☐ | Bedrock/saprolite |
| ☐ | ☒ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☐ | ☒ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☒ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☒Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to “individuals” for Size 1 and 2 streams and “taxa” for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☒ | Beetles |
| ☐ | ☒ | Caddisfly larvae (T) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☒ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☒ | Damselfly and dragonfly larvae |
| ☐ | ☒ | Dipterans |
| ☐ | ☒ | Mayfly larvae (E) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*) |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☒ | Other fish |
| ☐ | ☒ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☒ | Stonefly larvae (P) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☒ | Worms/leeches |

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☐B | ☐B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☐B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☐C | ☐C | Majority of streamside area with depressions able to pond water < 3 inches deep |

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☒Y | ☒Y | Are wetlands present in the streamside area? |
| ☐N | ☐N | |

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**

**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☒A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☒E Stream bed or bank soil reduced (dig through deposited sediment if present)
☐F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**

**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**

Consider aspect. Consider “leaf-on” condition.

☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

19. **Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**
**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide <u>or</u> extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide <u>or</u> no trees |

20. **Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation <u>or</u> modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

21. **Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

22. **Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer <u>or</u> predominantly herbaceous species <u>or</u> bare ground |

23. **Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

24. **Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing <u>or</u> communities with non-native invasive species present, but not dominant, over a large portion of the expected strata <u>or</u> communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent <u>or</u> communities with non-native invasive species dominant over a large portion of expected strata <u>or</u> communities composed of planted stands of non-characteristic species <u>or</u> communities inappropriately composed of a single species <u>or</u> no vegetation. |

25. **Conductivity – assessment reach metric (skip for all Coastal Plain streams)**
25a. ☐Yes ☒No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ______________________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Howard Creek

Stream Site Name: Bad Creek Pumped Storage Project

Date of Assessment: 10/2/2023

Stream Category: Mb3

Assessor Name/Organization: EBS / HDR

Notes of Field Assessment Form (Y/N): NO

Presence of regulatory considerations (Y/N): NO

Additional stream information/supplementary measurements included (Y/N): NO

NC SAM feature type (perennial, intermittent, Tidal Marsh Stream): Perennial

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **HIGH** | |
| (2) Baseflow | **HIGH** | |
| (2) Flood Flow | **HIGH** | |
| (3) Streamside Area Attenuation | **HIGH** | |
| (4) Floodplain Access | **HIGH** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | |
| (3) Stream Stability | **HIGH** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **HIGH** | |
| (4) Stream Geomorphology | **HIGH** | |
| (2) Stream/Intertidal Zone Interaction | NA | |
| (2) Longitudinal Tidal Flow | NA | |
| (2) Tidal Marsh Stream Stability | NA | |
| (3) Tidal Marsh Channel Stability | NA | |
| (3) Tidal Marsh Stream Geomorphology | NA | |
| (1) Water Quality | **HIGH** | |
| (2) Baseflow | **HIGH** | |
| (2) Streamside Area Vegetation | **HIGH** | |
| (3) Upland Pollutant Filtration | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **HIGH** | |
| (2) Intertidal Zone Filtration | NA | |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **HIGH** | |
| (3) Baseflow | **HIGH** | |
| (3) Substrate | **HIGH** | |
| (3) Stream Stability | **HIGH** | |
| (3) In-stream Habitat | **HIGH** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Tidal Marsh In-stream Habitat | NA | |
| (3) Flow Restriction | NA | |
| (3) Tidal Marsh Stream Stability | NA | |
| (4) Tidal Marsh Channel Stability | NA | |
| (4) Tidal Marsh Stream Geomorphology | NA | |
| (3) Tidal Marsh In-stream Habitat | NA | |
| (2) Intertidal Zone | NA | |
| Overall | **HIGH** | |

# NC SAM FIELD ASSESSMENT FORM
## Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek II Power Complex Project
2. Date of evaluation: 10/18/23
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: Paul Bright / HDR
5. County: Oconee
6. Nearest named water body on USGS 7.5-minute quad: Howard Creek
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.995706, -83.000461

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): S12
10. Length of assessment reach evaluated (feet): 300
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 1-3 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 5-8
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☐Perennial flow ☒Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A 
(more sinuous stream, flatter valley slope)

☒B 
(less sinuous stream, steeper valley slope)

17. Watershed size: (**skip for Tidal Marsh Stream**) ☐Size 1 (< 0.1 mi$^2$) ☐Size 2 (0.1 to < 0.5 mi$^2$) ☒Size 3 (0.5 to < 5 mi$^2$) ☐Size 4 (≥ 5 mi$^2$)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☒Yes ☐No If Yes, check all that apply to the assessment area.

| | | |
|---|---|---|
| ☐Section 10 water | ☒Classified Trout Waters | ☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V) |
| ☐Essential Fish Habitat | ☐Primary Nursery Area | ☐ High Quality Waters/Outstanding Resource Waters |
| ☐Publicly owned property | ☐NCDWR Riparian buffer rule in effect | ☐Nutrient Sensitive Waters |
| ☐Anadromous fish | ☐303(d) List | ☐CAMA Area of Environmental Concern (AEC) |

☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☒Yes ☐No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☐A Water throughout assessment reach.
   - ☒B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☒A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction or fill to the point of obstructing flow or a channel choked with aquatic macrophytes or ponded water or impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☐B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**

   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

6. **Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no evidence of conditions that adversely affect reference interaction |
| ☒B | ☒B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

7. **Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B <u>Excessive</u> sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach <u>and</u> causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☒I Other: ____________________ (explain in “Notes/Sketch” section)
☐J Little to no stressors

8. **Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

☐A Drought conditions <u>and</u> no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions <u>and</u> rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

9. **Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

10. **Natural In-stream Habitat Types – assessment reach metric**
10a. ☒Yes ☐No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☒B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only

☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

*********************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*****************************

11. **Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☒Yes ☐No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but < 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☒ | ☐ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☒ | ☐ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☒ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☐Yes ☒No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

1 >1 Numbers over columns refer to “individuals” for Size 1 and 2 streams and “taxa” for Size 3 and 4 streams.
☐ ☐Adult frogs
☐ ☐Aquatic reptiles
☐ ☐Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☐ ☐Beetles
☐ ☐Caddisfly larvae (T)
☐ ☐Asian clam (*Corbicula*)
☐ ☐Crustacean (isopod/amphipod/crayfish/shrimp)
☐ ☐Damselfly and dragonfly larvae
☐ ☐Dipterans
☐ ☐Mayfly larvae (E)
☐ ☐Megaloptera (alderfly, fishfly, dobsonfly larvae)
☐ ☐Midges/mosquito larvae
☐ ☐Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*)
☐ ☐Mussels/Clams (not *Corbicula*)
☐ ☐Other fish
☐ ☐Salamanders/tadpoles
☐ ☐Snails
☐ ☐Stonefly larvae (P)
☐ ☐Tipulid larvae
☐ ☐Worms/leeches

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

LB RB
☐A ☐A Little or no alteration to water storage capacity over a majority of the streamside area
☐B ☐B Moderate alteration to water storage capacity over a majority of the streamside area
☐C ☐C Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes)

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

LB RB
☐A ☐A Majority of streamside area with depressions able to pond water ≥ 6 inches deep
☐B ☐B Majority of streamside area with depressions able to pond water 3 to 6 inches deep
☐C ☐C Majority of streamside area with depressions able to pond water < 3 inches deep

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

LB RB
☐Y ☐Y Are wetlands present in the streamside area?
☒N ☒N

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**
**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☒A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☐F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**
**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**
Consider aspect. Consider “leaf-on” condition.

☐A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☒B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**

**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☒B | ☒B | ☒B | ☒B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide or no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation or modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**

**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).

**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer or predominantly herbaceous species or bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**

Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**

Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☒B | ☒B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☒No Was conductivity measurement recorded?

If No, select one of the following reasons. ☐No Water ☐Other: ____________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).

☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

Clearing of vegetation and ATV trail crossing was observed.

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Stream 12

| | | | |
|---|---|---|---|
| Stream Site Name | Bad Creek II Power Complex Project | Date of Assessment | 10/18/23 |
| Stream Category | Mb3 | Assessor Name/Organization | Paul Bright / HDR |

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | YES |
| Presence of regulatory considerations (Y/N) | YES |
| Additional stream information/supplementary measurements included (Y/N) | YES |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Intermittent |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **MEDIUM** | |
| (2) Baseflow | **LOW** | |
| (2) Flood Flow | **HIGH** | |
| (3) Streamside Area Attenuation | **MEDIUM** | |
| (4) Floodplain Access | **MEDIUM** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | NA |
| (3) Stream Stability | **HIGH** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **HIGH** | |
| (4) Stream Geomorphology | **HIGH** | |
| (2) Stream/Intertidal Zone Interaction | NA | NA |
| (2) Longitudinal Tidal Flow | NA | NA |
| (2) Tidal Marsh Stream Stability | NA | NA |
| (3) Tidal Marsh Channel Stability | NA | NA |
| (3) Tidal Marsh Stream Geomorphology | NA | NA |
| (1) Water Quality | **LOW** | |
| (2) Baseflow | **LOW** | |
| (2) Streamside Area Vegetation | **HIGH** | |
| (3) Upland Pollutant Filtration | **HIGH** | |
| (3) Thermoregulation | **MEDIUM** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **LOW** | |
| (2) Intertidal Zone Filtration | NA | NA |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **MEDIUM** | |
| (3) Baseflow | **LOW** | |
| (3) Substrate | **HIGH** | |
| (3) Stream Stability | **HIGH** | |
| (3) In-stream Habitat | **MEDIUM** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Tidal Marsh In-stream Habitat | NA | NA |
| (3) Flow Restriction | NA | NA |
| (3) Tidal Marsh Stream Stability | NA | NA |
| (4) Tidal Marsh Channel Stability | NA | NA |
| (4) Tidal Marsh Stream Geomorphology | NA | NA |
| (3) Tidal Marsh In-stream Habitat | NA | NA |
| (2) Intertidal Zone | NA | NA |
| Overall | **MEDIUM** | |

# NC SAM FIELD ASSESSMENT FORM
## Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek II Power Complex Project
2. Date of evaluation: 10/18/23
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: Paul Bright / HDR
5. County: Oconee
6. Nearest named water body on USGS 7.5-minute quad: Howard Creek
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.993024, -82.997765

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): S15
10. Length of assessment reach evaluated (feet): 175
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 1-2 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 12-15
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☒Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A

(more sinuous stream, flatter valley slope)

☒B

(less sinuous stream, steeper valley slope)

17. Watershed size: (**skip for Tidal Marsh Stream**) ☐Size 1 (< 0.1 mi$^2$) ☐Size 2 (0.1 to < 0.5 mi$^2$) ☒Size 3 (0.5 to < 5 mi$^2$) ☐Size 4 (≥ 5 mi$^2$)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☒Yes ☐No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☒Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)

☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☒Yes ☐No

**1. Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**

☒A Water throughout assessment reach.
☐B No flow, water in pools only.
☐C No water in assessment reach.

**2. Evidence of Flow Restriction – assessment reach metric**

☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction <u>or</u> fill to the point of obstructing flow <u>or</u> a channel choked with aquatic macrophytes <u>or</u> ponded water <u>or</u> impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
☒B Not A

**3. Feature Pattern – assessment reach metric**

☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
☒B Not A

**4. Feature Longitudinal Profile – assessment reach metric**

☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
☒B Not A

**5. Signs of Active Instability – assessment reach metric**

**Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).

☒A < 10% of channel unstable
☐B 10 to 25% of channel unstable
☐C > 25% of channel unstable

6. **Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no evidence of conditions that adversely affect reference interaction |
| ☒B | ☒B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] <u>or</u> too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) <u>or</u> floodplain/intertidal zone unnaturally absent <u>or</u> assessment reach is a man-made feature on an interstream divide |

7. **Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**
- ☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
- ☐B <u>Excessive</u> sedimentation (burying of stream features or intertidal zone)
- ☐C Noticeable evidence of pollutant discharges entering the assessment reach <u>and</u> causing a water quality problem
- ☐D Odor (not including natural sulfide odors)
- ☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
- ☐F Livestock with access to stream or intertidal zone
- ☐G Excessive algae in stream or intertidal zone
- ☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
- ☐I Other: ____________________ (explain in “Notes/Sketch” section)
- ☒J Little to no stressors

8. **Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.
- ☐A Drought conditions <u>and</u> no rainfall or rainfall not exceeding 1 inch within the last 48 hours
- ☐B Drought conditions <u>and</u> rainfall exceeding 1 inch within the last 48 hours
- ☒C No drought conditions

9. **Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

10. **Natural In-stream Habitat Types – assessment reach metric**

10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**
- ☒A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
- ☒B Multiple sticks and/or leaf packs and/or emergent vegetation
- ☒C Multiple snags and logs (including lap trees)
- ☐D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
- ☐E Little or no habitat

Check for Tidal Marsh Streams Only
- ☐F 5% oysters or other natural hard bottoms
- ☐G Submerged aquatic vegetation
- ☐H Low-tide refugia (pools)
- ☐I Sand bottom
- ☐J 5% vertical bank along the marsh
- ☐K Little or no habitat

***************************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS**********************************

11. **Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
- ☒A Riffle-run section **(evaluate 11c)**
- ☒B Pool-glide section **(evaluate 11d)**
- ☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but < 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☒ | Bedrock/saprolite |
| ☒ | ☐ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☒ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☐Yes ☒No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

1 >1 Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams.
☐ ☐Adult frogs
☐ ☐Aquatic reptiles
☐ ☐Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☐ ☐Beetles
☐ ☐Caddisfly larvae (T)
☐ ☐Asian clam (*Corbicula*)
☐ ☐Crustacean (isopod/amphipod/crayfish/shrimp)
☐ ☐Damselfly and dragonfly larvae
☐ ☐Dipterans
☐ ☐Mayfly larvae (E)
☐ ☐Megaloptera (alderfly, fishfly, dobsonfly larvae)
☐ ☐Midges/mosquito larvae
☐ ☐Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*)
☐ ☐Mussels/Clams (not *Corbicula*)
☐ ☐Other fish
☐ ☐Salamanders/tadpoles
☐ ☐Snails
☐ ☐Stonefly larvae (P)
☐ ☐Tipulid larvae
☐ ☐Worms/leeches

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

LB RB
☐A ☐A Little or no alteration to water storage capacity over a majority of the streamside area
☐B ☐B Moderate alteration to water storage capacity over a majority of the streamside area
☐C ☐C Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes)

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

LB RB
☐A ☐A Majority of streamside area with depressions able to pond water ≥ 6 inches deep
☐B ☐B Majority of streamside area with depressions able to pond water 3 to 6 inches deep
☐C ☐C Majority of streamside area with depressions able to pond water < 3 inches deep

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

LB RB
☒Y ☒Y Are wetlands present in the streamside area?
☐N ☐N

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**
**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☒A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☒D Evidence of bank seepage or sweating (iron in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☐F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**
**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**
Consider aspect. Consider "leaf-on" condition.

☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☐B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**
**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide <u>or</u> extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide <u>or</u> no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation <u>or</u> modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer <u>or</u> predominantly herbaceous species <u>or</u> bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | The total length of buffer breaks is < 25 percent. |
| ☒B | ☒B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing <u>or</u> communities with non-native invasive species present, but not dominant, over a large portion of the expected strata <u>or</u> communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent <u>or</u> communities with non-native invasive species dominant over a large portion of expected strata <u>or</u> communities composed of planted stands of non-characteristic species <u>or</u> communities inappropriately composed of a single species <u>or</u> no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**
25a. ☐Yes ☒No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ____________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:
One ATV trail crossing was observed at Stream 15. Small areas of vegetation along the stream have been removed.

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Stream 15

Stream Site Name: Bad Creek II Power Complex Project

Date of Assessment: 10/18/23

Stream Category: Mb3

Assessor Name/Organization: Paul Bright / HDR

Notes of Field Assessment Form (Y/N): YES

Presence of regulatory considerations (Y/N): YES

Additional stream information/supplementary measurements included (Y/N): YES

NC SAM feature type (perennial, intermittent, Tidal Marsh Stream): Perennial

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **HIGH** | |
| (2) Baseflow | **MEDIUM** | |
| (2) Flood Flow | **HIGH** | |
| (3) Streamside Area Attenuation | **MEDIUM** | |
| (4) Floodplain Access | **MEDIUM** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | |
| (3) Stream Stability | **HIGH** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **LOW** | |
| (4) Stream Geomorphology | **HIGH** | |
| (2) Stream/Intertidal Zone Interaction | NA | |
| (2) Longitudinal Tidal Flow | NA | |
| (2) Tidal Marsh Stream Stability | NA | |
| (3) Tidal Marsh Channel Stability | NA | |
| (3) Tidal Marsh Stream Geomorphology | NA | |
| (1) Water Quality | **LOW** | |
| (2) Baseflow | **MEDIUM** | |
| (2) Streamside Area Vegetation | **MEDIUM** | |
| (3) Upland Pollutant Filtration | **MEDIUM** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **LOW** | |
| (2) Intertidal Zone Filtration | NA | |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **MEDIUM** | |
| (3) Baseflow | **MEDIUM** | |
| (3) Substrate | **LOW** | |
| (3) Stream Stability | **HIGH** | |
| (3) In-stream Habitat | **HIGH** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **HIGH** | |
| (2) Tidal Marsh In-stream Habitat | NA | |
| (3) Flow Restriction | NA | |
| (3) Tidal Marsh Stream Stability | NA | |
| (4) Tidal Marsh Channel Stability | NA | |
| (4) Tidal Marsh Stream Geomorphology | NA | |
| (3) Tidal Marsh In-stream Habitat | NA | |
| (2) Intertidal Zone | NA | |
| Overall | **HIGH** | |

## NC SAM FIELD ASSESSMENT FORM
### Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek Pumped Storage Project
2. Date of evaluation: 10/18/2023
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: Paul Bright / HDR
5. County:
6. Nearest named water body on USGS 7.5-minute quad: Devils Fork
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.993519, -82.994454

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): Stream 16
10. Length of assessment reach evaluated (feet): 100
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 2-4 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 6-12
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☐Perennial flow ☒Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A

(more sinuous stream, flatter valley slope)

☒B

(less sinuous stream, steeper valley slope)

17. Watershed size: **(skip for Tidal Marsh Stream)** ☒Size 1 (< 0.1 mi²) ☐Size 2 (0.1 to < 0.5 mi²) ☐Size 3 (0.5 to < 5 mi²) ☐Size 4 (≥ 5 mi²)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☒Yes ☐No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☒Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☐Yes ☒No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☐A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction or fill to the point of obstructing flow or a channel choked with aquatic macrophytes or ponded water or impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☒B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**

   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

6. **Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no evidence of conditions that adversely affect reference interaction |
| ☒B | ☒B | Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching]) |
| ☐C | ☐C | Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] or too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) or floodplain/intertidal zone unnaturally absent or assessment reach is a man-made feature on an interstream divide |

7. **Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**
☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B Excessive sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach and causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☐I Other: _____________________ (explain in “Notes/Sketch” section)
☒J Little to no stressors

8. **Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.
☐A Drought conditions and no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions and rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

9. **Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

10. **Natural In-stream Habitat Types – assessment reach metric**
10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**
☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☒B Multiple sticks and/or leaf packs and/or emergent vegetation
☐C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only
☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

************************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*******************************

11. **Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☒ | ☐ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☐ | ☒ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☐ | ☒ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☒ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☒Yes ☐No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☐ | Beetles |
| ☐ | ☐ | Caddisfly larvae (T) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☐ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☐ | Damselfly and dragonfly larvae |
| ☐ | ☐ | Dipterans |
| ☐ | ☐ | Mayfly larvae (E) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*) |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☐ | Other fish |
| ☐ | ☒ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☐ | Stonefly larvae (P) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☐ | Worms/leeches |

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☐B | ☐B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**

**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☐B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☒C | ☒C | Majority of streamside area with depressions able to pond water < 3 inches deep |

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☐Y | ☐Y | Are wetlands present in the streamside area? |
| ☒N | ☒N | |

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**

**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

- ☒A Streams and/or springs (jurisdictional discharges)
- ☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
- ☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
- ☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
- ☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
- ☐F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**

**Check all that apply.**

- ☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
- ☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
- ☐C Urban stream (≥ 24% impervious surface for watershed)
- ☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
- ☐E Assessment reach relocated to valley edge
- ☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**

Consider aspect. Consider "leaf-on" condition.

- ☒A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
- ☐B Degraded (example: scattered trees)
- ☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**

**Consider "vegetated buffer" and "wooded buffer" separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide or no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Vegetated" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation or modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**

**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).

**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**

**Consider for left bank (LB) and right bank (RB) for Metric 19 ("Wooded" Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer or predominantly herbaceous species or bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**

Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | The total length of buffer breaks is < 25 percent. |
| ☐B | ☐B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**

Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☐B | ☐B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**

25a. ☐Yes ☒No Was conductivity measurement recorded?

If No, select one of the following reasons. ☐No Water ☐Other: ____________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).

☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Stream 16

| | | | |
|---|---|---|---|
| Stream Site Name | Bad Creek Pumped Storage Project | Date of Assessment | 10/18/2023 |
| Stream Category | Mb1 | Assessor Name/Organization | Paul Bright / HDR |

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | NO |
| Presence of regulatory considerations (Y/N) | YES |
| Additional stream information/supplementary measurements included (Y/N) | NO |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Intermittent |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **HIGH** | **HIGH** |
| (2) Baseflow | **HIGH** | **HIGH** |
| (2) Flood Flow | **HIGH** | **HIGH** |
| (3) Streamside Area Attenuation | **MEDIUM** | **MEDIUM** |
| (4) Floodplain Access | **MEDIUM** | **MEDIUM** |
| (4) Wooded Riparian Buffer | **HIGH** | **HIGH** |
| (4) Microtopography | NA | NA |
| (3) Stream Stability | **HIGH** | **HIGH** |
| (4) Channel Stability | **HIGH** | **HIGH** |
| (4) Sediment Transport | **HIGH** | **HIGH** |
| (4) Stream Geomorphology | **HIGH** | **HIGH** |
| (2) Stream/Intertidal Zone Interaction | NA | NA |
| (2) Longitudinal Tidal Flow | NA | NA |
| (2) Tidal Marsh Stream Stability | NA | NA |
| (3) Tidal Marsh Channel Stability | NA | NA |
| (3) Tidal Marsh Stream Geomorphology | NA | NA |
| (1) Water Quality | **MEDIUM** | **MEDIUM** |
| (2) Baseflow | **HIGH** | **HIGH** |
| (2) Streamside Area Vegetation | **HIGH** | **HIGH** |
| (3) Upland Pollutant Filtration | **HIGH** | **HIGH** |
| (3) Thermoregulation | **HIGH** | **HIGH** |
| (2) Indicators of Stressors | **NO** | **NO** |
| (2) Aquatic Life Tolerance | **LOW** | **NA** |
| (2) Intertidal Zone Filtration | NA | NA |
| (1) Habitat | **HIGH** | **HIGH** |
| (2) In-stream Habitat | **HIGH** | **HIGH** |
| (3) Baseflow | **HIGH** | **HIGH** |
| (3) Substrate | **HIGH** | **HIGH** |
| (3) Stream Stability | **HIGH** | **HIGH** |
| (3) In-stream Habitat | **HIGH** | **HIGH** |
| (2) Stream-side Habitat | **HIGH** | **HIGH** |
| (3) Stream-side Habitat | **HIGH** | **HIGH** |
| (3) Thermoregulation | **HIGH** | **HIGH** |
| (2) Tidal Marsh In-stream Habitat | NA | NA |
| (3) Flow Restriction | NA | NA |
| (3) Tidal Marsh Stream Stability | NA | NA |
| (4) Tidal Marsh Channel Stability | NA | NA |
| (4) Tidal Marsh Stream Geomorphology | NA | NA |
| (3) Tidal Marsh In-stream Habitat | NA | NA |
| (2) Intertidal Zone | NA | NA |
| Overall | **HIGH** | **HIGH** |

# NC SAM FIELD ASSESSMENT FORM
## Accompanies User Manual Version 2.1

USACE AID #: NCDWR #:

**INSTRUCTIONS:** Attach a sketch of the assessment area and photographs. Attach a copy of the USGS 7.5-minute topographic quadrangle, and circle the location of the stream reach under evaluation. If multiple stream reaches will be evaluated on the same property, identify and number all reaches on the attached map, and include a separate form for each reach. See the NC SAM User Manual for detailed descriptions and explanations of requested information. Record in the "Notes/Sketch" section if supplementary measurements were performed. See the NC SAM User Manual for examples of additional measurements that may be relevant.

**NOTE EVIDENCE OF STRESSORS AFFECTING THE ASSESSMENT AREA (do not need to be within the assessment area).**

**PROJECT/SITE INFORMATION:**

1. Project name (if any): Bad Creek II Power Complex Project
2. Date of evaluation: 10/19/23
3. Applicant/owner name: Duke Energy
4. Assessor name/organization: Paul Bright / HDR
5. County: Oconee
6. Nearest named water body on USGS 7.5-minute quad: Devil's Fork
7. River basin: Savannah
8. Site coordinates (decimal degrees, at lower end of assessment reach): 34.993745, -82.993409

**STREAM INFORMATION: (depth and width can be approximations)**

9. Site number (show on attached map): S17
10. Length of assessment reach evaluated (feet): 150
11. Channel depth from bed (in riffle, if present) to top of bank (feet): 2-3 ☐Unable to assess channel depth.
12. Channel width at top of bank (feet): 6-12
13. Is assessment reach a swamp steam? ☐Yes ☐No
14. Feature type: ☒Perennial flow ☐Intermittent flow ☐Tidal Marsh Stream

**STREAM CATEGORY INFORMATION:**

15. NC SAM Zone: ☒ Mountains (M) ☐ Piedmont (P) ☐ Inner Coastal Plain (I) ☐ Outer Coastal Plain (O)

16. Estimated geomorphic valley shape (**skip for Tidal Marsh Stream**):

☐A 
(more sinuous stream, flatter valley slope)

☒B 
(less sinuous stream, steeper valley slope)

17. Watershed size: (**skip for Tidal Marsh Stream**) ☐Size 1 (< 0.1 mi$^2$) ☐Size 2 (0.1 to < 0.5 mi$^2$) ☒Size 3 (0.5 to < 5 mi$^2$) ☐Size 4 (≥ 5 mi$^2$)

**ADDITIONAL INFORMATION:**

18. Were regulatory considerations evaluated? ☒Yes ☐No If Yes, check all that apply to the assessment area.

☐Section 10 water
☐Essential Fish Habitat
☐Publicly owned property
☐Anadromous fish
☒Classified Trout Waters
☐Primary Nursery Area
☐NCDWR Riparian buffer rule in effect
☐303(d) List
☐Water Supply Watershed (☐I ☐II ☐III ☐IV ☐V)
☐ High Quality Waters/Outstanding Resource Waters
☐Nutrient Sensitive Waters
☐CAMA Area of Environmental Concern (AEC)
☐Documented presence of a federal and/or state listed protected species within the assessment area.
List species:
☐Designated Critical Habitat (list species)

19. Are additional stream information/supplementary measurements included in "Notes/Sketch" section or attached? ☒Yes ☐No

1. **Channel Water – assessment reach metric (skip for Size 1 streams and Tidal Marsh Streams)**
   - ☒A Water throughout assessment reach.
   - ☐B No flow, water in pools only.
   - ☐C No water in assessment reach.

2. **Evidence of Flow Restriction – assessment reach metric**
   - ☒A At least 10% of assessment reach in-stream habitat or riffle-pool sequence is severely affected by a flow restriction or fill to the point of obstructing flow or a channel choked with aquatic macrophytes or ponded water or impoundment on flood or ebb within the assessment reach (examples: undersized or perched culverts, causeways that constrict the channel, tidal gates, debris jams, beaver dams).
   - ☐B Not A

3. **Feature Pattern – assessment reach metric**
   - ☐A A majority of the assessment reach has altered pattern (examples: straightening, modification above or below culvert).
   - ☒B Not A

4. **Feature Longitudinal Profile – assessment reach metric**
   - ☐A Majority of assessment reach has a substantially altered stream profile (examples: channel down-cutting, existing damming, over widening, active aggradation, dredging, and excavation where appropriate channel profile has not reformed from any of these disturbances).
   - ☒B Not A

5. **Signs of Active Instability – assessment reach metric**
   **Consider only current instability, not past events from which the stream has currently recovered.** Examples of instability include active bank failure, active channel down-cutting (head-cut), active widening, and artificial hardening (such as concrete, gabion, rip-rap).
   - ☒A < 10% of channel unstable
   - ☐B 10 to 25% of channel unstable
   - ☐C > 25% of channel unstable

6. **Streamside Area Interaction – streamside area metric**
**Consider for the Left Bank (LB) and the Right Bank (RB).**

LB RB
☐A ☐A Little or no evidence of conditions that adversely affect reference interaction
☒B ☒B Moderate evidence of conditions (examples: berms, levees, down-cutting, aggradation, dredging) that adversely affect reference interaction (examples: limited streamside area access, disruption of flood flows through streamside area, leaky or intermittent bulkheads, causeways with floodplain constriction, minor ditching [including mosquito ditching])
☐C ☐C Extensive evidence of conditions that adversely affect reference interaction (little to no floodplain/intertidal zone access [examples: causeways with floodplain and channel constriction, bulkheads, retaining walls, fill, stream incision, disruption of flood flows through streamside area] or too much floodplain/intertidal zone access [examples: impoundments, intensive mosquito ditching]) or floodplain/intertidal zone unnaturally absent or assessment reach is a man-made feature on an interstream divide

7. **Water Quality Stressors – assessment reach/intertidal zone metric**
**Check all that apply.**

☐A Discolored water in stream or intertidal zone (milky white, blue, unnatural water discoloration, oil sheen, stream foam)
☐B Excessive sedimentation (burying of stream features or intertidal zone)
☐C Noticeable evidence of pollutant discharges entering the assessment reach and causing a water quality problem
☐D Odor (not including natural sulfide odors)
☐E Current published or collected data indicating degraded water quality in the assessment reach. Cite source in “Notes/Sketch” section.
☐F Livestock with access to stream or intertidal zone
☐G Excessive algae in stream or intertidal zone
☐H Degraded marsh vegetation in the intertidal zone (removal, burning, regular mowing, destruction, etc)
☒I Other: ____________________ (explain in “Notes/Sketch” section)
☐J Little to no stressors

8. **Recent Weather – watershed metric (skip for Tidal Marsh Streams)**
For Size 1 or 2 streams, D1 drought or higher is considered a drought; for Size 3 or 4 streams, D2 drought or higher is considered a drought.

☐A Drought conditions and no rainfall or rainfall not exceeding 1 inch within the last 48 hours
☐B Drought conditions and rainfall exceeding 1 inch within the last 48 hours
☒C No drought conditions

9. **Large or Dangerous Stream – assessment reach metric**
☐Yes ☒No Is stream is too large or dangerous to assess? If Yes, skip to Metric 13 (Streamside Area Ground Surface Condition).

10. **Natural In-stream Habitat Types – assessment reach metric**
10a. ☐Yes ☒No Degraded in-stream habitat over majority of the assessment reach (examples of stressors include excessive sedimentation, mining, excavation, in-stream hardening [for example, rip-rap], recent dredging, and snagging) **(evaluate for Size 4 Coastal Plain streams only, then skip to Metric 12)**

10b. **Check all that occur** (occurs if > 5% coverage of assessment reach) **(skip for Size 4 Coastal Plain streams)**

☐A Multiple aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats)
☐B Multiple sticks and/or leaf packs and/or emergent vegetation
☒C Multiple snags and logs (including lap trees)
☒D 5% undercut banks and/or root mats and/or roots in banks extend to the normal wetted perimeter
☐E Little or no habitat

Check for Tidal Marsh Streams Only

☐F 5% oysters or other natural hard bottoms
☐G Submerged aquatic vegetation
☐H Low-tide refugia (pools)
☐I Sand bottom
☐J 5% vertical bank along the marsh
☐K Little or no habitat

**********************************REMAINING QUESTIONS ARE NOT APPLICABLE FOR TIDAL MARSH STREAMS*****************************

11. **Bedform and Substrate – assessment reach metric (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**

11a. ☐Yes ☒No Is assessment reach in a natural sand-bed stream? **(skip for Coastal Plain streams)**

11b. Bedform evaluated. **Check the appropriate box(es).**
☒A Riffle-run section **(evaluate 11c)**
☒B Pool-glide section **(evaluate 11d)**
☐C Natural bedform absent **(skip to Metric 12, Aquatic Life)**

11c. In riffle sections, check all that occur below the normal wetted perimeter of the assessment reach – whether or not submerged. **Check at least one box in each row (skip for Size 4 Coastal Plain streams and Tidal Marsh Streams)**. Not Present (NP) = absent, Rare (R) = present but ≤ 10%, Common (C) = > 10-40%, Abundant (A) = > 40-70%, Predominant (P) = > 70%. Cumulative percentages should not exceed 100% for each assessment reach.

| NP | R | C | A | P | |
|---|---|---|---|---|---|
| ☐ | ☒ | ☐ | ☐ | ☐ | Bedrock/saprolite |
| ☒ | ☐ | ☐ | ☐ | ☐ | Boulder (256 – 4096 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Cobble (64 – 256 mm) |
| ☐ | ☐ | ☐ | ☒ | ☐ | Gravel (2 – 64 mm) |
| ☐ | ☐ | ☒ | ☐ | ☐ | Sand (.062 – 2 mm) |
| ☐ | ☒ | ☐ | ☐ | ☐ | Silt/clay (< 0.062 mm) |
| ☒ | ☐ | ☐ | ☐ | ☐ | Detritus |
| ☒ | ☐ | ☐ | ☐ | ☐ | Artificial (rip-rap, concrete, etc.) |

11d. ☐Yes ☒No Are pools filled with sediment? (**skip for Size 4 Coastal Plain streams and Tidal Marsh Streams**)

**12. Aquatic Life – assessment reach metric (skip for Tidal Marsh Streams)**

12a. ☒Yes ☐No Was an in-stream aquatic life assessment performed as described in the User Manual?
If No, select one of the following reasons and skip to Metric 13. ☐No Water ☐Other: ____________________

12b. ☐Yes ☒No Are aquatic organisms present in the assessment reach (look in riffles, pools, then snags)? If Yes, check all that apply. If No, skip to Metric 13.

| 1 | >1 | Numbers over columns refer to "individuals" for Size 1 and 2 streams and "taxa" for Size 3 and 4 streams. |
|---|---|---|
| ☐ | ☐ | Adult frogs |
| ☐ | ☐ | Aquatic reptiles |
| ☐ | ☐ | Aquatic macrophytes and aquatic mosses (include liverworts, lichens, and algal mats) |
| ☐ | ☐ | Beetles |
| ☐ | ☐ | Caddisfly larvae (T) |
| ☐ | ☐ | Asian clam (*Corbicula*) |
| ☐ | ☐ | Crustacean (isopod/amphipod/crayfish/shrimp) |
| ☐ | ☐ | Damselfly and dragonfly larvae |
| ☐ | ☐ | Dipterans |
| ☐ | ☐ | Mayfly larvae (E) |
| ☐ | ☐ | Megaloptera (alderfly, fishfly, dobsonfly larvae) |
| ☐ | ☐ | Midges/mosquito larvae |
| ☐ | ☐ | Mosquito fish (*Gambusia*) or mud minnows (*Umbra pygmaea*) |
| ☐ | ☐ | Mussels/Clams (not *Corbicula*) |
| ☐ | ☐ | Other fish |
| ☐ | ☐ | Salamanders/tadpoles |
| ☐ | ☐ | Snails |
| ☐ | ☐ | Stonefly larvae (P) |
| ☐ | ☐ | Tipulid larvae |
| ☐ | ☐ | Worms/leeches |

**13. Streamside Area Ground Surface Condition – streamside area metric (skip for Tidal Marsh Streams and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Consider storage capacity with regard to both overbank flow and upland runoff.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Little or no alteration to water storage capacity over a majority of the streamside area |
| ☐B | ☐B | Moderate alteration to water storage capacity over a majority of the streamside area |
| ☐C | ☐C | Severe alteration to water storage capacity over a majority of the streamside area (examples: ditches, fill, soil compaction, livestock disturbance, buildings, man-made levees, drainage pipes) |

**14. Streamside Area Water Storage – streamside area metric (skip for Size 1 streams, Tidal Marsh Streams, and B valley types)**
**Consider for the Left Bank (LB) and the Right Bank (RB) of the streamside area.**

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Majority of streamside area with depressions able to pond water ≥ 6 inches deep |
| ☐B | ☐B | Majority of streamside area with depressions able to pond water 3 to 6 inches deep |
| ☐C | ☐C | Majority of streamside area with depressions able to pond water < 3 inches deep |

**15. Wetland Presence – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for the Left Bank (LB) and the Right Bank (RB).** Do not consider wetlands outside of the streamside area or within the normal wetted perimeter of assessment reach.

| LB | RB | |
|---|---|---|
| ☐Y | ☐Y | Are wetlands present in the streamside area? |
| ☒N | ☒N | |

**16. Baseflow Contributors – assessment reach metric (skip for Size 4 streams and Tidal Marsh Streams)**
**Check all contributors within the assessment reach or within view of <u>and</u> draining to the assessment reach.**

☒A Streams and/or springs (jurisdictional discharges)
☐B Ponds (include wet detention basins; do not include sediment basins or dry detention basins)
☐C Obstruction passing flow during low-flow periods within the assessment area (beaver dam, leaky dam, bottom-release dam, weir)
☐D Evidence of bank seepage or sweating (iron in water indicates seepage)
☐E Stream bed or bank soil reduced (dig through deposited sediment if present)
☐F None of the above

**17. Baseflow Detractors – assessment area metric (skip for Tidal Marsh Streams)**
**Check all that apply.**

☐A Evidence of substantial water withdrawals from the assessment reach (includes areas excavated for pump installation)
☐B Obstruction not passing flow during low-flow periods affecting the assessment reach (ex: watertight dam, sediment deposit)
☐C Urban stream (≥ 24% impervious surface for watershed)
☐D Evidence that the streamside area has been modified resulting in accelerated drainage into the assessment reach
☐E Assessment reach relocated to valley edge
☒F None of the above

**18. Shading – assessment reach metric (skip for Tidal Marsh Streams)**
Consider aspect. Consider "leaf-on" condition.

☐A Stream shading is appropriate for stream category (may include gaps associated with natural processes)
☒B Degraded (example: scattered trees)
☐C Stream shading is gone or largely absent

**19. Buffer Width – streamside area metric (skip for Tidal Marsh Streams)**
**Consider “vegetated buffer” and “wooded buffer” separately for left bank (LB) and right bank (RB) starting at the top of bank out to the first break.**

| Vegetated | | Wooded | | |
|---|---|---|---|---|
| LB | RB | LB | RB | |
| ☒A | ☒A | ☒A | ☒A | ≥ 100 feet wide or extends to the edge of the watershed |
| ☐B | ☐B | ☐B | ☐B | From 50 to < 100 feet wide |
| ☐C | ☐C | ☐C | ☐C | From 30 to < 50 feet wide |
| ☐D | ☐D | ☐D | ☐D | From 10 to < 30 feet wide |
| ☐E | ☐E | ☐E | ☐E | < 10 feet wide or no trees |

**20. Buffer Structure – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 (“Vegetated” Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Mature forest |
| ☐B | ☐B | Non-mature woody vegetation or modified vegetation structure |
| ☐C | ☐C | Herbaceous vegetation with or without a strip of trees < 10 feet wide |
| ☐D | ☐D | Maintained shrubs |
| ☐E | ☐E | Little or no vegetation |

**21. Buffer Stressors – streamside area metric (skip for Tidal Marsh Streams)**
**Check all appropriate boxes for left bank (LB) and right bank (RB).** Indicate if listed stressor abuts stream (Abuts), does not abut but is within 30 feet of stream (< 30 feet), or is between 30 to 50 feet of stream (30-50 feet).
**If none of the following stressors occurs on either bank, check here and skip to Metric 22:** ☒

| Abuts | | < 30 feet | | 30-50 feet | | |
|---|---|---|---|---|---|---|
| LB | RB | LB | RB | LB | RB | |
| ☐A | ☐A | ☐A | ☐A | ☐A | ☐A | Row crops |
| ☐B | ☐B | ☐B | ☐B | ☐B | ☐B | Maintained turf |
| ☐C | ☐C | ☐C | ☐C | ☐C | ☐C | Pasture (no livestock)/commercial horticulture |
| ☐D | ☐D | ☐D | ☐D | ☐D | ☐D | Pasture (active livestock use) |

**22. Stem Density – streamside area metric (skip for Tidal Marsh Streams)**
**Consider for left bank (LB) and right bank (RB) for Metric 19 (“Wooded” Buffer Width).**

| LB | RB | |
|---|---|---|
| ☒A | ☒A | Medium to high stem density |
| ☐B | ☐B | Low stem density |
| ☐C | ☐C | No wooded riparian buffer or predominantly herbaceous species or bare ground |

**23. Continuity of Vegetated Buffer – streamside area metric (skip for Tidal Marsh Streams)**
Consider whether vegetated buffer is continuous along stream (parallel). Breaks are areas lacking vegetation > 10 feet wide.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | The total length of buffer breaks is < 25 percent. |
| ☒B | ☒B | The total length of buffer breaks is between 25 and 50 percent. |
| ☐C | ☐C | The total length of buffer breaks is > 50 percent. |

**24. Vegetative Composition – streamside area metric (skip for Tidal Marsh Streams)**
Evaluate the dominant vegetation within 100 feet of each bank or to the edge of the watershed (whichever comes first) as it contributes to assessment reach habitat.

| LB | RB | |
|---|---|---|
| ☐A | ☐A | Vegetation is close to undisturbed in species present and their proportions. Lower strata composed of native species, with non-native invasive species absent or sparse. |
| ☒B | ☒B | Vegetation indicates disturbance in terms of species diversity or proportions, but is still largely composed of native species. This may include communities of weedy native species that develop after clear-cutting or clearing or communities with non-native invasive species present, but not dominant, over a large portion of the expected strata or communities missing understory but retaining canopy trees. |
| ☐C | ☐C | Vegetation is severely disturbed in terms of species diversity or proportions. Mature canopy is absent or communities with non-native invasive species dominant over a large portion of expected strata or communities composed of planted stands of non-characteristic species or communities inappropriately composed of a single species or no vegetation. |

**25. Conductivity – assessment reach metric (skip for all Coastal Plain streams)**
25a. ☐Yes ☒No Was conductivity measurement recorded?
If No, select one of the following reasons. ☐No Water ☐Other: ______________________________

25b. Check the box corresponding to the conductivity measurement (units of microsiemens per centimeter).
☐A < 46 ☐B 46 to < 67 ☐C 67 to < 79 ☐D 79 to < 230 ☐E ≥ 230

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Notes/Sketch:
One ATV access road has been constructed across Stream 17 and has two, 6-inch plastic culverts. Areas of streambank vegetation has been removed near the confluence of Stream 16.

# Draft NC SAM Stream Rating Sheet
# Accompanies User Manual Version 2.1

Stream 17

| | | | |
|---|---|---|---|
| Stream Site Name | Bad Creek II Power Complex Project | Date of Assessment | 10/19/23 |
| Stream Category | Mb3 | Assessor Name/Organization | Paul Bright / HDR |

| | |
|---|---|
| Notes of Field Assessment Form (Y/N) | YES |
| Presence of regulatory considerations (Y/N) | YES |
| Additional stream information/supplementary measurements included (Y/N) | YES |
| NC SAM feature type (perennial, intermittent, Tidal Marsh Stream) | Perennial |

| **Function Class Rating Summary** | **USACE/ All Streams** | **NCDWR Intermittent** |
|---|---|---|
| (1) Hydrology | **HIGH** | |
| (2) Baseflow | **MEDIUM** | |
| (2) Flood Flow | **HIGH** | |
| (3) Streamside Area Attenuation | **MEDIUM** | |
| (4) Floodplain Access | **MEDIUM** | |
| (4) Wooded Riparian Buffer | **HIGH** | |
| (4) Microtopography | NA | |
| (3) Stream Stability | **HIGH** | |
| (4) Channel Stability | **HIGH** | |
| (4) Sediment Transport | **HIGH** | |
| (4) Stream Geomorphology | **HIGH** | |
| (2) Stream/Intertidal Zone Interaction | NA | |
| (2) Longitudinal Tidal Flow | NA | |
| (2) Tidal Marsh Stream Stability | NA | |
| (3) Tidal Marsh Channel Stability | NA | |
| (3) Tidal Marsh Stream Geomorphology | NA | |
| (1) Water Quality | **LOW** | |
| (2) Baseflow | **MEDIUM** | |
| (2) Streamside Area Vegetation | **MEDIUM** | |
| (3) Upland Pollutant Filtration | **MEDIUM** | |
| (3) Thermoregulation | **MEDIUM** | |
| (2) Indicators of Stressors | **NO** | |
| (2) Aquatic Life Tolerance | **LOW** | |
| (2) Intertidal Zone Filtration | NA | |
| (1) Habitat | **HIGH** | |
| (2) In-stream Habitat | **HIGH** | |
| (3) Baseflow | **MEDIUM** | |
| (3) Substrate | **HIGH** | |
| (3) Stream Stability | **HIGH** | |
| (3) In-stream Habitat | **MEDIUM** | |
| (2) Stream-side Habitat | **HIGH** | |
| (3) Stream-side Habitat | **HIGH** | |
| (3) Thermoregulation | **MEDIUM** | |
| (2) Tidal Marsh In-stream Habitat | NA | |
| (3) Flow Restriction | NA | |
| (3) Tidal Marsh Stream Stability | NA | |
| (4) Tidal Marsh Channel Stability | NA | |
| (4) Tidal Marsh Stream Geomorphology | NA | |
| (3) Tidal Marsh In-stream Habitat | NA | |
| (2) Intertidal Zone | NA | |
| Overall | **HIGH** | |

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# Attachment E

## Attachment E - Riparian Vegetation Survey Plot Data and Photolog

### Stream 1 (Limber Pole Creek) – Upstream

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** |
|---|---|---|---|
| Ilex opaca | 7.6 | Rhododendron | 9.5 |
| Rhododendron | 5.1 | Betula lenta | 28.3 |
| Rhododendron | 7.6 | Oxydendrum arboreum | 12.7 |
| Acer rubrum | 26.7 | Acer saccharum | 14.0 |
| Rhododendron | 3.0 | Rhododendron | 10.5 |
| Rhododendron | 2.5 | Liquidambar styraciflua | 45.7 |
| Rhododendron | 7.6 | Betula lenta | 18.5 |
| Rhododendron | 7.6 | Rhododendron | 8.8 |
| Rhododendron | 5.1 | Pinus strobus | 94.9 |
| Rhododendron | 11.4 | Rhododendron | 9.8 |
| Rhododendron | 12.7 | Betula lenta | 21.3 |
| Nyssa sylvatica | 16.5 | Rhododendron | 13.6 |
| Liquidambar styraciflua | 33.0 | Liquidambar styraciflua | 21.4 |
| Pinus strobus | 42.4 | Acer saccharum | 10.4 |
| Rhododendron | 5.4 | Betula lenta | 13.1 |
| Rhododendron | 10.2 | Oxydendrum arboreum | 26.3 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **24.2** |
| | | **Average DBH - trees >10 cm (in)** | **9.5** |
| | | **Average tree density (No. trees/acre)** | **405** |

### Stream 1 (Limber Pole Creek) – Downstream

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** |
|---|---|---|---|
| Rhododendron | 7.0 | Rhododendron | 7.4 |
| Rhododendron | 14.9 | Rhododendron | 6.9 |
| Sourwood | 27.4 | Acer rubrum | 42.0 |
| Rhododendron | 12.0 | Acer rubrum | 29.9 |
| Rhododendron | 3.9 | Acer rubrum | 30.5 |
| Nyssa sylvatica | 13.6 | Rhododendron | 8.9 |
| Rhododendron | 9.5 | Rhododendron | 8.9 |
| Rhododendron | 7.0 | Betula papyrifera | 48.6 |
| Rhododendron | 3.5 | Liriodendron tulipifera | 43.0 |
| | | Rhododendron | 8.5 |
| | | Rhododendron | 17.0 |
| | | Rhododendron | 14.0 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **26.6** |
| | | **Average DBH - trees >10 cm (in)** | **10.5** |
| | | **Average tree density (No. trees/acre)** | **223** |

## Stream 7 (Howard Creek) – Upstream

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** |
|---|---:|---|---:|
| Carpinus caroliniana | 22.0 | Fagus grandifolia | 17.4 |
| Tsuga canadensis | 9.7 | Betula lenta | 28.3 |
| Liriodendron tulipifera | 45.9 | Liriodendron tulipifera | 27.5 |
| | | Rhododendron | 7.5 |
| | | Rhododendron | 9.6 |
| | | Rhododendron | 6.1 |
| | | Carpinus caroliniana | 7.0 |
| | | Liriodendron tulipifera | 43.5 |
| | | Acer rubrum | 6.4 |
| | | Fagus grandifolia | 34.1 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **31.2** |
| | | **Average DBH - trees >10 cm (in)** | **12.3** |
| | | **Average tree density (No. trees/acre)** | **142** |

## Stream 7 (Howard Creek) – Downstream

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** | **Right Bank (cont.)** | **DBH (cm)** |
|---|---:|---|---:|---|---:|
| Tsuga canadensis | 3.9 | Acer rubrum | 21.7 | Tsuga canadensis | 4 |
| Tsuga canadensis | 4.2 | Liriodendron tulipifera | 42.2 | Tsuga canadensis | 3 |
| Fagus grandifolia | 15.2 | Ilex opaca | 10.4 | Carpinus caroliniana | 2.5 |
| Tsuga canadensis | 3.5 | Tsuga canadensis | 7.6 | Tsuga canadensis | 3.5 |
| Tsuga canadensis | 3.5 | Tsuga canadensis | 2.5 | Kalmia latifolia | 4.2 |
| Tsuga canadensis | 3.5 | Tsuga canadensis | 4.2 | Tsuga canadensis | 3.5 |
| Tsuga canadensis | 4.1 | Tsuga canadensis | 4.0 | Tsuga canadensis | 2.8 |
| Tsuga canadensis | 4.0 | Tsuga canadensis | 3.5 | Liquidambar styraciflua | 4.5 |
| Tsuga canadensis | 3.5 | Tsuga canadensis | 5.4 | Liriodendron tulipifera | 20.3 |
| Tsuga canadensis | 4.0 | Tsuga canadensis | 3.5 | Liquidambar styraciflua | 2.8 |
| Ilex opaca | 2.1 | Tsuga canadensis | 3.5 | Liquidambar styraciflua | 2.8 |
| Halesia carolina | 19.5 | Tsuga canadensis | 3.5 | Tsuga canadensis | 8 |
| Rhododendron | 7.5 | Tsuga canadensis | 3.5 | Tsuga canadensis | 4 |
| | | Tsuga canadensis | 2.9 | Tsuga canadensis | 4 |
| | | Tsuga canadensis | 2.9 | Tsuga canadensis | 4 |
| | | | | | |
| | | **Average DBH - trees >10 cm (cm)** | | | **21.6** |
| | | **Average DBH - trees >10 cm (in)** | | | **8.5** |
| | | **Average tree density (No. trees/acre)** | | | **121** |

**Stream 12 – Upstream**

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** |
|---|---|---|---|
| Liriodendron tulipifera | 28.0 | Liquidambar styraciflua | 76.0 |
| Nyssa sylvatica | 3.5 | Tsuga canadensis | 12.0 |
| Nyssa sylvatica | 5.4 | Tsuga canadensis | 22.0 |
| Liriodendron tulipifera | 12.8 | Tsuga canadensis | 8.0 |
| Acer rubrum | 8.9 | Nyssa sylvatica | 20.5 |
| Carya tomentosa | 27.5 | Ilex opaca | 19.0 |
| Nyssa sylvatica | 3.5 | Kalmia latifolia | 14.0 |
| Liriodendron tulipifera | 56.5 | Quercus falcata | 68.0 |
| | | Carya tomentosa | 210.0 |
| | | Fraxinus pennsylvanica | 8.0 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **47.2** |
| | | **Average DBH - trees >10 cm (in)** | **18.6** |
| | | **Average tree density (No. trees/acre)** | **243** |

**Stream 12 – Downstream**

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** |
|---|---|---|---|
| Liriodendron tulipifera | 15.1 | Liriodendron tulipifera | 70.6 |
| Nyssa sylvatica | 1.9 | Ilex opaca | 4.7 |
| Nyssa sylvatica | 1.9 | Cornus amomum | 7.0 |
| Liriodendron tulipifera | 45.9 | Quercus alba | 4.9 |
| Liquidambar styraciflua | 12.0 | Liriodendron tulipifera | 48.4 |
| Liriodendron tulipifera | 24.5 | Tsuga canadensis | 12.4 |
| Liquidambar styraciflua | 7.9 | Tsuga canadensis | 7.3 |
| Acer rubrum | 4.4 | Acer rubrum | 48.0 |
| Liriodendron tulipifera | 7.6 | | |
| Liquidambar styraciflua | 9.8 | | |
| Liriodendron tulipifera | 34.0 | | |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **37.4** |
| | | **Average DBH - trees >10 cm (in)** | **14.7** |
| | | **Average tree density (No. trees/acre)** | **162** |

### Stream 15 – Upstream

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** |
|---|---|---|---|
| Liriodendron tulipifera | 12.2 | Quercus montana | 29.0 |
| Acer rubrum | 3.2 | Kalmia latifolia | 4.0 |
| | | Pinus strobus | 21.8 |
| | | Nyssa sylvatica | 4.5 |
| | | Nyssa sylvatica | 28.6 |
| | | Kalmia latifolia | 6.6 |
| | | Oxydendrum arboreum | 12.4 |
| | | Nyssa sylvatica | 5.5 |
| | | Nyssa sylvatica | 3.8 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **20.8** |
| | | **Average DBH - trees >10 cm (in)** | **8.2** |
| | | **Average tree density (No. trees/acre)** | **101** |

### Stream 15 – Downstream

| **Left Bank** | **DBH (cm)** | **Right Bank** | **DBH (cm)** |
|---|---|---|---|
| Acer rubrum | 10.7 | Quercus alba | 28.3 |
| Kalmia latifolia | 6.7 | Kalmia latifolia | 7.0 |
| Acer rubrum | 12.0 | Kalmia latifolia | 4.7 |
| Oxydendrum arboreum | 28.4 | Acer rubrum | 23.7 |
| Acer rubrum | 20.0 | Quercus alba | 37.2 |
| Quercus montana | 31.0 | Oxydendrum arboreum | 18.0 |
| Kalmia latifolia | 5.0 | Kalmia latifolia | 7.6 |
| | | Acer rubrum | 9.3 |
| | | Acer rubrum | 17.5 |
| | | Pinus strobus | 3.0 |
| | | Acer rubrum | 7.4 |
| | | Quercus alba | 41.5 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **24.4** |
| | | **Average DBH - trees >10 cm (in)** | **9.6** |
| | | **Average tree density (No. trees/acre)** | **223** |

### Stream 16 – Upstream

| **Right Bank** | **DBH (cm)** | **Left Bank** | **DBH (cm)** |
|---|---|---|---|
| Acer rubrum | 11.1 | Liriodendron tulipifera | 44.3 |
| Liriodendron tulipifera | 15.4 | Liriodendron tulipifera | 16.9 |
| Liriodendron tulipifera | 27.5 | Nyssa sylvatica | 3.8 |
| Acer rubrum | 16.5 | Acer rubrum | 12.2 |
| Oxydendrum arboreum | 12.1 | Liriodendron tulipifera | 13.3 |
| Acer rubrum | 5.6 | Liriodendron tulipifera | 34.8 |
| Magnolia tripetala | 5 | Oxydendrum arboreum | 6 |
| Quercus alba | 46 | Liriodendron tulipifera | 12.4 |
| Pinus strobus | 1 | Robinia pseudoacacia | 21.4 |
| Kalmia latifolia | 5.6 | | |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **21.8** |
| | | **Average DBH - trees >10 cm (in)** | **8.6** |
| | | **Average tree density (No. trees/acre)** | **263** |

### Stream 16 – Downstream

| **Right Bank** | **DBH (cm)** | **Left Bank** | **DBH (cm)** |
|---|---|---|---|
| Acer rubrum | 55 | Fagus grandifolia | 2.1 |
| Tilia americana | 11.6 | Liriodendron tulipifera | 19.4 |
| | | Liriodendron tulipifera | 25.5 |
| | | Liriodendron tulipifera | 15 |
| | | Liriodendron tulipifera | 19 |
| | | Oxydendrum arboreum | 4.6 |
| | | Liriodendron tulipifera | 6.8 |
| | | Oxydendrum arboreum | 7.5 |
| | | Oxydendrum arboreum | 3.4 |
| | | Oxydendrum arboreum | 2.2 |
| | | Kalmia latifolia | 4 |
| | | Liriodendron tulipifera | 37 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **26.1** |
| | | **Average DBH - trees >10 cm (in)** | **10.3** |
| | | **Average tree density (No. trees/acre)** | **142** |

### Stream 17 (Devils Fork) – Upstream

| **Right Bank** | **DBH (cm)** | **Left Bank** | **DBH (cm)** |
|---|---|---|---|
| Liriodendron tulipifera | 44.3 | Nyssa sylvatica | 21.3 |
| Liriodendron tulipifera | 16.9 | Quercus alba | 53.1 |
| Nyssa sylvatica | 3.8 | Kalmia latifolia | 3.5 |
| Acer rubrum | 12.2 | Acer rubrum | 13.4 |
| Liriodendron tulipifera | 13.3 | Oxydendrum arboreum | 3 |
| Liriodendron tulipifera | 34.8 | Liriodendron tulipifera | 3.3 |
| Oxydendrum arboreum | 6 | Asimina triloba | 3.3 |
| Liriodendron tulipifera | 12.4 | Kalmia latifolia | 2.4 |
| Robinia pseudoacacia | 21.4 | Kalmia latifolia | 4 |
| | | Asimina triloba | 2.5 |
| | | | |
| | | **Average DBH - trees >10 cm (cm)** | **24.3** |
| | | **Average DBH - trees >10 cm (in)** | **9.6** |
| | | **Average tree density (No. trees/acre)** | **202** |

### Stream 17 (Devils Fork) – Downstream

| **Right Bank** | **DBH (cm)** | **Left Bank** | **DBH (cm)** |
|---|---|---|---|
| Fagus grandifolia | 2.1 | Robinia pseudoacacia | 48 |
| Liriodendron tulipifera | 19.4 | Ilex opaca | 32 |
| Liriodendron tulipifera | 25.5 | Nyssa sylvatica | 4 |
| Liriodendron tulipifera | 15 | Cornus florida | 9.6 |
| Liriodendron tulipifera | 19 | Ilex opaca | 6.2 |
| Oxydendrum arboreum | 4.6 | Liriodendron tulipifera | 32 |
| Liriodendron tulipifera | 6.8 | Ilex opaca | 11.2 |
| Oxydendrum arboreum | 7.5 | Liriodendron tulipifera | 34 |
| Oxydendrum arboreum | 3.4 | Acer rubrum | 5 |
| Oxydendrum arboreum | 2.2 | Fagus grandifolia | 2.5 |
| Kalmia latifolia | 4 | Fagus grandifolia | 3.4 |
| Liriodendron tulipifera | 37 | Liriodendron tulipifera | 28.2 |
| | | Liriodendron tulipifera | 27.5 |
| | | Liriodendron tulipifera | 32 |
| | | Rhododendron | 4 |
| | | Rhododendron | 4.5 |
| | | Rhododendron | 7.5 |
| | | Rhododendron | 2.4 |
| | | Rhododendron | 4.7 |
| | | **Average DBH - trees >10 cm (cm)** | **27.8** |
| | | **Average DBH - trees >10 cm (in)** | **10.9** |
| | | **Average tree density (No. trees/acre)** | **263** |

Photo 1. View of vegetation plot on left bank of upstream reach at Stream 1 (Limber Pole Creek

Photo 2. View of vegetation plot on right bank of upstream reach at Stream 1 (Limber Pole Creek), facing southeast

Photo 3. View of vegetation plot on left bank of downstream reach at Stream 1 (Limber Pole Creek), facing southwest

Photo 4. View of vegetation plot on right bank of downstream reach at Stream 1 (Limber Pole Creek), facing southeast

Photo 5. View of vegetation plot on left bank of upstream reach at Stream 7 (Howard Creek), facing southeast

Photo 6. View of vegetation plot on right bank of upstream reach at Stream 7 (Howard Creek), facing southeast

Photo 7. View of vegetation plot on left bank of downstream reach at Stream 7 (Howard Creek), facing southwest

Photo 8. View of vegetation plot on right bank of downstream reach at Stream 7 (Howard Creek), facing northeast

Photo 9. View of vegetation plot on left bank of upstream reach at Stream 12, facing southeast

Photo 10. View of vegetation plot on right bank of upstream reach at Stream 12, facing northwest

Photo 11. View of vegetation plot on left bank of downstream reach at Stream 12, facing southwest

Photo 12. View of vegetation plot on right bank of downstream reach at Stream 12, facing south

Photo 13. View of vegetation plot on left bank of upstream reach at Stream 15, facing northwest

Photo 14. View of vegetation plot on left bank of upstream reach at Stream 15, facing northwest

Photo 15. View of vegetation plot on left bank of downstream reach at Stream 15, facing west

Photo 16. View of vegetation plot on right bank of upstream reach at Stream 16

Photo 17. View of vegetation plot on right bank of downstream reach at Stream 15, facing southeast

Photo 18. View of vegetation plot on left bank of upstream reach of Stream 16 and right bank of upstream reach of Stream 17 (Devils Fork), facing northeast

Photo 19. View of vegetation plot on left bank of upstream reach of Stream 17 (Devils Fork), facing northwest

Photo 20. View of vegetation plot on left bank of downstream reach of Stream 16 and right bank of downstream reach of Stream 17 (Devils Fork), facing north

Photo 21. View of vegetation plot on left bank of downstream reach of Stream 17 (Devils Fork), facing east

Photo 22. View of vegetation plot on right bank of downstream reach of Stream 16, facing west

# Attachment F

## Attachment F - Stream Quantification Tool Rapid Method Forms

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 1 (Limber Pole Creek) - Upstream

**SC SQT Rapid Method Form**
Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Limber Pole Creek - Upstream |
| Upstream Latitude: | 34.991512 |
| Upstream Longitude: | -83.02083761 |
| Downstream Latitude: | 34.991604 |
| Downstream Longitude: | -83.02053397 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 1.780579 |
| Strahler Stream Order: | 3 |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 7.5 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B.

| Armored Bank Lengths (ft): | | | | | | |
|---|---|---|---|---|---|---|

Notes: No bank armoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.82 | Back of depositional feature |
| | |
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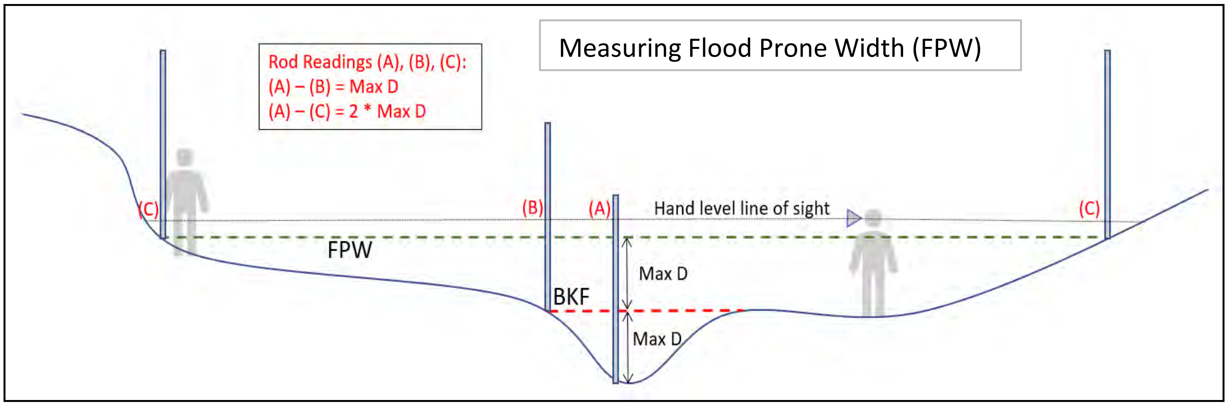
## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.82 |
| B. | Bankfull Width (ft) | 14.4 |
| E. | Regional Curve Bankfull Width (ft) | 22.295 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 1.3404 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 29.998 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 |
| I. | Flood Prone Width (FPW; ft) | 16.08 |

| Cross Section Measurements Depth measured from bankfull | | | |
|---|---|---|---|
| Station | Depth | Station | Depth |
| 0 | 0 | 13 | 1.08 |
| 0.1 | 0.22 | 14 | 0.18 |
| 1 | 0.5 | 14.4 | 0 |
| 2 | 0.88 | | |
| 3 | 0.9 | | |
| 4.9 | 1.05 | | |
| 5.5 | 1.4 | | |
| 6 | 1.52 | | |
| 7 | 1.5 | | |
| 8 | 1.35 | | |
| 9 | 1.28 | | |
| 10 | 1 | | |
| 11 | 1.12 | | |
| 12 | 1.1 | | |



## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 288 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 3.8 | 85 | | | | | | |
| End Station (Distance along tape) | 34.9 | 102.5 | | | | | | |
| Low Bank Height (ft) | 4.15 | 3.11 | | | | | | |
| Bankfull Max Depth (ft) | 1.52 | 1.9 | | | | | | |
| Bankfull Width (ft) | 14.4 | 22.3 | | | | | | |
| Flood Prone Width (ft) | 16.1 | 66.2 | | | | | | |
| Bankfull Mean Depth (ft) | 1.2 | 1.2 | | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | | | | | | | |
| Station At maximum pool depth | 43.8 | | | | | | | |
| Geomorphic P-P Spacing (ft) | | | | | | | | |
| Pool Depth (ft) Measured from Bankfull | 1.81 | | | | | | | |

D. Slope

| Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 103.2 | 103.2 | 0.039 |
| Stadia Rod Reading (ft) | 1694 | 1690 | 4.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 103.2 |
| Valley Length (ft) | 93.27 |
| Sinuosity | 1.11 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 15 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 49.2 |

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 1 (Limber Pole Creek) - Upstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Limber Pole Creek - Upstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 11.3 mm, medium gravel**

| | | | Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| 25 | 12 | 20 | 1.17 | 5 | 75 | 75 | 75 | silt- N/A | N/A | 31.65 / High | 1.0 / Low |
| | | | | | | | | | | | |
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Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 1 (Limber Pole Creek) - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Limber Pole Creek - Downstream |
| Upstream Latitude: | 34.991604 |
| Upstream Longitude: | -83.02053397 |
| Downstream Latitude: | 34.991628 |
| Downstream Longitude: | -83.0200869 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 146 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 1.780579 |
| Strahler Stream Order: | 3 |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 2.5 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes: No bank armoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.83 | bottom of undercut, top of mid-channel depositional bar |
| | |
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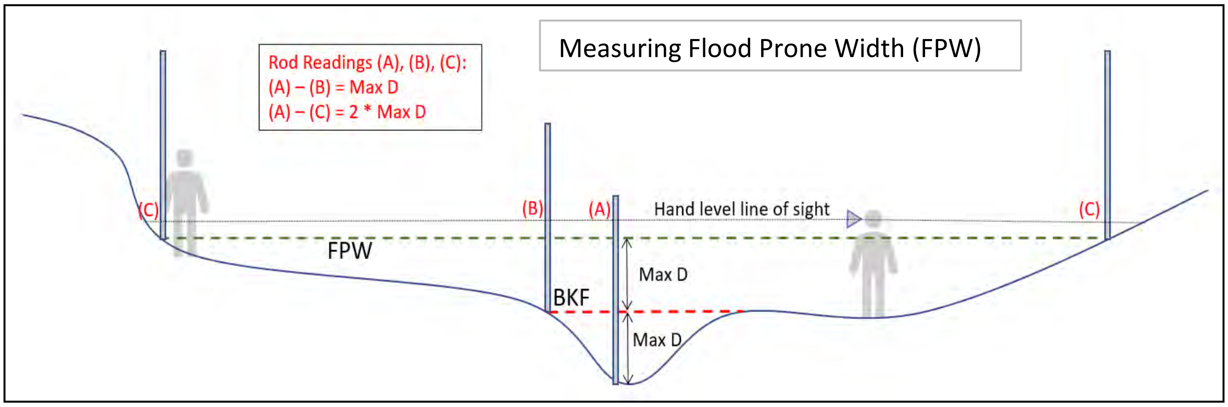
## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.83 |
| B. | Bankfull Width (ft) | 18.2 |
| E. | Regional Curve Bankfull Width (ft) | 22.295 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 1.3404 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 29.998 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 (SCDNR 2020) |
| I. | Flood Prone Width (FPW; ft) | 21.1 |

Cross Section Measurements
Depth measured from bankfull

| Station | Depth | Station | Depth |
|---|---|---|---|
| 0 | 0 | 13 | 0.64 |
| 0.1 | 1.3 | 14 | 0.54 |
| 1 | 1.28 | 15 | 0.84 |
| 2 | 1.18 | 16 | 0.88 |
| 3 | 1.28 | 17 | 0.84 |
| 4 | 1.16 | 18 | 0.84 |
| 5 | 0.88 | 18.2 | 0 |
| 6 | 0.62 | | |
| 7 | 0.5 | | |
| 8 | 0.4 | | |
| 9 | 0.4 | | |
| 10 | 0.48 | | |
| 11 | 0.54 | | |
| 12 | 0.54 | | |



## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 364 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 107 | | | | | | | |
| End Station (Distance along tape) | 146 | | | | | | | |
| Low Bank Height (ft) | 4.7 | | | | | | | |
| Bankfull Max Depth (ft) | 1.28 | | | | | | | |
| Bankfull Width (ft) | 18.2 | | | | | | | |
| Flood Prone Width (ft) | 38.0 | | | | | | | |
| Bankfull Mean Depth (ft) | 0.8 | | | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | | G | | | | | | |
| Station<br>At maximum pool depth | 24.1 | 66.6 | | | | | | |
| Geomorphic P-P Spacing (ft) | | | | | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 1.84 | 2.58 | | | | | | |

D. Slope

Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography

| | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 146.83 | 146.8 | 0.014 |
| Stadia Rod Reading (ft) | 1692 | 1690 | 2.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 146.83 |
| Valley Length (ft) | 136.04 |
| Sinuosity | 1.08 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 12 |
| Assessment length (ft) | 146.83 |
| # of LWD Pieces/100 m | 26.8 |

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 1 (Limber Pole Creek) - Downstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Limber Pole Creek - Downstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 14.55 mm, medium gravel**

| | | | Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| All streambanks stable | | | | | | | | | | | |
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Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 7 (Howard Creek) - Upstream

**SC SQT Rapid Method Form**
Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Howard Creek - Upstream |
| Upstream Latitude: | 34.991168 |
| Upstream Longitude: | -83.00275748 |
| Downstream Latitude: | 34.991031 |
| Downstream Longitude: | -83.0024676 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 4.13202 |
| Strahler Stream Order: | 2 |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 6.1 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes: No armored banks

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.02 | undercut bank, moss lines |
| | |
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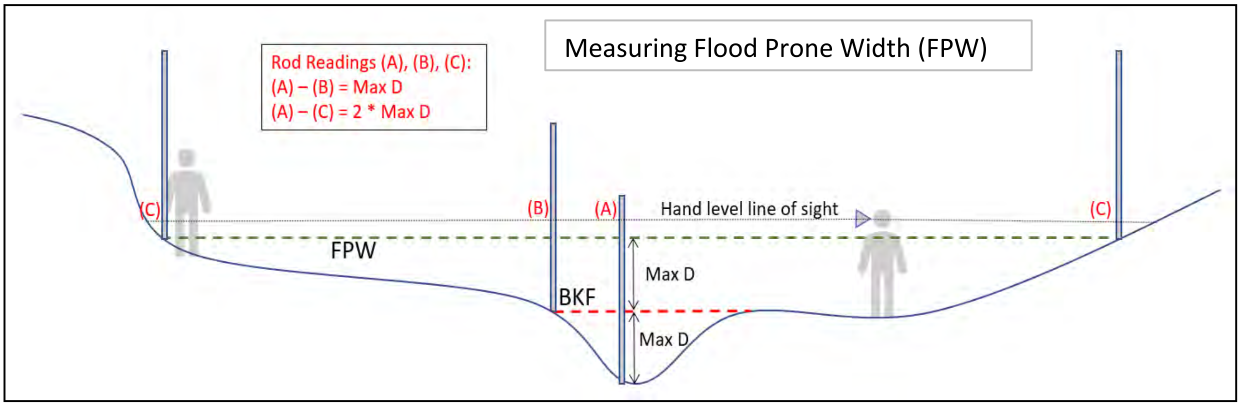
## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.02 |
| B. | Bankfull Width (ft) | 19.2 |
| E. | Regional Curve Bankfull Width (ft) | 31.22 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 1.7197 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 53.804 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 (SCDNR 2020) |
| I. | Flood Prone Width (FPW; ft) | 20.8 |

| Cross Section Measurements Depth measured from bankfull | | | |
|---|---|---|---|
| Station | Depth | Station | Depth |
| 0 | 0 | 13 | 0.82 |
| 0.1 | 0.7 | 14 | 1 |
| 1 | 0.71 | 15 | 0.7 |
| 2 | 0.68 | 16 | 1.02 |
| 3 | 0.48 | 17 | 1.02 |
| 4 | 0.4 | 18 | 1.02 |
| 5 | 0.52 | 19 | 0.9 |
| 6 | 0.48 | 19.2 | 0 |
| 7 | 0.1 | | |
| 8 | 0.42 | | |
| 9 | 0.5 | | |
| 10 | 0.88 | | |
| 11 | 1.2 | | |
| 12 | 0.68 | | |



## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 384 |

B. Riffle Data

| | R1 | R2 | R3 * | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 1 | 23.5 | 46 | 84.2 | | | | |
| End Station (Distance along tape) | 19 | 31.1 | 66.5 | 100 | | | | |
| Low Bank Height (ft) | 3.92 | 3.33 | 1.83 | 1.83 | | | | |
| Bankfull Max Depth (ft) | 0.62 | 1.2 | 1.02 | 1.46 | | | | |
| Bankfull Width (ft) | 12.7 | 12.1 | 19.2 | 17.1 | | | | |
| Flood Prone Width (ft) | 13 | 12.9 | 20.8 | 27.8 | | | | |
| Bankfull Mean Depth (ft) | 0.8 | 0.8 | 0.8 | 0.8 | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | G | G | | | | | |
| Station<br>At maximum pool depth | 23.2 | 40.5 | 72 | | | | | |
| Geomorphic P-P Spacing (ft) | | 17.3 | 31.5 | | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 1.18 | 1.36 | 1.42 | | | | | |

D. Slope

| Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 102.95 | 103.0 | 0.019 |
| Stadia Rod Reading (ft) | 1320 | 1318 | 2.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 102.95 |
| Valley Length (ft) | 95.14 |
| Sinuosity | 1.08 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 6 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 19.7 |

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 7 (Howard Creek) - Upstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Howard Creek - Upstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 34.6 mm, very coarse gravel**

| | | | Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| 12 | 15 | 3 | 0.68 | 2 | 60 | 125 | 40 | NA- silt | NA | 33.3 / High | 0.52 / Very Low |
| 25 | 10 | 3.33 | 1.2 | 2.5 | 50 | 130 | 40 | NA- silt | NA | 32.05 / High | 1.0 / Low |
| 30 | 8 | 4 | 1.2 | 2 | 40 | 145 | 30 | NA- silt | NA | 37.02 / High | 1.0 / Low |
| | | | | | | | | | | | |
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Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 7 (Howard Creek) - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Howard Creek - Downstream |
| Upstream Latitude: | 34.991031 |
| Upstream Longitude: | -83.0024676 |
| Downstream Latitude: | 34.990804 |
| Downstream Longitude: | -83.00220504 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 114 |
| Valley Type: | Confined Alluvial |
| Drainage Area (sq. mi.): | 4.13202 |
| Strahler Stream Order: | 2 |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 6.1 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes: No armored banks

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.48 | depositional bench w/veg - top |
| | |
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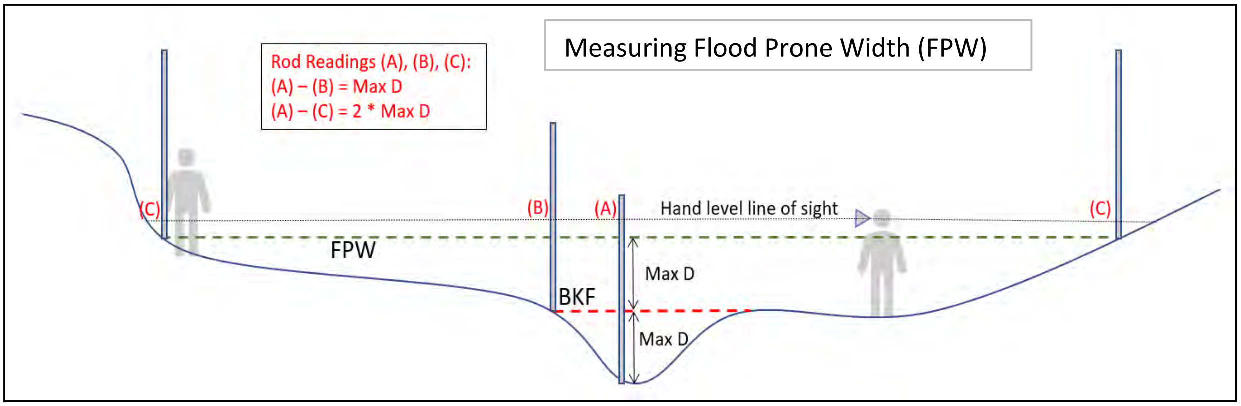
## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.48 |
| B. | Bankfull Width (ft) | 25.2 |
| E. | Regional Curve Bankfull Width (ft) | 31.22 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 1.7197 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 53.804 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 |
| I. | Flood Prone Width (FPW; ft) | 29.5 |

Cross Section Measurements
Depth measured from bankfull

| Station | Depth | Station | Depth |
|---|---|---|---|
| 0 | 0 | 14 | 0.78 |
| 0.1 | 0.4 | 15 | 1.16 |
| 1 | 0.62 | 16 | 1.18 |
| 2 | 0.78 | 17 | 0.88 |
| 3 | 0.88 | 18 | 1.18 |
| 4 | 0.8 | 19 | 1.4 |
| 5 | 0.58 | 20 | 0.86 |
| 6 | 0.54 | 21 | 0.88 |
| 7 | 1.24 | 22 | 0.58 |
| 8 | 1.28 | 23 | 0.36 |
| 10 | 1.16 | 24 | 0.25 |
| 11 | 0.48 | 25.2 | 0 |
| 12 | 0.52 | | |
| 13 | 0.74 | | |



Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 7 (Howard Creek) - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 504 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 33 | | | | | | | |
| End Station (Distance along tape) | 96.5 | | | | | | | |
| Low Bank Height (ft) | 2.67 | | | | | | | |
| Bankfull Max Depth (ft) | 1.28 | | | | | | | |
| Bankfull Width (ft) | 25.2 | | | | | | | |
| Flood Prone Width (ft) | 29.5 | | | | | | | |
| Bankfull Mean Depth (ft) | 0.9 | | | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | | | | | | | | |
| Station At maximum pool depth | 8.7 | | | | | | | |
| Geomorphic P-P Spacing (ft) | | | | | | | | |
| Pool Depth (ft) Measured from Bankfull | 2.64 | | | | | | | |

D. Slope

| Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 116.7 | 116.7 | 0.051 |
| Stadia Rod Reading (ft) | 1318 | 1312 | 6.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 116.74 |
| Valley Length (ft) | 110.97 |
| Sinuosity | 1.05 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 15 |
| Assessment length (ft) | 114 |
| # of LWD Pieces/100 m | 43.2 |

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 7 (Howard Creek) - Downstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Howard Creek - Downstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 56.69 mm, very coarse gravel**

| | | | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| 98 | 8 | 6 | 1.3 | 0 | 0 | 85 | 100 | Bedrock | NA | 2.69 / Very Low | 1.44 / Low |
| | | | | | | | | | | | |
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## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 12 - Upstream |
| Upstream Latitude: | 34.995613 |
| Upstream Longitude: | -83.0064477 |
| Downstream Latitude: | 34995642 |
| Downstream Longitude: | -83.00094113 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.031178 |
| Strahler Stream Order: | 1 |
| Flow Type: | Intermittent |
| Buffer Valley Slope (%): | 15.7 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes:  No bank amoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.3 | No water present. Veg/moss break. |
| | |
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Date: 10/2/2023 Stream 12 - Upstream **SC SQT Rapid Method Form**

Investigators: EBS, KC, SP (HDR) Version 1.0

## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.3 |
| B. | Bankfull Width (ft) | 5 |
| E. | Regional Curve Bankfull Width (ft) | 4.4209 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.4048 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 1.811 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 (SCDNR 2020) |
| I. | Flood Prone Width (FPW; ft) | 5.7 |

| Cross Section Measurements Depth measured from bankfull | | | |
|---|---|---|---|
| Station | Depth | Station | Depth |
| 0 | 0 | | |
| 0.1 | 0.42 | | |
| 1 | 0.38 | | |
| 2 | 0.36 | | |
| 3 | 0.28 | | |
| 4 | 0.18 | | |
| 5 | 0 | | |
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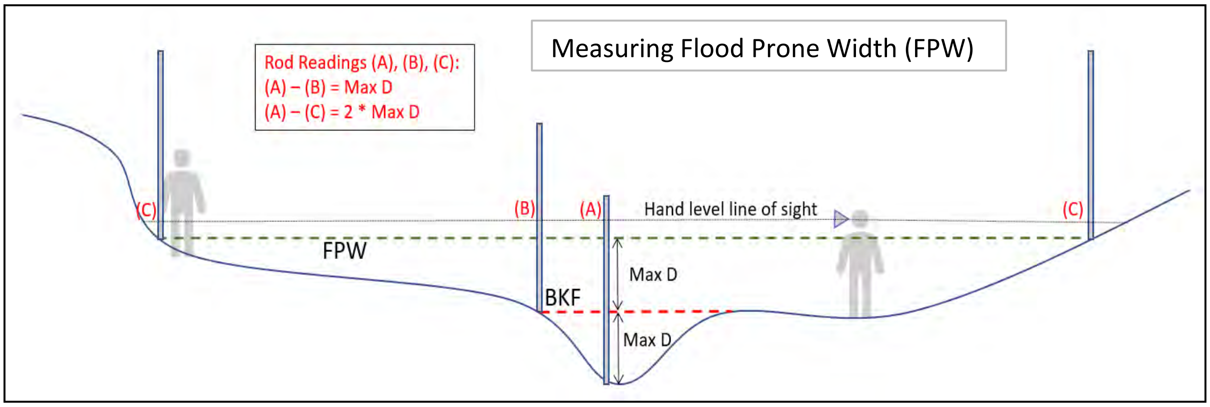

## IV. Representative Sub-Reach

A.

| | | | | |
|---|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | | 20*Bankfull Width | 100 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 12 | 32.5 | 46 | | | | | |
| End Station (Distance along tape) | 31 | 42.7 | 56 | | | | | |
| Low Bank Height (ft) | 2.9 | 1.62 | 1.62 | | | | | |
| Bankfull Max Depth (ft) | 0.42 | 0.5 | 0.68 | | | | | |
| Bankfull Width (ft) | 5 | 5.6 | 4.2 | | | | | |
| Flood Prone Width (ft) | 5.7 | 7.8 | 5.4 | | | | | |
| Bankfull Mean Depth (ft) | 0.3 | 0.3 | 0.3 | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | G | G | | | | | |
| Station<br>At maximum pool depth | 10.9 | 31 | 44.1 | | | | | |
| Geomorphic P-P Spacing (ft) | | 20.1 | 13.1 | | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 0.9 | 0.38 | 0.78 | | | | | |

D. Slope

| Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 99.88 | 99.9 | 0.100 |
| Stadia Rod Reading (ft) | 1542 | 1532 | 10.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 99.88 |
| Valley Length (ft) | 87.71 |
| Sinuosity | 1.14 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 3 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 9.8 |

Date: 10/2/2023

Investigators: EBS, KC, SP (HDR)

Stream 12 - Upstream

**SC SQT**

**BEHI/NBS Field Form**

Reach ID: **Stream 12 - Upstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 14.29, medium gravel**

| | | | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| All banks stable | | | | | | | | | | | |
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Date: 10/2/2023

Investigators: EBS, KC, SP (HDR)

Stream 12 - Downstream

**SC SQT Rapid Method Form**

Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 12 - Downstream |
| Upstream Latitude: | 34.995642 |
| Upstream Longitude: | -83.00094113 |
| Downstream Latitude: | 34.995534 |
| Downstream Longitude: | -83.00115561 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.031178 |
| Strahler Stream Order: | 1 |
| Flow Type: | Intermittent |
| Buffer Valley Slope (%): | 15.7 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | NA |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

Notes:  No bank amoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.75 | Back of bench |
| | |
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Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

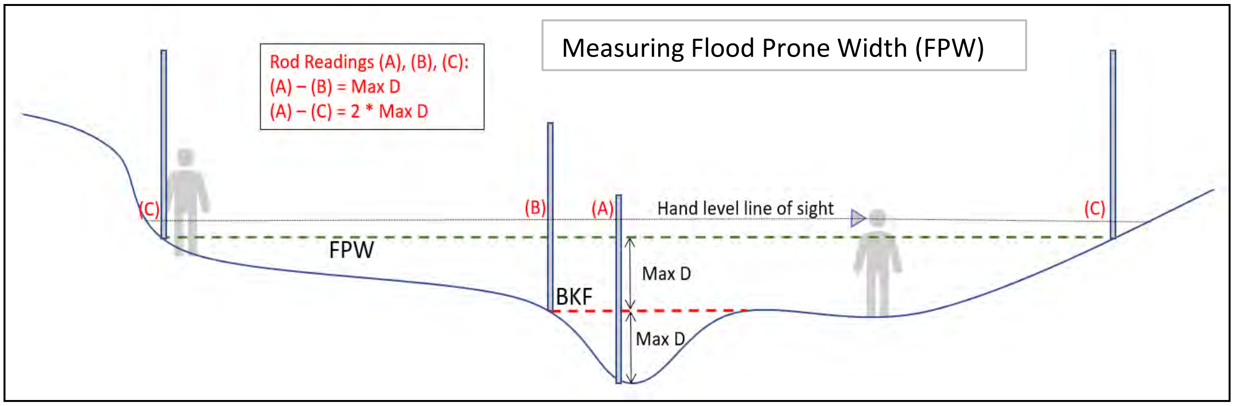
Stream 12 - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.75 |
| B. | Bankfull Width (ft) | 8.1 |
| E. | Regional Curve Bankfull Width (ft) | 4.4209 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.4048 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 1.811 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 |
| I. | Flood Prone Width (FPW; ft) | 9.5 |

| Cross Section Measurements<br>Depth measured from bankfull | | | |
|---|---|---|---|
| Station | Depth | Station | Depth |
| 0 | 0 | | |
| 0 | 0.12 | | |
| 1 | 0.16 | | |
| 2 | 0.46 | | |
| 3 | 0 | | |
| 3.5 | 0.38 | | |
| 4 | 0.66 | | |
| 5 | 0.58 | | |
| 6 | 0.68 | | |
| 7 | 0.82 | | |
| 8 | 0.82 | | |
| 8.1 | 0 | | |
| | | | |
| | | | |



Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 12 - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 162 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 18 | 30.9 | 77.6 | | | | | |
| End Station (Distance along tape) | 28.8 | 73.5 | 100 | | | | | |
| Low Bank Height (ft) | 1.46 | 3.2 | 1.85 | | | | | |
| Bankfull Max Depth (ft) | 0.82 | 0.8 | 0.8 | | | | | |
| Bankfull Width (ft) | 8.1 | 5.2 | 8.7 | | | | | |
| Flood Prone Width (ft) | 9.6 | 10.5 | 10.3 | | | | | |
| Bankfull Mean Depth (ft) | 0.5 | 0.5 | 0.5 | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | G | G | | | | | |
| Station<br>At maximum pool depth | 6.5 | 13 | 16.8 | 30.2 | 76.7 | | | |
| Geomorphic P-P Spacing (ft) | | 6.5 | 3.8 | | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 0.56 | 0.58 | 0.52 | 0.7 | 0.8 | | | |

D. Slope

Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography

| | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 100.7 | 100.7 | 0.079 |
| Stadia Rod Reading (ft) | 1530 | 1522 | 8.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 100.69 |
| Valley Length (ft) | 75.8 |
| Sinuosity | 1.33 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 16 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 52.5 |

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 12 - Downstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Stream 12 - Downstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 3.13, very fine gravel**

| | | | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| 20 | 10 | 7 | 0.5 | 6 | 60 | 60 | 40 | silt | NA | 25.37 / Moderate | 1.6 / Moderate |
| | | | | | | | | | | | |
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Date: 10/3/2023

Investigators: EBS, KC, SP (HDR)

Stream 15 - Upstream

**SC SQT Rapid Method Form**

Version 1.0

# I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 15 Upstream |
| Upstream Latitude: | 34.99311 |
| Upstream Longitude: | -82.99787492 |
| Downstream Latitude: | 34.992924 |
| Downstream Longitude: | -82.99763355 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.018879 |
| Strahler Stream Order: | First |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 8.1 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

# II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes: No bank amoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.72 | undercut |
| 0.47 | back of depositional bar |
| 0.31 | back of depositional bar |
| | |
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## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.5 |
| B. | Bankfull Width (ft) | 3.1 |
| E. | Regional Curve Bankfull Width (ft) | 3.6171 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.349 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 1.2786 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 (SCDNR 2020) |
| I. | Flood Prone Width (FPW; ft) | 4.3 |

| Cross Section Measurements<br>Depth measured from bankfull | | | |
|---|---|---|---|
| Station | Depth | Station | Depth |
| 0 | 0 | | |
| 0.1 | 0.54 | | |
| 1 | 0.62 | | |
| 1.5 | 0.74 | | |
| 2 | 0.62 | | |
| 3 | 0.42 | | |
| 3.1 | 0 | | |
| | | | |
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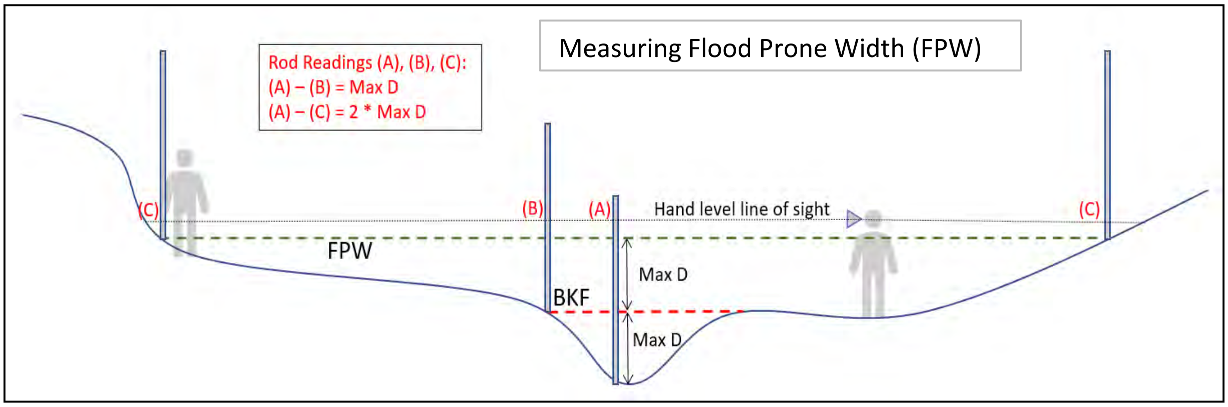

## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 62 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 27.2 | 42.3 | 48.8 | 65 | | | | |
| End Station (Distance along tape) | 33.8 | 45.6 | 51 | 65.5 | | | | |
| Low Bank Height (ft) | 1.42 | 1.32 | 1.46 | 1.18 | | | | |
| Bankfull Max Depth (ft) | 0.74 | 0.48 | 0.58 | 0.32 | | | | |
| Bankfull Width (ft) | 3.1 | 3.2 | 5.3 | 5.3 | | | | |
| Flood Prone Width (ft) | 4.3 | 4.55 | 5.6 | 6.7 | | | | |
| Bankfull Mean Depth (ft) | 0.6 | 0.6 | 0.6 | 0.6 | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | G | G | G | G | | | |
| Station<br>At maximum pool depth | 15.7 | 38 | 46.7 | 54.7 | 74.7 | | | |
| Geomorphic P-P Spacing (ft) | | 22.3 | 8.7 | 8.0 | 20.0 | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 0.86 | 1.24 | 0.68 | 0.72 | 0.68 | | | |

D. Slope

Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography

| | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 101.07 | 101.1 | 0.059 |
| Stadia Rod Reading (ft) | 1746 | 1740 | 6.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 100.2 |
| Valley Length (ft) | 99.62 |
| Sinuosity | 1.01 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 3 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 9.8 |

Date: 10/3/2023

Investigators: EBS, KC, SP (HDR)

Stream 15 - Upstream

**SC SQT**

**BEHI/NBS Field Form**

Reach ID: **Stream 15 - Upstream**

Valley Type: **Colluvial**

Bed Material: **D50 = 1.36, very coarse sand**

| | | | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| 7 | 10 | 4 | 0.9 | 4 | 30 | 120 | 20 | 10 - Fine san | NA | 44.12 / Very High | 1.43 / Low |
| 50 | 6 | 1.5 | 0.7 | 1 | 15 | 110 | 20 | Silt | NA | 35.49 / High | 0.97 / Very Low |
| 55 | 25 | 1.5 | 0.7 | 0.5 | 10 | 90 | 10 | 10 - Fine san | NA | 49.53 / Extreme | 1.2 / Low |
| 80 | 12 | 2 | 0.5 | 0.5 | 10 | 45 | 20 | Silt | NA | 36.93 / High | 1.13 / Low |
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Date: 10/3/2023

Investigators: EBS, KC, SP (HDR)

Stream 15 - Downstream

**SC SQT Rapid Method Form**

Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 15 Downstream |
| Upstream Latitude: | 34.992924 |
| Upstream Longitude: | -82.99763355 |
| Downstream Latitude: | 344.992705 |
| Downstream Longitude: | -82.997434 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.018879 |
| Strahler Stream Order: | 1 |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 30.1 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: no CFPs

B. Armored Bank Lengths (ft):

Notes: no bank armoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.58 | No great indicators - wide bedrock area, sheet flow |
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Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 15 - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.58 |
| B. | Bankfull Width (ft) | 3.2 |
| E. | Regional Curve Bankfull Width (ft) | 3.6171 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.349 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 1.2786 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 (SCDNR 2020) |
| I. | Flood Prone Width (FPW; ft) | 3.9 |

Cross Section Measurements
Depth measured from bankfull

| Station | Depth | Station | Depth |
|---|---|---|---|
| 0 | 0.44 | | |
| 1 | 0.54 | | |
| 2 | 0.52 | | |
| 3 | 0.7 | | |
| 3.1 | 0.7 | | |
| 3.2 | 0 | | |
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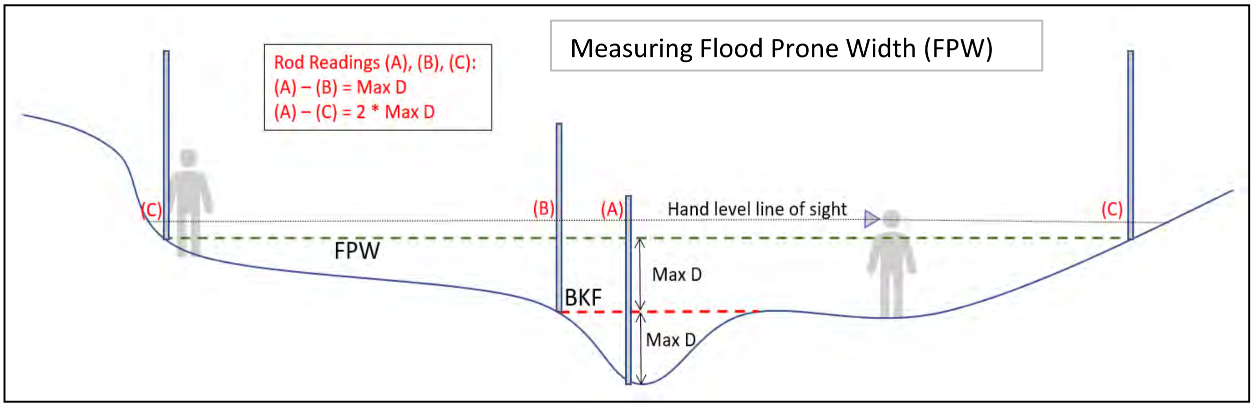

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 15 - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 64 |

B. Riffle Data

| | R1 | R2 * | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 42 | 55.8 | | | | | | |
| End Station (Distance along tape) | 44 | 59 | | | | | | |
| Low Bank Height (ft) | 1.12 | 1.32 | | | | | | |
| Bankfull Max Depth (ft) | 0.22 | 0.7 | | | | | | |
| Bankfull Width (ft) | 1.4 | 3.2 | | | | | | |
| Flood Prone Width (ft) | 4.5 | 3.9 | | | | | | |
| Bankfull Mean Depth (ft) | 0.5 | 0.5 | | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | G | G | G | | | | |
| Station<br>At maximum pool depth | 23.1 | 41.2 | 52.6 | 60.5 | | | | |
| Geomorphic P-P Spacing (ft) | | 18.1 | 11.4 | 7.9 | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 0.72 | 0.58 | 0.92 | 0.72 | | | | |

D. Slope

Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography

| | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 100.2 | 100.2 | 0.299 |
| Stadia Rod Reading (ft) | 1736 | 1706 | 30.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 100.24 |
| Valley Length (ft) | 98.49 |
| Sinuosity | 1.02 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 2 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 6.6 |

Date: 10/3/2023

Investigators: EBS, KC, SP (HDR)

Stream 15 - Downstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Stream 15 - Downstream**
Valley Type: **Colluvial**
Bed Material: **Bedrock**

| | | | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| All banks stable, no meanders | | | | | | | | | | | |
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## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 16 - Upstream |
| Upstream Latitude: | 34.993683 |
| Upstream Longitude: | -82.99403219 |
| Downstream Latitude: | 34.993628 |
| Downstream Longitude: | -82.99371234 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.019919 |
| Strahler Stream Order: | First |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 8.2 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes: No bank amoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.68 | top of depositional bar |
| 3.25 | top of bench |
| 0.14 | top of depositional bar |
| 0.5 | mid depositional bar opposite undercut bank |
| 0.56 | undercut bank |
| | |
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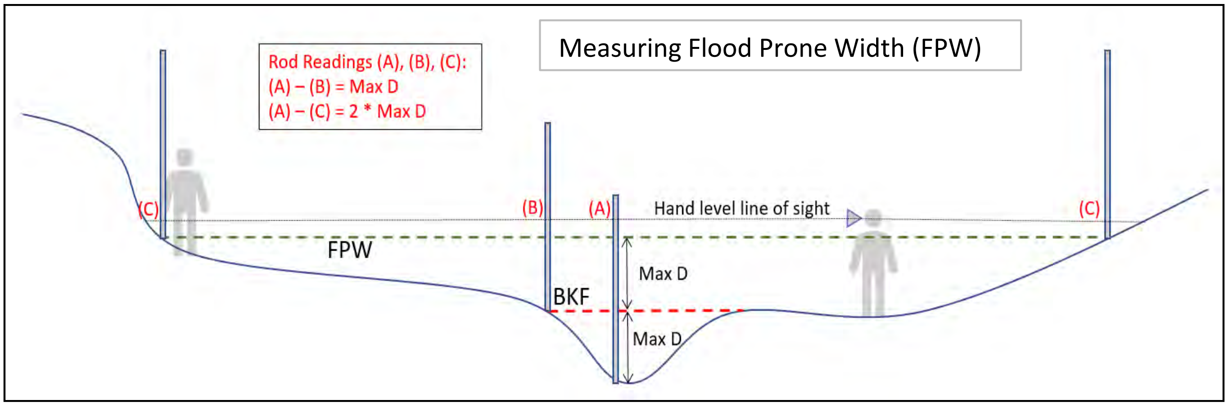
| | |

## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 1.026 |
| B. | Bankfull Width (ft) | 10.5 |
| E. | Regional Curve Bankfull Width (ft) | 3.6956 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.3545 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 1.3271 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 |
| I. | Flood Prone Width (FPW; ft) | 11.8 |

Cross Section Measurements
Depth measured from bankfull

| Station | Depth | Station | Depth |
|---|---|---|---|
| 0 | 0 | | |
| 0.1 | 0.38 | | |
| 1 | 0.46 | | |
| 2 | 0.4 | | |
| 3 | 0.68 | | |
| 4 | 0.78 | | |
| 5 | 0.62 | | |
| 6 | 0.4 | | |
| 7 | 0.62 | | |
| 8 | 0.58 | | |
| 9 | 0.64 | | |
| 10 | 0.66 | | |
| 10.5 | 0 | | |
| | | | |



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## D. Slope

Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography

| | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 100.2 | 100.2 | 0.080 |
| Stadia Rod Reading (ft) | 1496 | 1488 | 8.0 | |

## E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 100.21 |
| Valley Length (ft) | 97.11 |
| Sinuosity | 1.03 |

## F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 4 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 13.1 |

## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 210 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 7 | 31 | 37 | 45.5 | 56 | 60 | 66 | 88.5 |
| End Station (Distance along tape) | 29 | 34.5 | 39.5 | 53.2 | 58.2 | 65 | 85 | 93 |
| Low Bank Height (ft) | 1.96 | 1.87 | 1.12 | 1.48 | 0.9 | 0.64 | 1.42 | 1.42 |
| Bankfull Max Depth (ft) | 0.78 | 0.32 | 0.56 | 0.6 | 0.24 | 0.3 | 0.6 | 0.6 |
| Bankfull Width (ft) | 10.5 | 3 | 3.3 | 4.3 | 3.9 | 3.6 | 4.7 | 4.9 |
| Flood Prone Width (ft) | 11.8 | 4.5 | 5.7 | 6.1 | 5.3 | 8 | 7.6 | 6.8 |
| Bankfull Mean Depth (ft) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | G | G | G | G | G | G | G | G | G |
| Station<br>At maximum pool depth | 4 | 19.7 | 30 | 35.3 | 43 | 54.4 | 58.6 | 65.4 | 86.8 | 95 |
| Geomorphic P-P Spacing (ft) | | 15.7 | 10.3 | 5.3 | 7.7 | 11.4 | 4.2 | 6.8 | 21.4 | 8.2 |
| Pool Depth (ft)<br>Measured from Bankfull | 0.78 | 0.66 | 0.5 | 0.56 | 1.08 | 0.66 | 0.76 | 0.44 | 0.78 | 0.78 |

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 16 - Upstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Stream 16 - Upstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 10.2 mm, medium gravel**

| | | | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| 92 | 10 | 1.6 | 0.6 | 1 | 60 | 145 | 20 | Silt | N/A | 34.63 / High | 1.56 / Moderate |
| | | | | | | | | | | | |
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Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 16 - Downstream

**SC SQT Rapid Method Form**
Version 1.0

# I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 16 - Downstream |
| Upstream Latitude: | 34.993628 |
| Upstream Longitude: | -82.99371234 |
| Downstream Latitude: | 34.993423 |
| Downstream Longitude: | -82.99349421 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.049116 |
| Strahler Stream Order: | First |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 10.1 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

# II. Reach Walk

A. Number of concentrated flow points: 1

Notes: Double HDPE culvert

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes: No bank amoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.74 | Veg break |
| 1.06 | undercut bank/eroded |
| 0.86 | undercut bank/eroded |
| | |
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Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 16 - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.89 |
| B. | Bankfull Width (ft) | 6.2 |
| E. | Regional Curve Bankfull Width (ft) | 5.3023 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.4631 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 2.4826 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 |
| I. | Flood Prone Width (FPW; ft) | 7.1 |

Cross Section Measurements
Depth measured from bankfull

| Station | Depth | Station | Depth |
|---|---|---|---|
| 0 | 0 | | |
| 0.1 | 0.3 | | |
| 1 | 0.82 | | |
| 2 | 0.86 | | |
| 3 | 1 | | |
| 4 | 1.02 | | |
| 5 | 1.02 | | |
| 6 | 1 | | |
| 6.2 | 0 | | |
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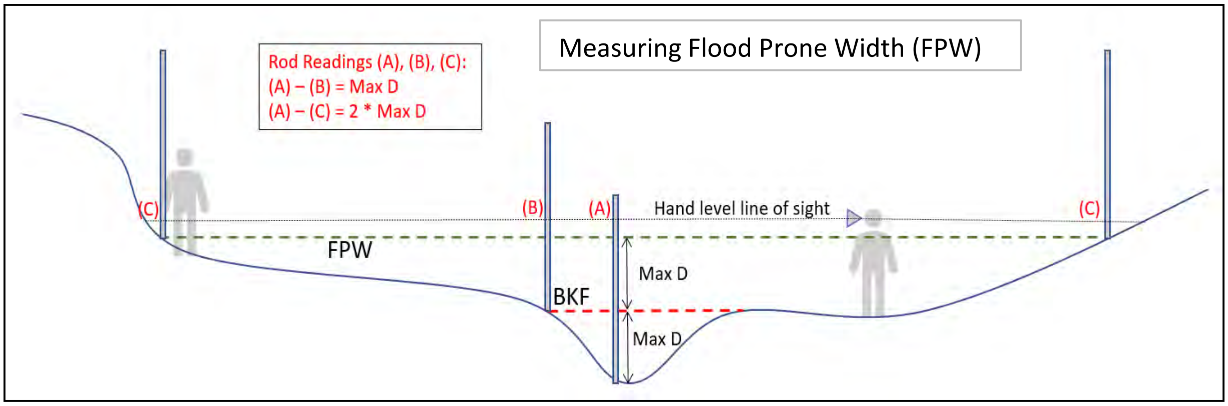

## IV. Representative Sub-Reach

A.

| | | | | |
|---|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | | 20*Bankfull Width | 124 |

B. Riffle Data

| | R1 | R2 | R3 * | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 0 | 35 | 41.5 | 58 | | | | |
| End Station (Distance along tape) | 29.2 | 38 | 54 | 83 | | | | |
| Low Bank Height (ft) | 1.42 | 2.2 | 2.1 | 2.32 | | | | |
| Bankfull Max Depth (ft) | 0.8 | 0.82 | 1.02 | 0.9 | | | | |
| Bankfull Width (ft) | 5.8 | 4.1 | 6.2 | 4.9 | | | | |
| Flood Prone Width (ft) | 9.6 | 5.5 | 7.1 | 5.8 | | | | |
| Bankfull Mean Depth (ft) | 0.9 | 0.9 | 0.9 | 0.9 | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | G | G | | | | | |
| Station<br>At maximum pool depth | 31.5 | 41 | 56.4 | | | | | |
| Geomorphic P-P Spacing (ft) | | 9.5 | 15.4 | | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 0.8 | 0.72 | 1.42 | | | | | |

D. Slope

Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography

| | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 101.7 | 101.7 | 0.079 |
| Stadia Rod Reading (ft) | 1486 | 1478 | 8.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 101.7 |
| Valley Length (ft) | 99.61 |
| Sinuosity | 1.02 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 2 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 6.6 |

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 16 - Downstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Stream 16 - Downstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 20.13 mm, coarse gravel**

|  |  |  | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking |
| 41 | 20 | 3 | 1 | 2 | 30 | 75 | 30 | silt | NA | 31.61 / High | 1.1 / Low |
| 46 | 15 | 2.5 | 1 | 2 | 50 | 130 | 30 | silt | NA | 32.02 / High | 1.1 / Low |
| 61 | 12 | 3.5 | 1 | 2.5 | 50 | 110 | 20 | silt | NA | 34.20 / High | 1.0 / Low |
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Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 17 (Devils Fork) - Upstream

**SC SQT Rapid Method Form**
Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Devils Fork - Upstream |
| Upstream Latitude: | 34.994000 |
| Upstream Longitude: | -82.99362823 |
| Downstream Latitude: | 34.993794 |
| Downstream Longitude: | -82.99344255 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.049116 |
| Strahler Stream Order: | Second |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 6.4 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

Notes: No bank armoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.58 | undercut |
| 0.44 | bench |
| | |
| | |
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## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.51 |
| B. | Bankfull Width (ft) | 5.1 |
| E. | Regional Curve Bankfull Width (ft) | 5.3023 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.4631 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 2.4826 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 (SCDNR 2020) |
| I. | Flood Prone Width (FPW; ft) | 6.05 |

Cross Section Measurements
Depth measured from bankfull

| Station | Depth | Station | Depth |
|---|---|---|---|
| 0 | 0 | | |
| 0.1 | 0.5 | | |
| 1 | 0.48 | | |
| 2 | 0.48 | | |
| 3 | 0.48 | | |
| 4 | 0.58 | | |
| 5 | 0.38 | | |
| 5.1 | 0 | | |
| | | | |
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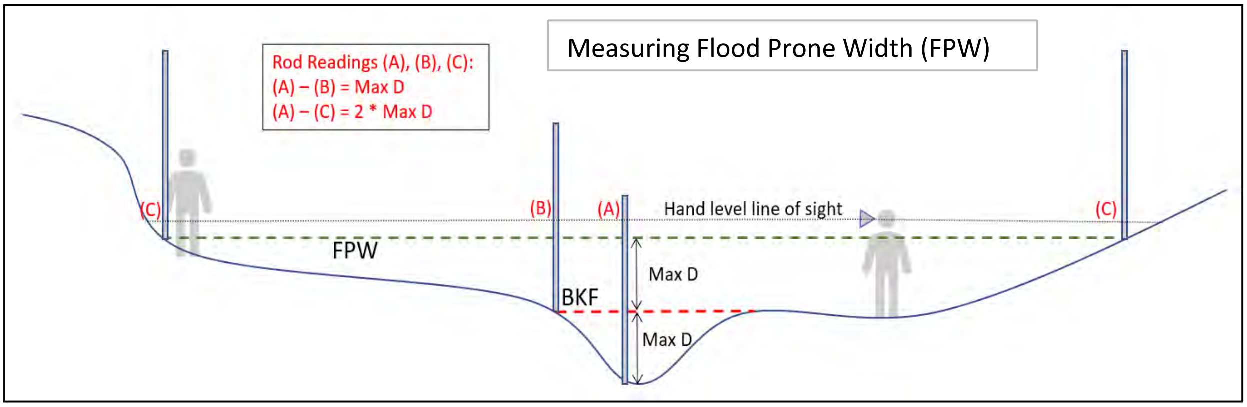

## IV. Representative Sub-Reach

A.

| | | | |
|---|---|---|---|
| Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 102 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 4 | 24.5 | 95 | | | | | |
| End Station (Distance along tape) | 23 | 69 | 100 | | | | | |
| Low Bank Height (ft) | 1.24 | 1.38 | 2.1 | | | | | |
| Bankfull Max Depth (ft) | 0.58 | 0.72 | 0.46 | | | | | |
| Bankfull Width (ft) | 5.1 | 5.6 | 2.46 | | | | | |
| Flood Prone Width (ft) | 6.05 | 6.8 | 3.2 | | | | | |
| Bankfull Mean Depth (ft) | 0.5 | 0.5 | 0.5 | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | G | | | | | | | |
| Station<br>At maximum pool depth | 3 | | | | | | | |
| Geomorphic P-P Spacing (ft) | | | | | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 0.32 | | | | | | | |

D. Slope

| Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 99.7 | 99.7 | 0.060 |
| Stadia Rod Reading (ft) | 1496 | 1490 | 6.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 99.86 |
| Valley Length (ft) | 93.55 |
| Sinuosity | 1.07 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 2 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 6.6 |

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 17 (Devils Fork) - Upstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Devils Fork - Upstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 9.32 mm, medium gravel**

| | | | **Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking | Notes |
| 26 | 6 | 3 | 0.6 | 2 | 40 | 85 | 40 | silt | NA | High | 1.44 / Low | Outside bend; Bankfull Max Depth from Riffle |
| | | | | | | | | | | | | |
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Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 17 (Devils Fork) - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## I. Reach Information and Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Devils Fork - Downstream |
| Upstream Latitude: | 34.993568 |
| Upstream Longitude: | -82.99330012 |
| Downstream Latitude: | 34.993794 |
| Downstream Longitude: | -82.99344255 |
| Ecoregion: | Blue Ridge |
| River Basin: | Savannah |
| Stream Reach Length (ft): | 100 |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.049116 |
| Strahler Stream Order: | Second |
| Flow Type: | Perennial |
| Buffer Valley Slope (%): | 6.6 |
| Dominant Buffer Land Use: | Forested |
| Stream Temperature: | Coldwater |
| Macroinvertebrate Sampling Method: | N/A |

| **Shading Key** |
|---|
| Desktop Value |
| Field Value |

## II. Reach Walk

A. Number of concentrated flow points:

Notes: No CFPs

B. Armored Bank Lengths (ft):

Notes: No bank armoring

C.

| Difference between BKF stage and WS (ft) | Describe the bankfull indicator |
|---|---|
| 0.32 | top of depositional bar |
| 0.28 | undercut bank |
| | |
| | |
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Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

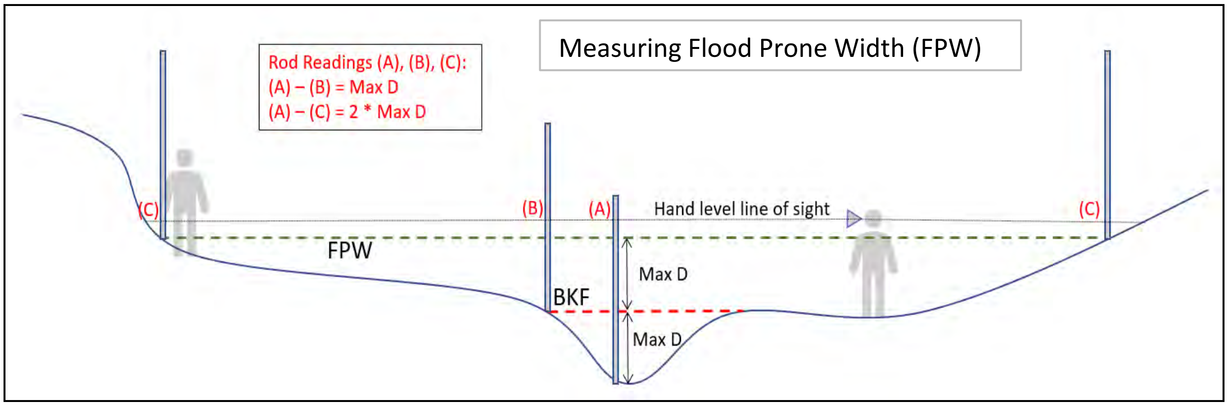
Stream 17 (Devils Fork) - Downstream

**SC SQT Rapid Method Form**
Version 1.0

## III. Bankfull Verification and Stable Riffle Cross Section

| | | |
|---|---|---|
| A. | Difference between BKF stage and WS (ft)<br>*Average or consensus value from reach walk.* | 0.3 |
| B. | Bankfull Width (ft) | 8.4 |
| E. | Regional Curve Bankfull Width (ft) | 5.3023 |
| F. | Regional Curve Bankfull Mean Depth (ft) | 0.4631 |
| G. | Regional Curve Bankfull Area (sq. ft.) | 2.4826 |
| H. | Curve Used | SCDNR Stream Geomorphology and Data Colelction and Analysis South Carolina Ecoregions 66, 45, 65, 63 (SCDNR 2020) |
| I. | Flood Prone Width (FPW; ft) | 8.8 |

| Cross Section Measurements<br>Depth measured from bankfull | | | |
|---|---|---|---|
| Station | Depth | Station | Depth |
| 0 | 0 | | |
| 0.1 | 0.3 | | |
| 1 | 0.26 | | |
| 2 | 0.14 | | |
| 3 | 0.08 | | |
| 4 | 0.18 | | |
| 5 | 0.36 | | |
| 6 | 0.3 | | |
| 7 | 0.36 | | |
| 8 | 0.38 | | |
| 8.2 | 0.36 | | |
| 8.4 | 0 | | |
| | | | |
| | | | |



## IV. Representative Sub-Reach

| | | | | |
|---|---|---|---|---|
| A. | Assessment Segment Length<br>At least 20 x the Bankfull Width | 100 | 20*Bankfull Width | 168 |

B. Riffle Data

| | R1 * | R2 | R3 | R4 | R5 | R6 | R7 | R8 |
|---|---|---|---|---|---|---|---|---|
| Begin Station (Distance along tape) | 32.5 | 80.2 | | | | | | |
| End Station (Distance along tape) | 57 | 100 | | | | | | |
| Low Bank Height (ft) | 2.02 | 2.04 | | | | | | |
| Bankfull Max Depth (ft) | 0.38 | 0.52 | | | | | | |
| Bankfull Width (ft) | 8.4 | 7.8 | | | | | | |
| Flood Prone Width (ft) | 8.8 | 7.95 | | | | | | |
| Bankfull Mean Depth (ft) | 0.3 | 0.3 | | | | | | |

C. Pool Data

| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| Geomorphic Pool? | | | | | | | | |
| Station<br>At maximum pool depth | 79 | | | | | | | |
| Geomorphic P-P Spacing (ft) | | | | | | | | |
| Pool Depth (ft)<br>Measured from Bankfull | 0.52 | | | | | | | |

D. Slope

Due to difficulty with dense vegetation, slope was calcluated using GIS and 2-foot topography

| | Begin | End | Difference | Slope (ft/ft) |
|---|---|---|---|---|
| Station along tape (ft) | 0 | 102 | 102.0 | 0.039 |
| Stadia Rod Reading (ft) | 1490 | 1486 | 4.0 | |

E. Sinuosity

Calculated in GIS using delineated boundaries

| | |
|---|---|
| Stream Length (ft) | 102 |
| Valley Length (ft) | 87.6 |
| Sinuosity | 1.16 |

F. LWD Piece Count *(find 328-feet segment within assessment sub-reach with the MOST LWD)*

Entire stream reach assessed for LWD

| | |
|---|---|
| # of LWD Pieces | 8 |
| Assessment length (ft) | 100 |
| # of LWD Pieces/100 m | 26.2 |

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 17 (Devils Fork) - Downstream

**SC SQT**
**BEHI/NBS Field Form**

Reach ID: **Devils Fork - Downstream**
Valley Type: **Colluvial**
Bed Material: **D50 = 0.45 mm, medium sand**

|  |  |  | Bank Erosion Hazard Index (BEHI) & Near-bank Stress (NBS) |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station ID | Bank Length (Ft) | Study Bank Height (ft) | BKF Height (ft) | Root Depth (ft) | Root Density (%) | Bank Angle (degrees) | Surface Protection (%) | Bank Material Adjustment | Stratification Adjustment | BEHI Total/ Category | NBS Ranking | Notes |
| No unstable banks |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
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# Attachment G

## Attachment G - Streams Photolog

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Photo 1. View of Stream 1 (Limber Pole Creek), facing upstream.

Photo 2. View of Stream 1 (Limber Pole Creek), facing downstream.

Photo 3. View of Stream 7 (Howard Creek), facing upstream.

Photo 4. View of Stream 7 (Howard Creek), facing downstream.

Photo 5. View of Stream 12, facing upstream.

Photo 6. View of Stream 12, facing downstream.

Photo 7. View of Stream 15, facing upstream.

Photo 8. View of Stream 15, facing downstream.

Photo 9. View of Stream 15, facing downstream.

Photo 10. View of Stream 16, facing upstream.

Photo 11. View of Stream 16, facing downstream.

Photo 12. View of concentrated flow point on Stream 16, beginning of downstream reach.

Photo 13. View of Stream 17 (Devils Fork), facing upstream.

Photo 14. View of Stream 17 (Devils Fork), facing downstream.

# Attachment H

## Attachment H - Fish Community Sampling Data and Photo Vouchers

Table 1. Stream reach widths, sample lengths, and shock times for each sampling event.

| **Stream reach** | **Sample date** | **Stream widths (m)** | | | | | | **Sample length (m)** | **Effort (s)** |
|---|---|---|---|---|---|---|---|---|---|
| | | **0** | **25** | **50** | **75** | **100** | **Mean** | | |
| Stream 1 (Limber Pole Creek) - Upstream | 7/25/2023 | 2.9 | 3.1 | 2.7 | 2.7 | 2.8 | 2.8 | 100 | 721 |
| | 9/5/2023 | 2.9 | 2.8 | 3.2 | 4.1 | 3.3 | 3.3 | 100 | 829 |
| | 10/9/2023 | 2.7 | 2.8 | 3.3 | 4.0 | 2.9 | 3.1 | 100 | 957 |
| Stream 1 (Limber Pole Creek)- Downstream | 7/25/2023 | 4.0 | 3.5 | 4.2 | 2.7 | 4.1 | 3.7 | 111 | 1,304 |
| | 9/5/2023 | 3.7 | 5.3 | 4.7 | 2.6 | 4.6 | 4.2 | 125 | 1,093 |
| | 10/9/2023 | 3.9 | 5.0 | 4.2 | 2.6 | 3.8 | 3.9 | 117 | 1,397 |
| Stream 7 (Howard Creek)- Upstream | 7/25/2023 | 7.1 | 7.5 | 5.9 | 5.1 | 6.0 | 6.3 | 190 | 2,344 |
| | 9/6/2023 | 6.9 | 7.6 | 5.5 | 6.2 | 6.2 | 6.5 | 194 | 3,381 |
| | 10/10/2023 | 6.8 | 8.1 | 6.7 | 5.8 | 6.1 | 6.7 | 201 | 4,027 |
| Stream 7 (Howard Creek) - Downstream | 7/25/2023 | 6.5 | 5.3 | 8.7 | 7.4 | 7.0 | 7.0 | 209 | 2,695 |
| | 9/6/2023 | 7.1 | 6.0 | 7.4 | 8.4 | 5.7 | 6.9 | 208 | 3,581 |
| | 10/10/2023 | 5.1 | 8.6 | 4.2 | 5.0 | 4.6 | 5.5 | 165 | 3,978 |

Table 2. Water quality parameters for each sampling event.

| **Stream reach** | **Sample date** | **Temperature (°C)** | **Dissolved oxygen (mg/L)** | **Specific conductivity (µS/cm)** | **pH (units)** | **Salinity (ppt)** | **Turbidity (NTU)** |
|---|---|---|---|---|---|---|---|
| Stream 1 (Limber Pole Creek) - Upstream | 7/25/2023 | 19.4 | 8.6 | 15 | 6.6 | 0.01 | 7.5 |
| | 9/5/2023 | 20.4 | 8.4 | 18 | 7.0 | 0.01 | 4.0 |
| | 10/9/2023 | 11.6 | 9.9 | 16 | 6.9 | 0.01 | 1.1 |
| Stream 1 (Limber Pole Creek)- Downstream | 7/25/2023 | 19.4 | 8.6 | 15 | 6.6 | 0.01 | 7.5 |
| | 9/5/2023 | 20.4 | 8.4 | 18 | 7.0 | 0.01 | 4.0 |
| | 10/9/2023 | 11.6 | 9.9 | 16 | 6.9 | 0.01 | 1.1 |
| Stream 7 (Howard Creek)- Upstream | 7/25/2023 | 18.8 | 8.9 | 26 | 6.9 | 0.01 | 2.4 |
| | 9/6/2023 | 19.5 | 8.7 | 30 | 7.3 | 0.01 | 3.0 |
| | 10/10/2023 | 13.0 | 9.9 | 27 | 7.4 | 0.01 | 1.6 |
| Stream 7 (Howard Creek) - Downstream | 7/25/2023 | 18.8 | 8.9 | 26 | 6.9 | 0.01 | 2.4 |
| | 9/6/2023 | 20.8 | 7.9 | 28 | 7.1 | 0.01 | 3.0 |
| | 10/10/2023 | 13.9 | 9.7 | 21 | 6.9 | 0.01 | 1.6 |

Table 3. Fish collected within each stream reaches for each sampling event.

| **Stream reach** | **Sample date** | **Rainbow Trout** | **Western Blacknose Dace** | **Salamanders (*Desmognathus*)** |
|---|---|---|---|---|
| Stream 1 (Limber Pole Creek) - Upstream | 7/25/2023 | 0 | 0 | 10 |
| | 9/5/2023 | 0 | 0 | 15 |
| | 10/9/2023 | 0 | 0 | 15 |
| Stream 1 (Limber Pole Creek)- Downstream | 7/25/2023 | 0 | 0 | 9 |
| | 9/5/2023 | 0 | 0 | 8 |
| | 10/9/2023 | 0 | 0 | 5 |
| Stream 7 (Howard Creek)- Upstream | 7/25/2023 | 39 | 108 | 12 |
| | 9/6/2023 | 22 | 97 | 8 |
| | 10/10/2023 | 40 | 133 | 2 |
| Stream 7 (Howard Creek) - Downstream | 7/25/2023 | 30 | 130 | 5 |
| | 9/6/2023 | 3 | 39 | 10 |
| | 10/10/2023 | 31 | 136 | 3 |

Table 4. Catch rates and densities of fish each stream reaches for each sampling event.

| **Stream reach** | **Sample date** | **Catch rate (No./hr)** | | | **Density (No./100 m)** | | |
|---|---|---|---|---|---|---|---|
| | | **Rainbow Trout** | **Western Blacknose Dace** | **Total** | **Rainbow Trout** | **Western Blacknose Dace** | **Total** |
| Stream 1 (Limber Pole Creek) - Upstream | 7/25/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 9/5/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10/9/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stream 1 (Limber Pole Creek)- Downstream | 7/25/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 9/5/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10/9/2023 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stream 7 (Howard Creek)- Upstream | 7/25/2023 | 59.9 | 165.9 | 225.8 | 20.5 | 56.8 | 77.4 |
| | 9/6/2023 | 23.4 | 103.3 | 126.7 | 11.3 | 50.0 | 61.3 |
| | 10/10/2023 | 35.8 | 118.9 | 154.7 | 19.9 | 66.2 | 86.1 |
| Stream 7 (Howard Creek) - Downstream | 7/25/2023 | 40.1 | 173.7 | 213.7 | 14.4 | 62.2 | 76.6 |
| | 9/6/2023 | 3.0 | 39.2 | 42.2 | 1.4 | 18.8 | 20.2 |
| | 10/10/2023 | 28.1 | 123.1 | 151.1 | 18.8 | 82.4 | 101.2 |

Photo 1. Stream 1 (Limber Pole Creek) - Upstream Fish Sampling Location

Photo 2. Stream 1 (Limber Pole Creek) - Downstream Fish Sampling Location

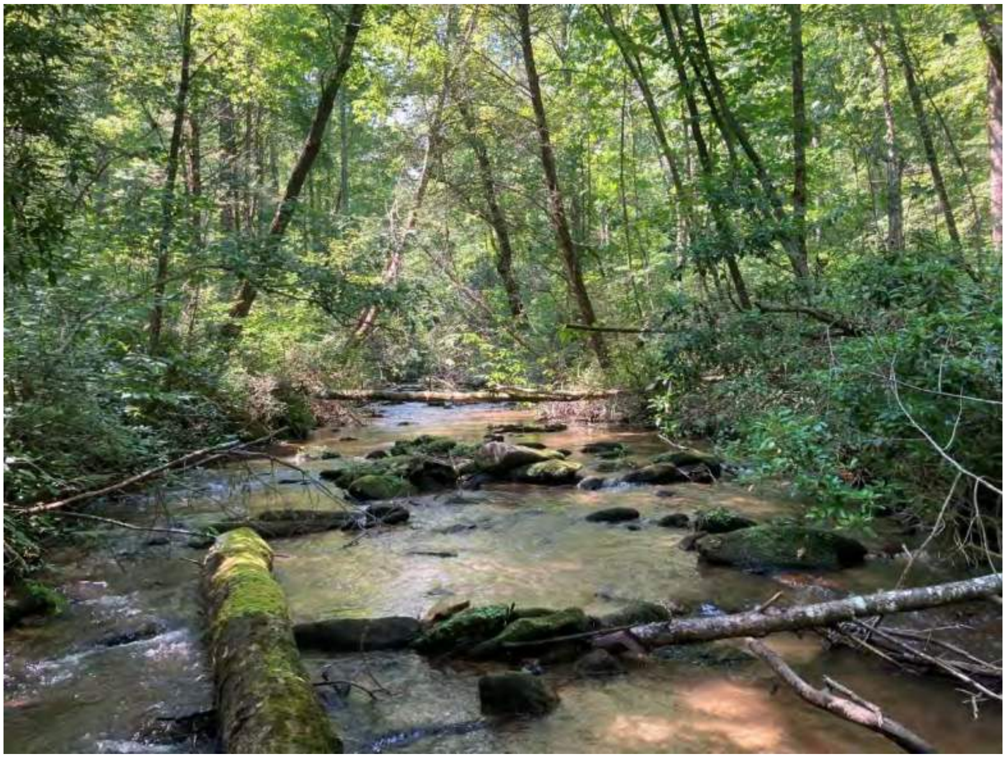

Photo 3. Stream 7 (Howard Creek) - Upstream Fish Sampling Location

Photo 4. Stream 7 (Howard Creek) - Downstream Fish Sampling Location

Photo 5. Rainbow Trout Collected from Stream 7 (Howard Creek)

Photo 6. Western Blacknose Dace Collected from Stream 7 (Howard Creek)

Photo 7. Salamanders collected from Stream 1 (Limber Pole Creek)

Photo 8. Salamanders collected from Stream 7 (Howard Creek)

# Attachment I

## Attachment I - Macroinvertebrate Sampling Data and Photolog

Table 1. Summary of Organisms Collected during Macroinvertebrate Surveys

| **Taxon** | **Pollution Tolerance Value[1]** | **Functional Feeding Group[2]** | **Stream 1 (Limber Pole Creek)** | | **Stream 7 (Howard Creek)** | |
|---|---|---|---|---|---|---|
| | | | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| **Annelida** | | | | | | |
| **Class Clitellata** | | | | | | |
| **Subclass Oligochaeta** | | CG | | | | |
| **Order Lumbriculida** | | | | | | |
| Lumbriculidae | 7 | CG | | | 2 | |
| **Arthropoda** | | | | | | |
| **Insecta** | | | | | | |
| **Ephemeroptera** | | | | | | |
| Baetidae | | CG | | | | |
| *Acentrella turbida* | *2* | CG | 6 | | | 2 |
| *Baetis flavistriga* | *6.8* | CG | 1 | | 44 | 1 |
| *Baetis pluto* | *3.4* | | 5 | 1 | 5 | 5 |
| *Plauditus sp.* | *5.4* | CG | | 3 | 7 | |
| *Heterocloeon sp.* | *3.7* | SC | | | 2 | |
| Ephemerillidae | | CG | | | | |
| *Drunella tuberculata* | *0* | SC | 25 | 14 | 2 | |
| *Ephemerella sp.* | *2.1* | SC | 1 | | | |
| *Ephemerella catawba* | *0* | | | 1 | | |
| *Serratella sp.* | *1.7* | SC | 2 | | | |
| *Serratella frisoni* | | | | 2 | 7 | |
| *Teloganopsis deficiens* | *2.6* | SC | 2 | 1 | | 2 |
| Ephemeridae | | CG | | | | |
| *Ephemera sp.* | *2* | CG | 1 | 3 | | |
| Heptageniidae | | SC | | 2 | | 21 |

| **Taxon** | **Pollution Tolerance Value**[1] | **Functional Feeding Group**[2] | **Stream 1 (Limber Pole Creek)** | | **Stream 7 (Howard Creek)** | |
|---|---|---|---|---|---|---|
| | | | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| *Epeorus sp.* | *1.6* | CG | 6 | 2 | 10 | 30 |
| *Epeorus dispar* | *1* | CG | 13 | 7 | | |
| *Epeorus vitreus* | *1.2* | CG | | | 2 | 2 |
| *Heptagenia sp.* | *1.9* | SC | | 2 | | |
| *Heptagenia marginalis gp.* | *2.2* | SC | 1 | | | 1 |
| *Leucrocuta sp.* | *2* | SC | 2 | 4 | 2 | 2 |
| *Stenonema sp.* | | SC | 10 | 5 | 37 | 29 |
| *Stenonema meririvulanum* | *0.5* | SC | 3 | 2 | 4 | 5 |
| Isonychiidae | | CG | | | | |
| *Isonychia sp.* | *3.6* | CG | 2 | 8 | | |
| **Odonata** | | | | | | |
| Cordulegastridae | 5.7 | P | | | | |
| *Cordulegaster sp.* | *5.7* | P | | 1 | | |
| Gomphidae | | | | | 1 | |
| *Lanthus sp.* | *1.6* | P | | 2 | | 3 |
| *Lanthus vernalis* | *0.8* | | | | 2 | |
| **Plecoptera** | | | | | | |
| Leuctridae | | SH | | | | |
| *Leuctra sp.* | *1.5* | SH | 3 | 3 | 5 | 3 |
| Peltoperlidae | | SH | | | | |
| *Peltoperla sp.* | | | 6 | 37 | | 3 |
| Perlidae | | P | | | 3 | 5 |
| *Acroneuria abnormis* | *2.1* | P | 10 | | 1 | 5 |
| *Eccoptura xanthenes* | *4.7* | P | | | | 1 |
| *Paragnetina sp.* | *1.5* | P | | | 5 | 6 |

| **Taxon** | **Pollution Tolerance Value[1]** | **Functional Feeding Group[2]** | **Stream 1 (Limber Pole Creek)** | | **Stream 7 (Howard Creek)** | |
|---|---|---|---|---|---|---|
| | | | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| *Paragnetina immarginata* | *1.1* | P | | | 5 | 13 |
| *Perlesta sp.* | *2.9* | P | | | 1 | 1 |
| Perlodidae | | P | | | 6 | |
| Pteronarcidae | 1.6 | SH | | | | |
| *Pteronarcys (Allonarcys) sp.* | *1.8* | SH | 1 | 9 | | 3 |
| *Pteronarcys dorsata* | *2.4* | SH | | | 1 | |
| *Pteronarcys scotti* | | SH | 1 | 2 | | |
| **Hemiptera** | | | | | | |
| Veliidae | | P | | | | |
| *Rhagovelia obesa* | | P | | 1 | | |
| **Trichoptera** | | | 1 | | | |
| Glossosomatidae | | SC | | | | |
| *Glossosoma sp.* | *1.4* | SC | 2 | | | |
| *Glossosoma nigrior* | | SC | | | 20 | 14 |
| Goeridae | | | | | | |
| *Goera calcarata* | 1 | | | | 1 | |
| Hydropsychidae | | FC | | | | |
| *Cheumatopsyche sp.* | *6.6* | FC | | | 41 | 5 |
| *Diplectrona modesta* | *2.3* | FC | 33 | 30 | 3 | 4 |
| *Hydropsyche sparna* | *2.5* | FC | | | 18 | 32 |
| Limnephilidae | | | | | | |
| *Pycnopsyche sp.* | *2.5* | SH | 1 | | | 2 |
| Philopotamidae | | FC | | | | |
| *Dolophilodes distinctus* | *0.1* | FC | 3 | | 1 | 5 |
| Psychomyiidae | | CG | | | | |

| **Taxon** | **Pollution Tolerance Value**[1] | **Functional Feeding Group**[2] | **Stream 1 (Limber Pole Creek)** | | **Stream 7 (Howard Creek)** | |
|---|---|---|---|---|---|---|
| | | | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| *Lype diversa* | *3.9* | SC | | | 2 | |
| *Psychomyia flavida* | *3* | CG | | | 3 | |
| Rhyacophilidae | | P | | | | |
| *Rhyacophila carolina* | *0.4* | P | 1 | | | |
| *Rhyacophila fuscula* | *1.6* | P | | | 1 | 4 |
| Uenoidae | | | | | | |
| *Neophylax mitchelli* | *0* | | 1 | 1 | 1 | 1 |
| *Neophylax oligius* | *2.4* | | | | 1 | |
| **Coleoptera** | | | | | | |
| Dryopidae | | | | | | |
| *Helichus fastigiatus* | 4.6 | SC | | 1 | | |
| Elmidae | | CG | | | | |
| *Optioservus sp.* | 2.1 | SC | | 1 | | |
| *Optioservus ovalis* | 2.1 | SC | | | 1 | |
| *Optioservus tardella* | 0 | SC | 4 | | 21 | 3 |
| *Stenelmis sp.* | 5.6 | SC | | | | 1 |
| Gyrinidae | | P | | | | |
| *Dineutus sp.* | 5 | P | 2 | | 1 | |
| Psephenidae | | SC | | | | |
| *Ectopria nervosa* | 4.3 | SC | | | | 1 |
| *Psephenus herricki* | 2.4 | SC | 8 | 14 | 46 | 23 |
| **Diptera** | | | | | | |
| Athericidae | | | | | | |
| *Atherix lantha* | 1.8 | P | | | | 1 |
| Ceratopogonidae | | P | 1 | | | |

| **Taxon** | **Pollution Tolerance Value**[1] | **Functional Feeding Group**[2] | **Stream 1 (Limber Pole Creek)** | | **Stream 7 (Howard Creek)** | |
|---|---|---|---|---|---|---|
| | | | **Upstream** | **Downstream** | **Upstream** | **Downstream** |
| Chironomidae | | | | | | |
| *Parametriocnemus sp.* | 3.9 | CG | | | | 1 |
| *Rheotanytarsus sp.* | 6.5 | FC | | | 1 | |
| *Rheotanytarsus exiguus gp.* | 5.9 | FC | | | | 1 |
| Dixidae | | CG | | | | |
| *Dixa sp.* | 2.5 | CG | 1 | | | |
| Limoniidae | | | | | | |
| *Antocha sp.* | 4.4 | CG | | | 3 | |
| *Dicranophragma sp.* | | | 1 | | | |
| *Hexatoma sp.* | 3.5 | P | 1 | | | |
| Pediciidae | | | | | | |
| *Dicranota sp.* | 0 | P | | 1 | | 1 |
| Simuliidae | | FC | | | | |
| *Simulium sp.* | 4.9 | FC | | | | 3 |
| Tipulidae | | SH | | | | |
| *Tipula sp.* | 7.5 | SH | 2 | 1 | | 1 |
| **Total No. of Organisms** | -- | -- | **163** | **161** | **319** | **246** |
| **Total No. of Taxa** | -- | -- | **35** | **29** | **39** | **39** |
| **EPT Index** | -- | -- | **27** | **21** | **30** | **28** |
| **Biotic Index Assigned Values** | -- | -- | **1.68** | **2.04** | **2.98** | **2.25** |
| **EPT Score** | -- | -- | **3.93** | **3.19** | **4.31** | **4.06** |
| **Biotic Index Score** | -- | -- | **9.04** | **8.57** | **7.31** | **8.29** |
| **South Carolina Bioclassification** | -- | -- | **6.49** | **5.88** | **5.81** | **6.17** |

[1] South Carolina Department of Health and Environmental Control (SCDHEC). 2017. Standard Operating and Quality Control Procedures for Macroinvertebrate Sampling. Technical Report No. 0914-17. Bureau of Water. Columbia, South Carolina.

[2] Functional Feeding Groups: CG = collector-gatherer; FC = filterer-collector; P = predator; SC = scraper; SH = shredder


Photo 1. View of Upstream Reach of Stream 1 (Limber Pole Creek), facing upstream.


Photo 2. View of Downstream Reach of Stream 1 (Limber Pole Creek), facing upstream

Photo 3. View of Upstream Reach of Stream 7 (Howard Creek), facing downstream

Photo 4. View of Downstream Reach of Stream 7 (Howard Creek), facing upstream.

## SC DHEC ABS

## Macroinvertebrate Habitat Assessment

Station L4 Date 8/1/2023 Time 12:00pm Jars ____ Vials ____

Stream Limber Pole Creek Location Upstream reach County Oconee County

Collectors EM, JK, LA Field QC Logbook ____ Page# ____

pH (SU) 6.1 DO (mg/L) 8.31 $H_2O$ Temp (C°) 19.5 Cond (umhos/cm) 94.9

---

Aquatic Habitat Score: Excellent = 5 Good = 4 Good-Fair = 3 Fair = 2 Poor = 1 Nonexistent = 0

| *Habitat | Score | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| Root Banks | 5 | [✓ 4] | 3 | 2 | 1 | 0 | |
| Logs, Sticks, Snags | 5 | [✓ 4] | 3 | 2 | 1 | 0 | |
| Rock/Gravel Riffle | 5 | [✓ 4] | 3 | 2 | 1 | 0 | |
| Mature Leaf Pack | 5 | 4 | 3 | 2 | [✓ 1] | 0 | |
| Aquatic Vegetation | 5 | 4 | [✓ 3] | 2 | 1 | 0 | |

*If aufwuchs and/or sediment on the habitats appear to adversely affect colonization by macroinvertebrates, this impact is noted in the comments section; however, the habitat score does not change.

---

Braided channel: 5 4 3 2 1 [✓ 0]

5 – Multiple clear channels with water under most conditions. "Main" channel hard to distinguish.
3 – Side channel(s) present but with less flow/water.
1 – Islands or side channels only during high water.
0 – Not braided

Stream detritus % pine needles: 0 %

Amount of pine needles in stream: 5 (more) 4 3 2 1 (less) [✓ 0]

Velocity/Flow: 5 [✓ 4] 3 2 1 0

Sedimentation: [✓ 3 (Little or No)] 2 (Moderate) 1 (Severe)

Species observed but not collected:

## SC DHEC ABS

## Macroinvertebrate Habitat Assessment

Station L3 Date 8/1/2023 Time 2:15pm Jars ____ Vials ____

Stream Limber Pole Creek Location Downstream reach County Oconee County

Collectors EM, JK, LA Field QC Logbook ____ Page# ____

pH (SU) 6.89 DO (mg/L) 824, 910% $H_2O$ Temp (C°) 20.2 Cond (umhos/cm) 92.4

---

Aquatic Habitat Score: Excellent = 5 Good = 4 Good-Fair = 3 Fair = 2 Poor = 1 Nonexistent = 0

| *Habitat | Score | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| Root Banks | 5 | 4 | [✓ 3] | 2 | 1 | 0 | |
| Logs, Sticks, Snags | 5 | 4 | [✓ 3] | 2 | 1 | 0 | |
| Rock/Gravel Riffle | [✓ 5] | 4 | 3 | 2 | 1 | 0 | |
| Mature Leaf Pack | 5 | 4 | 3 | 2 | [✓ 1] | 0 | |
| Aquatic Vegetation | 5 | 4 | 3 | 2 | 1 | [✓ 0] | |

*If aufwuchs and/or sediment on the habitats appear to adversely affect colonization by macroinvertebrates, this impact is noted in the comments section; however, the habitat score does not change.

---

| | | | | | | |
|---|---|---|---|---|---|---|
| Braided channel: | 5 | 4 | 3 | 2 | 1 | [✓ 0] |
| | Multiple clear channels with water under most conditions. "Main" channel hard to distinguish. | | Side channel(s) present but with less flow/water. | | Islands or side channels only during high water. | Not braided |

Stream detritus % pine needles: 0 %

| | | | | | | |
|---|---|---|---|---|---|---|
| Amount of pine needles in stream: | 5<br>more | 4 | 3 | 2 | 1<br>less | [✓ 0] |
| Velocity/Flow: | 5 | [✓ 4] | 3 | 2 | 1 | 0 |

Sedimentation: 3 (Little or No) [✓ 2 (Moderate)] 1 (Severe)

Species observed but not collected:

---

Crayfish and salamanders

## SC DHEC ABS

## Macroinvertebrate Habitat Assessment

Station H5 Date 8/2/2023 Time ______ Jars ______ Vials ______

Stream Howard Creek Location Upstream Reach County Oconee County

Collectors EM, JK, LA Field QC Logbook ______ Page# ______

pH (SU) 7.42 DO (mg/L) 8.77, 94.9% $H_2O$ Temp (C°) 19.2 Cond (umhos/cm) 99.5

---

Aquatic Habitat Score: Excellent = 5 Good = 4 Good-Fair = 3 Fair = 2 Poor = 1 Nonexistent = 0

| *Habitat | Score | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| Root Banks | 5 | 4 | [✓ 3] | 2 | 1 | 0 | |
| Logs, Sticks, Snags | 5 | 4 | [✓ 3] | 2 | 1 | 0 | |
| Rock/Gravel Riffle | [✓ 5] | 4 | 3 | 2 | 1 | 0 | |
| Mature Leaf Pack | 5 | 4 | 3 | 2 | [✓ 1] | 0 | |
| Aquatic Vegetation | 5 | 4 | 3 | 2 | [✓ 1] | 0 | |

*If aufwuchs and/or sediment on the habitats appear to adversely affect colonization by macroinvertebrates, this impact is noted in the comments section; however, the habitat score does not change.

---

Braided channel: 5 4 3 2 1 [✓ 0]

5: Multiple clear channels with water under most conditions. "Main" channel hard to distinguish.

3: Side channel(s) present but with less flow/water.

1: Islands or side channels only during high water.

0: Not braided

Stream detritus % pine needles: 0 %

Amount of pine needles in stream: 5 (more) 4 3 2 1 (less) [✓ 0]

Velocity/Flow: 5 [✓ 4] 3 2 1 0

Sedimentation: [✓ 3 (Little or No)] 2 (Moderate) 1 (Severe)

Species observed but not collected:

---

Crayfish and fish

## SC DHEC ABS

## Macroinvertebrate Habitat Assessment

Station H4 Date 8/2/2023 Time 9:12am Jars ____ Vials ____

Stream Howard Creek Location Downstream reach County Oconee County

Collectors EM, JK, LA Field QC Logbook ____ Page# ____

pH (SU) 7.44 DO (mg/L) 8.87, 96% $H_2O$ Temp (C°) 19.2 Cond (umhos/cm) 100.7

---

Aquatic Habitat Score: Excellent = 5 Good = 4 Good-Fair = 3 Fair = 2 Poor = 1 Nonexistent = 0

| *Habitat | Score | | | | | | Comments |
|---|---|---|---|---|---|---|---|
| Root Banks | 5 | [✓ 4] | 3 | 2 | 1 | 0 | |
| Logs, Sticks, Snags | 5 | 4 | [✓ 3] | 2 | 1 | 0 | |
| Rock/Gravel Riffle | [✓ 5] | 4 | 3 | 2 | 1 | 0 | |
| Mature Leaf Pack | 5 | 4 | 3 | 2 | [✓ 1] | 0 | |
| Aquatic Vegetation | 5 | 4 | 3 | 2 | [✓ 1] | 0 | |

*If aufwuchs and/or sediment on the habitats appear to adversely affect colonization by macroinvertebrates, this impact is noted in the comments section; however, the habitat score does not change.

---

| | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|
| Braided channel: | 5<br>Multiple clear channels with water under most conditions. "Main" channel hard to distinguish. | 4 | 3<br>Side channel(s) present but with less flow/water. | 2 | 1<br>Islands or side channels only during high water. | [✓ 0]<br>Not braided |

Stream detritus % pine needles: 0 %

| | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|
| Amount of pine needles in stream: | 5<br>more | 4 | 3 | 2 | 1<br>less | [✓ 0] |
| Velocity/Flow: | 5 | [✓ 4] | 3 | 2 | 1 | 0 |

Sedimentation: [✓ 3 (Little or No)] 2 (Moderate) 1 (Severe)

Species observed but not collected:

---

1 dusky salamander
Several crayfish

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# Attachment J

## Attachment J - SQT Catchment Assessment and Matrix Summaries

Version 1.1
Version Last Updated: 7-Dec-22

**Notes**

1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## Programmatic Goals

Select: Other

Expand on the programmatic goals of this project:

The goals for this Limber Pole Creek are to preserve its current condition by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed. Little restoration potential exists for this surface water; the surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Approximately 97.4 percent of the drainage area to Limber Pole Creek is classified as forested based on the NLCD, with a completely intact riparian buffer.

## Project Description

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Project ID: | 10261671 - EEOC1 Bad Creek Relicensing |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| 12-digit HUC: | 30601010104 |

## Reach Summary

| Worksheet Title | Reach ID | Reach Description | Reach Break Criteria | ECS | PCS | ΔFF |
|---|---|---|---|---|---|---|
| Quantification_Tool_US | er Pole Creek - Upst | Upstream of temp access rd crossi | Single reach upstream to | 0.48 | 0.48 | |
| Quantification_Tool_DS | r Pole Creek - Downs | Downstream of temp access rd cro | Single reach from temporary access road, downstream | 0.5 | 0.5 | |
| | | | | | | |
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| | | |
|---|---|---|
| **Applicable Reach(es):** | Limber Pole Upstream and Downstream Reaches | |
| **Overall Catchment Condition (select:)** | **Good** | Describe how any categories rated as poor were considered in the selection of the restoration potential of the reach(es): None - stream is in natural condition with only 0.3% of impervious area in drainage area and 97.4% forested. |

| **Categories** | | **Description of Catchment Condition** | | | **Rating (P/F/G)** |
|---|---|---|---|---|---|
| | | **Poor** | **Fair** | **Good** | |
| 1 | Concentrated Flow | Existing concentrated flow/impairments immediately upstream of the project reach with no treatments in place. | Potential for concentrated flow/impairments from adjacent land use or channel immediately | No potential for concentrated flow/impairments from adjacent land use and/or channel immediately upstream of project reach. | G |
| 2 | Impervious cover | ≥ 25% | >10% and <25% | ≤ 10% | G |
| 3 | Urbanization | Rapidly urbanizing/urban. | Some urban growth potential, or uncertain growth potential. May | Rural communities/slow growth potential, or primarily forested. | G |
| 4 | Development Activities (e.g. utility rights-of-way, pipeline, mining, silviculture, roads) | High development or potential for impacts in contributing watershed or within 1 mile of project reach, or high potential of impacts >1 mile away from project reach. | Moderate development or moderate potential for impacts, but none within 1 mile of project reach. | No development or no potential for impacts. | G |
| 5 | Percent Forested | ≤ 20% | >20% and <70% | ≥ 70% | G |
| 6 | Riparian Vegetation | <50% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | 50-80% of contributing stream length (project reach and upstream channel) has >25-m (~82 | >80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | G |
| 7 | Sediment Supply | Multiple, large anthropogenic-caused sources of sediment supply from upstream bank erosion and surface runoff. | Moderate anthropogenic-caused sediment supply from upstream bank erosion and surface runoff. | A few small anthropogenic-caused sediment supply sources. Upstream bank erosion and surface runoff is minimal, as sediment supply is low. | G |
| 8 | Proximity to 303(d) or TMDL listed waters | Project reach on, upstream, or downstream of a 303(d) waterway without a TMDL/watershed management plan to address deficiencies. | Project reach on, upstream, or downstream of a 303(d) waterway with a TMDL/ watershed management | Project reach is not on the 303(d) list. | G |
| 9 | Agricultural Land Use | Livestock access to stream and/or intensive cropland immediately upstream of the project reach. | Agricultural land uses are present in the catchment, but impacts are likely attenuated | There is little to no agricultural land uses or forested buffers exist between the receiving waters and the agriculture land and/or livestock. | G |
| 10 | NPDES Permits | Many NPDES permits within the catchment or some within 1 mile of the project reach. | A few NPDES permits within the catchment and none within 1 mile | No NPDES permits within the catchment and none within 1 mile of the project reach. | G |
| 11 | Inline Watershed Impoundments | Impoundment(s) are located near the project area (within 1 mile upstream or downstream), and/or impoundment(s) within the catchment have a negative effect on project area (e.g., flow alteration or reduced sediment supply) and fish passage. | A few small impoundments within the catchment and none within one mile of the project reach. | No impoundment (including farm ponds) upstream or downstream of project area OR only natural impoundments that allow for fish passage. | G |
| 12 | Organism Recruitment | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) is concrete, piped, or hardened. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material. | G |
| 13 | Other | | | | |

## Site Information and Reference Curve Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Limber Pole Creek - Upstream |
| Restoration Potential: | Partial |
| Preservation (Y/N): | Yes |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| Existing Stream Length (ft): | 100 |
| Proposed Stream Length (ft): | |
| Existing Stream Type: | B |
| Reference Stream Type: | B |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 1.78 |
| Stream Slope (%): | 3.9 |
| Strahler Stream Order: | Third |
| Flow Type: | Perennial |
| Proposed Bed Material: | |
| Buffer Valley Slope (%): | 5 - 20 % |
| Dominant Buffer Land Use: | Single Family Residential |
| Proposed Canopy Cover (%) at project closeout: | |
| Stream Temperature: | Coldwater |
| Fish Bioassessment Class: | 2 - Upland Savannah |

## Notes

1. Users input values that are highlighted
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## FUNCTIONAL CHANGE SUMMARY

| | |
|---|---|
| Existing Condition Score (ECS) | 0.48 |
| Proposed Condition Score (PCS) | 0.48 |
| Change in Functional Condition (PCS - ECS) | 0.00 |
| Percent Condition Change | 0% |
| Existing Stream Length (ft) | 100.0 |
| Proposed Stream Length (ft) | |
| Additional Stream Length (ft) | |
| Existing Functional Foot Score (FFS) | |
| Proposed Functional Foot Score (FFS) | |
| **Proposed FFS - Existing FFS (ΔFF)** | |
| Functional Yield (ΔFF/LF) | |

Explain the restoration potential of this reach based on the programmatic goals and catchment assessment results:

Little restoration potential. Surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Approximately 97.4 percent of the drainage area to Limber Pole Creek is classified as forested based on the NLCD. Limber Pole Creek is in stable condition with conditions typical of B-type streams.

Explain the goals and objectives for this reach:

The goals for this reach are to preserve its current condition by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed.

| Functional Category | Function-Based Parameters | Metric | EXISTING CONDITION ASSESSMENT | | | | PROPOSED CONDITION ASSESSMENT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Field Value | Index Value | Parameter | Category | Field Value | Index Value | Parameter | Category |
| Hydrology | Reach Runoff | Land Use Coefficient | 55 | 1.00 | 1.00 | 1.00 | | | | |
| | | Concentrated Flow Points (#/1000 LF) | 0 | 1.00 | | | | | | |
| Hydraulics | Floodplain Connectivity | Bank Height Ratio (ft/ft) | 2.3 | 0.00 | 0.45 | 0.64 | | | | |
| | | Entrenchment Ratio (ft/ft) | 1.8 | 0.9 | | | | | | |
| | Flow Dynamics | Width/Depth Ratio State (O/E) | 0.864334 | 0.83 | 0.83 | | | | | |
| Geomorphology | Large Woody Debris | LWD Index | | | 1.00 | 0.74 | | | | |
| | | LWD Piece Count (#/100m) | 49.2 | 1.00 | | | | | | |
| | Lateral Migration | Erosion Rate (ft/yr) | | | 0.58 | | | | | |
| | | Dominant BEHI/NBS | H/L | 0.20 | | | | | | |
| | | Percent Streambank Erosion (%) | 6 | 0.95 | | | | | | |
| | | Percent Streambank Armoring (%) | | | | | | | | |
| | Riparian Vegetation | Buffer Width (ft) | 300 | 1.00 | 0.83 | | | | | |
| | | Average DBH (in) | 9.519488 | 1.00 | | | | | | |
| | | Tree Density (#/acre) | 405 | 0.50 | | | | | | |
| | | Native Shrub Density (#/acre) | | | | | | | | |
| | | Native Herbaceous Cover (%) | | | | | | | | |
| | | Monoculture Area (%) | | | | | | | | |
| | Bed Form Diversity | Pool Spacing Ratio (ft/ft) | | | 0.55 | | | | | |
| | | Pool Depth Ratio (ft/ft) | 1.6 | 0.18 | | | | | | |
| | | Percent Riffle (%) | 49 | 0.92 | | | | | | |
| Physicochemical | Temperature | Summer Daily Maximum (°F) | | | | | | | | |
| | Bacteria | E. Coli (MPN/100 ml) | | | | | | | | |
| | Nitrogen | Total Nitrogen (mg/L) | | | | | | | | |
| | Phosphorus | Total Phosphorus (mg/L) | | | | | | | | |
| | Suspended Sediment | Total Suspended Solids (mg/L) | | | | | | | | |
| | | Turbidity (NTU) | | | | | | | | |
| Biology | Macroinvertebrates | EPT Taxa Present | | | | | | | | |
| | Fish | South Carolina Biotic Index | | | | | | | | |

| | |
|---|---|
| Version 1.1 | **Notes** |
| Version Last Updated: 7-Dec-22 | 1. Users input values that are highlighted based on restoration potential |
| | 2. Users select values from a pull-down menu |
| | 3. Leave values blank for field values that were not measured |

## Programmatic Goals

| | | |
|---|---|---|
| Select: | Other | |

Expand on the programmatic goals of this project:

The goals for this project are to preserve the current condition of Howard Creek by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed. Little restoration potential exists for this surface water; the surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Only 0.4 percent of the drainage area to Howard Creek is classified as impervious area based on the 2019 NLCD. Both, upstream and downstream reaches exhibit a completely intact, forested riparian buffer.

## Project Description

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Project ID: | Howard Creek |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| 12-digit HUC: | 30601010104 |

## Reach Summary

| Worksheet Title | Reach ID | Reach Description | Reach Break Criteria | ECS | PCS | ΔFF |
|---|---|---|---|---|---|---|
| Quantification_Tool_US | ward Creek - Upstre | Upstream of temporary access road cr | Single reach upstream to access | 0.45 | 0.45 | |
| Quantification_Tool_DS | ard Creek - Downstr | Downstream of temporary access roac | Single reach from temporary access road, downstream | 0.44 | 0.44 | |
| | | | | | | |
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| | | | | | |
|---|---|---|---|---|---|
| **Applicable Reach(es):** | | Howard Creek Upstream and Downstream reaches | | | |
| **Overall Catchment Condition (select:)** | | **Good** | Describe how any categories rated as poor were considered in the selection of the restoration potential of the reach(es):<br>None - stream is in natural condition with only 0.4% impervious area within drainage area. | | |

| **Categories** | | **Description of Catchment Condition** | | | **Rating (P/F/G)** |
|---|---|---|---|---|---|
| | | **Poor** | **Fair** | **Good** | |
| 1 | Concentrated Flow | Existing concentrated flow/impairments immediately upstream of the project reach with no treatments in place. | Potential for concentrated flow/impairments from adjacent land use or channel immediately upstream of the project reach, but measures are in place to protect resources. | No potential for concentrated flow/impairments from adjacent land use and/or channel immediately upstream of project reach. | G |
| 2 | Impervious cover | ≥ 25% | >10% and <25% | ≤ 10% | G |
| 3 | Urbanization | Rapidly urbanizing/urban. | Some urban growth potential, or uncertain growth potential. May consist of single family homes/suburban. | Rural communities/slow growth potential, or primarily forested. | G |
| 4 | Development Activities (e.g. utility rights-of-way, pipeline, mining, silviculture, roads) | High development or potential for impacts in contributing watershed or within 1 mile of project reach, or high potential of impacts >1 mile away from project reach. | Moderate development or moderate potential for impacts, but none within 1 mile of project reach. | No development or no potential for impacts. | G |
| 5 | Percent Forested | ≤ 20% | >20% and <70% | ≥ 70% | G |
| 6 | Riparian Vegetation | <50% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | 50-80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | >80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | G |
| 7 | Sediment Supply | Multiple, large anthropogenic-caused sources of sediment supply from upstream bank erosion and surface runoff. | Moderate anthropogenic-caused sediment supply from upstream bank erosion and surface runoff. | A few small anthropogenic-caused sediment supply sources. Upstream bank erosion and surface runoff is minimal, as sediment supply is low. | G |
| 8 | Proximity to 303(d) or TMDL listed waters | Project reach on, upstream, or downstream of a 303(d) waterway without a TMDL/watershed management plan to address deficiencies. | Project reach on, upstream, or downstream of a 303(d) waterway with a TMDL/ watershed management plan addressing deficiencies. | Project reach is not on the 303(d) list. | G |
| 9 | Agricultural Land Use | Livestock access to stream and/or intensive cropland immediately upstream of the project reach. | Agricultural land uses are present in the catchment, but impacts are likely attenuated within the project reach. | There is little to no agricultural land uses or forested buffers exist between the receiving waters and the agriculture land and/or livestock. | G |
| 10 | NPDES Permits | Many NPDES permits within the catchment or some within 1 mile of the project reach. | A few NPDES permits within the catchment and none within 1 mile of the project reach. | No NPDES permits within the catchment and none within 1 mile of the project reach. | G |
| 11 | Inline Watershed Impoundments | Impoundment(s) are located near the project area (within 1 mile upstream or downstream), and/or impoundment(s) within the catchment have a negative effect on project area (e.g., flow alteration or reduced sediment supply) and fish passage. | A few small impoundments within the catchment and none within one mile of the project reach. | No impoundment (including farm ponds) upstream or downstream of project area OR only natural impoundments that allow for fish passage. | G |
| 12 | Organism Recruitment | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) is concrete, piped, or hardened. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material that is highly embedded by fine sediment, but proximate stream reaches support desirable aquatic communities. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material. | G |
| 13 | Other | | | | |

## Site Information and Reference Curve Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Howard Creek - Upstream |
| Restoration Potential: | Partial |
| Preservation (Y/N): | Yes |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| Existing Stream Length (ft): | 100 |
| Proposed Stream Length (ft): | |
| Existing Stream Type: | Bc |
| Reference Stream Type: | Bc |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 4.16 |
| Stream Slope (%): | 1.9 |
| Strahler Stream Order: | Second |
| Flow Type: | Perennial |
| Proposed Bed Material: | |
| Buffer Valley Slope (%): | 5 - 20 % |
| Dominant Buffer Land Use: | Single Family Residential |
| Proposed Canopy Cover (%) at project closeout: | |
| Stream Temperature: | Coldwater |
| Fish Bioassessment Class: | 2 - Upland Savannah |

## Notes

1. Users input values that are highlighted
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## FUNCTIONAL CHANGE SUMMARY

| | |
|---|---|
| Existing Condition Score (ECS) | 0.45 |
| Proposed Condition Score (PCS) | 0.45 |
| Change in Functional Condition (PCS - ECS) | 0.00 |
| Percent Condition Change | 0% |
| Existing Stream Length (ft) | 100.0 |
| Proposed Stream Length (ft) | |
| Additional Stream Length (ft) | |
| Existing Functional Foot Score (FFS) | |
| Proposed Functional Foot Score (FFS) | |
| **Proposed FFS - Existing FFS (ΔFF)** | |
| Functional Yield (ΔFF/LF) | |

Explain the restoration potential of this reach based on the programmatic goals and catchment assessment results:

No restoration potential. Surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Only 0.4 percent of the drainage area to Howard Creek is classified as impervious area based on the 2019 NLCD. Howard Creek is in stable condition with conditions typical of B-type streams.

Explain the goals and objectives for this reach:

The goals for this reach are to preserve its current condition by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed.

| Functional Category | Function-Based Parameters | Metric | EXISTING CONDITION ASSESSMENT | | | | PROPOSED CONDITION ASSESSMENT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Field Value | Index Value | Parameter | Category | Field Value | Index Value | Parameter | Category |
| Hydrology | Reach Runoff | Land Use Coefficient | 55 | 1.00 | 1.00 | 1.00 | | | | |
| | | Concentrated Flow Points (#/1000 LF) | 0 | 1.00 | | | | | | |
| Hydraulics | Floodplain Connectivity | Bank Height Ratio (ft/ft) | 3.1 | 0.00 | 0.18 | 0.53 | | | | |
| | | Entrenchment Ratio (ft/ft) | 1.2 | 0.35 | | | | | | |
| | Flow Dynamics | Width/Depth Ratio State (O/E) | 1.095508 | 0.88 | 0.88 | | | | | |
| Geomorphology | Large Woody Debris | LWD Index | | | 0.79 | 0.73 | | | | |
| | | LWD Piece Count (#/100m) | 19.7 | 0.79 | | | | | | |
| | Lateral Migration | Erosion Rate (ft/yr) | | | 0.40 | | | | | |
| | | Dominant BEHI/NBS | H/L | 0.20 | | | | | | |
| | | Percent Streambank Erosion (%) | 16.5 | 0.60 | | | | | | |
| | | Percent Streambank Armoring (%) | | | | | | | | |
| | Riparian Vegetation | Buffer Width (ft) | 300 | 1.00 | 1.00 | | | | | |
| | | Average DBH (in) | 12.30034 | 1.00 | | | | | | |
| | | Tree Density (#/acre) | 142 | 1.00 | | | | | | |
| | | Native Shrub Density (#/acre) | | | | | | | | |
| | | Native Herbaceous Cover (%) | | | | | | | | |
| | | Monoculture Area (%) | | | | | | | | |
| | Bed Form Diversity | Pool Spacing Ratio (ft/ft) | 1.3 | 1.00 | 0.73 | | | | | |
| | | Pool Depth Ratio (ft/ft) | 1.7 | 0.21 | | | | | | |
| | | Percent Riffle (%) | 62 | 0.97 | | | | | | |
| Physicochemical | Temperature | Summer Daily Maximum (°F) | | | | | | | | |
| | Bacteria | E. Coli (MPN/100 ml) | | | | | | | | |
| | Nitrogen | Total Nitrogen (mg/L) | | | | | | | | |
| | Phosphorus | Total Phosphorus (mg/L) | | | | | | | | |
| | Suspended Sediment | Total Suspended Solids (mg/L) | | | | | | | | |
| | | Turbidity (NTU) | | | | | | | | |
| Biology | Macroinvertebrates | EPT Taxa Present | | | | | | | | |
| | Fish | South Carolina Biotic Index | | | | | | | | |

| | | |
|---|---|---|
| Version 1.1 | | **Notes** |
| Version Last Updated: | 7-Dec-22 | 1. Users input values that are highlighted based on restoration potential |
| | | 2. Users select values from a pull-down menu |
| | | 3. Leave values blank for field values that were not measured |

## Programmatic Goals

| | | |
|---|---|---|
| Select: | Other | |

Expand on the programmatic goals of this project:

The goals for this project are to preserve the current condition of Stream 12 by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed. Little restoration potential exists for this surface water; the surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. 89.9 percent of the drainage area is classified as forested and only 0.9 percent is classified as impervious according to the 2019 NLCD.

## Project Description

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Project ID: | Stream 12 |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| 12-digit HUC: | 30601010104 |

## Reach Summary

| **Worksheet Title** | **Reach ID** | **Reach Description** | **Reach Break Criteria** | **ECS** | **PCS** | **ΔFF** |
|---|---|---|---|---|---|---|
| Quantification_Tool_US | tream 12 - Upstrean | Upstream of temporary access road cr | Single reach upstream to access | 0.39 | 0.39 | |
| Quantification_Tool_DS | ream 12 Downstrea | Downstream of temporary access road | Single reach from temporary access road, downstream | 0.48 | 0.48 | |
| | | | | | | |
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| | | |
| --- | --- | --- |
| **Applicable Reach(es):** | Stream 12 upstream and downstream | |
| **Overall Catchment Condition (select:)** | **Good** | Describe how any categories rated as poor were considered in the selection of the restoration potential of the reach(es):<br>Overall catchment condition is good. An existing electric transmission ROW is located just east (upstream) of Stream 12. |

| | **Categories** | **Description of Catchment Condition** | | | **Rating (P/F/G)** |
| --- | --- | --- | --- | --- | --- |
| | | **Poor** | **Fair** | **Good** | |
| 1 | Concentrated Flow | Existing concentrated flow/impairments immediately upstream of the project reach with no treatments in place. | Potential for concentrated flow/impairments from adjacent land use or channel immediately upstream of the project reach, but measures are in place to protect resources. | No potential for concentrated flow/impairments from adjacent land use and/or channel immediately upstream of project reach. | G |
| 2 | Impervious cover | ≥ 25% | >10% and <25% | ≤ 10% | G |
| 3 | Urbanization | Rapidly urbanizing/urban. | Some urban growth potential, or uncertain growth potential. May consist of single family homes/suburban. | Rural communities/slow growth potential, or primarily forested. | G |
| 4 | Development Activities (e.g. utility rights-of-way, pipeline, mining, silviculture, roads) | High development or potential for impacts in contributing watershed or within 1 mile of project reach, or high potential of impacts >1 mile away from project reach. | Moderate development or moderate potential for impacts, but none within 1 mile of project reach. | No development or no potential for impacts. | P |
| 5 | Percent Forested | ≤ 20% | >20% and <70% | ≥ 70% | G |
| 6 | Riparian Vegetation | <50% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | 50-80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | >80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | F |
| 7 | Sediment Supply | Multiple, large anthropogenic-caused sources of sediment supply from upstream bank erosion and surface runoff. | Moderate anthropogenic-caused sediment supply from upstream bank erosion and surface runoff. | A few small anthropogenic-caused sediment supply sources. Upstream bank erosion and surface runoff is minimal, as sediment supply is low. | G |
| 8 | Proximity to 303(d) or TMDL listed waters | Project reach on, upstream, or downstream of a 303(d) waterway without a TMDL/watershed management plan to address deficiencies. | Project reach on, upstream, or downstream of a 303(d) waterway with a TMDL/ watershed management plan addressing deficiencies. | Project reach is not on the 303(d) list. | G |
| 9 | Agricultural Land Use | Livestock access to stream and/or intensive cropland immediately upstream of the project reach. | Agricultural land uses are present in the catchment, but impacts are likely attenuated within the project reach. | There is little to no agricultural land uses or forested buffers exist between the receiving waters and the agriculture land and/or livestock. | G |
| 10 | NPDES Permits | Many NPDES permits within the catchment or some within 1 mile of the project reach. | A few NPDES permits within the catchment and none within 1 mile of the project reach. | No NPDES permits within the catchment and none within 1 mile of the project reach. | G |
| 11 | Inline Watershed Impoundments | Impoundment(s) are located near the project area (within 1 mile upstream or downstream), and/or impoundment(s) within the catchment have a negative effect on project area (e.g., flow alteration or reduced sediment supply) and fish passage. | A few small impoundments within the catchment and none within one mile of the project reach. | No impoundment (including farm ponds) upstream or downstream of project area OR only natural impoundments that allow for fish passage. | G |
| 12 | Organism Recruitment | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) is concrete, piped, or hardened. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material that is highly embedded by fine sediment, but proximate stream reaches support desirable aquatic communities. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material. | G |
| 13 | Other | | | | |

## Site Information and Reference Curve Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 12 - Upstream |
| Restoration Potential: | Partial |
| Preservation (Y/N): | Yes |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| Existing Stream Length (ft): | 100 |
| Proposed Stream Length (ft): | |
| Existing Stream Type: | Ba |
| Reference Stream Type: | Ba |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.0311178 |
| Stream Slope (%): | 10 |
| Strahler Stream Order: | First |
| Flow Type: | Intermittent |
| Proposed Bed Material: | |
| Buffer Valley Slope (%): | 21 - 40 % |
| Dominant Buffer Land Use: | Single Family Residential |
| Proposed Canopy Cover (%) at project closeout: | |
| Stream Temperature: | Coldwater |
| Fish Bioassessment Class: | |

## Notes

1. Users input values that are highlighted
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## FUNCTIONAL CHANGE SUMMARY

| | |
|---|---|
| Existing Condition Score (ECS) | 0.39 |
| Proposed Condition Score (PCS) | 0.39 |
| Change in Functional Condition (PCS - ECS) | 0.00 |
| Percent Condition Change | 0% |
| Existing Stream Length (ft) | 100.0 |
| Proposed Stream Length (ft) | |
| Additional Stream Length (ft) | |
| Existing Functional Foot Score (FFS) | |
| Proposed Functional Foot Score (FFS) | |
| **Proposed FFS - Existing FFS (ΔFF)** | |
| Functional Yield (ΔFF/LF) | |

Explain the restoration potential of this reach based on the programmatic goals and catchment assessment results:

Little restoration potential. Surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Approximately 89.9 percent of the drainage area to Stream 12 is classified as forested based on the NLCD, with only 0.9 percent impervious. Stream 12 is in stable condition with conditions typical of A-type streams.

Explain the goals and objectives for this reach:

The goals for this reach are to preserve its current condition by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed.

| Functional Category | Function-Based Parameters | Metric | EXISTING CONDITION ASSESSMENT | | | | PROPOSED CONDITION ASSESSMENT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Field Value | Index Value | Parameter | Category | Field Value | Index Value | Parameter | Category |
| Hydrology | Reach Runoff | Land Use Coefficient | 55 | 1.00 | 1.00 | 1.00 | | | | |
| | | Concentrated Flow Points (#/1000 LF) | 0 | 1.00 | | | | | | |
| Hydraulics | Floodplain Connectivity | Bank Height Ratio (ft/ft) | 4.8 | 0.00 | 0.18 | 0.20 | | | | |
| | | Entrenchment Ratio (ft/ft) | 1.2 | 0.35 | | | | | | |
| | Flow Dynamics | Width/Depth Ratio State (O/E) | 1.621309 | 0.22 | 0.22 | | | | | |
| Geomorphology | Large Woody Debris | LWD Index | | | 0.43 | 0.76 | | | | |
| | | LWD Piece Count (#/100m) | 9.8 | 0.43 | | | | | | |
| | Lateral Migration | Erosion Rate (ft/yr) | | | | | | | | |
| | | Dominant BEHI/NBS | | | | | | | | |
| | | Percent Streambank Erosion (%) | | | | | | | | |
| | | Percent Streambank Armoring (%) | | | | | | | | |
| | Riparian Vegetation | Buffer Width (ft) | 300 | 1.00 | 1.00 | | | | | |
| | | Average DBH (in) | 18.5794 | 1.00 | | | | | | |
| | | Tree Density (#/acre) | 243 | 1.00 | | | | | | |
| | | Native Shrub Density (#/acre) | | | | | | | | |
| | | Native Herbaceous Cover (%) | | | | | | | | |
| | | Monoculture Area (%) | | | | | | | | |
| | Bed Form Diversity | Pool Spacing Ratio (ft/ft) | 3.3 | 1.00 | 0.85 | | | | | |
| | | Pool Depth Ratio (ft/ft) | 2.5 | 0.80 | | | | | | |
| | | Percent Riffle (%) | 39 | 0.74 | | | | | | |
| Physicochemical | Temperature | Summer Daily Maximum (°F) | | | | | | | | |
| | Bacteria | E. Coli (MPN/100 ml) | | | | | | | | |
| | Nitrogen | Total Nitrogen (mg/L) | | | | | | | | |
| | Phosphorus | Total Phosphorus (mg/L) | | | | | | | | |
| | Suspended Sediment | Total Suspended Solids (mg/L) | | | | | | | | |
| | | Turbidity (NTU) | | | | | | | | |
| Biology | Macroinvertebrates | EPT Taxa Present | | | | | | | | |
| | Fish | South Carolina Biotic Index | | | | | | | | |

Version 1.1
Version Last Updated: 7-Dec-22

**Notes**

1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## Programmatic Goals

| | | |
|---|---|---|
| Select: | Other | |

Expand on the programmatic goals of this project:

## Project Description

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Project ID: | Stream 15 |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| 12-digit HUC: | 30601010104 |

## Reach Summary

| Worksheet Title | Reach ID | Reach Description | Reach Break Criteria | ECS | PCS | ΔFF |
|---|---|---|---|---|---|---|
| Quantification_Tool_US | tream 15 - Upstrean | Reach upstream of temporary access r | Upstream of access road | 0.37 | 0.37 | |
| Quantification_Tool_DS | eam 15 - Downstrea | Reach downstream of temporary acces | Downstream of access road | 0.36 | 0.36 | |
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| | | |
|---|---|---|
| **Applicable Reach(es):** | Stream 15 upstream and downstream | |
| **Overall Catchment Condition (select:)** | **Good** | Describe how any categories rated as poor were considered in the selection of the restoration potential of the reach(es): None were rated as poor. Catchment is in good condition with approximately 85.6 percent of classified as forested and 5 percent classified as impervious based on the NLCD. |

| **Categories** | | **Description of Catchment Condition** | | | **Rating (P/F/G)** |
|---|---|---|---|---|---|
| | | **Poor** | **Fair** | **Good** | |
| 1 | Concentrated Flow | Existing concentrated flow/impairments immediately upstream of the project reach with no treatments in place. | Potential for concentrated flow/impairments from adjacent land use or channel immediately upstream of the project reach, but measures are in place to protect resources. | No potential for concentrated flow/impairments from adjacent land use and/or channel immediately upstream of project reach. | G |
| 2 | Impervious cover | ≥ 25% | >10% and <25% | ≤ 10% | G |
| 3 | Urbanization | Rapidly urbanizing/urban. | Some urban growth potential, or uncertain growth potential. May consist of single family homes/suburban. | Rural communities/slow growth potential, or primarily forested. | G |
| 4 | Development Activities (e.g. utility rights-of-way, pipeline, mining, silviculture, roads) | High development or potential for impacts in contributing watershed or within 1 mile of project reach, or high potential of impacts >1 mile away from project reach. | Moderate development or moderate potential for impacts, but none within 1 mile of project reach. | No development or no potential for impacts. | G |
| 5 | Percent Forested | ≤ 20% | >20% and <70% | ≥ 70% | G |
| 6 | Riparian Vegetation | <50% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | 50-80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | >80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | F |
| 7 | Sediment Supply | Multiple, large anthropogenic-caused sources of sediment supply from upstream bank erosion and surface runoff. | Moderate anthropogenic-caused sediment supply from upstream bank erosion and surface runoff. | A few small anthropogenic-caused sediment supply sources. Upstream bank erosion and surface runoff is minimal, as sediment supply is low. | F |
| 8 | Proximity to 303(d) or TMDL listed waters | Project reach on, upstream, or downstream of a 303(d) waterway without a TMDL/watershed management plan to address deficiencies. | Project reach on, upstream, or downstream of a 303(d) waterway with a TMDL/ watershed management plan addressing deficiencies. | Project reach is not on the 303(d) list. | G |
| 9 | Agricultural Land Use | Livestock access to stream and/or intensive cropland immediately upstream of the project reach. | Agricultural land uses are present in the catchment, but impacts are likely attenuated within the project reach. | There is little to no agricultural land uses or forested buffers exist between the receiving waters and the agriculture land and/or livestock. | G |
| 10 | NPDES Permits | Many NPDES permits within the catchment or some within 1 mile of the project reach. | A few NPDES permits within the catchment and none within 1 mile of the project reach. | No NPDES permits within the catchment and none within 1 mile of the project reach. | G |
| 11 | Inline Watershed Impoundments | Impoundment(s) are located near the project area (within 1 mile upstream or downstream), and/or impoundment(s) within the catchment have a negative effect on project area (e.g., flow alteration or reduced sediment supply) and fish passage. | A few small impoundments within the catchment and none within one mile of the project reach. | No impoundment (including farm ponds) upstream or downstream of project area OR only natural impoundments that allow for fish passage. | G |
| 12 | Organism Recruitment | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) is concrete, piped, or hardened. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material that is highly embedded by fine sediment, but proximate stream reaches support desirable aquatic communities. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material. | G |
| 13 | Other | | | | |

## Site Information and Reference Curve Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 15 - Upstream |
| Restoration Potential: | Partial |
| Preservation (Y/N): | Yes |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| Existing Stream Length (ft): | 100 |
| Proposed Stream Length (ft): | |
| Existing Stream Type: | G |
| Reference Stream Type: | B |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.0016884 |
| Stream Slope (%): | 5.9 |
| Strahler Stream Order: | First |
| Flow Type: | Perennial |
| Proposed Bed Material: | |
| Buffer Valley Slope (%): | 5 - 20 % |
| Dominant Buffer Land Use: | Single Family Residential |
| Proposed Canopy Cover (%) at project closeout: | |
| Stream Temperature: | Coldwater |
| Fish Bioassessment Class: | 2 - Upland Savannah |

## Notes

1. Users input values that are highlighted
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## FUNCTIONAL CHANGE SUMMARY

| | |
|---|---|
| Existing Condition Score (ECS) | 0.37 |
| Proposed Condition Score (PCS) | 0.37 |
| Change in Functional Condition (PCS - ECS) | 0.00 |
| Percent Condition Change | 0% |
| Existing Stream Length (ft) | 100.0 |
| Proposed Stream Length (ft) | |
| Additional Stream Length (ft) | |
| Existing Functional Foot Score (FFS) | |
| Proposed Functional Foot Score (FFS) | |
| **Proposed FFS - Existing FFS (ΔFF)** | |
| Functional Yield (ΔFF/LF) | |

Explain the restoration potential of this reach based on the programmatic goals and catchment assessment results:

Some restoration potential. Surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Approximately 85.6 percent of the drainage area to Stream 15 is classified as forested and 5 percent classified as impervious based on the NLCD. Approximately 26.5 percent of the reach exhibited bank erosion.

Explain the goals and objectives for this reach:

The goals for this reach are to preserve its current condition by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed.

| Functional Category | Function-Based Parameters | Metric | EXISTING CONDITION ASSESSMENT | | | | PROPOSED CONDITION ASSESSMENT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Field Value | Index Value | Parameter | Category | Field Value | Index Value | Parameter | Category |
| Hydrology | Reach Runoff | Land Use Coefficient | 55.95389925 | 0.96 | 0.98 | 0.98 | | | | |
| | | Concentrated Flow Points (#/1000 LF) | 0 | 1.00 | | | | | | |
| Hydraulics | Floodplain Connectivity | Bank Height Ratio (ft/ft) | 2.3 | 0.00 | 0.27 | 0.37 | | | | |
| | | Entrenchment Ratio (ft/ft) | 1.3 | 0.53 | | | | | | |
| | Flow Dynamics | Width/Depth Ratio State (O/E) | 0.578687 | 0.47 | 0.47 | | | | | |
| Geomorphology | Large Woody Debris | LWD Index | | | 0.43 | 0.48 | | | | |
| | | LWD Piece Count (#/100m) | 9.8 | 0.43 | | | | | | |
| | Lateral Migration | Erosion Rate (ft/yr) | | | 0.21 | | | | | |
| | | Dominant BEHI/NBS | Ex/L | 0.00 | | | | | | |
| | | Percent Streambank Erosion (%) | 26.5 | 0.42 | | | | | | |
| | | Percent Streambank Armoring (%) | | | | | | | | |
| | Riparian Vegetation | Buffer Width (ft) | 300 | 1.00 | 0.88 | | | | | |
| | | Average DBH (in) | 8.188976 | 0.88 | | | | | | |
| | | Tree Density (#/acre) | 102 | 0.76 | | | | | | |
| | | Native Shrub Density (#/acre) | | | | | | | | |
| | | Native Herbaceous Cover (%) | | | | | | | | |
| | | Monoculture Area (%) | | | | | | | | |
| | Bed Form Diversity | Pool Spacing Ratio (ft/ft) | 4.6 | 0.82 | 0.40 | | | | | |
| | | Pool Depth Ratio (ft/ft) | 1.4 | 0.12 | | | | | | |
| | | Percent Riffle (%) | 13 | 0.25 | | | | | | |
| Physicochemical | Temperature | Summer Daily Maximum (°F) | | | | | | | | |
| | Bacteria | E. Coli (MPN/100 ml) | | | | | | | | |
| | Nitrogen | Total Nitrogen (mg/L) | | | | | | | | |
| | Phosphorus | Total Phosphorus (mg/L) | | | | | | | | |
| | Suspended Sediment | Total Suspended Solids (mg/L) | | | | | | | | |
| | | Turbidity (NTU) | | | | | | | | |
| Biology | Macroinvertebrates | EPT Taxa Present | | | | | | | | |
| | Fish | South Carolina Biotic Index | | | | | | | | |

Version 1.1
Version Last Updated: 7-Dec-22

| Notes |
|---|
| 1. Users input values that are highlighted based on restoration potential |
| 2. Users select values from a pull-down menu |
| 3. Leave values blank for field values that were not measured |

## Programmatic Goals

| | | |
|---|---|---|
| Select: | Other | |

Expand on the programmatic goals of this project:

## Project Description

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Project ID: | Stream 16 |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| 12-digit HUC: | 30601010104 |

## Reach Summary

| Worksheet Title | Reach ID | Reach Description | Reach Break Criteria | ECS | PCS | ΔFF |
|---|---|---|---|---|---|---|
| Quantification_Tool_US | tream 16 - Upstrea | Upstream of temp access rd crossing | Single reach upstream to | 0.45 | 0.45 | |
| Quantification_Tool_DS | ream 16 - Downstrea | Downstream of temp access rd crossin | Single reach from temporary access road, downstream | 0.37 | 0.37 | |
| | | | | | | |
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|  |  |  |
|---|---|---|
| **Applicable Reach(es):** | Stream 16 |  |
| **Overall Catchment Condition (select:)** | **Good** | Describe how any categories rated as poor were considered in the selection of the restoration potential of the reach(es): double HDPE installed at the upper extent of project reach. Expected to be replaced by a spanning structure (bridge). |

| **Categories** |  | **Description of Catchment Condition** |  |  | **Rating (P/F/G)** |
|---|---|---|---|---|---|
|  |  | **Poor** | **Fair** | **Good** |  |
| 1 | Concentrated Flow | Existing concentrated flow/impairments immediately upstream of the project reach with no treatments in place. | Potential for concentrated flow/impairments from adjacent land use or channel immediately upstream of the project reach, but measures are in place to protect resources. | No potential for concentrated flow/impairments from adjacent land use and/or channel immediately upstream of project reach. | P |
| 2 | Impervious cover | ≥ 25% | >10% and <25% | ≤ 10% | G |
| 3 | Urbanization | Rapidly urbanizing/urban. | Some urban growth potential, or uncertain growth potential. May consist of single family homes/suburban. | Rural communities/slow growth potential, or primarily forested. | G |
| 4 | Development Activities (e.g. utility rights-of-way, pipeline, mining, silviculture, roads) | High development or potential for impacts in contributing watershed or within 1 mile of project reach, or high potential of impacts >1 mile away from project reach. | Moderate development or moderate potential for impacts, but none within 1 mile of project reach. | No development or no potential for impacts. | F |
| 5 | Percent Forested | ≤ 20% | >20% and <70% | ≥ 70% | G |
| 6 | Riparian Vegetation | <50% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | 50-80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | >80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | G |
| 7 | Sediment Supply | Multiple, large anthropogenic-caused sources of sediment supply from upstream bank erosion and surface runoff. | Moderate anthropogenic-caused sediment supply from upstream bank erosion and surface runoff. | A few small anthropogenic-caused sediment supply sources. Upstream bank erosion and surface runoff is minimal, as sediment supply is low. | G |
| 8 | Proximity to 303(d) or TMDL listed waters | Project reach on, upstream, or downstream of a 303(d) waterway without a TMDL/watershed management plan to address deficiencies. | Project reach on, upstream, or downstream of a 303(d) waterway with a TMDL/ watershed management plan addressing deficiencies. | Project reach is not on the 303(d) list. | G |
| 9 | Agricultural Land Use | Livestock access to stream and/or intensive cropland immediately upstream of the project reach. | Agricultural land uses are present in the catchment, but impacts are likely attenuated within the project reach. | There is little to no agricultural land uses or forested buffers exist between the receiving waters and the agriculture land and/or livestock. | G |
| 10 | NPDES Permits | Many NPDES permits within the catchment or some within 1 mile of the project reach. | A few NPDES permits within the catchment and none within 1 mile of the project reach. | No NPDES permits within the catchment and none within 1 mile of the project reach. | G |
| 11 | Inline Watershed Impoundments | Impoundment(s) are located near the project area (within 1 mile upstream or downstream), and/or impoundment(s) within the catchment have a negative effect on project area (e.g., flow alteration or reduced sediment supply) and fish passage. | A few small impoundments within the catchment and none within one mile of the project reach. | No impoundment (including farm ponds) upstream or downstream of project area OR only natural impoundments that allow for fish passage. | G |
| 12 | Organism Recruitment | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) is concrete, piped, or hardened. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material that is highly embedded by fine sediment, but proximate stream reaches support desirable aquatic communities. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material. | G |
| 13 | Other |  |  |  |  |

## Site Information and Reference Curve Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Stream 16 - Upstream |
| Restoration Potential: | Partial |
| Preservation (Y/N): | Yes |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| Existing Stream Length (ft): | 100 |
| Proposed Stream Length (ft): | |
| Existing Stream Type: | Ba |
| Reference Stream Type: | Ba |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.017309 |
| Stream Slope (%): | 8 |
| Strahler Stream Order: | First |
| Flow Type: | Intermittent |
| Proposed Bed Material: | |
| Buffer Valley Slope (%): | 5 - 20 % |
| Dominant Buffer Land Use: | Single Family Residential |
| Proposed Canopy Cover (%) at project closeout: | |
| Stream Temperature: | Coldwater |
| Fish Bioassessment Class: | |

## Notes

1. Users input values that are highlighted
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## FUNCTIONAL CHANGE SUMMARY

| | |
|---|---|
| Existing Condition Score (ECS) | 0.45 |
| Proposed Condition Score (PCS) | 0.45 |
| Change in Functional Condition (PCS - ECS) | 0.00 |
| Percent Condition Change | 0% |
| Existing Stream Length (ft) | 100.0 |
| Proposed Stream Length (ft) | |
| Additional Stream Length (ft) | |
| Existing Functional Foot Score (FFS) | |
| Proposed Functional Foot Score (FFS) | |
| **Proposed FFS - Existing FFS (∆FF)** | |
| Functional Yield (∆FF/LF) | |

Explain the restoration potential of this reach based on the programmatic goals and catchment assessment results:

Little restoration potential. Surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Approximately 87.6 percent of the drainage area to Stream 16 is classified as forested based on the NLCD. Stream 16 is in stable condition with conditions typical of A-type streams.

Explain the goals and objectives for this reach:

The goals for this reach are to preserve its current condition by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed.

| Functional Category | Function-Based Parameters | Metric | EXISTING CONDITION ASSESSMENT | | | | PROPOSED CONDITION ASSESSMENT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Field Value | Index Value | Parameter | Category | Field Value | Index Value | Parameter | Category |
| Hydrology | Reach Runoff | Land Use Coefficient | 55 | 1.00 | 1.00 | 1.00 | | | | |
| | | Concentrated Flow Points (#/1000 LF) | 0 | 1.00 | | | | | | |
| Hydraulics | Floodplain Connectivity | Bank Height Ratio (ft/ft) | 2.6 | 0.00 | 0.38 | 0.55 | | | | |
| | | Entrenchment Ratio (ft/ft) | 1.5 | 0.75 | | | | | | |
| | Flow Dynamics | Width/Depth Ratio State (O/E) | 1.21579 | 0.73 | 0.73 | | | | | |
| Geomorphology | Large Woody Debris | LWD Index | | | 0.57 | 0.70 | | | | |
| | | LWD Piece Count (#/100m) | 13.1 | 0.57 | | | | | | |
| | Lateral Migration | Erosion Rate (ft/yr) | | | 0.60 | | | | | |
| | | Dominant BEHI/NBS | H/M | 0.20 | | | | | | |
| | | Percent Streambank Erosion (%) | 5 | 1.00 | | | | | | |
| | | Percent Streambank Armoring (%) | | | | | | | | |
| | Riparian Vegetation | Buffer Width (ft) | 300 | 1.00 | 0.97 | | | | | |
| | | Average DBH (in) | 8.59782 | 0.92 | | | | | | |
| | | Tree Density (#/acre) | 264 | 0.99 | | | | | | |
| | | Native Shrub Density (#/acre) | | | | | | | | |
| | | Native Herbaceous Cover (%) | | | | | | | | |
| | | Monoculture Area (%) | | | | | | | | |
| | Bed Form Diversity | Pool Spacing Ratio (ft/ft) | 0.8 | 1.00 | 0.66 | | | | | |
| | | Pool Depth Ratio (ft/ft) | 1.4 | 0.12 | | | | | | |
| | | Percent Riffle (%) | 66 | 0.87 | | | | | | |
| Physicochemical | Temperature | Summer Daily Maximum (°F) | | | | | | | | |
| | Bacteria | E. Coli (MPN/100 ml) | | | | | | | | |
| | Nitrogen | Total Nitrogen (mg/L) | | | | | | | | |
| | Phosphorus | Total Phosphorus (mg/L) | | | | | | | | |
| | Suspended Sediment | Total Suspended Solids (mg/L) | | | | | | | | |
| | | Turbidity (NTU) | | | | | | | | |
| Biology | Macroinvertebrates | EPT Taxa Present | | | | | | | | |
| | Fish | South Carolina Biotic Index | | | | | | | | |

Version 1.1
Version Last Updated: 7-Dec-22

**Notes**

1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## Programmatic Goals

Select: Other

Expand on the programmatic goals of this project:

## Project Description

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Project ID: | Devils Fork |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| 12-digit HUC: | 30601010104 |

## Reach Summary

| **Worksheet Title** | **Reach ID** | **Reach Description** | **Reach Break Criteria** | **ECS** | **PCS** | **ΔFF** |
|---|---|---|---|---|---|---|
| Quantification_Tool_US | evils Fork - Upstrear | Upstream of temporary access road cr | Single reach upstream to access | 0.4 | 0.4 | |
| Quantification_Tool_DS | vils Fork - Downstre | Downstream of temporary access road | Single reach from temporary access road, downstream | 0.37 | 0.37 | |
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|  |  |  |
|---|---|---|
| **Applicable Reach(es):** | Devils Fork upstream and downstream |  |
| **Overall Catchment Condition (select:)** | **Good** | Describe how any categories rated as poor were considered in the selection of the restoration potential of the reach(es):<br>None - all categories rated Good. |

| **Categories** |  | **Description of Catchment Condition** |  |  | **Rating (P/F/G)** |
|---|---|---|---|---|---|
|  |  | **Poor** | **Fair** | **Good** |  |
| 1 | Concentrated Flow | Existing concentrated flow/impairments immediately upstream of the project reach with no treatments in place. | Potential for concentrated flow/impairments from adjacent land use or channel immediately upstream of the project reach, but measures are in place to protect resources. | No potential for concentrated flow/impairments from adjacent land use and/or channel immediately upstream of project reach. | G |
| 2 | Impervious cover | ≥ 25% | >10% and <25% | ≤ 10% | G |
| 3 | Urbanization | Rapidly urbanizing/urban. | Some urban growth potential, or uncertain growth potential. May consist of single family homes/suburban. | Rural communities/slow growth potential, or primarily forested. | G |
| 4 | Development Activities (e.g. utility rights-of-way, pipeline, mining, silviculture, roads) | High development or potential for impacts in contributing watershed or within 1 mile of project reach, or high potential of impacts >1 mile away from project reach. | Moderate development or moderate potential for impacts, but none within 1 mile of project reach. | No development or no potential for impacts. | G |
| 5 | Percent Forested | ≤ 20% | >20% and <70% | ≥ 70% | G |
| 6 | Riparian Vegetation | <50% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | 50-80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | >80% of contributing stream length (project reach and upstream channel) has >25-m (~82 ft) corridor width. | G |
| 7 | Sediment Supply | Multiple, large anthropogenic-caused sources of sediment supply from upstream bank erosion and surface runoff. | Moderate anthropogenic-caused sediment supply from upstream bank erosion and surface runoff. | A few small anthropogenic-caused sediment supply sources. Upstream bank erosion and surface runoff is minimal, as sediment supply is low. | G |
| 8 | Proximity to 303(d) or TMDL listed waters | Project reach on, upstream, or downstream of a 303(d) waterway without a TMDL/watershed management plan to address deficiencies. | Project reach on, upstream, or downstream of a 303(d) waterway with a TMDL/ watershed management plan addressing deficiencies. | Project reach is not on the 303(d) list. | G |
| 9 | Agricultural Land Use | Livestock access to stream and/or intensive cropland immediately upstream of the project reach. | Agricultural land uses are present in the catchment, but impacts are likely attenuated within the project reach. | There is little to no agricultural land uses or forested buffers exist between the receiving waters and the agriculture land and/or livestock. | G |
| 10 | NPDES Permits | Many NPDES permits within the catchment or some within 1 mile of the project reach. | A few NPDES permits within the catchment and none within 1 mile of the project reach. | No NPDES permits within the catchment and none within 1 mile of the project reach. | G |
| 11 | Inline Watershed Impoundments | Impoundment(s) are located near the project area (within 1 mile upstream or downstream), and/or impoundment(s) within the catchment have a negative effect on project area (e.g., flow alteration or reduced sediment supply) and fish passage. | A few small impoundments within the catchment and none within one mile of the project reach. | No impoundment (including farm ponds) upstream or downstream of project area OR only natural impoundments that allow for fish passage. | G |
| 12 | Organism Recruitment | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) is concrete, piped, or hardened. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material that is highly embedded by fine sediment, but proximate stream reaches support desirable aquatic communities. | Channel immediately upstream or downstream of the project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material. | G |
| 13 | Other |  |  |  |  |

## Site Information and Reference Curve Stratification

| | |
|---|---|
| Project Name: | Bad Creek Pumped Storage Project |
| Reach ID: | Devils Fork - Upstream |
| Restoration Potential: | Partial |
| Preservation (Y/N): | Yes |
| Ecoregion: | Blue Ridge Mountains |
| River Basin: | Savannah |
| Existing Stream Length (ft): | 100 |
| Proposed Stream Length (ft): | |
| Existing Stream Type: | Ba |
| Reference Stream Type: | Ba |
| Valley Type: | Colluvial |
| Drainage Area (sq. mi.): | 0.048813 |
| Stream Slope (%): | 6 |
| Strahler Stream Order: | Second |
| Flow Type: | Perennial |
| Proposed Bed Material: | |
| Buffer Valley Slope (%): | 5 - 20 % |
| Dominant Buffer Land Use: | Single Family Residential |
| Proposed Canopy Cover (%) at project closeout: | |
| Stream Temperature: | Coldwater |
| Fish Bioassessment Class: | |

## Notes

1. Users input values that are highlighted
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured

## FUNCTIONAL CHANGE SUMMARY

| | |
|---|---|
| Existing Condition Score (ECS) | 0.40 |
| Proposed Condition Score (PCS) | 0.40 |
| Change in Functional Condition (PCS - ECS) | 0.00 |
| Percent Condition Change | 0% |
| Existing Stream Length (ft) | 100.0 |
| Proposed Stream Length (ft) | |
| Additional Stream Length (ft) | |
| Existing Functional Foot Score (FFS) | |
| Proposed Functional Foot Score (FFS) | |
| **Proposed FFS - Existing FFS (ΔFF)** | |
| Functional Yield (ΔFF/LF) | |

Explain the restoration potential of this reach based on the programmatic goals and catchment assessment results:

Little restoration potential. Surrounding landscape and watershed exhibit little anthropogenic influence or degradation on the stream. Approximately 87.6 percent of the drainage area to Devils Fork is classified as forested and 2.2 percent classified as impervious based on the NLCD. Devils Fork is in stable condition with conditions typical of A-type streams.

Explain the goals and objectives for this reach:

The goals for this reach are to preserve its current condition by implementing Best Management Practices and avoidance and minimization measures to the maximum extent practicable if Bad Creek II is pursued and if the proposed temporary acess road is constructed.

| Functional Category | Function-Based Parameters | Metric | EXISTING CONDITION ASSESSMENT | | | | PROPOSED CONDITION ASSESSMENT | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Field Value | Index Value | Parameter | Category | Field Value | Index Value | Parameter | Category |
| Hydrology | Reach Runoff | Land Use Coefficient | 55 | 1.00 | 1.00 | 1.00 | | | | |
| | | Concentrated Flow Points (#/1000 LF) | 0 | 1.00 | | | | | | |
| Hydraulics | Floodplain Connectivity | Bank Height Ratio (ft/ft) | 2.2 | 0.00 | 0.18 | 0.48 | | | | |
| | | Entrenchment Ratio (ft/ft) | 1.2 | 0.35 | | | | | | |
| | Flow Dynamics | Width/Depth Ratio State (O/E) | 0.831366 | 0.79 | 0.79 | | | | | |
| Geomorphology | Large Woody Debris | LWD Index | | | 0.29 | 0.53 | | | | |
| | | LWD Piece Count (#/100m) | 6.6 | 0.29 | | | | | | |
| | Lateral Migration | Erosion Rate (ft/yr) | | | 0.60 | | | | | |
| | | Dominant BEHI/NBS | H/L | 0.20 | | | | | | |
| | | Percent Streambank Erosion (%) | 3 | 1.00 | | | | | | |
| | | Percent Streambank Armoring (%) | | | | | | | | |
| | Riparian Vegetation | Buffer Width (ft) | 300 | 1.00 | 1.00 | | | | | |
| | | Average DBH (in) | 9.570866 | 1.00 | | | | | | |
| | | Tree Density (#/acre) | 203 | 1.00 | | | | | | |
| | | Native Shrub Density (#/acre) | | | | | | | | |
| | | Native Herbaceous Cover (%) | | | | | | | | |
| | | Monoculture Area (%) | | | | | | | | |
| | Bed Form Diversity | Pool Spacing Ratio (ft/ft) | | | 0.22 | | | | | |
| | | Pool Depth Ratio (ft/ft) | 0.7 | 0.00 | | | | | | |
| | | Percent Riffle (%) | 83 | 0.44 | | | | | | |
| Physicochemical | Temperature | Summer Daily Maximum (°F) | | | | | | | | |
| | Bacteria | E. Coli (MPN/100 ml) | | | | | | | | |
| | Nitrogen | Total Nitrogen (mg/L) | | | | | | | | |
| | Phosphorus | Total Phosphorus (mg/L) | | | | | | | | |
| | Suspended Sediment | Total Suspended Solids (mg/L) | | | | | | | | |
| | | Turbidity (NTU) | | | | | | | | |
| Biology | Macroinvertebrates | EPT Taxa Present | | | | | | | | |
| | Fish | South Carolina Biotic Index | | | | | | | | |

# Attachment 4

## Consultation Documentation

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| | |
|---|---|
| **From:** | Elizabeth Miller <MillerE@dnr.sc.gov> |
| **Sent:** | Thursday, December 21, 2023 1:33 PM |
| **To:** | Crutchfield Jr., John U; Abney, Michael A; Amy Breedlove; Dan Rankin; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; Morgan Kern; SelfR; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Lorianne Riggin; Tom Daniel |
| **Cc:** | Kulpa, Sarah; Huff, Jen; McCarney-Castle, Kerry; Salazar, Maggie; Mularski, Eric |
| **Subject:** | RE: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW) |
| **Attachments:** | 20231221 Impacts to Surface Waters and Associated Aquatic Fauna Draft Report_SCDNR Comments.docx |
| | |
| **Categories:** | Bad Creek |

Hi John,

Staff with the South Carolina Department of Natural Resources (SCDNR) have reviewed the Bad Creek Hydroelectric Project's Impacts to Surface Waters and Associated Aquatic Fauna Draft Report. We appreciated the opportunity to discuss our concerns and ask questions during the December 18th meeting. As discussed during the meeting, the SCDNR is providing a summary of our comments in the attached document by the extended deadline. Please let me know if you have any questions.

Thank you,

Elizabeth

Elizabeth C. Miller
SCDNR
Office: 843-953-3881
Cell: 843-729-4636

---

**From:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Sent:** Friday, November 17, 2023 1:50 PM
**To:** Abney, Michael A <Michael.Abney@duke-energy.com>; Amy Chastain <BreedloveA@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; John Haines <jhains@g.clemson.edu>; Lynn Quattro <QuattroL@dnr.sc.gov>; Olds, Melanie J <melanie_olds@fws.gov>; Morgan Amedee <amedeemd@dhec.sc.gov>; Morgan Kern <KernM@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; William T. Wood <WoodW@dnr.sc.gov>
**Cc:** Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Huff, Jen <Jen.Huff@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>; Mularski, Eric -

HDRInc <Eric.Mularski@HDRInc.com>
**Subject:** Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)
**Importance:** High

Dear Bad Creek Relicensing Aquatic Resources Committee:

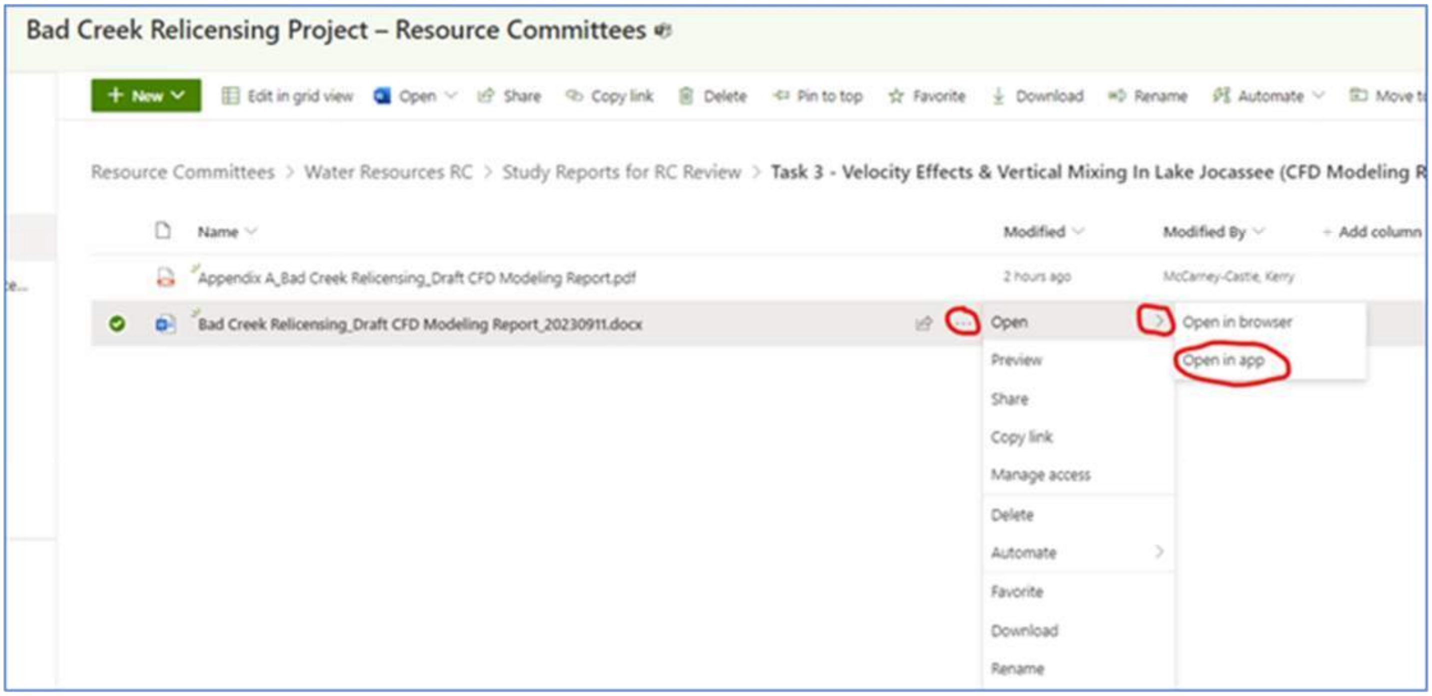
Duke Energy is pleased to distribute the Aquatic Resources Study Task 3 draft report *Impacts to Surface Waters and Associated Aquatic Fauna* for stakeholder review. The report (.doc) and associated attachments (.pdf) are available on the Bad Creek Relicensing SharePoint site at the following link: Task 3 - Impacts to Surface Waters and Associated Aquatic Fauna  Draft Report.

Duke Energy is requesting a three-week review period, therefore, please submit all comments by **December 8th**. 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!*])



Bad Creek Relicensing Project – Resource Committees

Resource Committees > Water Resources RC > Study Reports for RC Review > Task 3 - Velocity Effects & Vertical Mixing In Lake Jocassee (CFD Modeling R

| Name | Modified | Modified By |
|---|---|---|
| Appendix A_Bad Creek Relicensing_Draft CFD Modeling Report.pdf | 2 hours ago | McCarney-Castle, Kerry |
| Bad Creek Relicensing_Draft CFD Modeling Report_20230911.docx | | |

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:** Elizabeth Miller; Lorianne Riggin; Tom Daniel; Dan Rankin; William T. Wood; Amy Breedlove
**Cc:** Stuart, Alan Witten; Kulpa, Sarah; Settevendemio, Erin; Mularski, Eric; Abney, Michael A; Wahl, Nick; McCarney-Castle, Kerry
**Subject:** Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary
**Date:** Thursday, December 21, 2023 3:51:07 PM
**Attachments:** image001.png
SCDNR_SQT Tool conversation_Dec18_20231221.docx
**Importance:** High

---

Dear Elizabeth, Lorianne, Tom, Dan, William, and Amy:

Please find attached a draft summary of our meeting on 12/18/2023 regarding discussion concerning the Impacts to Surface Waters and Associate Aquatic Fauna Draft Report.  You can access the draft meeting summary by using the Bad Creek Relicensing SharePoint site link below or use the attached Word document, whichever you prefer.

SCDNR_SQT Tool conversation_Dec18_20231221.docx

We would appreciate if SC DNR could review and provide any comments on the meeting summary by Friday, 12/29/2023 so we can incorporate into the Initial Study Report to be filed with FERC by 1/4/2024.

Please let Alan of me know if you have any questions.

Thanks, and Best Holiday Wishes!

***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:** Stuart, Alan Witten; Kulpa, Sarah; Settevendemio, Erin; Abney, Michael A; Wahl, Nick; Mularski, Eric; McCarney-Castle, Kerry; Huff, Jen
**Subject:** FW: [EXTERNAL] RE: Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary
**Date:** Thursday, December 21, 2023 4:56:02 PM
**Attachments:** image002.png
image003.png

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**From:** Tom Daniel <DanielT@dnr.sc.gov>
**Sent:** Thursday, December 21, 2023 4:04 PM
**To:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Cc:** Elizabeth Miller <MillerE@dnr.sc.gov>
**Subject:** [EXTERNAL] RE: Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary

Hi John,

I did not intend to give the impression that the SQT does not apply to colluvial valleys. Instead I meant that the SQT tool parameters for floodplain connectivity does not always translate to a high condition score for geomorphology for some high gradient streams. I would recommend the following revision. Sorry for the confusion on my part. Thanks!

*T. Daniel noted the SQT was intended to portray streams with floodplain connectivity, which doesn't ~~really apply~~ always translate to high geomorphology scores for some colluvial river systems (like the subject streams)*

**Tom Daniel**
Inland Project Manager, Office of Environmental Programs
South Carolina Department of Natural Resources
1000 Assembly Street, PO Box 167
Columbia, SC  29202
Office: 803-734-3766
Mobile: 803-240-4826
danielt@dnr.sc.gov
www.dnr.sc.gov/environmental

Empowering South Carolinians to *Live Life Outdoors*

---

**From:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Sent:** Thursday, December 21, 2023 3:50 PM
**To:** Elizabeth Miller <MillerE@dnr.sc.gov>; Lorianne Riggin <RigginL@dnr.sc.gov>; Tom Daniel <DanielT@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; William T. Wood <WoodW@dnr.sc.gov>; Amy Chastain <BreedloveA@dnr.sc.gov>
**Cc:** Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Mularski, Eric -HDRInc <Eric.Mularski@HDRInc.com>; Abney, Michael A <Michael.Abney@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>
**Subject:** Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary
**Importance:** High

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SCDNR_SQT Tool conversation_Dec18_20231221.docx

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Please let Alan of me know if you have any questions.

Thanks, and Best Holiday Wishes!

***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:** Elizabeth Miller; Lorianne Riggin; Tom Daniel; Dan Rankin; William T. Wood; Amy Breedlove
**Cc:** Stuart, Alan Witten; Kulpa, Sarah; Settevendemio, Erin; Mularski, Eric; Abney, Michael A; Wahl, Nick; McCarney-Castle, Kerry
**Subject:** RE: [EXTERNAL] RE: Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary
**Date:** Friday, December 22, 2023 11:00:35 AM
**Attachments:** image003.png
image004.png
image005.png

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Elizabeth: Per request, use the SharePoint Wildlife and Botanical Resource Committee link below to access the kmz files.

Wildlife and Botanical RC

Regards,
John

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**From:** Elizabeth Miller <MillerE@dnr.sc.gov>
**Sent:** Friday, December 22, 2023 10:25 AM
**To:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Lorianne Riggin <RigginL@dnr.sc.gov>; Tom Daniel <DanielT@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; William T. Wood <WoodW@dnr.sc.gov>; Amy Chastain <BreedloveA@dnr.sc.gov>
**Cc:** Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Mularski, Eric -HDRInc <Eric.Mularski@HDRInc.com>; Abney, Michael A <Michael.Abney@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>
**Subject:** [EXTERNAL] RE: Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary

Hi John,

Yes, we would like access to the stream feature kmz files if possible.

Thank you,

Elizabeth

Elizabeth C. Miller

SCDNR
Office: 843-953-3881
Cell: 843-729-4636

---

**From:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Sent:** Friday, December 22, 2023 6:28 AM
**To:** Elizabeth Miller <MillerE@dnr.sc.gov>; Lorianne Riggin <RigginL@dnr.sc.gov>; Tom Daniel <DanielT@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; William T. Wood <WoodW@dnr.sc.gov>; Amy Chastain <BreedloveA@dnr.sc.gov>
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PDF Bad Creek_Fisher Knob Access Road NRA_20231117.pdf

Please let Alan or me know if you have any questions.

Regards,

John

---

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**Sent:** Thursday, December 21, 2023 3:50 PM
**To:** Elizabeth Miller <MillerE@dnr.sc.gov>; rigginl@dnr.sc.gov; Tom Daniel <danielt@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; William Wood <woodw@dnr.sc.gov>; Amy Breedlove <BreedloveA@dnr.sc.gov>
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Thanks, and Best Holiday Wishes!

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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:** Lorianne Riggin
**To:** Crutchfield Jr., John U; Elizabeth Miller; Tom Daniel; Dan Rankin; William T. Wood; Amy Breedlove
**Cc:** Stuart, Alan Witten; Kulpa, Sarah; Settevendemio, Erin; Mularski, Eric; Abney, Michael A; Wahl, Nick; McCarney-Castle, Kerry
**Subject:** RE: [EXTERNAL] RE: Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary
**Date:** Sunday, December 31, 2023 5:38:46 AM
**Attachments:** image001.png
image002.png
image003.png
image004.png
20231227 SCDNR SQT Tool conversation Dec18 20231221 SCDNR edits.docx

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Good Morning Brandon,

Please see attached comments from SCDNR on the notes.

Thanks,
Lorianne

Lorianne Riggin
Office of Environmental Programs Director, SCDNR
Office 803-734-4199
Cell 803-667-2488
1000 Assembly Street, PO Box 167
Columbia, SC 29202
www.dnr.sc.gov/environmental

---

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**Sent:** Friday, December 22, 2023 11:00 AM
**To:** Elizabeth Miller <MillerE@dnr.sc.gov>; Lorianne Riggin <RigginL@dnr.sc.gov>; Tom Daniel <DanielT@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; William T. Wood <WoodW@dnr.sc.gov>; Amy Chastain <BreedloveA@dnr.sc.gov>
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**Subject:** RE: [EXTERNAL] RE: Bad Creek Relicensing Impacts to Surface Waters and Associated

Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary

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🗀 Wildlife and Botanical RC

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John

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***** 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.

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John

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Office 980-373-2288| Cell 919-757-1095

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# Meeting Summary

Project: Bad Creek Pumped Storage Project Relicensing

Subject: SCDNR Comments on Aquatic Resources Impacts to Surface Waters Report

Date: Monday, December 18, 2023

Location: Microsoft Teams

**Attendees (virtual meeting)**

John Crutchfield, Duke Energy
Alan Stuart, Duke Energy
Nick Wahl, Duke Energy
Sarah Kulpa, HDR
Erin Settevendemio, HDR
Kerry McCarney-Castle, HDR
Eric Mularski, HDR

William Wood, SCDNR
Elizabeth Miller, SCDNR
Lorianne Riggin, SCDNR
Tom Daniel, SCDNR
Amy Chastain, SCDNR
Dan Rankin, SCDNR

## Introduction

John Crutchfield welcomed participants and opened the meeting. The purpose of the meeting was to discuss comments/concerns from the South Carolina Department of Natural Resources (SCDNR) on the Aquatic Resources Study Impacts to Surface Waters Report submitted by Duke Energy and, more specifically, how the South Carolina Stream Quantification Tool (SQT) was applied to stream reaches in the vicinity of the Bad Creek Project that may be impacted by construction of a new temporary access road.

## Discussion

Elizabeth Miller began the discussion by asking about individual stream segments and why they were split into upstream and downstream reaches (upstream and downstream of road crossings) instead of one whole reach.

Nick Wahl and Erin Settevendemio indicated that in each of the spots where the temporary access road could potentially cause impacts, dividing the stream into segments (upstream and downstream) would allow a control reach (reference reach) upstream if there was a need to conduct monitoring during construction or decommissioning of the temporary road.

Lorianne Riggin asked if there were bank pins/markers or ~~bank pin points~~coordinates to established where cross sections were taken on each reach; coordinates were provided to mark the upstream and downstream extents~~ to mark the reaches~~…the SQT needs the appropriate length of stream input to dictate representative functioning of a stream and while you can do less than less than 20 bank full widths, one still would need to survey for 2 meander wave-lengths and wondered if HDR was able to capture at least 2 meander wavelengths of stream reach for the assessed streams.

E. Settevendemio indicated HDR did capture a representative length for each stream assessed however, because these are headwater mountain streams, they are not sinuous, which is why the approach of 100 feet upstream and downstream of the stream crossing was used as the approach for a total of 200 feet of stream reach. Longitudinal station numbers were recorded to note exact location of cross sections; however, bank pins were not installed.

L. Riggin asked specifically about Howard Creek where there is 20x bank full width entered in the SQT, which would have been 350 feet of stream length, so there would likely have been 2 meander wavelengths captured. E. Settevendemio confirmed that 2 meander wavelengths would have been captured at that site. L. Rigg~~e~~in stated that the data shows the upstream reach had four riffles and downstream there was only one. E. Settevendemio stated the downstream reach was different from the upstream reach because there was a log ~~functioning as an impoundment~~impounding water, as well as a cascade, so it was very different from upstream conditions.

Alan Stuart asked if pulling up a Google Earth would help; E. Settevendemio noted there's not enough resolution/too much vegetation to see the individual stream reaches on typical imagery.

E. Settevendemio asked, in general, how different stream types are dealt with in the SQT – for instance on a small stream (A1+) with bedrock cascades (no riffle features, disconnected from the floodplain). L. Riggin indicated A-type streams are challenging to work with in the SQT because that type of stream usually isn't a stream being modeled with the SQT. Therefore, geomorphological features such as the entrenchment ratio may be skewed (because there may not be an appropriate database or reference curve to pull from). Basically, it is difficult (and possibly not appropriate) to use the SQT for A-type streams. Tom Daniel mentioned if the input stream is an A-type stream but the reference is a B, you can still get an entrenchment value. However, if the reference stream type is an A, then it draws from the A curve then the value comes back as FALSE. The tool will not evaluate entrenchment ratio for A-type streams.

L. Riggin mentioned many of the stream sheets returned FALSE for buffer (buffer land use category) and noted that the drop-down menu for the single family residential (which was discussed during the first meeting in June) should have been selected to capture land use/slope.

- ACTION ITEM: HDR will modify SQT spreadsheet input to "single family residential", thereby fixing the FALSE/ERROR and resulting in more accurate assessment of the stream reach. HDR will also revise buffer valley slopes as needed.

L. Riggin also indicated that for macroinvertebrates and fish up to Level 5 of the SQT tool, measurements under Level 4 must be carried out (i.e., cannot skip levels to go from Level 3 to Level 5), such that total suspended solids (TSS) or turbidity should be measured for the tool to estimate the next level. Results for macroinvertebrates and fish are good to have, but results cannot be entered directly into the SQT tool. Tom Daniel mentioned, while it's not necessarily relevant for this project, when dealing with debits/credits, Level 3 which is partial restoration potential is an important category to have populated.

- ACTION ITEM: HDR will modify SQT spreadsheet input to "Partial Restoration".

A. Stuart asked since TSS/Turbidity wasn't collected, will the SQT not work and is it necessary to go back and collect that data. L. Riggin and T. Daniel replied only Howard Creek would be applicable because of the ~~basin~~ drainage area size requirements – not applicable to all streams – therefore, it likely is not feasible or necessary, especially because the results indicate Howard Creek is fully functional. A. Stuart asked if the data could be collected at a later time; Lorianne indicated turbidity or TSS would need to be ~~4~~ sampled 4 times~~s~~ (quarterly basis) ~~collected~~ during the calendar year – as long as the sample is taken at the same stream reach on the same. Sampling should occur on a pre-established and standardized schedule (e.g., 2nd Tuesday of every 2nd month). Eric Mularski asked if the TSS or turbidity measurements would need to go to a lab for processing and L. Riggin confirmed yes, they must be state lab-certified. T. Daniel reiterated it likely doesn't make sense to go out and collect data now (after the fact) just from Howard Creek. It wouldn't support the tool any further since the stream is already rated as fully function~~ing~~al.

L. Riggin asked if HDR converted LWD (large woody debris) piece count to input into the SQT. E. Settevendemio confirmed.

L. Riggin asked if the bedrock section of Stream 15 (i.e., the cascade reach) continued for 100 feet as is shown on the output. If there were no indicators of bank~~-~~full without any real flow and no defined channel, then SQT might not be appropriate for that reach. E. Settevendemio noted the cascade reach went as far as was visible from the end of the reach.

E. Settevendemio asked about the applicability of the SQT on disappearing streams throughout the reach, as HDR was unsure of how to handle these types of features in the field. L. Riggin indicated choosing different stream breaks would have been the correct option and there is a section in Chapter 3 of the manual that indicates if there is a hard break that changes the features, it's best to choose a representative reach upstream and then after the stream re-emerges, to begin another reference reach. E. Settevendemio stated that HDR had the manual in the field for reference during surveys, and it was still unclear to the surveyors how to approach this type of situation.

E. Miller asked why Stream 15 went from a B-type to a G-type (Rosgen) – Lorianne guessed the upstream end was more of an upstream seepage and then it transitioned into a bedrock cascade. E. Settevendemio concurred and added there was some bank erosion on the G section with an adjacent ~~to a~~ wetland, and therefore was classified as a G instead of B. The wetland ran alongside the stream. E. Mularski indicated the area had a defined bed and bank.

L. Riggin asked about inputting values into the SQT to compare to Rosgen stream types and decide which reference curve the SQT pulls from. For instance, width/depth ratios on Howard Creek, Upstream 16, and downstream Stream 17 were different results than expected (i.e., different results were obtained when she keyed in the parameters vs. what was included in the report). E. Settevendemio noted there are plus/minus values to the Rosgen values that could have resulted in slightly different results. As an example, while the entrenchment ratio for Howard Creek was higher than you would typically see for a B-type stream, the width-depth ratio reflected an F or B type stream classification. Having been in the field and understanding that Howard Creek is in a stable, high-quality condition, and the F-type stream classification does not make sense, therefore it was classified as a B-type stream.

L. Riggin asked HDR to specifically re-assess the Rosgen type~~input~~ for Stream 15 for upstream and downstream and Stream 16 because they may stratify differently in the tool based on different input.

- ACTION ITEM: HDR will evaluate specific sections of streams as suggested by the SCDNR and will provide responses/report revisions in 2024.

T. Daniel indicated there are a few smaller items SCDNR had concerns about:

1. It is unclear how ~~-~~mean depth was calculated (unclear where data are coming from in the output, which cross-section is being used for mean depth (stable) and then everything else dependent on mean depth). E. Settevendemio indicated most of that information is behind the scenes and included in the hidden spreadsheets.

2. Stream 16 (upstream) – on the stable cross section the max depth is 0.78 ft but the actual cross section in the tool and others associated with it are different depths (though riffle 1 is 0.76 added Lorianne, which is very close to 0.78 ft). Overall, it is difficult to figure out which is the representative reach and sometimes they don't match up.
    - ACTION ITEM: E. Settevendemio indicated she would clarify which cross sections were used as the stable cross sections and provide the extra data (from the hidden spreadsheets) and workbooks.
3. The lengths of the riffle sections are confusing – 15 upstream/downstream total length was 12.6 ft and 3.7 ft in the SQT. Riffle 1 was 2 ft and Riffle 2 was <2 ft, so not sure where the total lengths are coming from. E. Settevendemio agreed – riffle lengths were variable but noted the field team consisted of two Rosgen-trained scientists and another familiar with stream geomorphology carrying out the assessments; it was a collaborative effort and best professional judgement was used to agree on specific geomorphological features. L. Riggin agreed A-type streams are difficult to assess.

L. Riggin noted there were several streams that didn't have bank erosion hazard index/near bank stress (BEHI/NBS). Settevendemio responded BEHI NBS measurements were only calculated only at points where erosion was occurring and contributing sediment to the stream. T. Daniel added that outside meander bends are also limited in B-type streams/those with low sinuosity.

L. Riggin stated she had looked at data through the lens of the EPA Rapid Bioassessment Protocol (which was the approach used during the assessment) on how to assess existing function and indicated that most of the streams assessed for the Project are fully functional or partially impaired (with values very close to fully functional) according to the U.S. Army of Corps Charleston District Guidelines High Gradient Stream Assessment Sheets. E. Settevendemio concurred that the various stream habitat assessments performed for this study indicate that these streams are fully functional.

T. Daniel indicated the SQT scores are good/high already, and with the additional modifications, the scores will only go up. E. Settevendemio acknowledged she was surprised the scores weren't higher initially. T. Daniel noted the SQT was intended to portray streams with floodplain connectivity, which doesn't really apply to colluvial rivers (like the subject streams). L. Riggin added that the highest score the streams can attain is 0.6 (due to only the first three functional levels being assessed).

E. Settevendemio asked for clarification if it was important to go back out to Howard Creek for turbidity/TSS. L. Riggin indicated it would likely be a waste of time for this exercise as the score for Howard Creek already indicates a fully functioning stream. It would not really change the value or output greatly in the SQT~~advance this exercise for SQT application~~; however, she deferred to E. Miller for overall scope and need for the purposes the stakeholders wanted to evaluate these streams.

L. Riggin asked how long the temporary access roads would be in place – A. Stuart indicated they would be in for the duration of the Bad Creek II Powerhouse construction (up to 7 years).

Dan Rankin asked how the roads would be constructed (if they would be Coweta-style roads, using bridges as opposed to culverts and broad-based dips, etc.). A. Stuart indicated impacts will be minimized to the extent practicable, using bridges instead of culverts, and noted the bridges will be removed – they are plain metal expansion bridges. A. Stuart noted if D. Rankin has any information for Coweta-style broad based on dip roads, Duke Energy would appreciate reviewing. A. Stuart asked about dips and if they are in certain areas near the creeks or if they are used throughout the road extent. D. Rankin indicated the object is to get the water off the road to prevent erosion of the fill; broad based dips get water off roads in small volumes (low energy flow).

- ACTION ITEM: D. Rankin said he would ask Randy Fowler for information on the roads and send along information to Duke Energy.

L. Riggin noted if we are doing bridges that span~~s~~ the creeks with no fill below ordinary high water mark (OHWM), there would be no 404 permit/mitigation required: however, she wondered if the concept plans are far enough along to know about the specifics/designs (any grading below OHWM or fill associated with stabilization of the banks for bridge installation). A. Stuart indicated the engineering design is not far enough along yet to make any determinations. A. Stuart indicated road designs would be provided as soon as they become available.

E. Mularski indicated a WOTUS survey has been carried out for the streams that may be impacted by the access roads and will be used in the road design.

- ACTION ITEM: Duke Energy/HDR to send the Natural Resources Assessment report and stream feature KMZ for the temporary access road to SCDNR. (Note this report is presently being finalized by the Duke Energy and HDR teams.)

Regarding collection of TSS/turbidity, E. Miller reiterated since Howard Creek is already fully functioning, she doesn't ~~not~~ think it necessary to collect that data. D. Rankin acknowledged the abundance of turbidity data already existing for Howard Creek, but also noted it may be of value to measure turbidity downstream.

The group discussed what is needed and timing for comments and responses, relative to the pending Initial Study Report (ISR) deadline (January 4). SCDNR will submit written comments by Friday December 22. Sarah Kulpa indicated that in the ISR, Duke Energy will include the draft (version sent to Resources Committee for review) Aquatic Resources Study Impacts to Surface Waters Report, with SCDNR's [pending] comments attached. The ISR will note that this meeting was held, and Duke Energy will continue to collaborate with the SCDNR to address comments for the final Aquatic Resources Study Impacts to Surface Waters Report.

The meeting adjourned at the close of the hour. John thanked everyone for their participation in this process.

**From:** Crutchfield Jr., John U
**To:** Elizabeth Miller; Lorianne Riggin; Tom Daniel; Dan Rankin; William T. Wood; Amy Breedlove
**Cc:** Stuart, Alan Witten; Kulpa, Sarah; Settevendemio, Erin; Mularski, Eric; Abney, Michael A; Wahl, Nick; McCarney-Castle, Kerry
**Subject:** RE: Bad Creek Relicensing Impacts to Surface Waters and Associated Aquatic Fauna Draft Report - 12/18/2023 Meeting Summary REVISED
**Date:** Tuesday, January 9, 2024 12:52:46 PM
**Attachments:** image002.png
20231218 Bad Creek Meeting SCDNR Comments on Aquatic Resources Report Discussion.docx
**Importance:** High

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Dear Elizabeth, Lorianne, Tom, Dan, William, and Amy:

Please find attached the revised December 18, 2023 meeting summary regarding the Impacts to Surface Waters and Associated Aquatic Fauna Draft Report. This meeting summary incorporates edits received from Lorianne and Tom.

The revised meeting summary can also be accessed via the Bad Creek Relicensing SharePoint site by using the link provided below:

20231218 Meeting to discuss SCDNR Comments on Aquatic Resources Report

Please let Alan and me know if you have any questions or further comments.

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 Summary

| | |
|---|---|
| Project: | Bad Creek Pumped Storage Project Relicensing |
| Subject: | SCDNR Comments on Aquatic Resources Impacts to Surface Waters Report Discussion |
| Date: | Monday, December 18, 2023 |
| Location: | Microsoft Teams |

**Attendees (virtual meeting)**

John Crutchfield, Duke Energy
Alan Stuart, Duke Energy
Nick Wahl, Duke Energy
Sarah Kulpa, HDR
Erin Settevendemio, HDR
Kerry McCarney-Castle, HDR
Eric Mularski, HDR

William Wood, SCDNR
Elizabeth Miller, SCDNR
Lorianne Riggin, SCDNR
Tom Daniel, SCDNR
Amy Chastain, SCDNR
Dan Rankin, SCDNR

## Introduction

John Crutchfield welcomed participants and opened the meeting. The purpose of the meeting was to discuss comments/concerns from the South Carolina Department of Natural Resources (SCDNR) on the Aquatic Resources Study Impacts to Surface Waters Report submitted by Duke Energy and, more specifically, how the South Carolina Stream Quantification Tool (SQT) was applied to stream reaches in the vicinity of the Bad Creek Project that may be impacted by construction of a new temporary access road.

## Discussion

Elizabeth Miller began the discussion by asking about individual stream segments and why they were split into upstream and downstream reaches (upstream and downstream of road crossings) instead of one whole reach.

Nick Wahl and Erin Settevendemio indicated that in each of the spots where the temporary access road could potentially cause impacts, dividing the stream into segments (upstream and downstream) would allow a control reach (reference reach) upstream if there was a need to conduct monitoring during construction or decommissioning of the temporary road.

Lorianne Riggin asked if there were bank pins/markers or coordinates to established where cross sections were taken on each reach; coordinates were provided to mark the upstream and downstream extents…the SQT needs the appropriate length of stream input to dictate representative functioning of a stream and while you can do less than less than 20 bank full widths, one still would need to survey for 2 meander wave-lengths and wondered if HDR was able to capture at least 2 meander wavelengths of stream reach for the assessed streams.

E. Settevendemio indicated HDR did capture a representative length for each stream assessed however, because these are headwater mountain streams, they are not sinuous, which is why the approach of 100 feet upstream and downstream of the stream crossing was used as the approach for a total of 200 feet of stream reach. Longitudinal station numbers were recorded to note exact location of cross sections; however, bank pins were not installed.

L. Riggin asked specifically about Howard Creek where there is 20x bank full width entered in the SQT, which would have been 350 feet of stream length, so there would likely have been 2 meander wavelengths captured. E. Settevendemio confirmed that 2 meander wavelengths would have been captured at that site. L. Riggin stated that the data shows the upstream reach had four riffles and downstream there was only one. E. Settevendemio stated the downstream reach was different from the upstream reach because there was a log impounding water, as well as a cascade, so it was very different from upstream conditions.

Alan Stuart asked if pulling up a Google Earth would help; E. Settevendemio noted there's not enough resolution/too much vegetation to see the individual stream reaches on typical imagery.

E. Settevendemio asked, in general, how different stream types are dealt with in the SQT – for instance on a small stream (A1+) with bedrock cascades (no riffle features, disconnected from the floodplain). L. Riggin indicated A-type streams are challenging to work with in the SQT because that type of stream usually isn't a stream being modeled with the SQT. Therefore, geomorphological features such as the entrenchment ratio may be skewed (because there may not be an appropriate database or reference curve to pull from). Basically, it is difficult (and possibly not appropriate) to use the SQT for A-type streams. Tom Daniel mentioned if the input stream is an A-type stream but the reference is a B, you can still get an entrenchment value. However, if the reference stream type is an A, then it draws from the A curve then the value comes back as FALSE. The tool will not evaluate entrenchment ratio for A-type streams.

L. Riggin mentioned many of the stream sheets returned FALSE for buffer (buffer land use category) and noted that the drop-down menu for the single family residential (which was discussed during the first meeting in June) should have been selected to capture land use/slope.

- ACTION ITEM: HDR will modify SQT spreadsheet input to "single family residential", thereby fixing the FALSE/ERROR and resulting in more accurate assessment of the stream reach. HDR will also revise buffer valley slopes as needed.

L. Riggin also indicated that for macroinvertebrates and fish up to Level 5 of the SQT tool, measurements under Level 4 must be carried out (i.e., cannot skip levels to go from Level 3 to Level 5), such that total suspended solids (TSS) or turbidity should be measured for the tool to estimate the next level. Results for macroinvertebrates and fish are good to have, but results cannot be entered directly into the SQT tool. Tom Daniel mentioned, while it's not necessarily relevant for this project, when dealing with debits/credits, Level 3 which is partial restoration potential is an important category to have populated.

- ACTION ITEM: HDR will modify SQT spreadsheet input to "Partial Restoration".

A. Stuart asked since TSS/Turbidity wasn't collected, will the SQT not work and is it necessary to go back and collect that data. L. Riggin and T. Daniel replied only Howard Creek would be applicable because of the drainage area size requirements – not applicable to all streams – therefore, it likely is not feasible or necessary, especially because the results indicate Howard Creek is fully functional. A. Stuart asked if the data could be collected at a later time; Lorianne indicated turbidity or TSS would need to be sampled 4 times (quarterly basis) during the calendar year – as long as the sample is taken at the same stream reach on the same. Sampling should occur on a pre-established and standardized schedule (e.g., 2nd Tuesday of every 2nd month). Eric Mularski asked if the TSS or turbidity measurements would need to go to a lab for processing and L. Riggin confirmed yes, they must be state lab-certified. T. Daniel reiterated it likely doesn't make sense to go out and collect data now (after the fact) just from Howard Creek. It wouldn't support the tool any further since the stream is already rated as fully functional.

L. Riggin asked if HDR converted LWD (large woody debris) piece count to input into the SQT. E. Settevendemio confirmed.

L. Riggin asked if the bedrock section of Stream 15 (i.e., the cascade reach) continued for 100 feet as is shown on the output. If there were no indicators of bankfull without any real flow and no defined channel, then SQT might not be appropriate for that reach. E. Settevendemio noted the cascade reach went as far as was visible from the end of the reach.

E. Settevendemio asked about the applicability of the SQT on disappearing streams throughout the reach, as HDR was unsure of how to handle these types of features in the field. L. Riggin indicated choosing different stream breaks would have been the correct option and there is a section in Chapter 3 of the manual that indicates if there is a hard break that changes the features, it's best to choose a representative reach upstream and then after the stream re-emerges, to begin another reference reach. E. Settevendemio stated that HDR had the manual in the field for reference during surveys, and it was still unclear to the surveyors how to approach this type of situation.

E. Miller asked why Stream 15 went from a B-type to a G-type (Rosgen) – Lorianne guessed the upstream end was more of an upstream seepage and then it transitioned into a bedrock cascade. E. Settevendemio concurred and added there was some bank erosion on the G section with an adjacent wetland, and therefore was classified as a G instead of B. The wetland ran alongside the stream. E. Mularski indicated the area had a defined bed and bank.

L. Riggin asked about inputting values into the SQT to compare to Rosgen stream types and decide which reference curve the SQT pulls from. For instance, width/depth ratios on Howard Creek, Upstream 16, and downstream Stream 17 were different results than expected (i.e., different results were obtained when she keyed in the parameters vs. what was included in the report). E. Settevendemio noted there are plus/minus values to the Rosgen values that could have resulted in slightly different results. As an example, while the entrenchment ratio for Howard Creek was higher than you would typically see for a B-type stream, the width-depth ratio reflected an F or B type stream classification. Having been in the field and understanding that Howard Creek is in a stable, high-quality condition, and the F-type stream classification does not make sense, therefore it was classified as a B-type stream.

L. Riggin asked HDR to specifically re-assess the Rosgen type for Stream 15 for upstream and downstream and Stream 16 because they may stratify differently in the tool based on different input.

- ACTION ITEM: HDR will evaluate specific sections of streams as suggested by the SCDNR and will provide responses/report revisions in 2024.

T. Daniel indicated there are a few smaller items SCDNR had concerns about:

1. It is unclear how mean depth was calculated (unclear where data are coming from in the output, which cross-section is being used for mean depth (stable) and then everything else dependent on mean depth). E. Settevendemio indicated most of that information is behind the scenes and included in the hidden spreadsheets.

2. Stream 16 (upstream) – on the stable cross section the max depth is 0.78 ft but the actual cross section in the tool and others associated with it are different depths (though riffle 1 is 0.76 added Lorianne, which is very close to 0.78 ft). Overall, it is difficult to figure out which is the representative reach and sometimes they don't match up.
    - ACTION ITEM: E. Settevendemio indicated she would clarify which cross sections were used as the stable cross sections and provide the extra data (from the hidden spreadsheets) and workbooks.
3. The lengths of the riffle sections are confusing – 15 upstream/downstream total length was 12.6 ft and 3.7 ft in the SQT. Riffle 1 was 2 ft and Riffle 2 was <2 ft, so not sure where the total lengths are coming from. E. Settevendemio agreed – riffle lengths were variable but noted the field team consisted of two Rosgen-trained scientists and another familiar with stream geomorphology carrying out the assessments; it was a collaborative effort and best professional judgement was used to agree on specific geomorphological features. L. Riggin agreed A-type streams are difficult to assess.

L. Riggin noted there were several streams that didn't have bank erosion hazard index/near bank stress (BEHI/NBS). Settevendemio responded BEHI NBS measurements were only calculated only at points where erosion was occurring and contributing sediment to the stream. T. Daniel added that outside meander bends are also limited in B-type streams/those with low sinuosity.

L. Riggin stated she had looked at data through the lens of the EPA Rapid Bioassessment Protocol (which was the approach used during the assessment) on how to assess existing function and indicated that most of the streams assessed for the Project are fully functional or partially impaired (with values very close to fully functional) according to the U.S. Army of Corps Charleston District Guidelines High Gradient Stream Assessment Sheets. E. Settevendemio concurred that the various stream habitat assessments performed for this study indicate that these streams are fully functional.

T. Daniel indicated the SQT scores are good/high already, and with the additional modifications, the scores will only go up. E. Settevendemio acknowledged she was surprised the scores weren't higher initially. T. Daniel noted the SQT was intended to portray streams with floodplain connectivity, which doesn't always translate to high geomorphology scores for some colluvial rivers systems (like the subject streams). L. Riggin added that the highest score the streams can attain is 0.6 (due to only the first three functional levels being assessed).

E. Settevendemio asked for clarification if it was important to go back out to Howard Creek for turbidity/TSS. L. Riggin indicated it would likely be a waste of time for this exercise as the score for Howard Creek already indicates a fully functioning stream. It would not really change the value or output greatly in the SQT; however, she deferred to E. Miller for overall scope and need for the purposes the stakeholders wanted to evaluate these streams.

L. Riggin asked how long the temporary access roads would be in place – A. Stuart indicated they would be in for the duration of the Bad Creek II Powerhouse construction (up to 7 years).

Dan Rankin asked how the roads would be constructed (if they would be Coweta-style roads, using bridges as opposed to culverts and broad-based dips, etc.). A. Stuart indicated impacts will be minimized to the extent practicable, using bridges instead of culverts, and noted the bridges will be removed – they are plain metal expansion bridges. A. Stuart noted if D. Rankin has any information for Coweta-style broad based on dip roads, Duke Energy would appreciate reviewing. A. Stuart asked about dips and if they are in certain areas near the creeks or if they are used throughout the road extent. D. Rankin indicated the object is to get the water off the road to prevent erosion of the fill; broad based dips get water off roads in small volumes (low energy flow).

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The group discussed what is needed and timing for comments and responses, relative to the pending Initial Study Report (ISR) deadline (January 4). SCDNR will submit written comments by Friday December 22. Sarah Kulpa indicated that in the ISR, Duke Energy will include the draft (version sent to Resources Committee for review) Aquatic Resources Study Impacts to Surface Waters Report, with SCDNR's [pending] comments attached. The ISR will note that this meeting was held, and Duke Energy will continue to collaborate with the SCDNR to address comments for the final Aquatic Resources Study Impacts to Surface Waters Report.

The meeting adjourned at the close of the hour. John Crutchfield thanked everyone for their participation in this process.

**From:** Crutchfield Jr., John U
**To:** Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; Morgan Kern; SelfR; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Mularski, Eric
**Cc:** Kulpa, Sarah; McCarney-Castle, Kerry; Salazar, Maggie
**Subject:** Bad Creek Relicensing - Aquatic Resources Task 3 Final Report
**Date:** Wednesday, February 14, 2024 11:56:19 AM
**Attachments:** image001.png
**Importance:** High

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Dear Bad Creek Relicensing Aquatic Resources Committee:

The final report for the Aquatic Resources Task 3 (Impacts to Surface Waters and Associated Aquatic Fauna) is completed and available for distribution to Committee members at the following Bad Creek Relicensing SharePoint site:

FINAL Report

The final report includes supporting attachments and the Comment Response Table (pdf file) which addresses SCDNR review comments.

Please let Alan or me know if you have any questions.

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:** Elizabeth Miller; Lorianne Riggin
**Cc:** Stuart, Alan Witten; Abney, Michael A; Wahl, Nick; Kulpa, Sarah; Settevendemio, Erin; Mularski, Eric; McCarney-Castle, Kerry; Salazar, Maggie
**Subject:** FW: Bad Creek Relicensing - Aquatic Resources Task 3 Final Report
**Date:** Wednesday, February 14, 2024 12:02:41 PM
**Attachments:** image001.png
SQT_Rapid_Method_Workbooks.zip
**Importance:** High

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Elizabeth and Lorianne: Per SCDNR's previous request, please find attached the SC SQT Workbooks (zip file).

Let Alan or me know if you have any questions.

Thanks, John

---

**From:** Crutchfield Jr., John U
**Sent:** Wednesday, February 14, 2024 11:56 AM
**To:** Abney, Michael A <Michael.Abney@duke-energy.com>; Amy Breedlove <BreedloveA@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; John Haines <jhains@g.clemson.edu>; Lynn Quattro <quattrol@dnr.sc.gov>; Melanie Olds <melanie_olds@fws.gov>; Morgan Amedee <amedeemd@dhec.sc.gov>; Morgan Kern <kernm@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; William Wood <woodw@dnr.sc.gov>; Mularski, Eric -HDRInc <Eric.Mularski@HDRInc.com>
**Cc:** Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>
**Subject:** Bad Creek Relicensing - Aquatic Resources Task 3 Final Report
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Regards,
***John Crutchfield***

Project Manager II
Water Strategy, Hydro Licensing & Lake Services
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Office 980-373-2288| Cell 919-757-1095

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| 1. | South Carolina Department of Natural Resources | 12/21/2023 | Table 6-3 | Is the Stream 16 that is listed as a reference reach the same Stream 16 that is proposed to be impacted by the proposed road? If it is the same stream, the SCDNR recommends that streams that are being proposed for impact would not make appropriate reference reaches. | Reference reach selections for comparison of the USEPA Rapid Bioassessment Protocol were based on stream size, stream type, and overall condition. The streams used as reference reaches were in stable, fully functioning condition. Stream 16 was originally used as a reference reach because HDR believed the stream was in reference-reach type condition; furthermore, the no impacts are expected to Stream 16 (or any other stream along the temporary access road), and most particularly, the upstream reach of the streams along the access road which are above the area of activity. Regardless, the use of a reference reach to obtain reference reach index is not a required part of the USEPA RBP analysis and has been removed from the analysis and report. |
| 2. | South Carolina Department of Natural Resources | 12/21/2023 | Table 6-7 | The maximum score should be a 0.6 as the streams were not measured for suspended solids which would be required for any EPT Taxa Present to be used. Due to the drainage area requirements for the use of EPT Taxa in the SC SQT (reference curve stratification), the use of EPT index would have to be used and not included in the tool. | HDR has reviewed the *SQT Data Collection and Analysis Manual*; it is unclear where in the document it is stated that suspended solids are a required measurement alongside macroinvertebrate sampling. HDR acknowledges that this is stated on page 27 of the *SQT User Manual*, however in practical application of this method (field data collection first, followed by data entry to the tool), we recommend that the requirement for TSS be made explicit in the *SQT Data Collection and Analysis Manual*.<br>HDR reduced the maximum score to 0.6 and removed entries for the physiochemical and biological high-level functional classes for all streams. |

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| 3. | South Carolina Department of Natural Resources | 12/21/2023 | Table 6-7 | The upstream extent of Stream 15 is classified as a G but the downstream end an A1a+. Do these sections have a clearly defined bed and bank – a channel? | Yes, both stream reaches exhibited bed and bank features. Additional photographs have been added - see photographs 7 through 9 in Attachment G. |
| 4. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment 2 [B] | All streams should be labeled on the maps and figures should be labeled. | Labels for all streams were added to figures. |
| 5. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment 2 [B] | To avoid confusion and aid in agency review, the SCDNR recommends each stream has its own unique name. For example, Stream 15 is listed in Attachment 1 and 2 as two different streams. | Stream names have been updated to format "Stream #" in the report for clarity; however, stream names in Attachment A (*Aquatic Resources Study Approach to Stream Surveys Memo*) cannot be updated as the streams referenced as "Potential Access Road Crossings" were estimated prior to field surveys. Attachment A was provided to SCDNR and the Aquatic Resources Committee in August 2023 and was included with the ISR for completeness. |
| 6. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment C | On page 47 of the pdf, the assessment for Stream 17/Devils Fork totals 140. However, on page 53 of the assessment, the score for Stream 17 scores 143 and on page 55 of the assessment, Devils Fork scores 155. Please clarify if these scores are redundant scores for a single stream or if they are scores for three different stream reaches. | Labels on data forms have been clarified according to stream locations. Devils Fork was surveyed in two separate locations (one in spoil area G, one at the temporary access road crossing). |
| 7. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment C | Vegetative Protection scores in forested areas typically receive the highest scores to reflect "vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally." Consider upward revisions to streams with lower scores in this metric (e.g., S12, S16, S17/Devils Fork, and S4) | Streams with lower scores for Vegetative Protection were increased per SCDNR's recommendation. |

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| 8. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment C | Riparian Vegetative Zone Width (i.e., riparian buffer width) scores for streams in forested areas should typically receive the highest rating. Consider upward revisions to streams with lower scores in this metric. (e.g., S7/Howard Creek, S12, S15, S16, and S17/Devils Fork) | Streams with lower scores for Riparian Vegetative Zone Width were increased per SCDNR's recommendation. |
| 9. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | The values for Bankfull Mean Depth used in the SQT tool are not disclosed in the materials, nor can the calculations based on Bankfull Mean Depth be replicated using the information provided in the stable riffle cross sections. Please provide the values for Bankfull Mean Depth for all stream reaches and/or show how the values for Bankfull Mean Depth were calculated. | Some of the information in the SC SQT workbooks is hidden and therefore not presented when workbooks were generated as pdfs. The workbooks will be provided to SCDNR for ease of review and transparency. Bankfull mean depth is located in cell V42. |
| 10. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | The Pool Depth Ratio parameter can be very sensitive to changes in the calculations for Bankfull Mean Depth. SCDNR staff were unable to verify Bankfull Mean Depth calculations using the information provided and were therefore unable to verify the values of Pool Depth Ratio for most stream reaches. | Some of the information in the SC SQT workbooks is hidden and therefore not presented when workbooks were generated as pdfs. The workbooks will be provided to SCDNR for their review for ease of review and transparency. Pool depth ratio is located in cell M85. |
| 11. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | The values for Bankfull Max Depth do not always match the values provided in the stable riffle cross section (e.g., LP Creek Up, LP Creek Down, HC Down, UT12 Up, UT15 Down, UT16 Up, UT17 Up), which can influence calculations of BHR and ER. To enable review and QA/QC of the SQT results, please indicate which of the riffle cross sections is the stable riffle cross section. | An asterisk has been added to the Riffle Data which indicates which riffle was used for the stable cross section. |

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| 12. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | To avoid introducing rounding error into calculated parameters, please use full resolution (i.e., unrounded) measurements in all calculations. | Numbers have been updated where needed to avoid rounding. |
| 13. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | The Flood Prone Width for Limber Pole Creek (Downstream) should be verified and/or revised as appropriate. | HDR appreciates SCDNR's thorough review. This number was incorrectly entered as the height of flood prone width (2x max bankfull depth) and has been updated to reflect the flood prone width. |
| 14. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | Many of the riffle stations are very short, sometimes shorter than 5 feet (e.g., 15 U&D (multiple), 16 Up (multiple), 16 Down (R2), 17 Up (R1)). Please note that the term riffle refers to the cascade sections of steep mountain streams. Riffles are measured from head of riffle to head of pool (runs are considered riffles) and so the percent riffle metric would be the complement of percent pool. (i.e., % Riffle = 1 - % Pool). The station lengths (and % riffle parameter) should be verified and revised as appropriate for all reaches, particularly those mentioned above. | Streams 15, 16, and 17 are much smaller than Streams 1 or 7, and therefore have higher frequency of riffles and pools. HDR followed the procedure to include runs as part of riffles, and glides as part of pools. The field surveyors included one Rosgen-trained Biologist and two Water Resources Engineers, one of which is Rosgen trained and the other having prior experience with stream surveying. The delineation of riffles and pools was made on a consensus basis using observation of typical stream geomorphology characteristics such as thalweg slope, surface water slope, water depth, and substrate sorting. The percentage of riffles was also affected by the presence of cascades (e.g., Stream 15) which were not counted as riffles, or stream flow disappearing underground (e.g., Stream 17). Data entry has been reviewed, confirmed and/or adjusted where needed. |
| 15. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | Stream 15 Downstream notes that there wasn't a great bankfull indicator due to a wide bedrock area. Is that representative of the entire 100 feet of Stream 15 downstream? Is there a defined channel at all? If not, SQT may not be an appropriate method for assessing the function of this aquatic feature. | An additional photo of the downstream reach of Stream 15 was added to Attachment G. The steep bedrock area encompassed the entire 100-foot reach and beyond. Bed and bank are present. |

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| 16. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | Stream 16 – notes that 20 times the bankfull width (10.5) is 20.5 – it should be 210. | This has been corrected. |
| 17. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | Please check if the appropriate Rosgen stream type was chosen for Stream 15 Upstream and Stream 16 Downstream. | Both upstream Stream 15 and downstream Stream 16 are entrenched with low width/depth ratio, low sinuosity, and moderate slope, which are all characteristics of G-type streams. Both reaches also exhibit streambank erosion, which is typical of G-type streams. No change was made to the Rosgen classifications for these streams. |
| 18. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | In the cross section measurement depth data, the first and last bankfull depth measurements should always be the edge of the channel (i.e., bankfull depth = 0). Please verify the accuracy of this information as errors in bankfull depth measurements can potentially influence many of the geomorphic ratios. | Agree – cross sections were corrected where needed. |
| 19. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | Please reference Chapter 3 of the SQT Data Collection manual to assess if reach breaks were needed on any streams analyzed (e.g., the stream that went subsurface). | The stream reaches were segmented between "upstream" and "downstream" of the potential temporary access road because the manual states that reaches should be segmented with respect to impact activities. Although no impacts are proposed, the division of the stream reaches at the road crossing is the targeted area of activity related to access road construction. |
| 20. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment F | For Stream 16, please provide coordinates and a photo of the concentrated flow point. | Photo of the concentrated flow point (CFP) has been added to the Attachment G stream photolog – Photo 12. |
| 21. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment J | As stated in the 6/21/2023 meeting summary for the discussion on the SC SQT, for riparian buffer width in the SQT, it was recommended that the Dominant Buffer Land Use for Single | The Dominant Buffer Land Use was updated to apply "Single Family Residential". HDR recommends that the manual provide additional guidance on the selection of this metric, as this |

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| | | | | Family Residential should be used. All of the SQT datasheets do not include the Dominant Buffer Land Use and therefore the Buffer Width values entered are yielding a FALSE index value. This is one of the many stratifications in the SQT that guides the tool which reference curve it should be referencing. This needs to be updated on all the streams measured with SQT. | selection is not intuitive for application to undeveloped areas. |
| 22. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment J | Buffer valley slope values for colluvial valleys are often reported as being less than 10%, with some reported as less than 5%. Please note that the buffer slopes should account for the slope of the adjacent valley. Colluvial, V-shaped valleys are often associated with steep buffer slopes. Please note any considerable changes in buffer valley slope within a given stream reach. | Buffer valley slopes were confirmed or adjusted as necessary based on slope calculated in GIS using two-foot topography for the valleys of each stream reach. Buffer valley slope was updated for Stream 1 US/DS, Stream 7 US/DS, and Stream 12 US/DS. |
| 23. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment J | Most of the stream reaches surveyed with SQT seem to utilize 100 linear feet as the reach to be surveyed. The SQT does allow for less than 20 times the bankfull width to be surveyed so long as it captures at least two meander wavelengths. Some of the streams surveyed would not have meander wavelengths due to them being Rosgen Type B streams – step-pool streams. Of all the streams surveyed does the 100 feet capture at least two meander wavelengths or at least four step-pool features?<br>Why were reaches of streams broken into 100 feet segments – e.g., Limberpole Upstream and Downstream instead of 200 feet of Limberpole being assessed in the SQT? | As stated during the December 18, 2023 virtual meeting between SCDNR, Duke Energy, and HDR, as well as in the Stream Survey Approach Memo, no impacts to streams crossed by the temporary access road are proposed. The 100-foot length per reach was selected with intention to balance the needs of the Bad Creek Pumped Storage Project relicensing and SCDNR's request to use the tool. In the *Data Collection and Analysis Manual,* it states that "if the entire reach is shorter than 20 times the bankfull width, then the entire project reach should be assessed." For the purposes of this analysis, the project area was considered to be 100 feet upstream and downstream of the temporary access road crossing (this is also the area that was delineated |

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| | | | | | for Waters of the U.S.). Therefore, this was the extent that was applied for the SQT.<br>The stream reaches were segmented between "upstream" and "downstream" of the potential temporary access road because the manual states that reaches should be segmented with respect to impact activities. Although no impacts are proposed, the division of the stream reaches at the road crossing is the targeted area of activity related to access road construction. |
| 24. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment J | Consistently throughout, the SQT worksheets include the use of the EPT index entered as the field value instead of EPT taxa present. As discussed in the 6/15/23 comments from SCDNR in response to the 5/24/2023 SQT Meeting Notes, the SCDNR noted that "The Macroinvertebrate reference curves within the SQT are only applicable to perennial streams with a drainage area of 3 square miles or larger. . . We recommend that other metrics are used for macroinvertebrates, like a simple baseline of EPT be established between June 15 and September 15 and monitored post-disturbance within that same time period. DHEC should be consulted and provide input on this recommendation." As previously mentioned, please update all SQT workbooks to remove EPT. | EPT was removed from the SQT worksheets per SCDNR's request. |
| 25. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment J | SQT Limber Pole Creek Upstream – LWD piece count entered as 39.4 but it is 49.2. | Agree – this has been updated. |
| 26. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment J | On all the SQT workbooks, under restoration potential, choose partial in the Site | This has been updated for all stream reaches. |

| No. | Agency | Date Submitted | Report Section | Comment | Duke Energy Response |
|---|---|---|---|---|---|
| | | | | Information and Reference Curve Stratification section. | |
| 27. | South Carolina Department of Natural Resources | 12/21/2023 | Attachment J | On all the SQT workbooks, please make sure the appropriate valley slope is chosen to properly have buffer width field values to reference the appropriate reference curve in the Site Information and Reference Curve Stratification section. Many appear to be lower than expected for Rosgen A or B Type streams. | Buffer valley slopes were confirmed or adjusted as necessary based on slope calculated in GIS using two-foot topography for the valleys of each stream reach. Buffer valley slope was updated for Stream 1 US/DS, Stream 7 US/DS, and Stream 12 US/DS. |
| 28. | South Carolina Department of Natural Resources | 12/21/2023 | N/A | In the meeting held 12/18/23, it was mentioned that the upstream reach for many of these segments was going to be used as a reference for downstream. Keep in mind that it is important to define what the upstream segment may be reference for; for example, if it is for water quality parameters or biology, that makes complete sense. For geomorphology, a reference reach can be within the same ecoregion and the same Rosgen stream type; it doesn't necessarily have to be in the same stream, but it can be. | Duke Energy agrees that the term "reference" reach is not applicable if the upstream and downstream reaches differ in stream type. A more appropriate term would be "comparative" reach, with intent to use the upstream reaches as a control for external, stochastic events which may influence stream condition and function, but not which is caused by activities associated with the temporary access road, such as a large storm event. In combination with "before and after" assessments, this will allow us to evaluate potential effects, if any, with consideration of changes due to natural causes. |

**From:** Crutchfield Jr., John U
**To:** Alex Pellett; Alison Jakupca; Amy Breedlove; Andrew Grosse; Austen Attaway; bereskind; Wes Cooler; Dan Rankin; Andy Douglas; Greg Mixon; jhains@g.clemson.edu; Erika Hollis; Jeff Phillips; Jennifer Kindel; jtk7140@me.com; Keith A. Bradley; Kelly Kirven; Ken Forrester; Kulpa, Sarah; quattrol; Dunn, Lynne; Raber, Maverick James; McCarney-Castle, Kerry; Abney, Michael A; Elizabeth Miller; lputnammitchell@gmail.com; Amedee, Morgan D.; Morgan Kern; Mularski, Eric; Wahl, Nick; Olds, Melanie J; Pat Cloninger; More, Priyanka; Bill Ranson-Retired; SelfR; Rowdy Harris; Salazar, Maggie; Samantha Tessel; Fletcher, Scott T; Scott Harder; Settevendemio, Erin; Chris Starker; Stuart, Alan Witten; Tom Daniel; Dale Wilde; William T. Wood; suewilliams130@gmail.com; simmonsw@dnr.sc.gov; gcyantis2@yahoo.com; Kevin Nebiolo
**Cc:** Lineberger, Jeff
**Subject:** Bad Creek Relicensing Joint Resource Committees Meeting- CHEOPS Modeling Results (Water Resources Task No. 4)--SAVE THE DATE
**Date:** Wednesday, February 21, 2024 5:40:02 PM
**Importance:** High

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Dear Bad Creek Relicensing Resource Committee Stakeholders:

Duke Energy would like to convene a joint meeting of the Water Resources, Aquatic Resources, Recreation & Visual Resources and Operations Resources Committees to review the CHEOPS modeling results including the previously established Performance Measures.

The meeting will be a virtual Teams meeting scheduled for Thursday, April 4, 9 am-12 pm.

A meeting notice will be sent to you in the next few days.

Please let Alan or me know if you have any questions.

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:** Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; gcyantis2; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; Morgan Kern; SelfR; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Mularski, Eric
**Cc:** Kulpa, Sarah; McCarney-Castle, Kerry; Salazar, Maggie
**Subject:** RE: Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report (Available for Review)
**Date:** Friday, May 3, 2024 12:45:56 PM
**Attachments:** image001.png
image002.png
**Importance:** High

---

Dear Bad Creek Relicensing Aquatic Resources Committee:

Duke Energy is pleased to distribute the ***Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report*** for Resource Committee review. This draft report satisfies Task 2 of the Bad Creek Relicensing Aquatic Resources Study. The deliverable is available on the Bad Creek Relicensing SharePoint site at the following folder link: Task 2 - Effects of BCII and Expanded Weir on Aq Habitat. Please make all comments and edits in the Word version using tracked changes. The attachments for the report are provided in the PDF included in the folder.

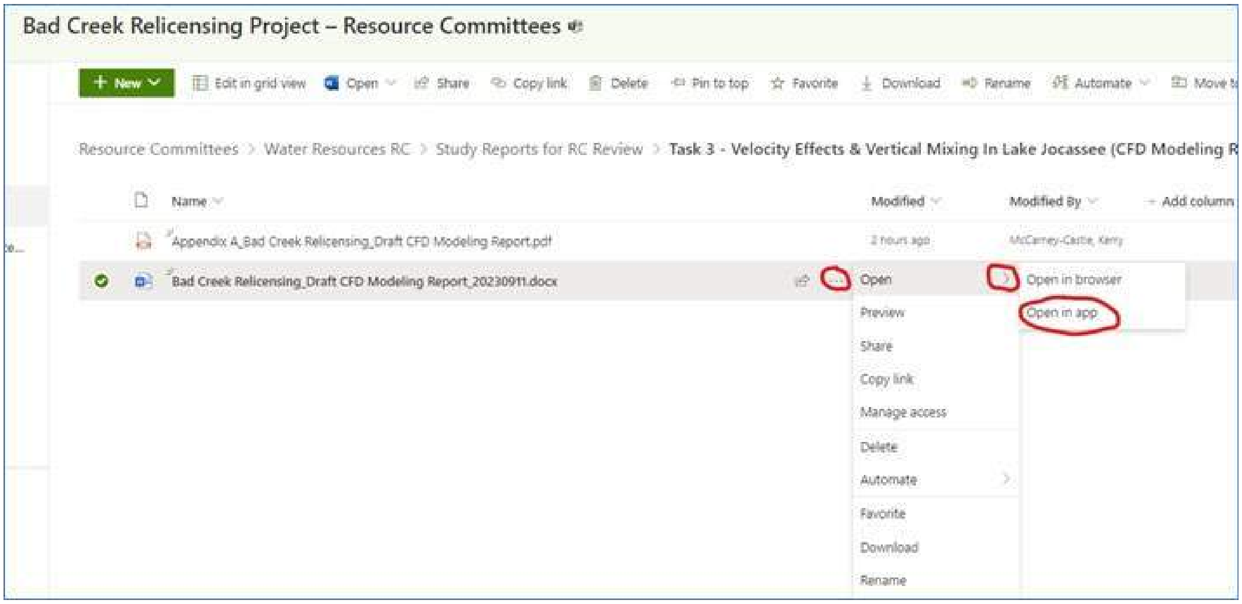
Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **June 3rd**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

-

**Important – Please Read!**

- 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!*])



Bad Creek Relicensing Project – Resource Committees

Resource Committees > Water Resources RC > Study Reports for RC Review > Task 3 - Velocity Effects & Vertical Mixing In Lake Jocassee (CFD Modeling R

| Name | Modified | Modified By |
|---|---|---|
| Appendix A_Bad Creek Relicensing_Draft CFD Modeling Report.pdf | 2 hours ago | McCarney-Castle, Kerry |
| Bad Creek Relicensing_Draft CFD Modeling Report_20230911.docx | | |

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] Effects of Bad Creek II and Expanded Weir on Aquatic Habitat
**Date:** Monday, May 13, 2024 1:53:58 PM

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**From:** Erika Hollis <ehollis@upstateforever.org>
**Sent:** Monday, May 13, 2024 1:48 PM
**To:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Subject:** [EXTERNAL] Effects of Bad Creek II and Expanded Weir on Aquatic Habitat

John,

I have reviewed the draft report and have no comments. Thank you.

Erika J. Hollis
Clean Water Director
Upstate Forever
507 Pettigru St
Greenville, SC 29601
(864) 250-0500 ext. 117
ehollis@upstateforever.org

| | |
|---|---|
| **From:** | Crutchfield Jr., John U |
| **To:** | Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; gcyantis2; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; Morgan Kern; Ross Self; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Mularski, Eric |
| **Cc:** | Kulpa, Sarah; McCarney-Castle, Kerry; Salazar, Maggie |
| **Subject:** | RE: Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Report (FINAL REPORT ISSUANCE) |
| **Date:** | Monday, June 3, 2024 5:31:56 PM |
| **Attachments:** | image003.png |
| **Importance:** | High |

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Dear Bad Creek Relicensing Aquatic Resources Committee:

I wanted to notify you the ***Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Report*** has been finalized and can be accessed at the following link:

PDF 20240603_Aquatic Resources Task 2_Effects of BCII and Expanded Weir on Aq Habitat_Final Report.pdf

Please let Alan or me know if you have any questions.

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:** Olds, Melanie J
**To:** Crutchfield Jr., John U; Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; gcyantis2; jhains@g.clemson.edu; quattrol; Amedee, Morgan D.; Morgan Kern; Ross Self; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Mularski, Eric
**Cc:** Kulpa, Sarah; McCarney-Castle, Kerry; Salazar, Maggie
**Subject:** Re: [EXTERNAL] RE: Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report (Available for Review)
**Date:** Monday, June 3, 2024 8:35:33 AM
**Attachments:** image001.png
image002.png
Outlook-mdfya4ir.png
Outlook-2vz4aai5.png

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John,

The Service has review the Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report and has no comments.

*Melanie*

**Melanie Olds**
*Fish & Wildlife Biologist*
*Regulatory Team Lead/FERC Coordinator*

U.S. Fish and Wildlife Service
South Carolina Ecological Services Field Office
176 Croghan Spur Road, Suite 200
Charleston, SC 29407
Phone: (843) 534-0403

---

**From:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Sent:** Friday, May 3, 2024 12:45 PM
**To:** Abney, Michael A <michael.abney@duke-energy.com>; Amy Breedlove <BreedloveA@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; John Haines <jhains@g.clemson.edu>; quattrol@dnr.sc.gov <quattrol@dnr.sc.gov>; Olds, Melanie J <melanie_olds@fws.gov>; Morgan Amedee <amedeemd@dhec.sc.gov>; Morgan Kern <kernm@dnr.sc.gov>; SelfR@dnr.sc.gov <SelfR@dnr.sc.gov>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; William Wood <woodw@dnr.sc.gov>; Mularski, Eric -HDRInc <Eric.Mularski@HDRInc.com>
**Cc:** Kulpa, Sarah -hdrinc <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>
**Subject:** [EXTERNAL] RE: Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report (Available for Review)

Dear Bad Creek Relicensing Aquatic Resources Committee:

Duke Energy is pleased to distribute the ***Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report*** for Resource Committee review. This draft report satisfies Task 2 of the Bad Creek Relicensing Aquatic Resources Study. The deliverable is available on the Bad Creek Relicensing SharePoint site at the following folder link: 🗀 Task 2 - Effects of BCII and Expanded Weir on Aq Habitat. Please make all comments and edits in the Word version using tracked changes. The attachments for the report are provided in the PDF included in the folder.

Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **June 3rd**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

**Important – Please Read!**

- 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.
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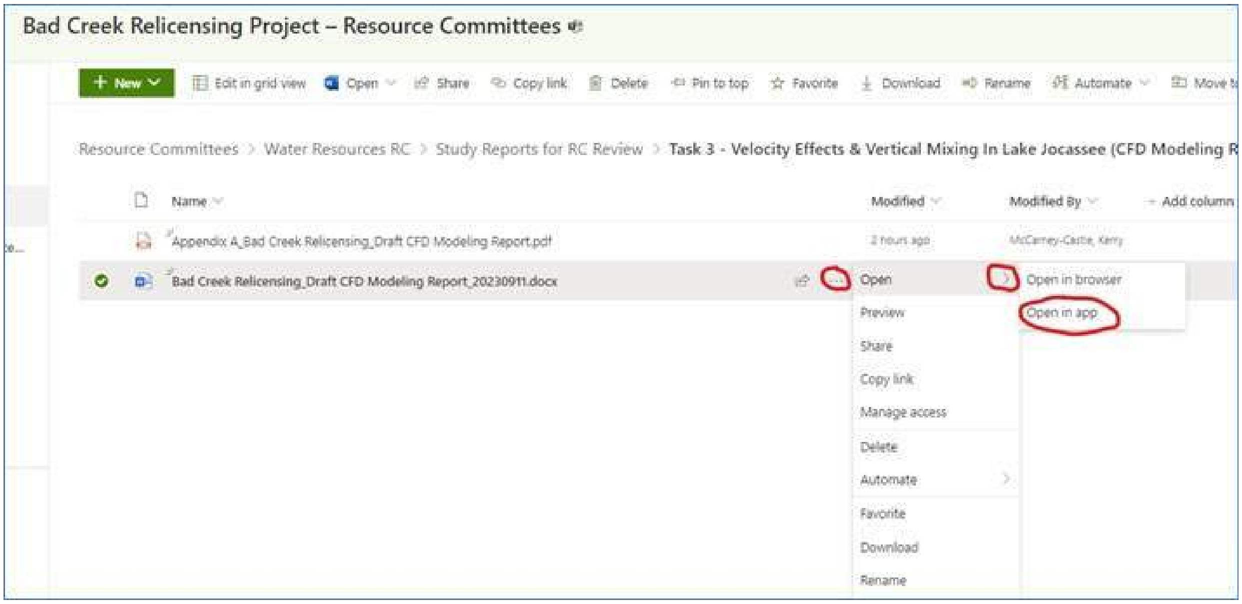
  (Note: If you are new to SharePoint, a very brief tutorial with screenshots is available on the home page of the Resource Committees tab called **"**Editing a Document in SharePoint". This is the same tutorial that was presented during the kick-off meeting. [*The tutorial provides an alternative way to open the document in Word – either technique works!]*)



Bad Creek Relicensing Project – Resource Committees

Resource Committees > Water Resources RC > Study Reports for RC Review > Task 3 - Velocity Effects & Vertical Mixing In Lake Jocassee (CFD Modeling R

| Name | Modified | Modified By |
|---|---|---|
| Appendix A_Bad Creek Relicensing_Draft CFD Modeling Report.pdf | 2 hours ago | McCarney-Castle, Kerry |
| Bad Creek Relicensing_Draft CFD Modeling Report_20230911.docx | | |

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 - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report (Available for Review)
**Date:** Tuesday, June 4, 2024 6:31:03 AM
**Attachments:** image003.png
image004.png

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**From:** gcyantis2@yahoo.com <gcyantis2@yahoo.com>
**Sent:** Monday, June 3, 2024 8:23 PM
**To:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Subject:** [EXTERNAL] RE: Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report (Available for Review)

John,
AQD had no comments.
Thank you,
Gerry

---

**From:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Sent:** Tuesday, May 28, 2024 7:52 AM
**To:** Abney, Michael A <Michael.Abney@duke-energy.com>; Amy Breedlove <BreedloveA@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; John Haines <jhains@g.clemson.edu>; Lynn Quattro <quattrol@dnr.sc.gov>; Melanie Olds <melanie_olds@fws.gov>; Morgan Amedee <amedeemd@dhec.sc.gov>; Morgan Kern <kernm@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; William Wood <woodw@dnr.sc.gov>; Mularski, Eric -HDRInc <Eric.Mularski@HDRInc.com>
**Cc:** Kulpa, Sarah -hdrinc <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>
**Subject:** RE: Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report (Available for Review)

Dear Bad Creek Relicensing Aquatic Resources Committee:

Just a reminder that comments are due on **June 3** for the ***Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report.***

Regards,
John Crutchfield

---

**From:** Crutchfield Jr., John U
**Sent:** Friday, May 3, 2024 12:46 PM

**To:** Abney, Michael A <Michael.Abney@duke-energy.com>; Amy Breedlove <BreedloveA@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; John Haines <jhains@g.clemson.edu>; Lynn Quattro <quattrol@dnr.sc.gov>; Melanie Olds <melanie_olds@fws.gov>; Morgan Amedee <amedeemd@dhec.sc.gov>; Morgan Kern <kernm@dnr.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; William Wood <woodw@dnr.sc.gov>; Mularski, Eric -HDRInc <Eric.Mularski@HDRInc.com>
**Cc:** Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>
**Subject:** RE: Bad Creek Relicensing - Aquatic Resources Task 2: Effects of Bad Creek II and Expanded Weir on Aquatic Habitat Draft Report (Available for Review)
**Importance:** High

Dear Bad Creek Relicensing Aquatic Resources Committee:

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-

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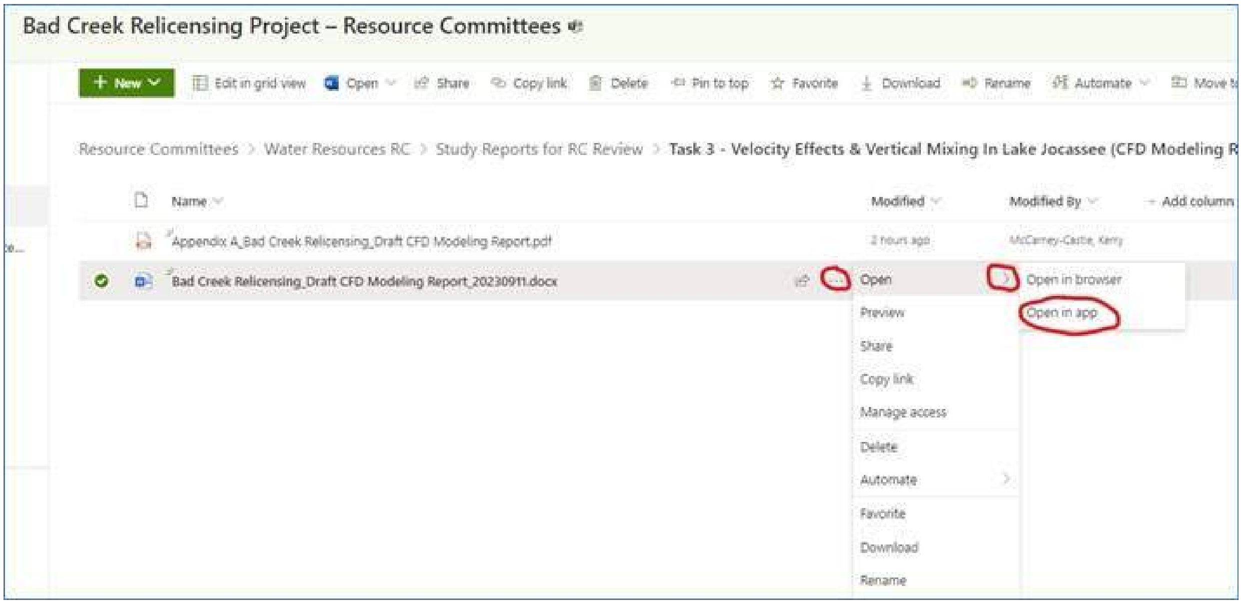

| Name | Modified | Modified By |
|---|---|---|
| Appendix A_Bad Creek Relicensing_Draft CFD Modeling Report.pdf | 2 hours ago | McCarney-Castle, Kerry |
| Bad Creek Relicensing_Draft CFD Modeling Report_20230911.docx | | |

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:** Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; Huff, Jen; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; Ross Self; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Morgan D. Amedee; Ericah Beason
**Cc:** Kulpa, Sarah; Alison Jakupca; Kevin Nebiolo; McCarney-Castle, Kerry; Salazar, Maggie
**Subject:** Bad Creek Relicensing--Fish Entrainment Report Draft Addenda (READY FOR REVIEW)
**Date:** Wednesday, October 30, 2024 1:18:28 PM
**Attachments:** image001.png
image002.png
**Importance:** High

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Dear Bad Creek Relicensing Aquatic Resources Committee:

Duke Energy is pleased to distribute two draft addendum reports associated with the ***Bad Creek Desktop Entrainment Analysis*** for Resource Committee review. The final Desktop Entrainment Analysis study report was distributed with the Initial Study Report as Appendix B, Attachment 1 in January 2024; however, since that time, new technology (i.e., variable speed units) has been proposed for Bad Creek II and existing unit upgrades have been completed, requiring additional entrainment modeling to account for increased pumping rates. Results are presented in Addendum 1. Additionally, in comments dated March 1, 2024, FERC staff requested additional information regarding population growth rate estimates for the Bad Creek entrainment analysis. These results are presented in Addendum 2. The two deliverables are available on the Bad Creek Relicensing SharePoint site at the following link: Entrainment Report Addenda

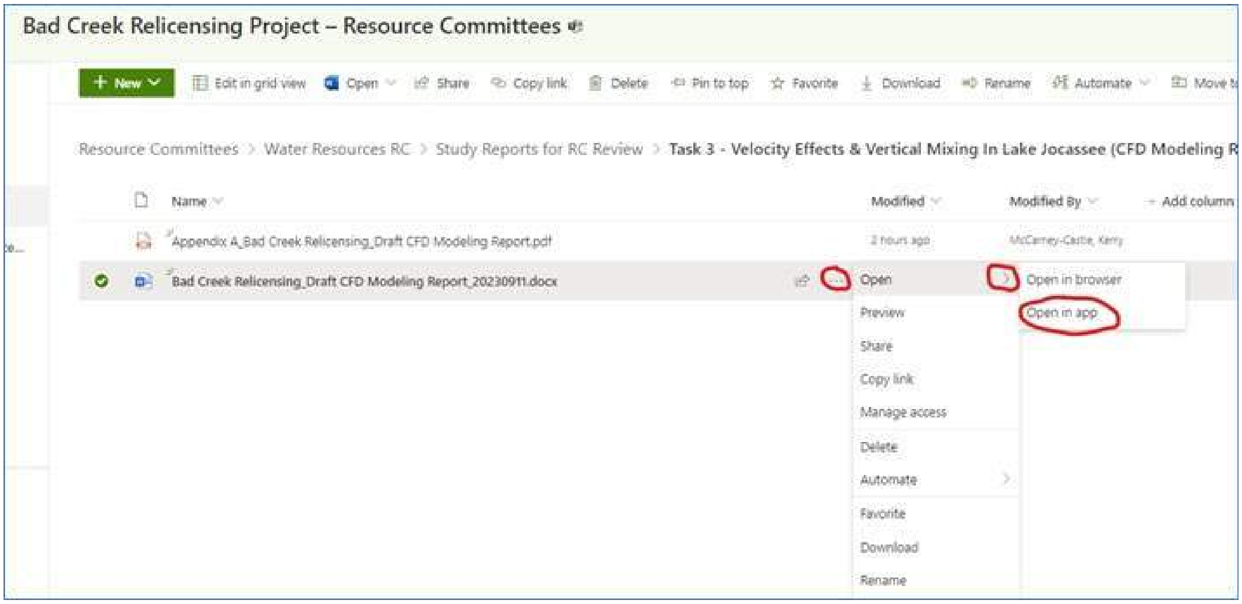
Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **November 28th**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

-

**Important – Please Read!**

- 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!]*)



| Name | Modified | Modified By | Add column |
|---|---|---|---|
| Appendix A_Bad Creek Relicensing_Draft CFD Modeling Report.pdf | 2 hours ago | McCarney-Castle, Kerry | |
| Bad Creek Relicensing_Draft CFD Modeling Report_20230911.docx | | | |

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--Fish Entrainment Report Draft Addenda (READY FOR REVIEW)
**Date:** Monday, November 25, 2024 2:31:20 PM
**Attachments:** image001.png
image002.png

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**From:** Erika Hollis <ehollis@upstateforever.org>
**Sent:** Monday, November 25, 2024 2:21:47 PM
**To:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Subject:** [EXTERNAL] Re: Bad Creek Relicensing--Fish Entrainment Report Draft Addenda (READY FOR REVIEW)

John,

I have reviewed the draft addendum reports for the Bad Creek 2 Entrainment Analysis and Upstate Forever has no comments.

Thank you.

-Erika

Erika J. Hollis
Clean Water Director
Upstate Forever
507 Pettigru St
Greenville, SC 29601
(864) 203-1937
ehollis@upstateforever.org

Upstate Forever is a conservation organization that protects critical lands, waters, and the unique character of the Upstate of South Carolina. Learn more at upstateforever.org.

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**From:** Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
**Date:** Friday, November 22, 2024 at 6:48 AM
**To:** Abney, Michael A <Michael.Abney@duke-energy.com>, Amy Breedlove <BreedloveA@dnr.sc.gov>, Dan Rankin <RankinD@dnr.sc.gov>, Elizabeth Miller <MillerE@dnr.sc.gov>, Erika Hollis <ehollis@upstateforever.org>, Erin Settevendemio <Erin.Settevendemio@hdrinc.com>, Gerry Yantis <gcyantis2@yahoo.com>, Jen Huff <jen.huff@hdrinc.com>, John Haines <jhains@g.clemson.edu>, Lynn Quattro <quattrol@dnr.sc.gov>, Melanie Olds <melanie_olds@fws.gov>, Morgan Amedee <amedeemd@dhec.sc.gov>, Ross Self <SelfR@dnr.sc.gov>, alan.stuart@duke-energy.com <alan.stuart@duke-energy.com>, Wahl, Nick

<Nick.Wahl@duke-energy.com>, William Wood <woodw@dnr.sc.gov>, Morgan D. Amedee <morgan.amedee@des.sc.gov>, Ericah Beason <BeasonE@dnr.sc.gov>
**Cc:** Kulpa, Sarah -hdrinc <Sarah.Kulpa@hdrinc.com>, Alison Jakupca <Alison.Jakupca@KleinschmidtGroup.com>, Kevin Nebiolo <Kevin.Nebiolo@KleinschmidtGroup.com>, Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>, Maggie Salazar <maggie.salazar@hdrinc.com>
**Subject:** RE: Bad Creek Relicensing--Fish Entrainment Report Draft Addenda (READY FOR REVIEW)

Dear Bad Creek Relicensing Aquatic Resources Committee:

Just a reminder that comments are due on the draft addendum reports are due COB on November 28.

Thanks, John

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**From:** Crutchfield Jr., John U
**Sent:** Wednesday, October 30, 2024 1:18 PM
**To:** Abney, Michael A <Michael.Abney@duke-energy.com>; Amy Breedlove <BreedloveA@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Erin Settevendemio <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; Jen Huff <jen.huff@hdrinc.com>; John Haines <jhains@g.clemson.edu>; Lynn Quattro <quattrol@dnr.sc.gov>; Melanie Olds <melanie_olds@fws.gov>; Morgan Amedee <amedeemd@dhec.sc.gov>; Ross Self <SelfR@dnr.sc.gov>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; William Wood <woodw@dnr.sc.gov>; Morgan D. Amedee <morgan.amedee@des.sc.gov>; Ericah Beason <BeasonE@dnr.sc.gov>
**Cc:** Kulpa, Sarah -hdrinc <Sarah.Kulpa@hdrinc.com>; Alison Jakupca <Alison.Jakupca@KleinschmidtGroup.com>; Kevin Nebiolo <Kevin.Nebiolo@KleinschmidtGroup.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>
**Subject:** Bad Creek Relicensing--Fish Entrainment Report Draft Addenda (READY FOR REVIEW)
**Importance:** High

Dear Bad Creek Relicensing Aquatic Resources Committee:

Duke Energy is pleased to distribute two draft addendum reports associated with the ***Bad Creek Desktop Entrainment Analysis*** for Resource Committee review. The final Desktop Entrainment Analysis study report was distributed with the Initial Study Report as Appendix B, Attachment 1 in January 2024; however, since that time, new technology (i.e., variable speed units) has been proposed for Bad Creek II and existing unit upgrades have been completed, requiring additional entrainment modeling to account for increased pumping rates. Results are presented in Addendum 1.  Additionally, in comments dated March 1, 2024, FERC staff requested additional information regarding population growth rate estimates for the Bad Creek entrainment analysis. These results are presented in Addendum 2. The two deliverables are available on the Bad Creek Relicensing SharePoint site at the following link: Entrainment Report Addenda

Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **November 28th**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

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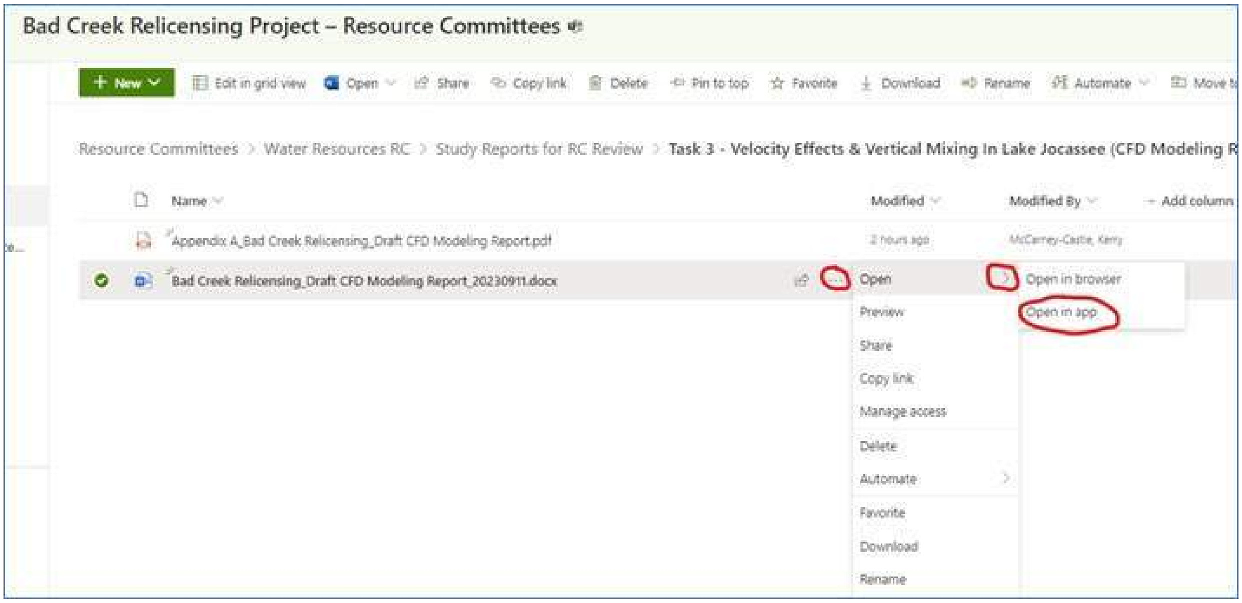

| Name | Modified | Modified By |
|---|---|---|
| Appendix A_Bad Creek Relicensing_Draft CFD Modeling Report.pdf | 2 hours ago | McCarney-Castle, Kerry |
| Bad Creek Relicensing_Draft CFD Modeling Report_20230911.docx | | |

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:** Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; Huff, Jen; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; Ross Self; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Morgan D. Amedee; Ericah Beason
**Cc:** Kulpa, Sarah; Alison Jakupca; Kevin Nebiolo; McCarney-Castle, Kerry; Salazar, Maggie
**Subject:** RE: Bad Creek Relicensing--Fish Entrainment Report Addenda (FINAL)
**Date:** Monday, December 2, 2024 9:04:21 AM
**Attachments:** image001.png
**Importance:** High

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Dear Bad Creek Relicensing Aquatic Resources Committee:

Duke Energy is pleased to distribute the two finalized addenda associated with the ***Bad Creek Desktop Entrainment Analysis*****.** These addenda, along with the final 2023 Desktop Entrainment Report, satisfy Task 1 of the Aquatic Resources Relicensing Study and are accessible from the folder linked below. They will be filed with the Updated Study Report as attachments to the final Entrainment Analysis report (Addendum 1 and Addendum 2). As always, Duke Energy appreciates your participation in the Bad Creek Relicensing.

Entrainment Report Addenda

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
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