Aquatic Resources Study Report

Bad Creek Pumped Storage Project

Oconee County, South Carolina

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1 Project Introduction and Background

Duke Energy Carolinas, LLC (Duke Energy or Licensee) is the owner and operator of the 1,400-megawatt Bad Creek Pumped Storage Project (Project) (FERC Project No. 2740) located in Oconee County, South Carolina, approximately eight miles north of Salem. The Project utilizes the Bad Creek Reservoir as the upper reservoir and Lake Jocassee, which is licensed as part of the Keowee-Toxaway 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, 2024, 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, filed the Updated Study Report (USR) [18 CFR §5.15(c)] January 3, 2025 and held the USR meeting on January 16, 2025. This report 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 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. Documentation of consultation with the Resource Committee is presented in Attachment 4.

Table 1. Aquatic Resources Study Attachments

Study Report Title	Attachment	Attachment Title
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

DESKTOP ENTRAINMENT ANALYSES

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

Prepared for:
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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.

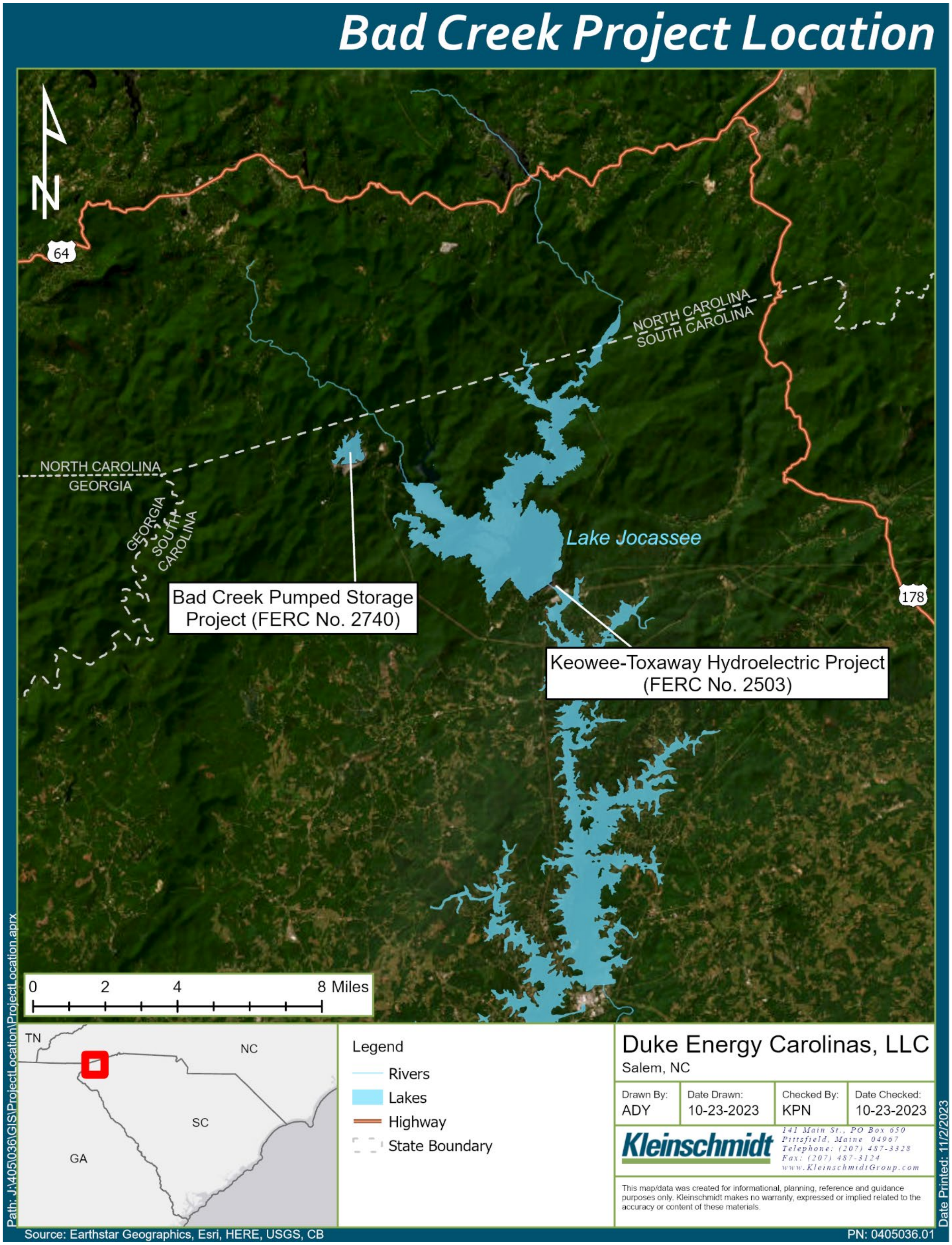

Figure 1.1 Bad Creek Project Location Map

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.

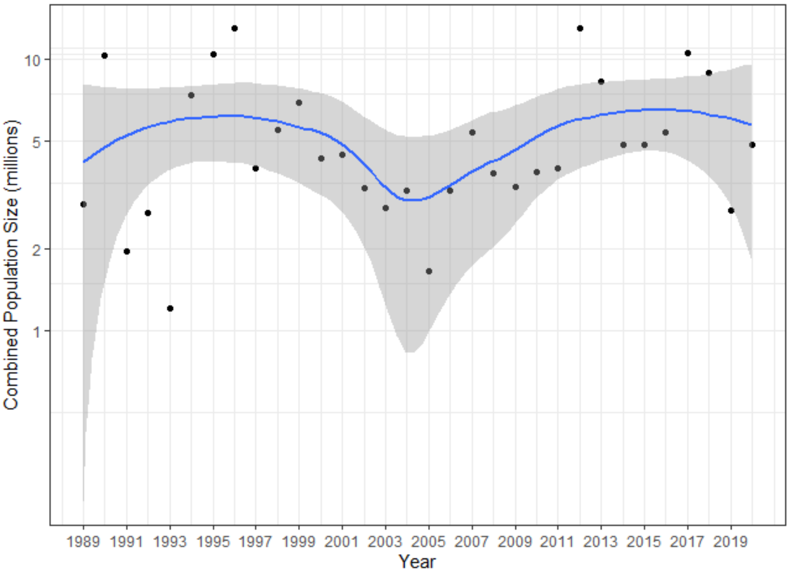

Figure 2.1 Estimated Local Population Size (Combined Species) 1989-2020, with Local Regression Smoother Trend Estimate Overlaid

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).

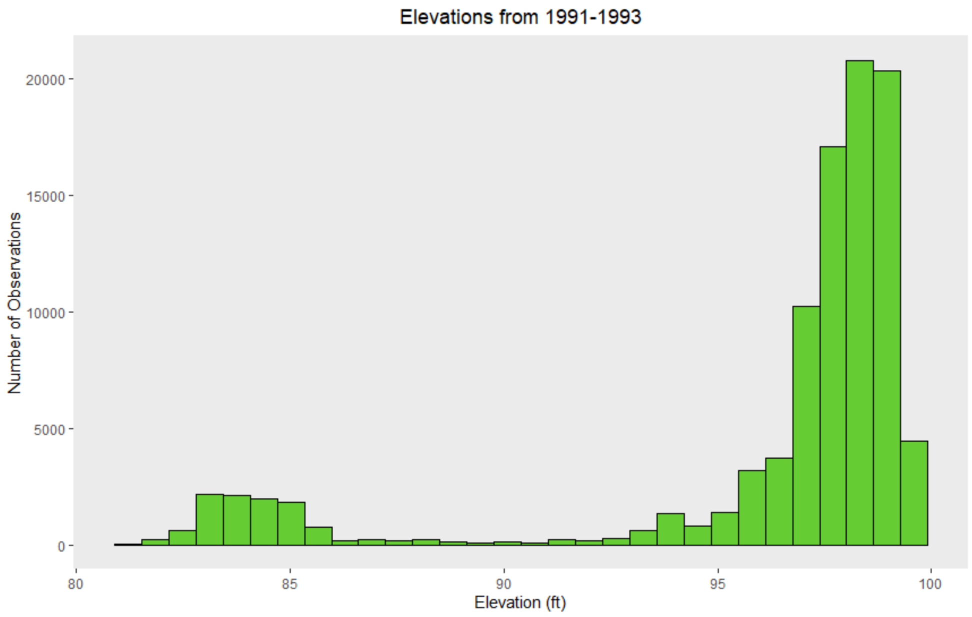

Figure 3.1 **Jocassee Forebay local datum elevation observations from 1991-1993**

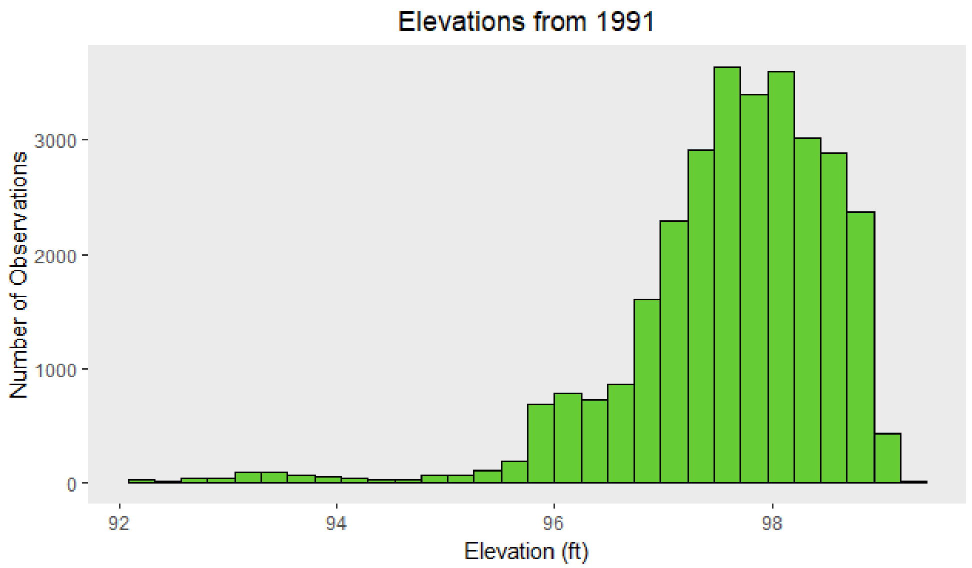

Figure 3.2 **Jocassee Forebay local datum elevation observations in 1991**

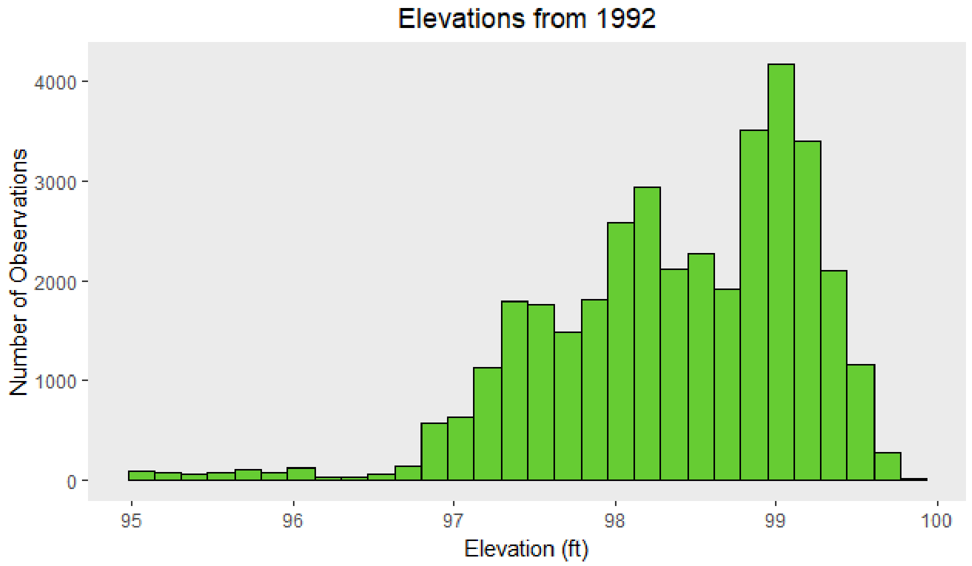

Figure 3.3 Jocassee Forebay local datum elevation observations in 1992

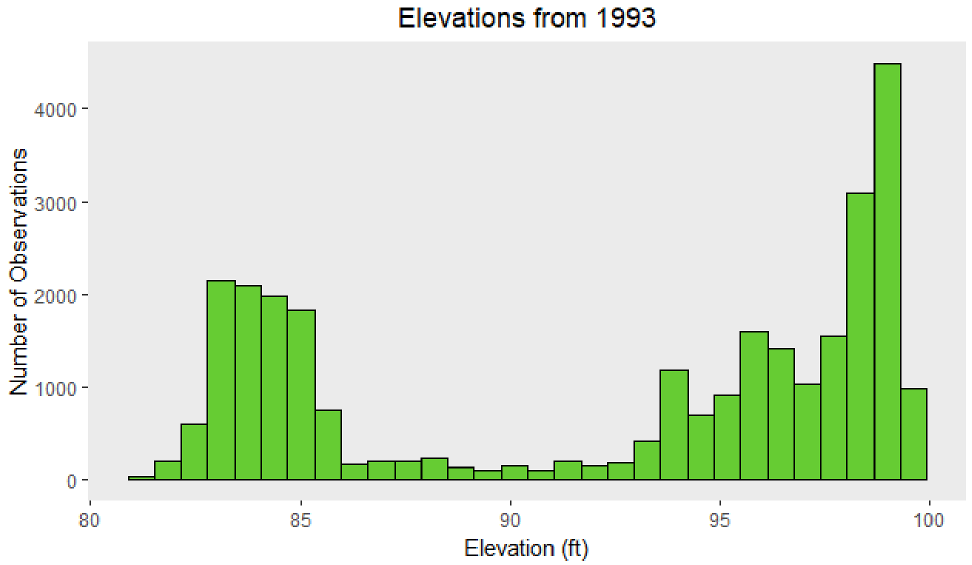

Figure 3.4 Jocassee Forebay local datum elevation observations in 1993

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

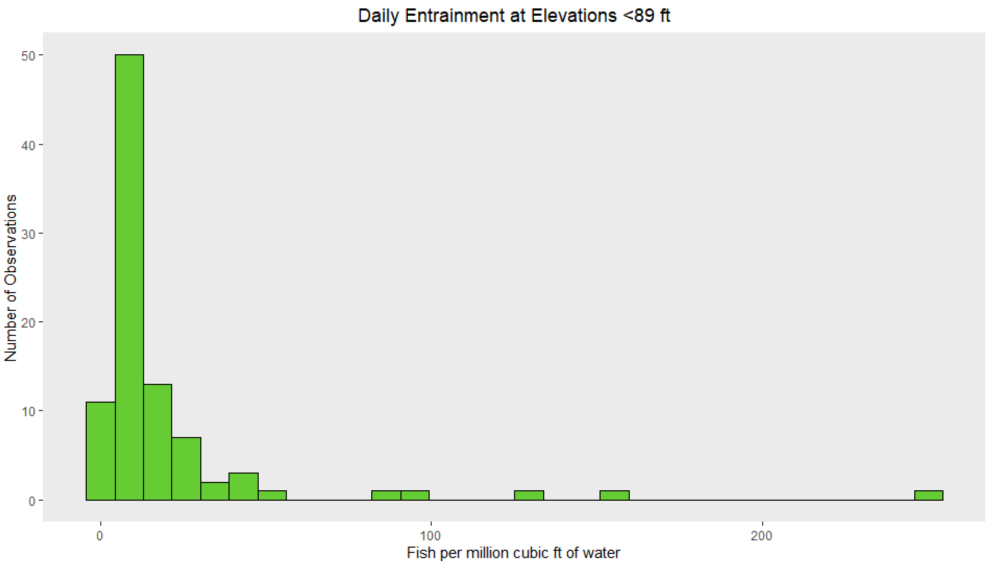

**Figure 3.5	Daily entrainment at elevations less than 89 ft**

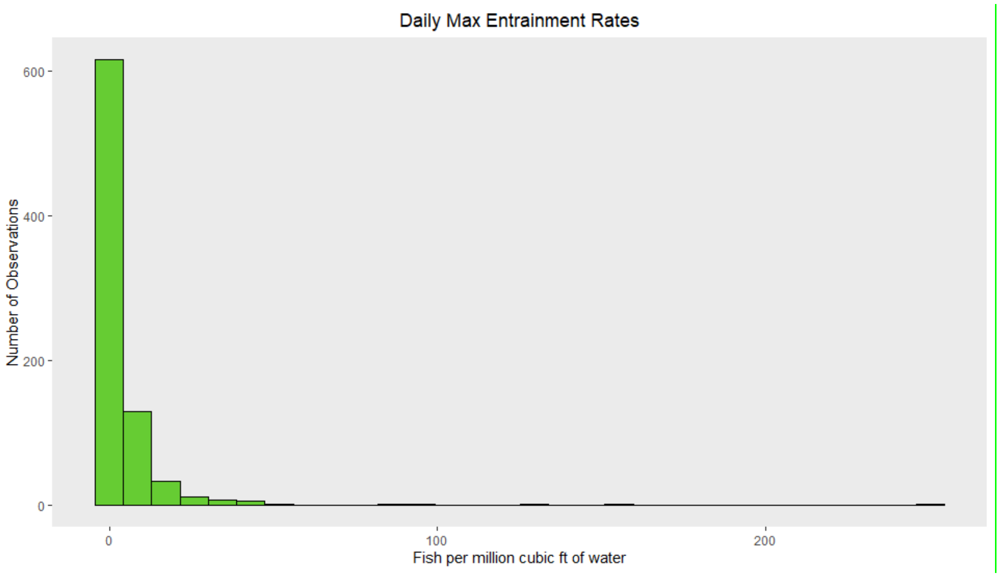

**Figure 3.6	Daily Entrainment Rates from 1991-1993**

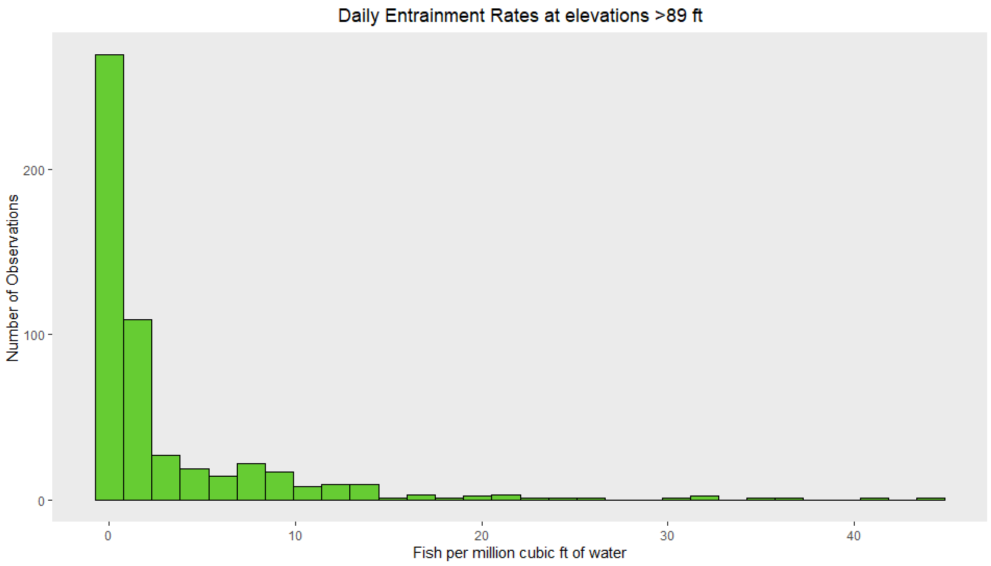

Figure 3.7 Daily entrainment at elevations greater than 89 ft

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

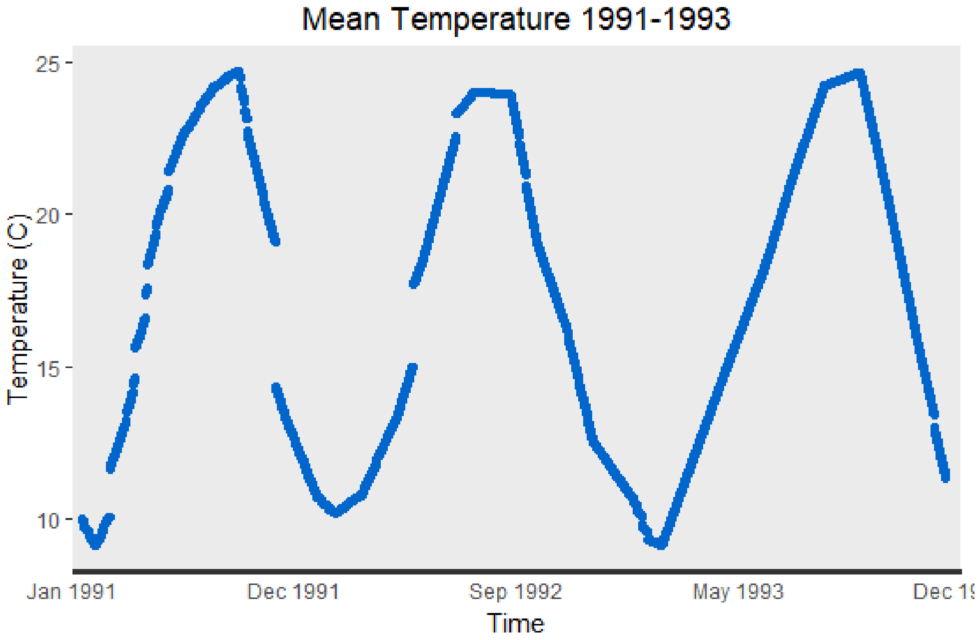

Figure 3.8 Lake Jocassee Mean daily temperature (C) from 1991-1993

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.

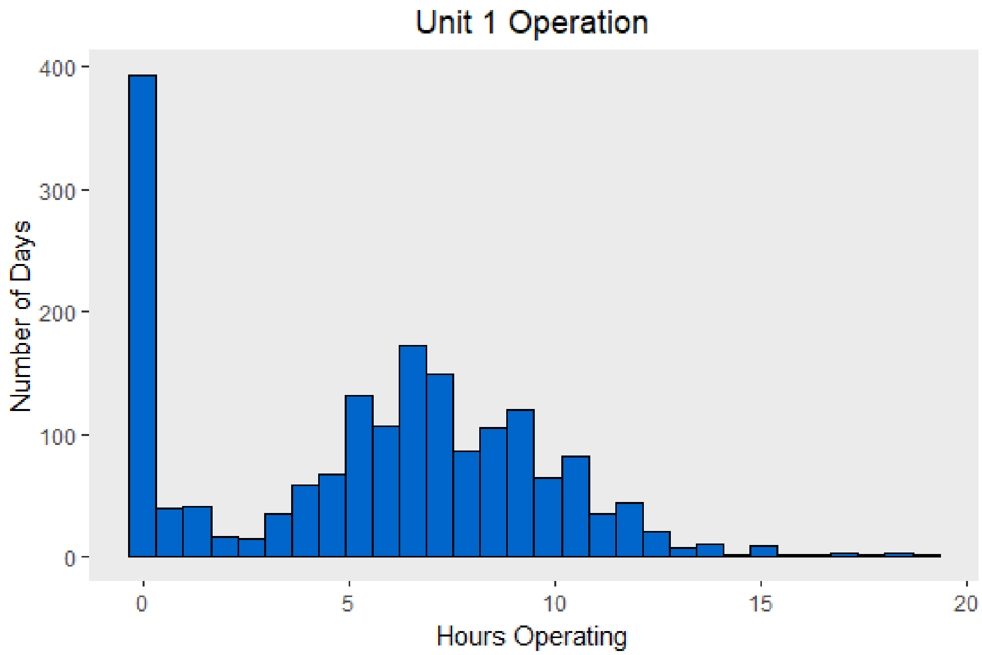

Figure 3.9 Unit 1 Operation

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.

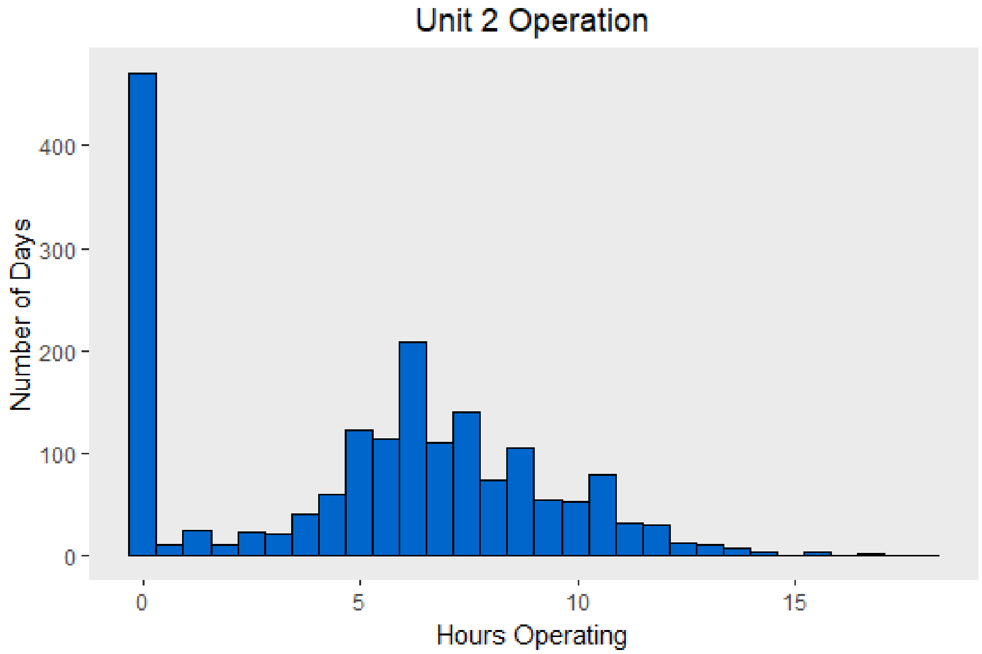

Figure 3.10 Unit 2 Operation

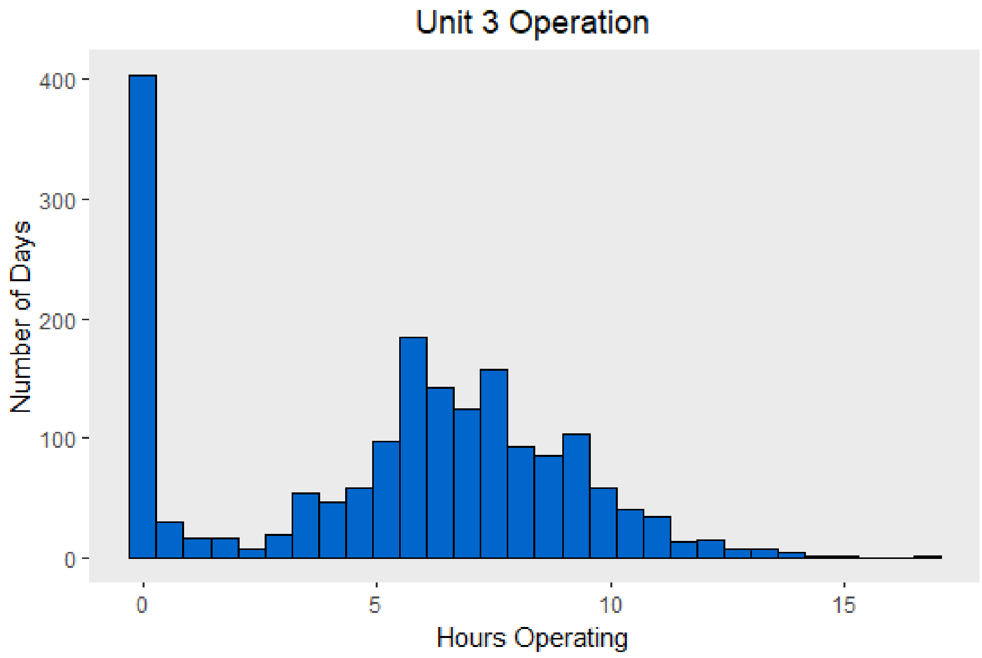

Figure 3.11 Unit 3 Operation

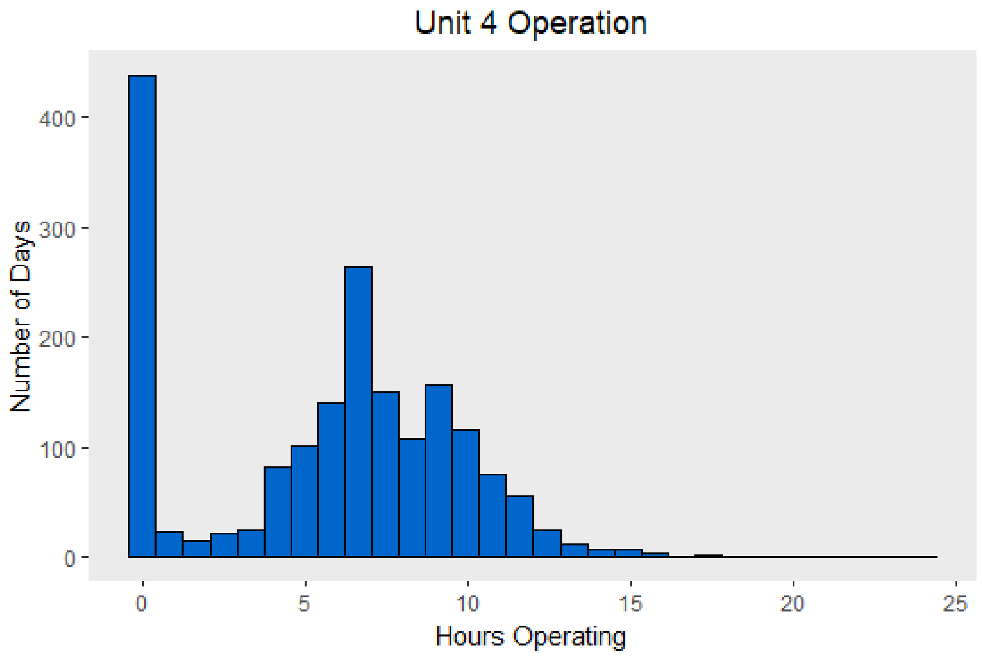

Figure 3.12 Unit 4 Operation

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).

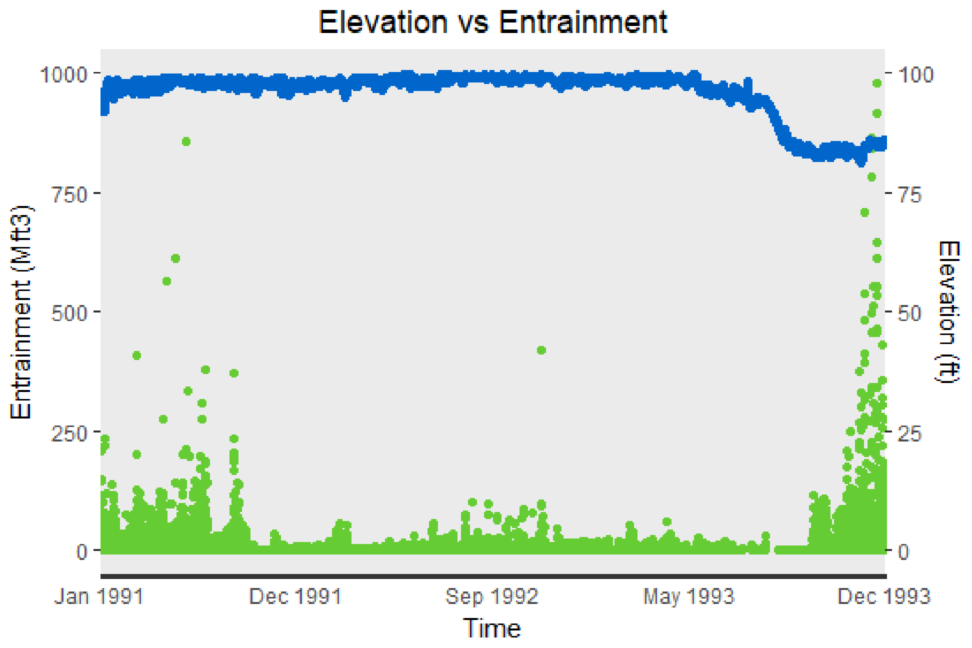

Figure 3.13 Instantaneous elevation and entrainments rate from 1991-1993, green represents the entrainment observations and blue represents the forebay elevation observations.

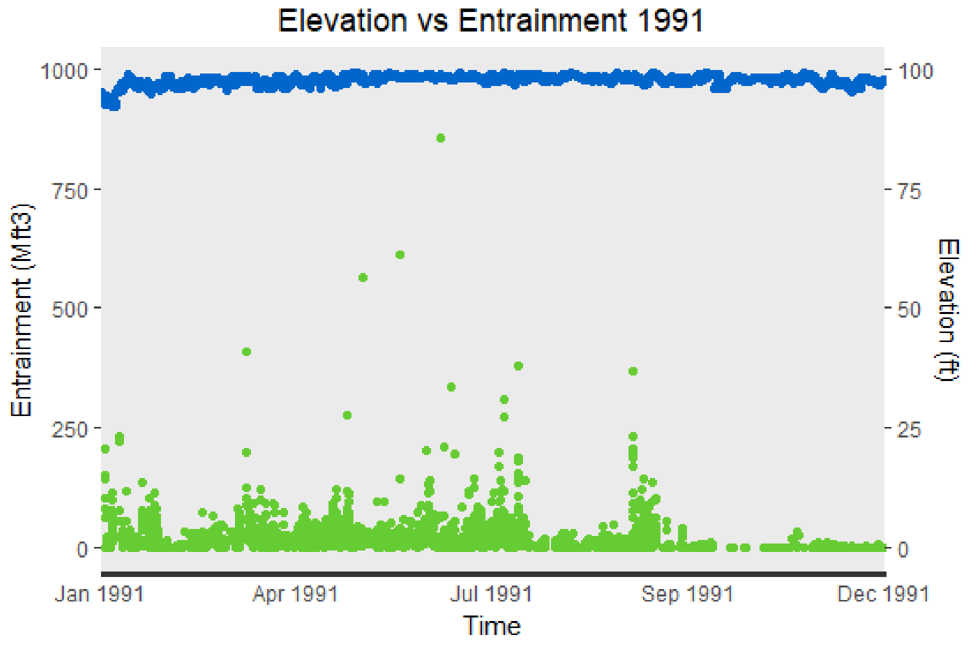

Figure 3.14 1991 Instantaneous elevation and entrainment rate, where green represents the entrainment observations and blue represents the forebay elevation observations.

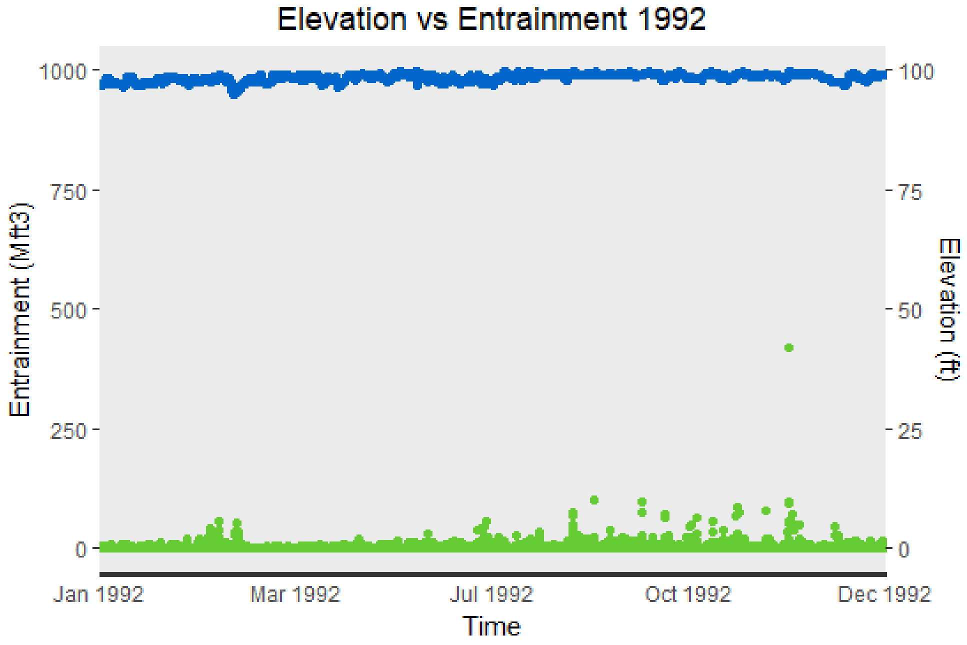

Figure 3.15 1992 Instantaneous elevation and entrainments rate, where green represents the entrainment observations and blue represents the forebay elevation observations.

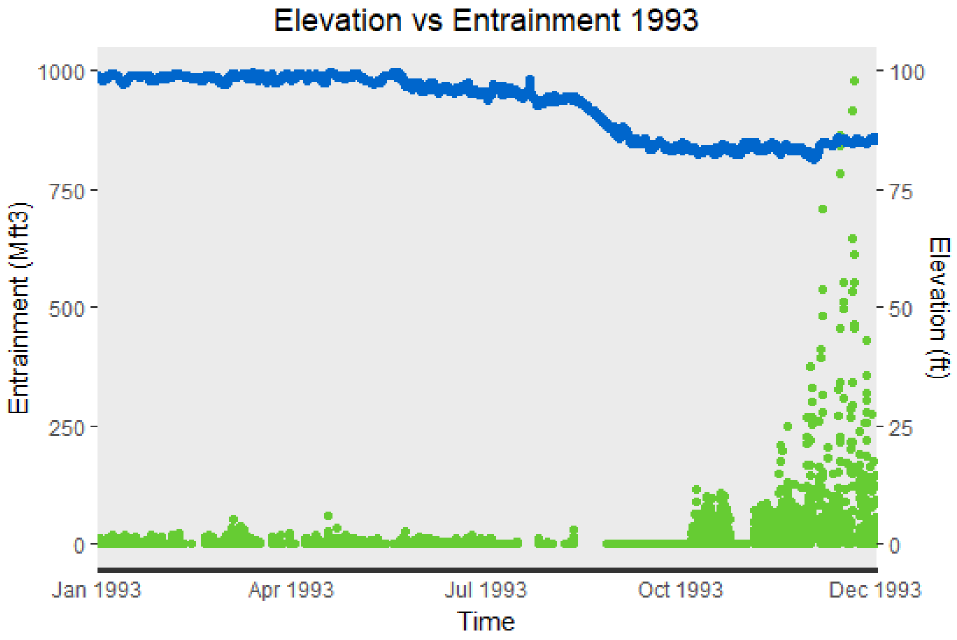

Figure 3.16 1993 Instantaneous elevation and entrainments rate, where green represents the entrainment observations and blue represents the forebay elevation observations.

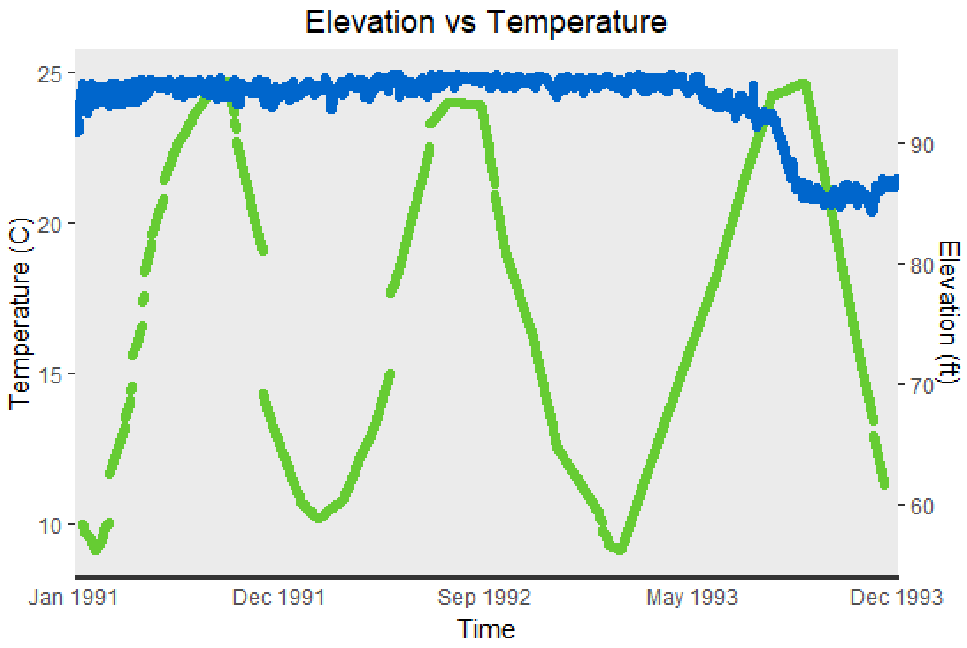

Figure 3.17 Comparison of elevation and temperature data from 1991-1993, with green being temperature and blue being forebay elevation.

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.

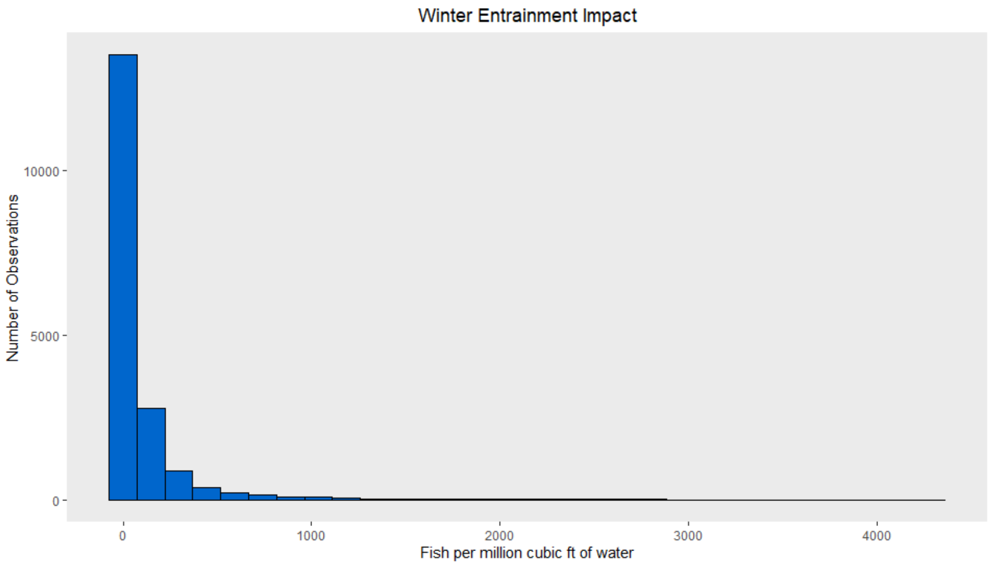

Figure 3.18 Winter Daily Entrainment Impact

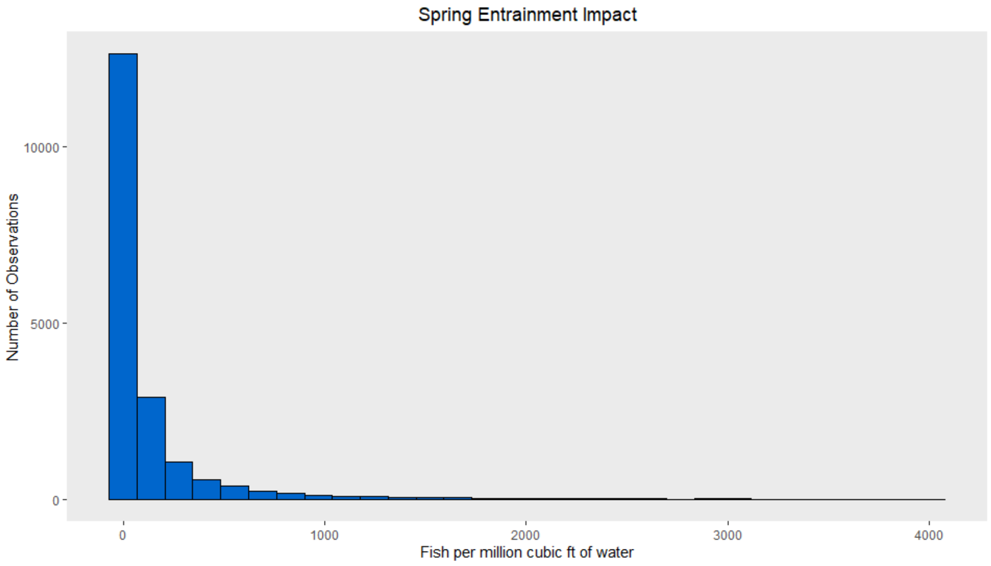

Figure 3.19 Spring Daily Entrainment Impact

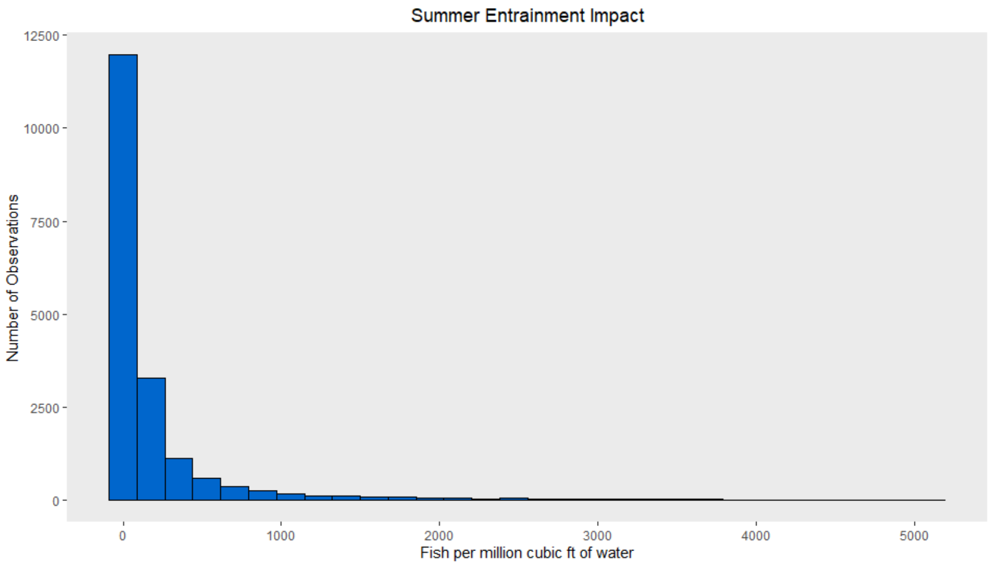

Figure 3.20 Summer Entrainment Impact

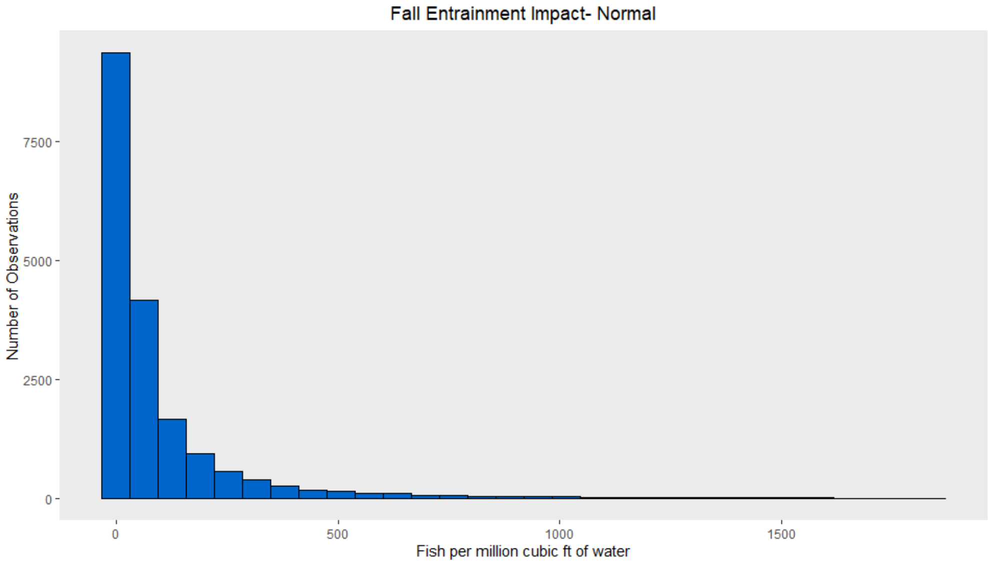

Figure 3.21 Fall Entrainment Impact-High Operating Level

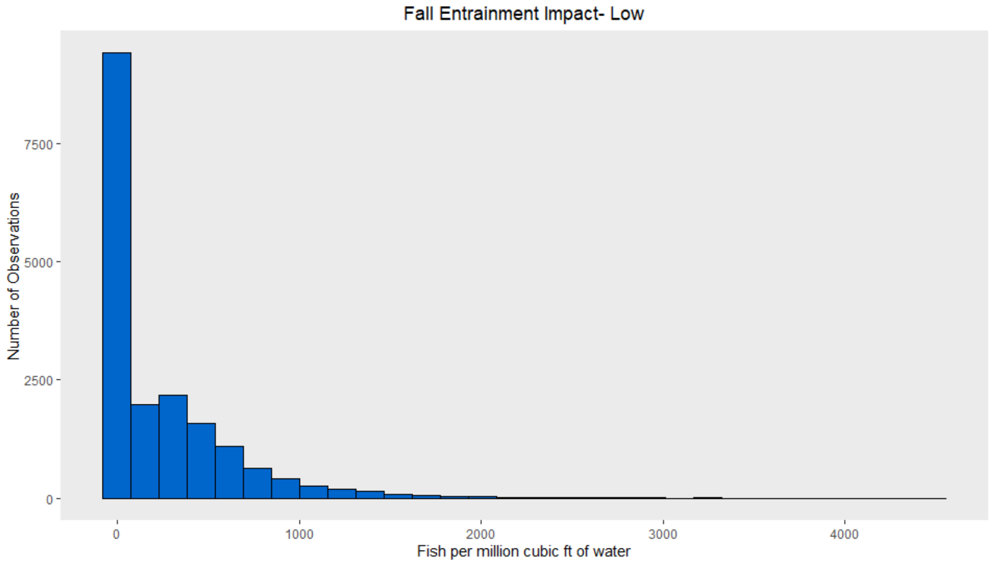

Figure 3.22 Fall Entrainment Impact-Low Operating Level

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.

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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.

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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	5.68×10^{-5}
Larvae	0.178	27	4.79	0	50	5.68×10^{-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	9.43×10^{-4}
Yolk-sac Larvae	0.143	13	1.90	0	50	9.43×10^{-4}
Post Yolk-sac Larvae	0.044	40	1.80	0	50	9.43×10^{-4}
Juveniles	0.0207	306	6.50	0	50	0.0612
Age 1	8.22×10^{-4}	365	0.3	0	50	7
Age 2	8.22×10^{-4}	365	0.3	0	50	41
Age 3	8.22×10^{-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 (λ) 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 (λ) 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 (λ) 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 (λ) 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 (λ) 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 (λ) 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 (λ) 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.

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Attachment 2

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

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

FINAL REPORT

AQUATIC RESOURCES STUDY

Bad Creek Pumped Storage Project
FERC Project No. 2740

Oconee County, South Carolina

June 3, 2024

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).

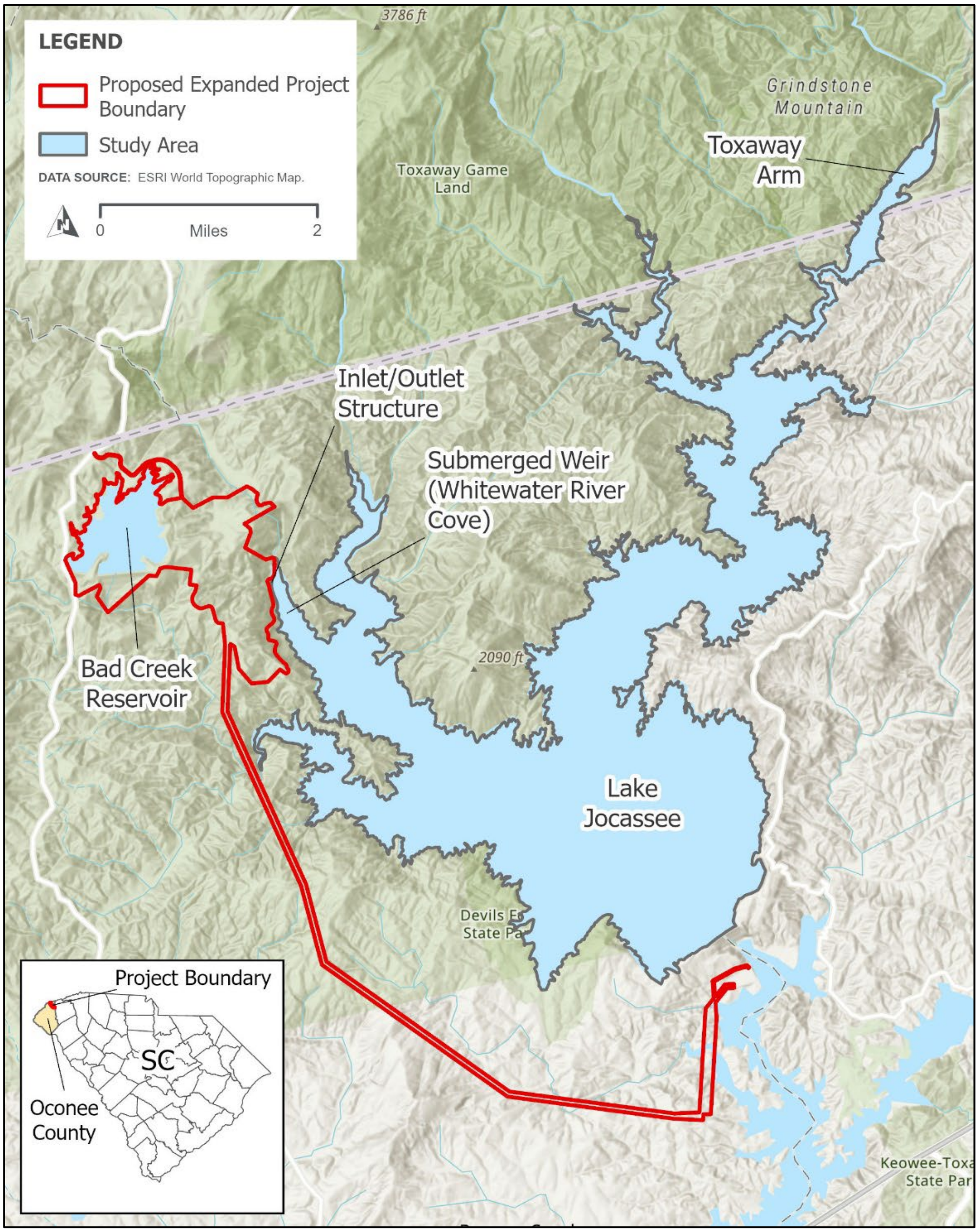

Figure 3-1. Aquatic Resources Study Task 2 Study Area

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).

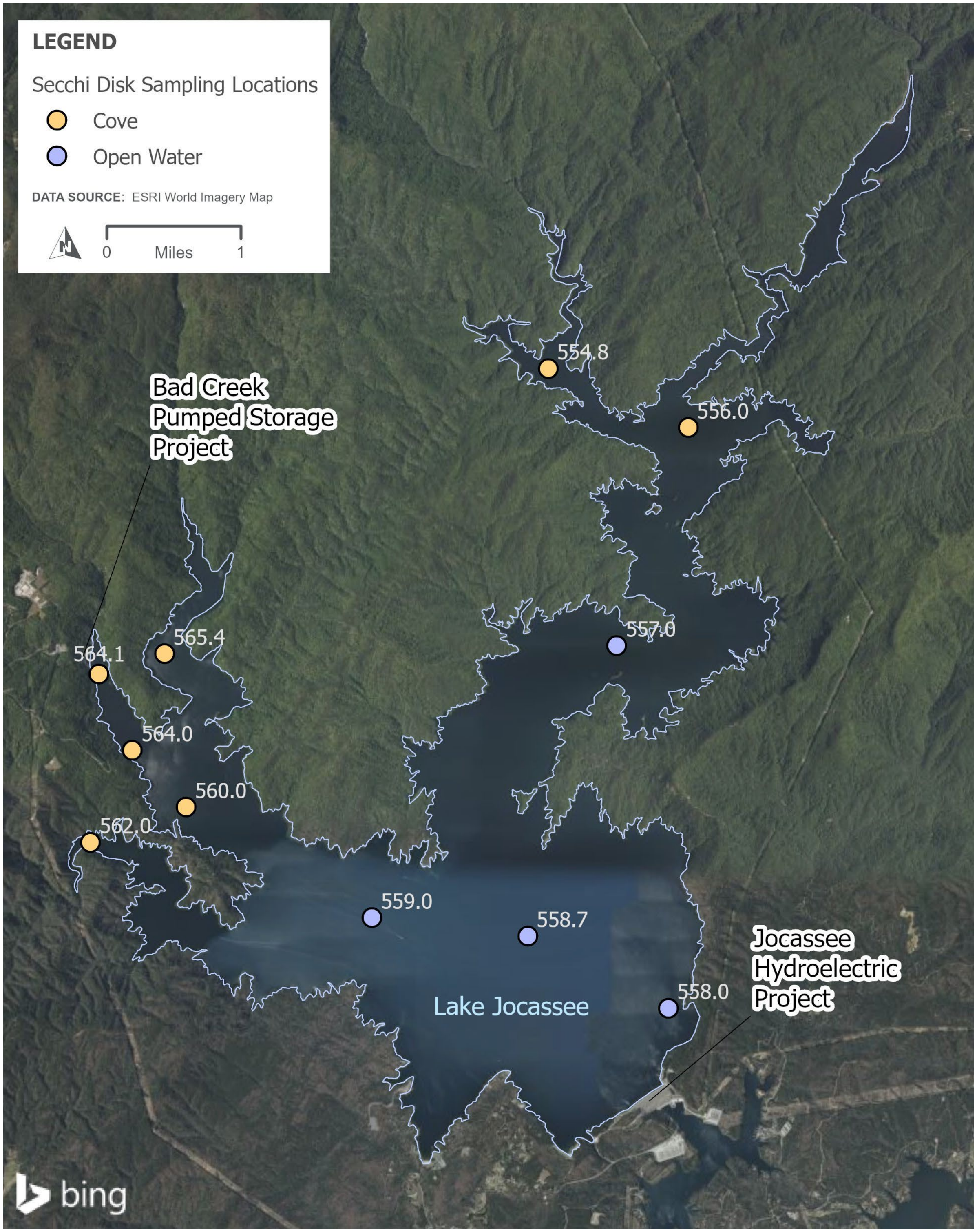

Figure 4-1. Secchi Depth Sampling Locations

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 (η), or the point at which less than 1 percent of light is detected in the water column, was calculated using known relationships between Secchi depth and light extinction (Poole and Atkins 1929) (Equation [Eq.] 1). Light at any given depth can be calculated from Eq. 2 and rearranged to find the depth of the euphotic zone using Eq. 3 and 4 (Lee and Rast 1997).

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

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

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

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

Where:

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

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

Five surface water elevations were evaluated in the littoral zone analysis: maximum elevation, normal minimum elevation, minimum elevation, and two elevations which were defined in the CHEOPS performance measures as maximizing littoral habitat during the growing/spawning season (corresponding to performance measures 26 through 29). Water surface elevations for the scenarios are summarized in Table 4-2.

Table 4-2. Summary of Water Surface Elevations for Evaluated Littoral Zone Scenarios

Littoral Zone Scenario	Elevation (ft msl)
Maximum Elevation	1,110
Littoral Zone Habitat During Growing/Spawning Season (High)[1]	1,107[2]
Littoral Zone Habitat During Growing/Spawning Season (Low)[1]	1,105[2]
Normal Minimum Elevation	1,096
Minimum Elevation	1,080

[1] The "growing season" was defined as April 1 to September 30 and "spawning season" was defined as April 1 to May 31 in the CHEOPS performance measures.

[2] Lake Jocassee fish habitat elevations provided by Bill Marshall of SCDNR during KT Project relicensing.

5 Results

5.1 Pelagic Trout Habitat Assessment

5.1.1 Pelagic Trout Habitat Monitoring

Suitable pelagic trout habitat exists in the water column where specific water quality conditions required by trout are met; that is, water temperature less than 20°C and DO concentrations greater than 5.0 mg/L. During late summer thermal stratification, water in the upper water column (epilimnion) is warmed by solar radiation, eventually exceeding 20°C. In the lower portion of the water column (hypolimnion, below the thermocline), DO becomes limited due to minimal water circulation and consumption by anaerobic bacteria, declining below 5.0 mg/L. Therefore, suitable pelagic trout habitat is found between these two thresholds in the water column (Figure 5-1).

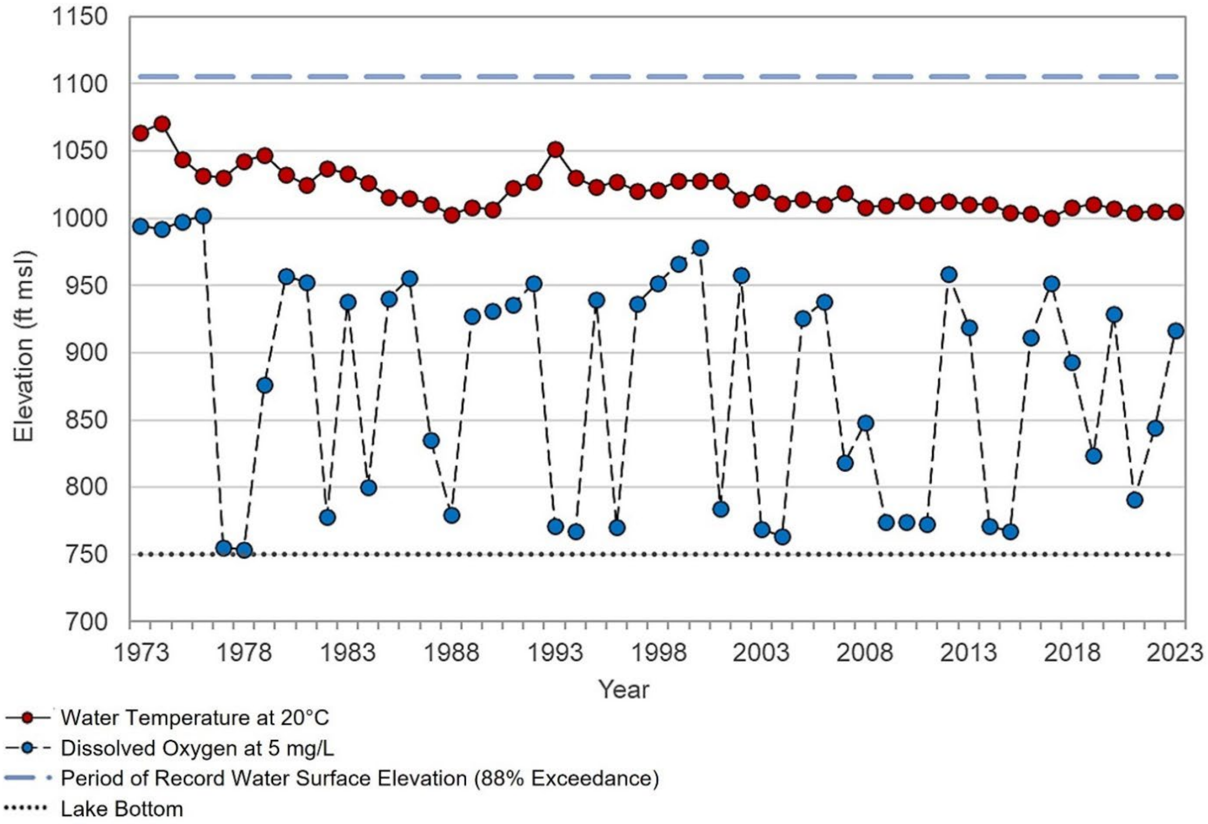

Figure 5-1. Pelagic Trout Habitat Thresholds from 1973-2023

Pelagic trout habitat “thickness” (i.e., the portion of the water column between the upper 20°C and lower 5.0 mg/L) has varied widely from year to year since monitoring began in 1973, both before and after operation of the Project (Figure 5-2). Water quality parameters for trout habitat are measured at the deepest part of the lake at location 558.0 (Figure 4-1), and therefore provide the maximum thickness of trout habitat potentially existing in the lake during the late summer period (when trout habitat would be at minimum). Factors driving the variability in trout habitat thickness include severity of summer conditions, depth of preceding winter mixing, and operations at Jocassee Pumped Storage Station.

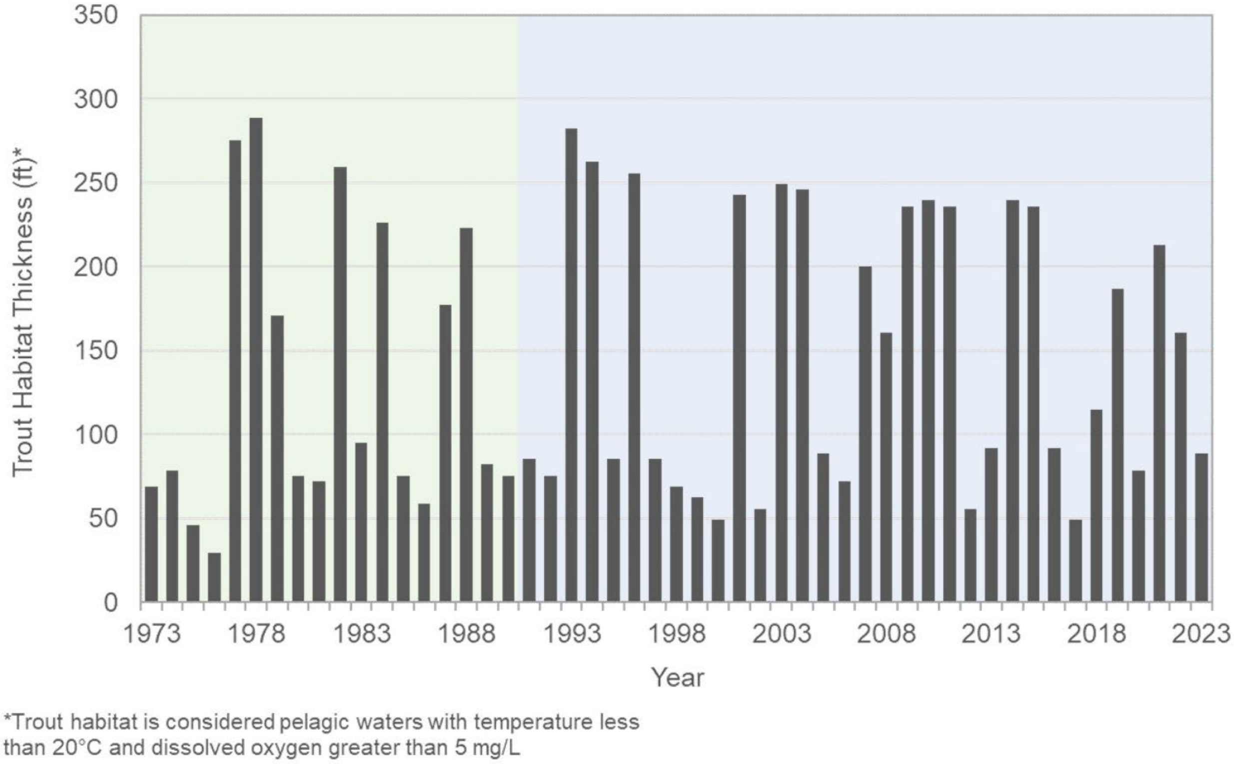

Figure 5-2. Measured or Predicted Pelagic Trout Habitat Thickness from 1973-2023; green and blue shaded areas represent time prior to and following commencement of Project operations (1991)

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

5.1.2 CFD Model Results

Findings from the CFD study indicate that in generation mode, the energy of the water discharged from operations is dissipated as it is forced across the top of the existing submerged weir and similar vertical mixing patterns result from the existing and proposed expanded weir geometries under existing and proposed generation flows. Additionally, results showed Bad Creek II powerhouse operations will not alter existing stratification patterns in the downstream section of the Whitewater River cove or further downstream into Lake Jocassee. Water quality profile data (current and historic) support CFD model results; results from field monitoring as well as CFD modeling indicate the water column is completely mixed (i.e., no natural stratification) near the inlet/outlet structure upstream of the weir; however, just downstream of the weir, stratification is comparable to rest of the waterbody, indicating the weir is functioning as intended and mixing is largely confined to the Whitewater River cove upstream of the weir.

5.1.2.1 Maximum Generation, Maximum Elevation Scenario

Under the maximum elevation scenario during generation, the CFD model predicted the expanded submerged weir may cause slight flow acceleration across the top of the weir and downstream into the lower Whitewater River cove (Attachment B, Figures 1 and 2). The effect of added generation from the additional powerhouse did not extend beyond the Whitewater River cove. Water column mixing effects were observed immediately downstream of the weir, but do not extend more than approximately 1,050 ft from the weir (Attachment B, Figure 3) which is approximately halfway from the weir to sampling location 564.0.[4]

5.1.2.2 Maximum Generation, Minimum Elevation Scenario

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

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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).

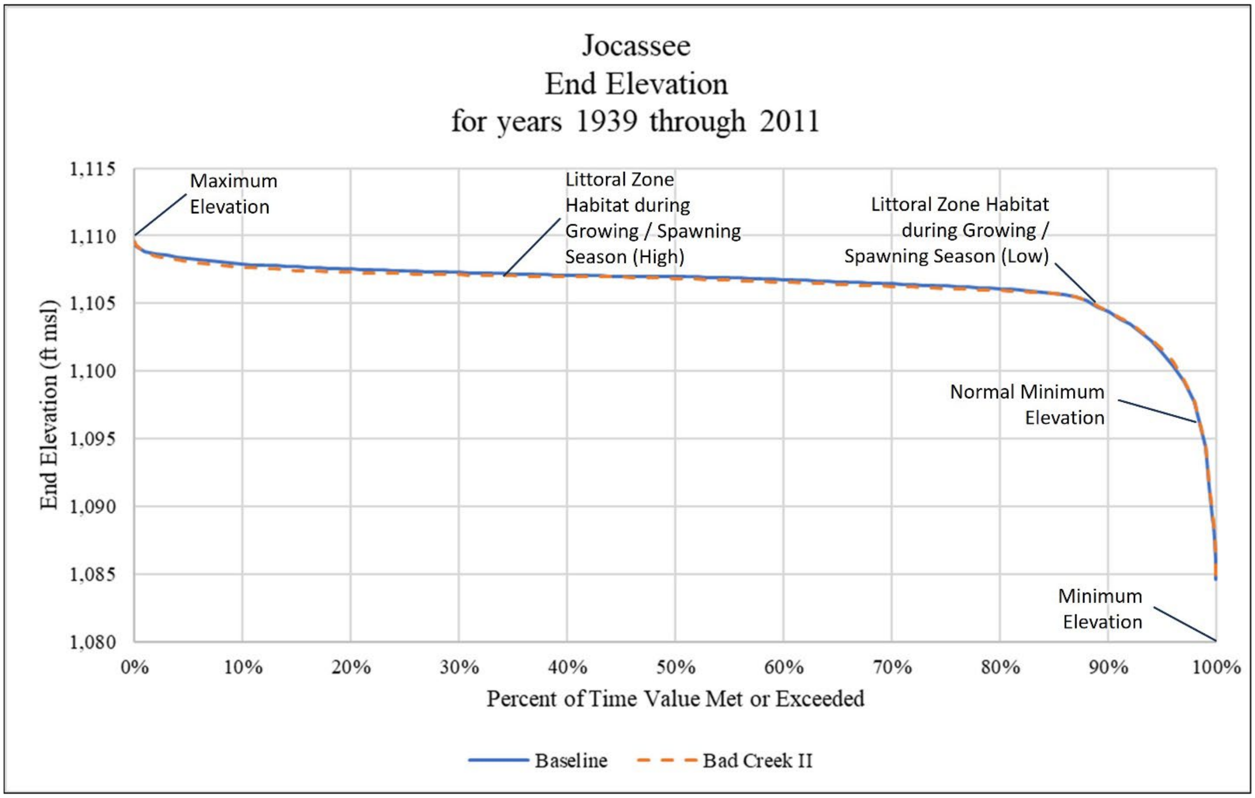

Figure 5-3. Normal Hydrology Jocassee 24-hour Reservoir Fluctuation for 1939-2011 (HDR 2024)

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).

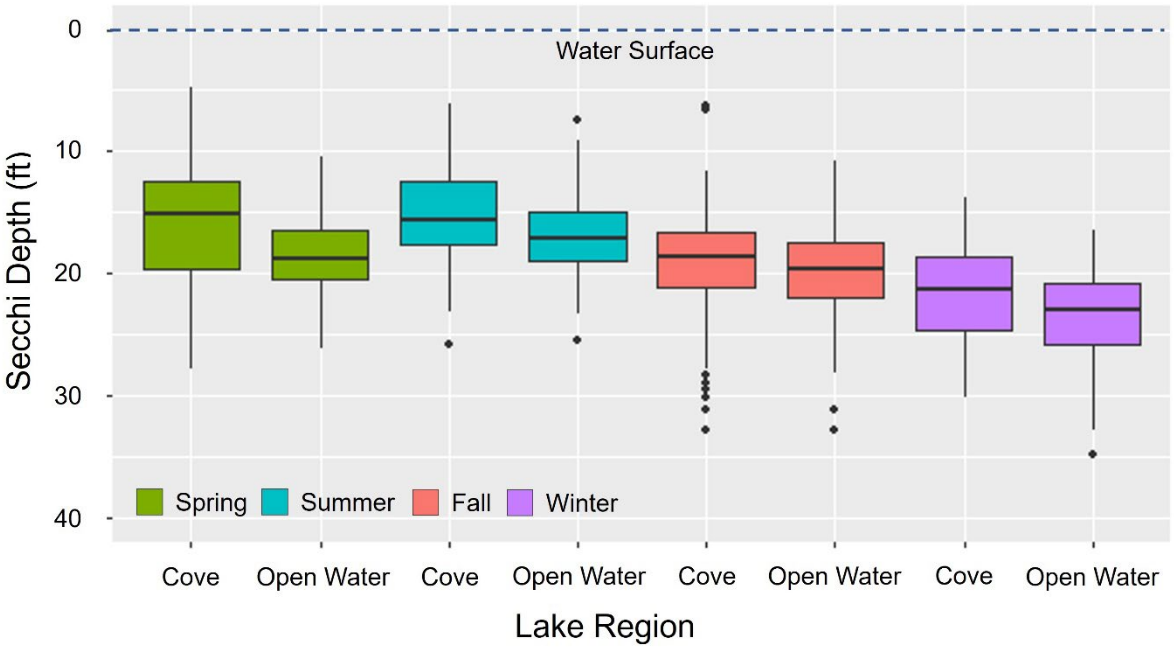

Figure 5-4. Box Plot of Secchi Depth Data (Duke Energy 2024) for Cove and Open Water Locations

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

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Attachment A

Attachment A – Pelagic Trout Habitat Figures (Foris 2014)

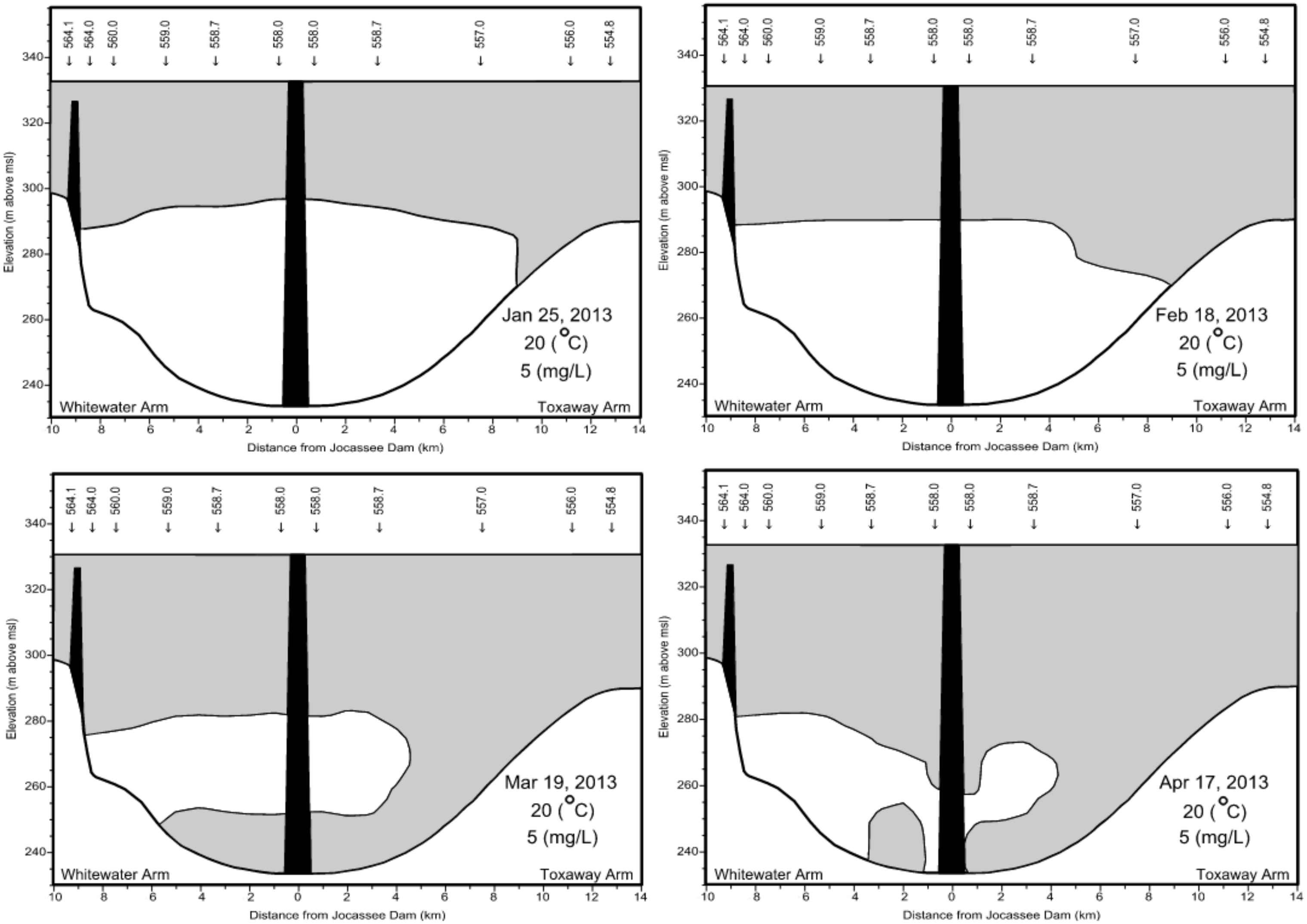


Figure 1. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, January – April 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from Jocassee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

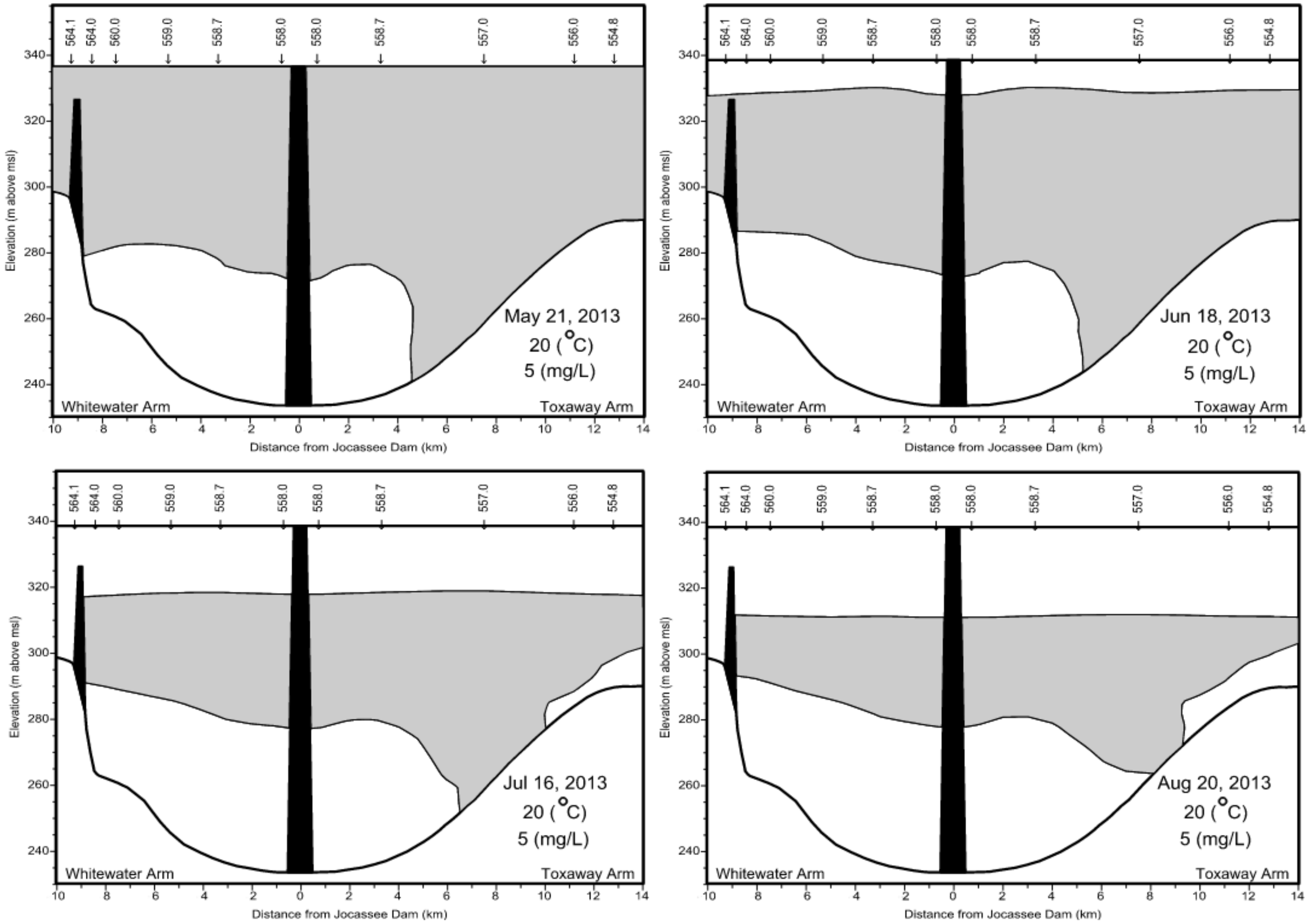


Figure 2. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, May – August 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from Jocassee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

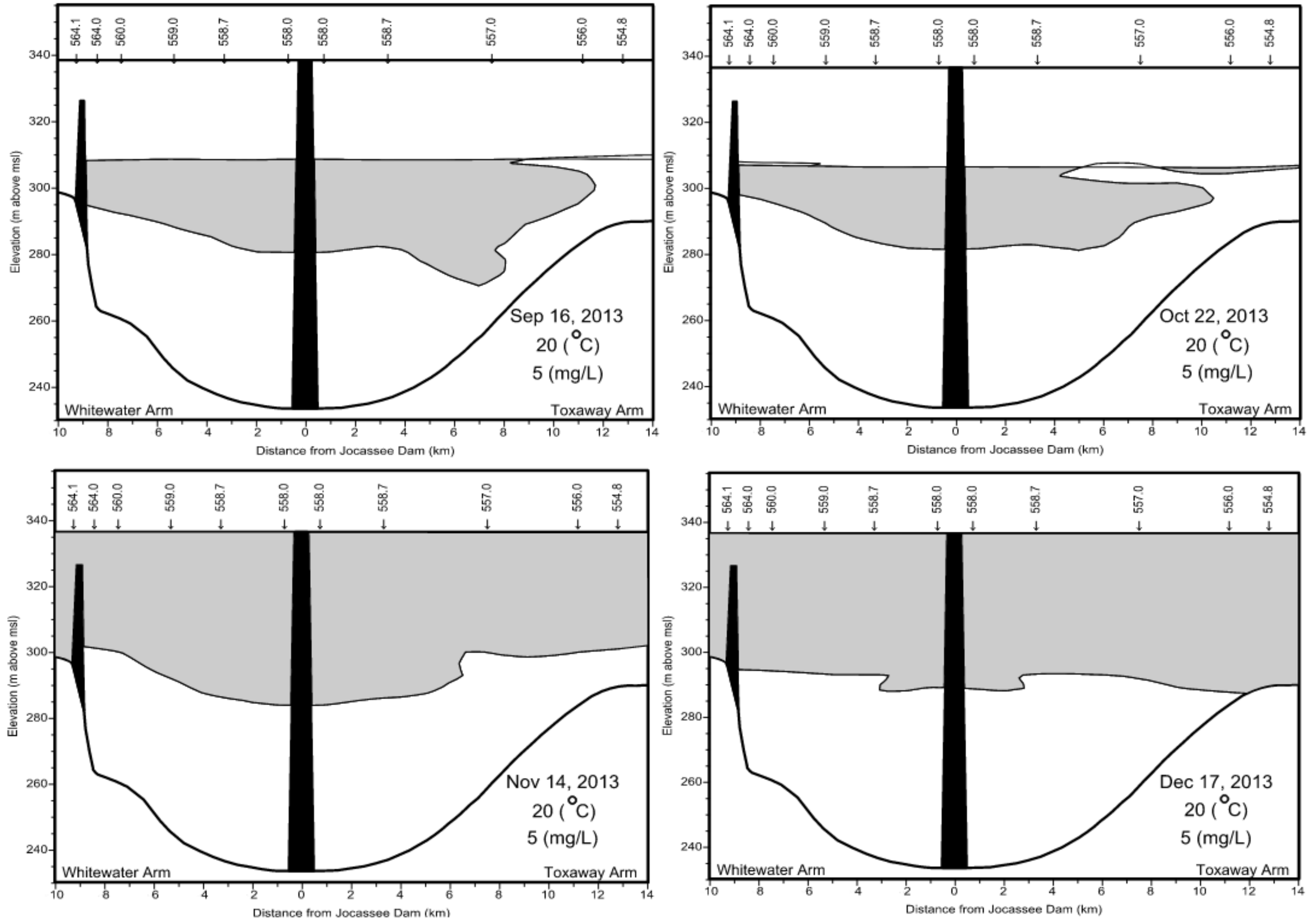


Figure 3. Seasonal distribution of suitable pelagic trout habitat (shaded area) for Lake Jocassee, September – December 2013 (Foris 2014). Pelagic trout habitat is the area of the water column less than 20°C and dissolved oxygen greater than 5.0 mg/L. The structure (black) at approximately 9 km from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

Attachment B

Attachment B – CFD Modeling Figures

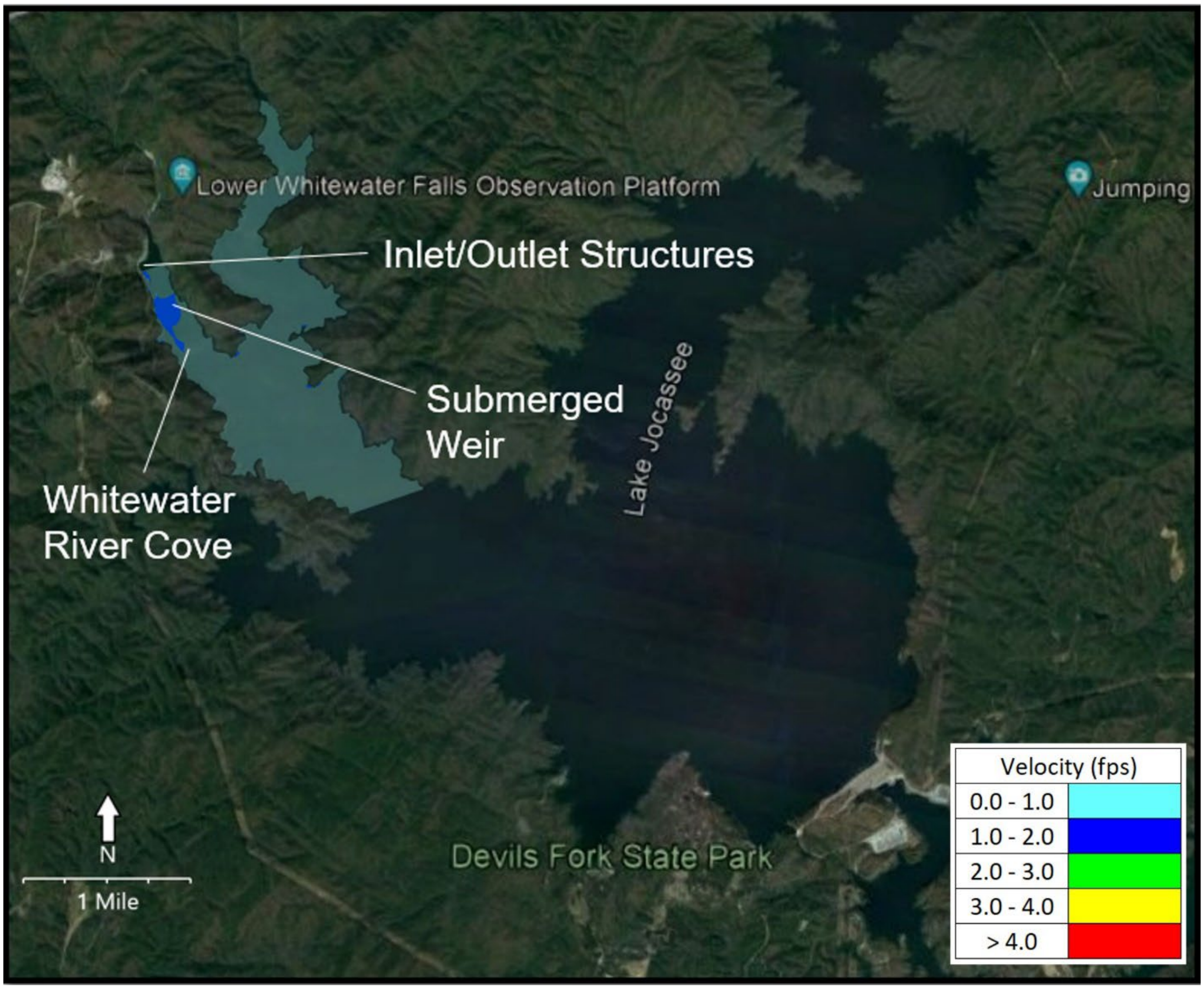


Figure 1. Proposed Generation with Expanded Weir at Full Pond (1,110 ft msl) – Velocity Contours (HDR 2023)

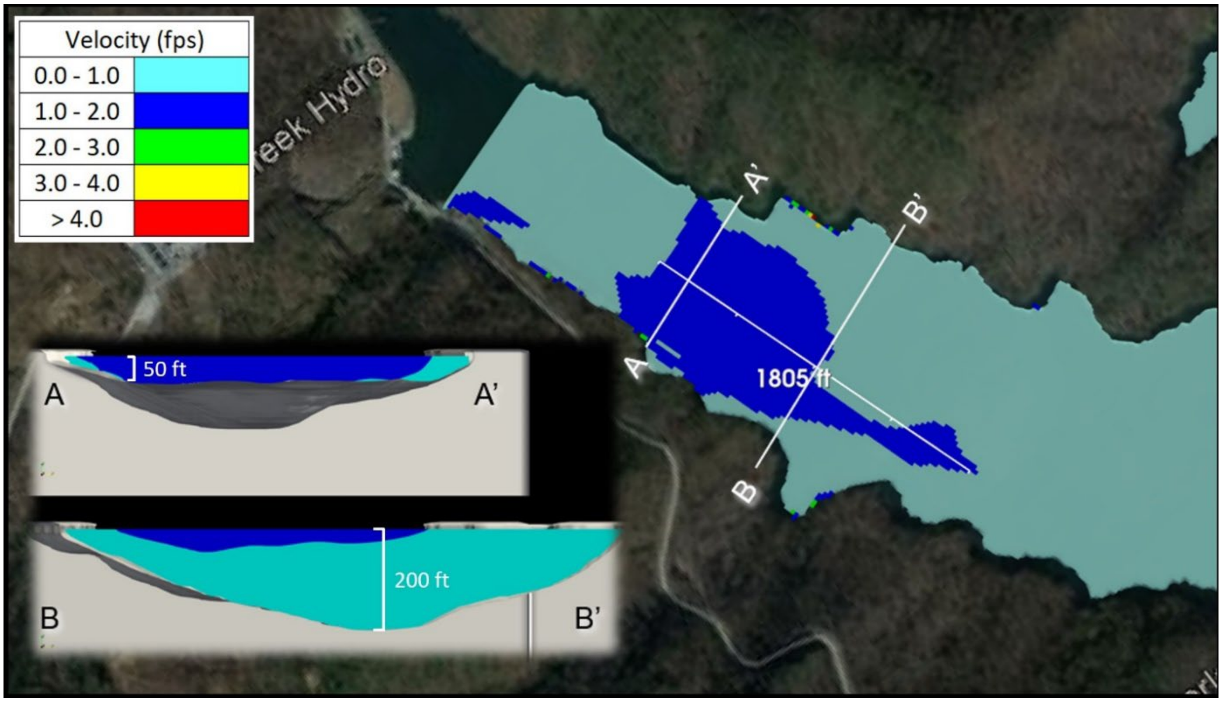


Figure 2. Proposed Generation (Expanded Weir) at Full Pond (1,110 ft msl) – Velocity Contours in Submerged Weir Vicinity (Flow is Left to Right) (HDR 2023)

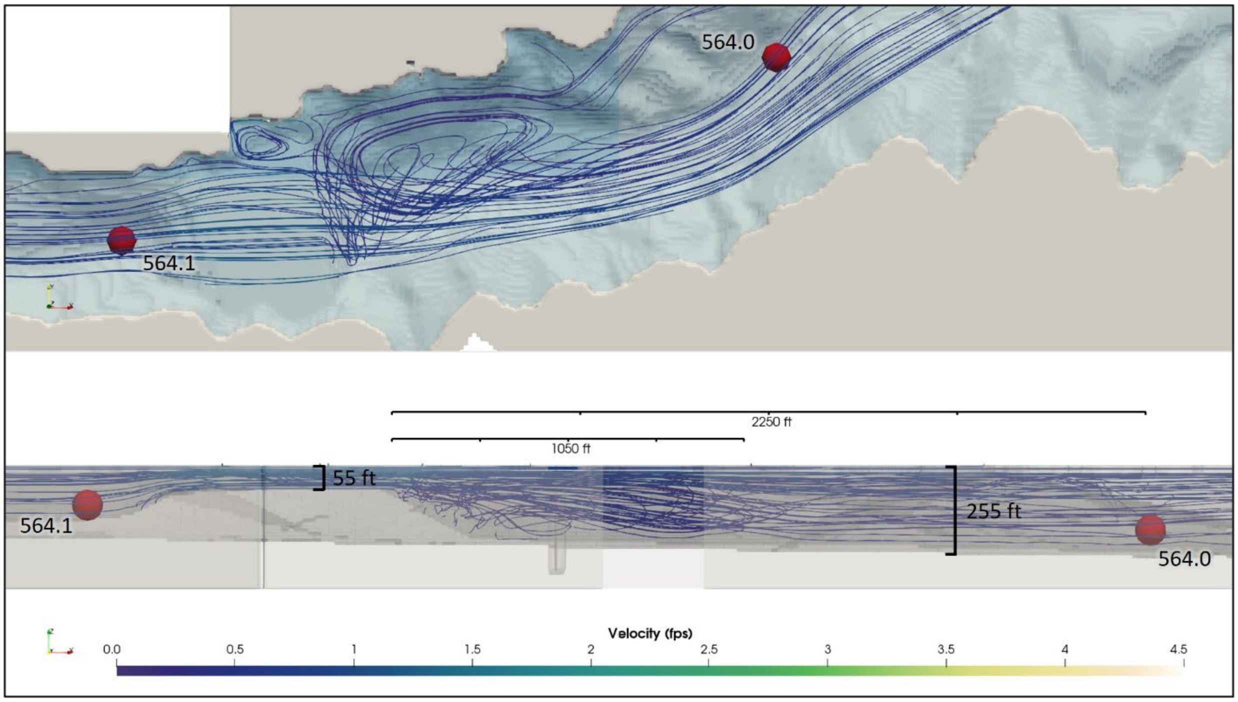


Figure 3. Proposed Generation (Expanded Weir) at Full Pond (1,110 ft msl) – Whitewater River Cove Streamlines (flow is left to right, red circles represent water quality sampling locations) (HDR 2023)

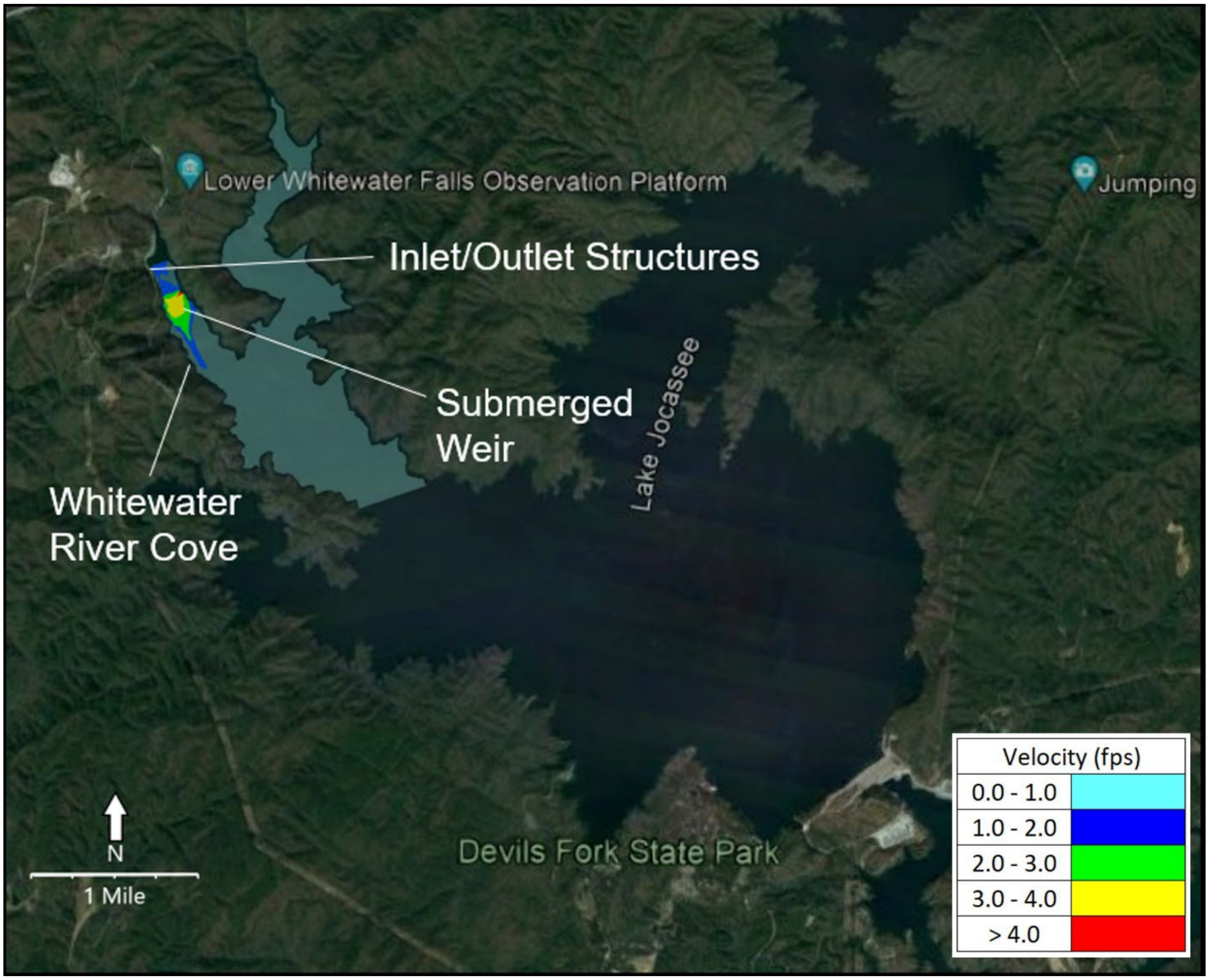


Figure 4. Proposed Generation with Expanded Weir at Maximum Drawdown (1,080 ft msl – Velocity Contours (HDR 2023)

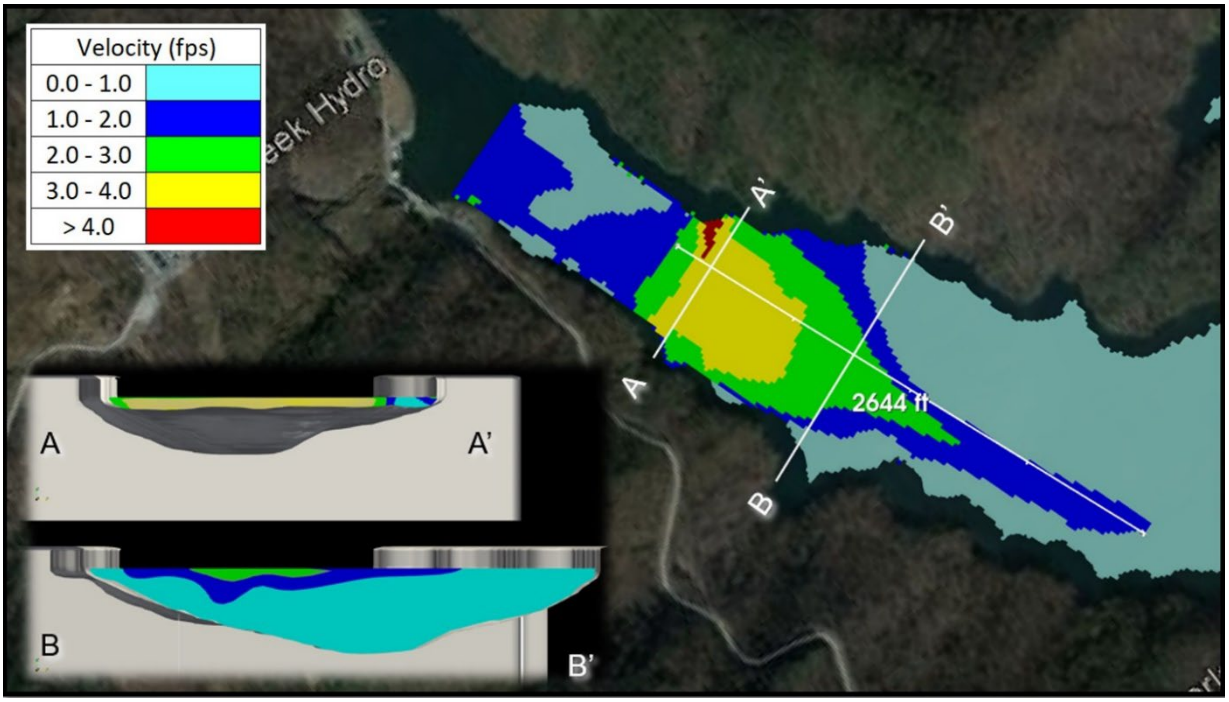


Figure 5. Proposed Generation (Expanded Weir) at Maximum Drawdown (1,080 ft msl) – Velocity Contours in Submerged Weir Vicinity (Flow is Left to Right) (HDR 2023)

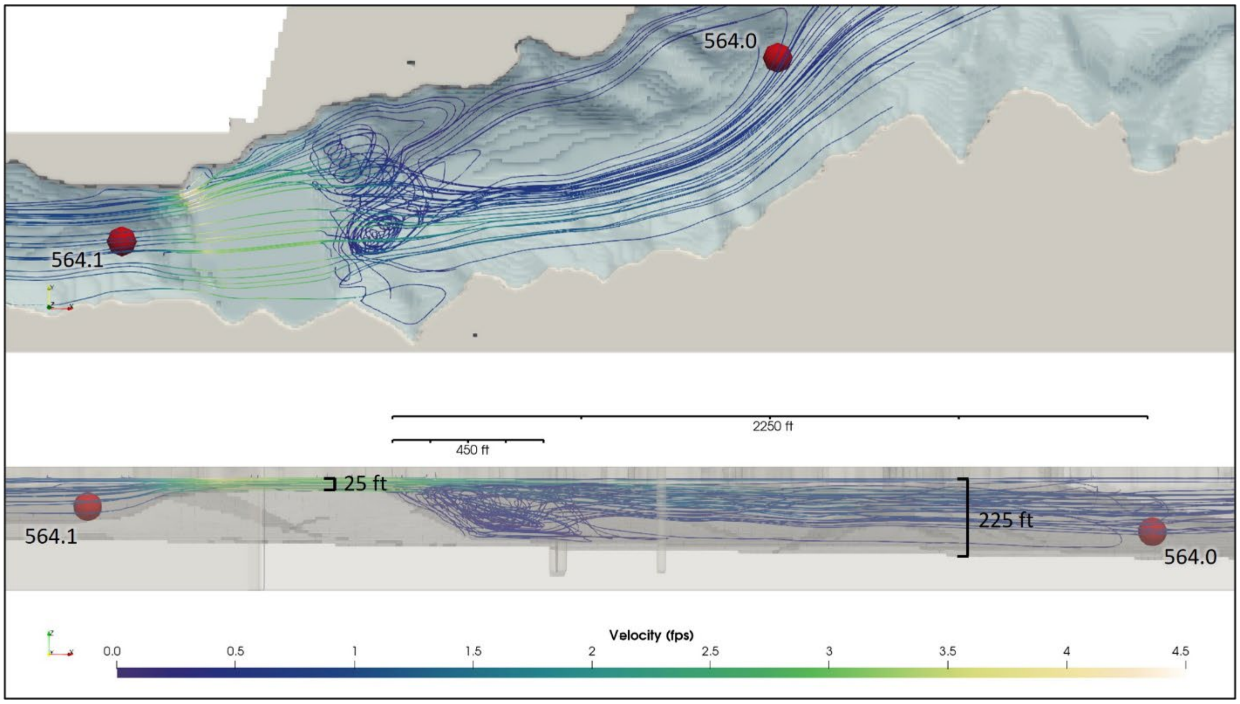
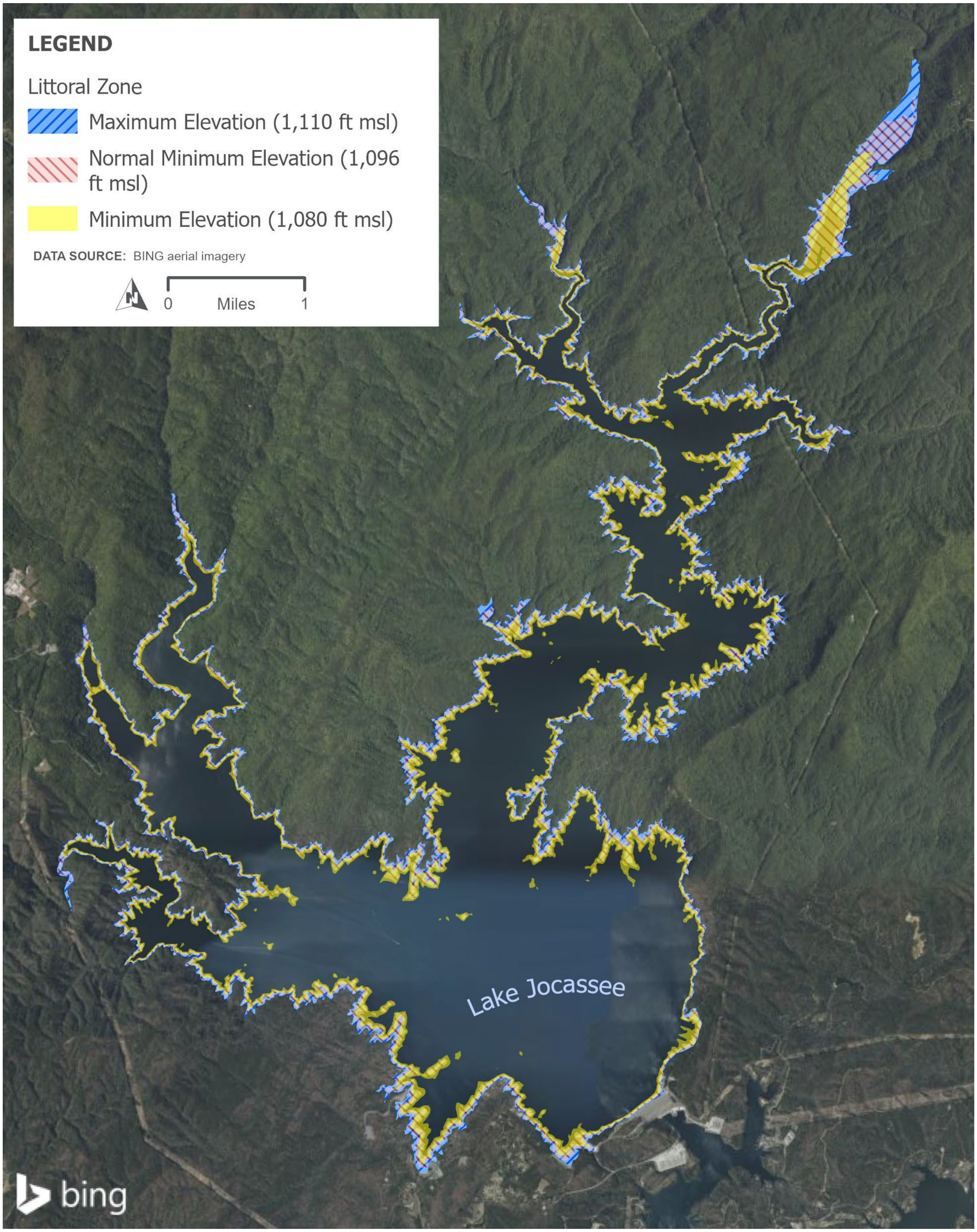


Figure 6. Proposed Generation (Expanded Weir) at Maximum Drawdown (1,080 ft msl) – Whitewater River Cove Streamlines (flow is left to right, red circles represent water quality sampling locations) (HDR 2023)

Attachment C

Attachment C – Littoral Habitat Figures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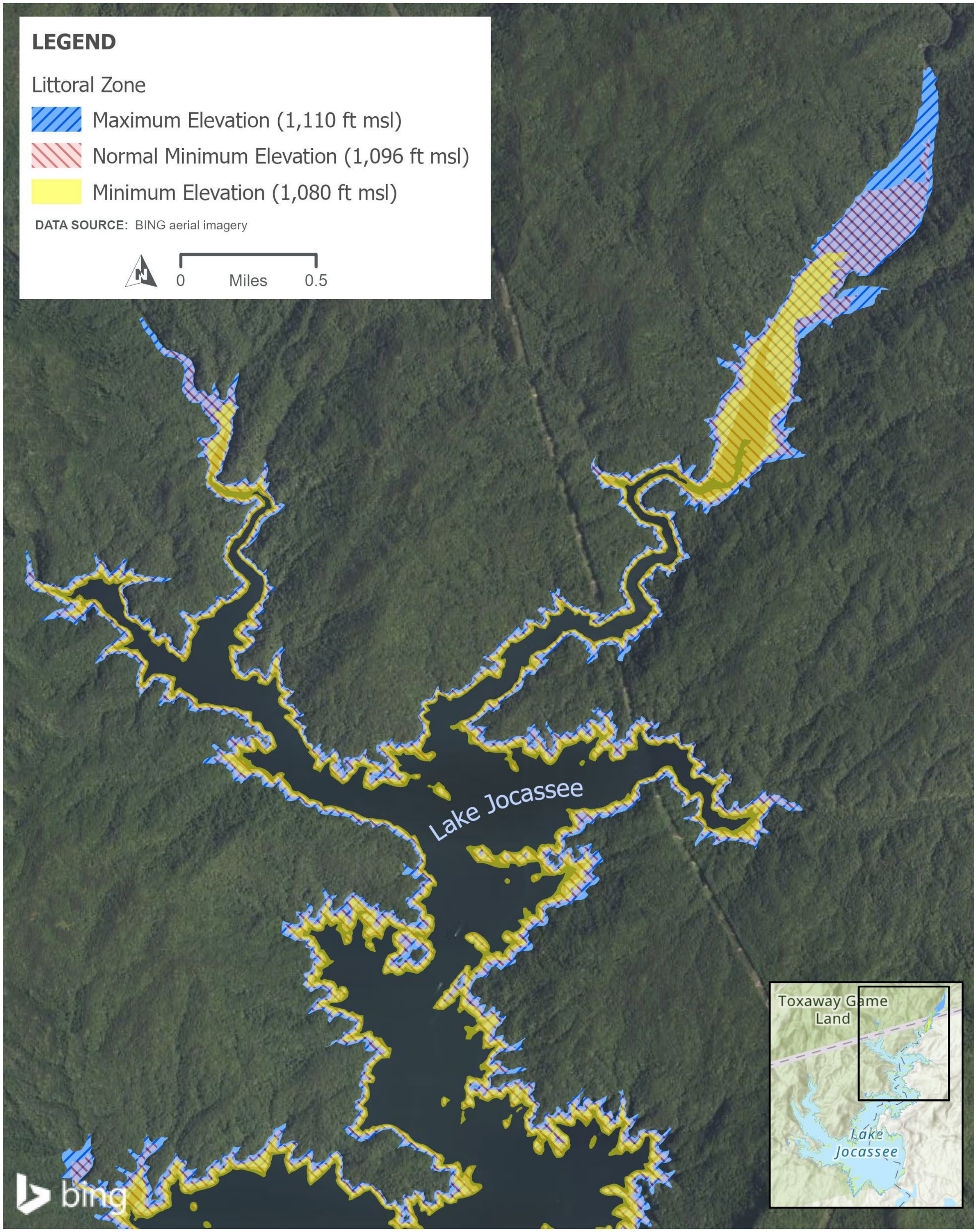
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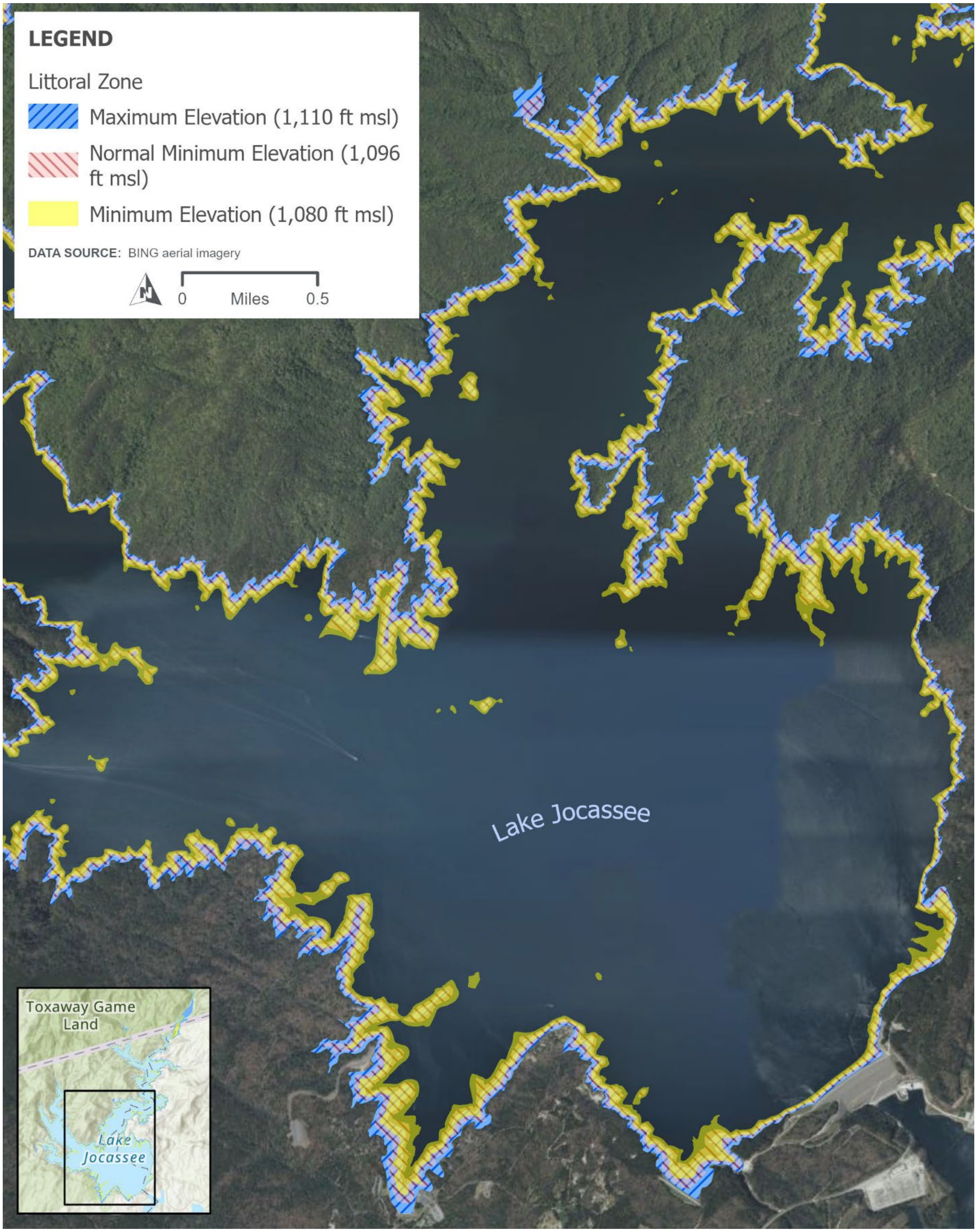
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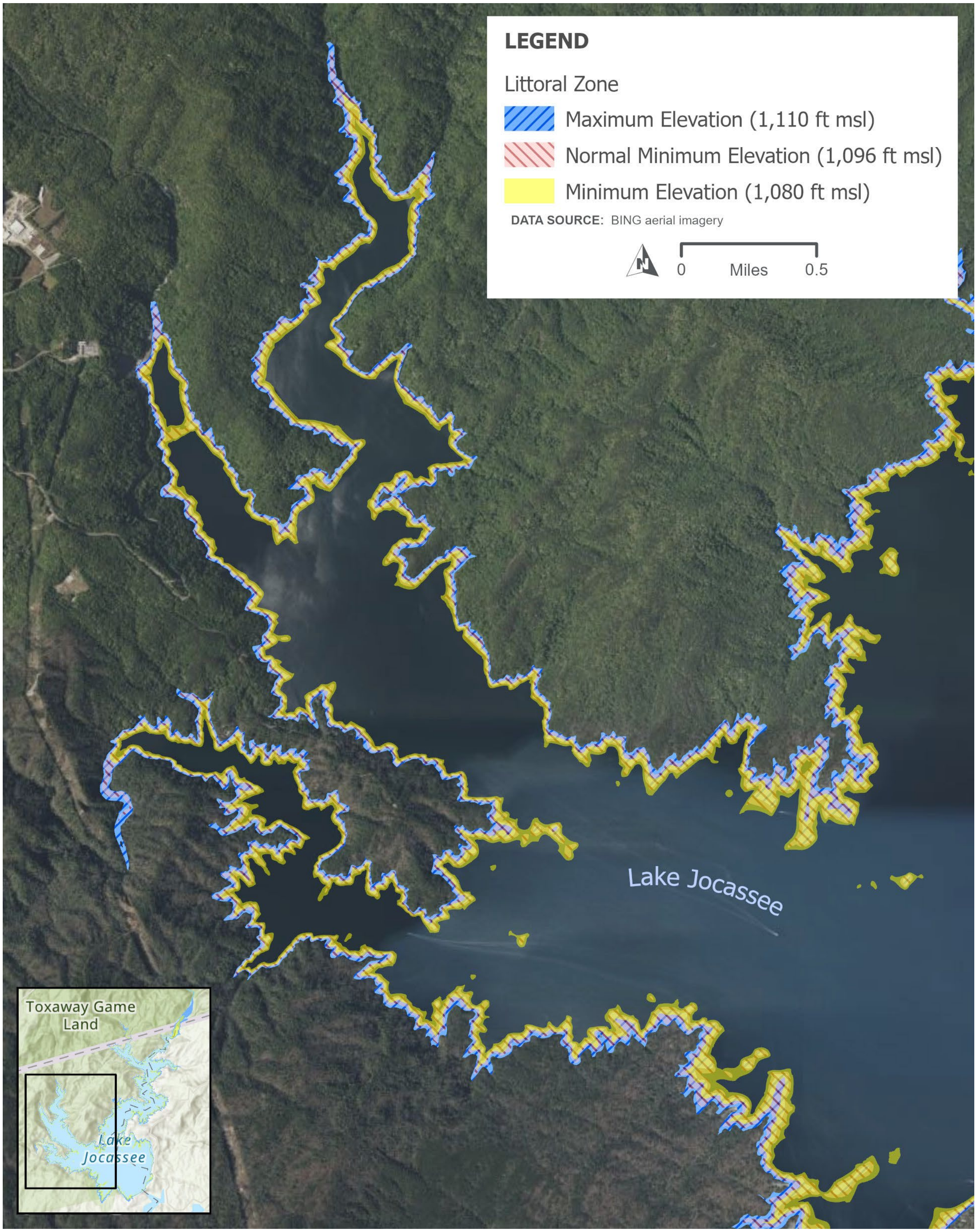
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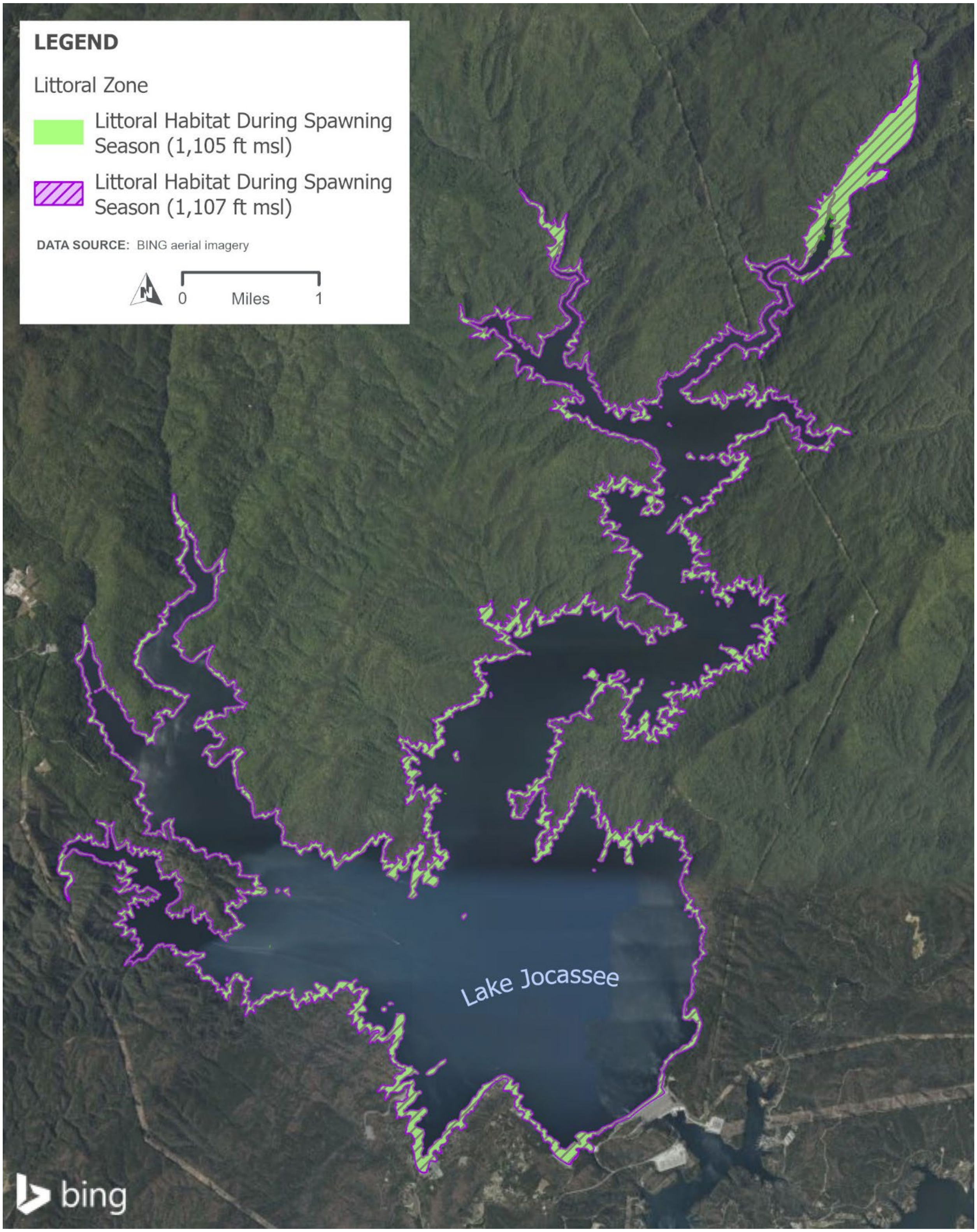
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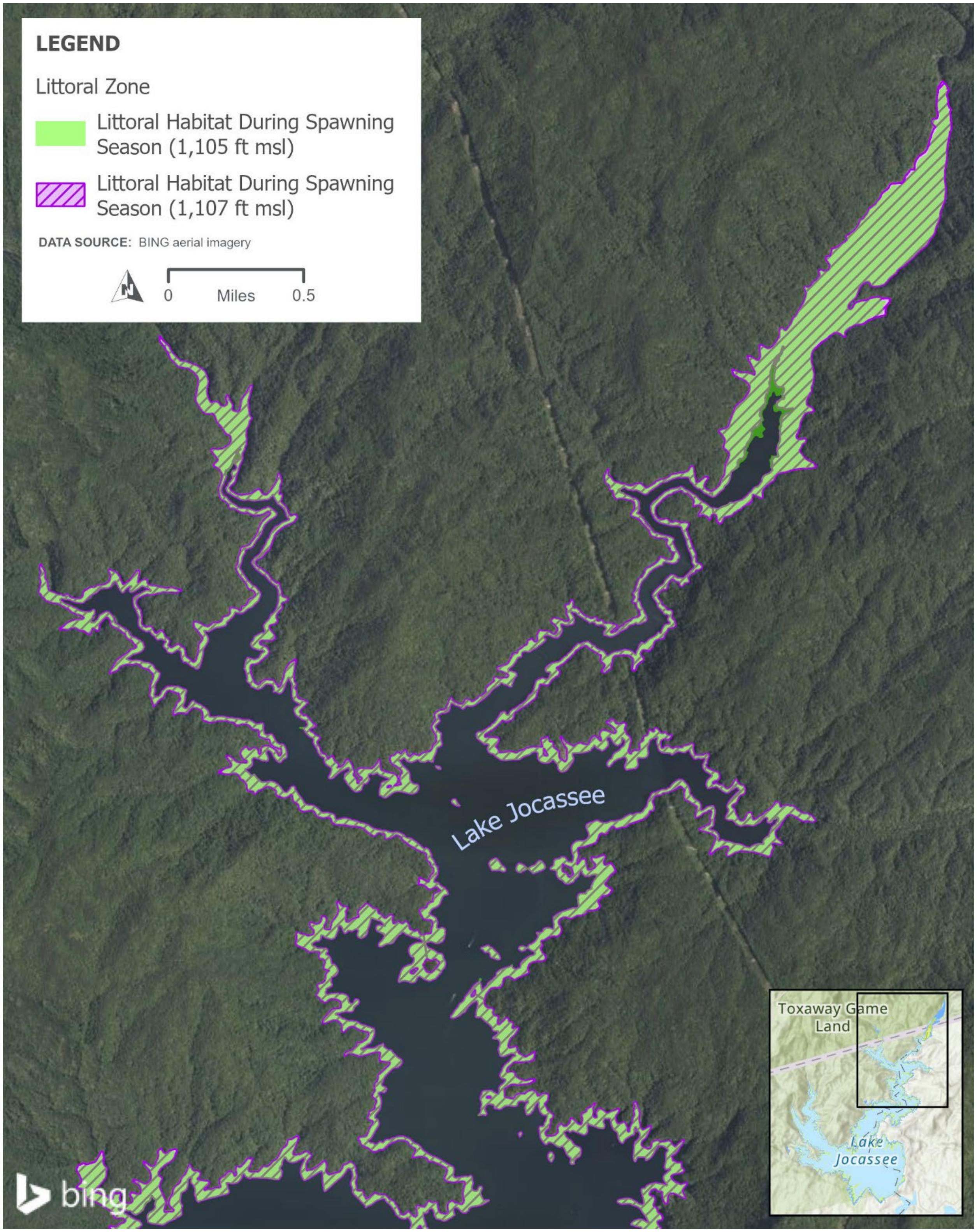
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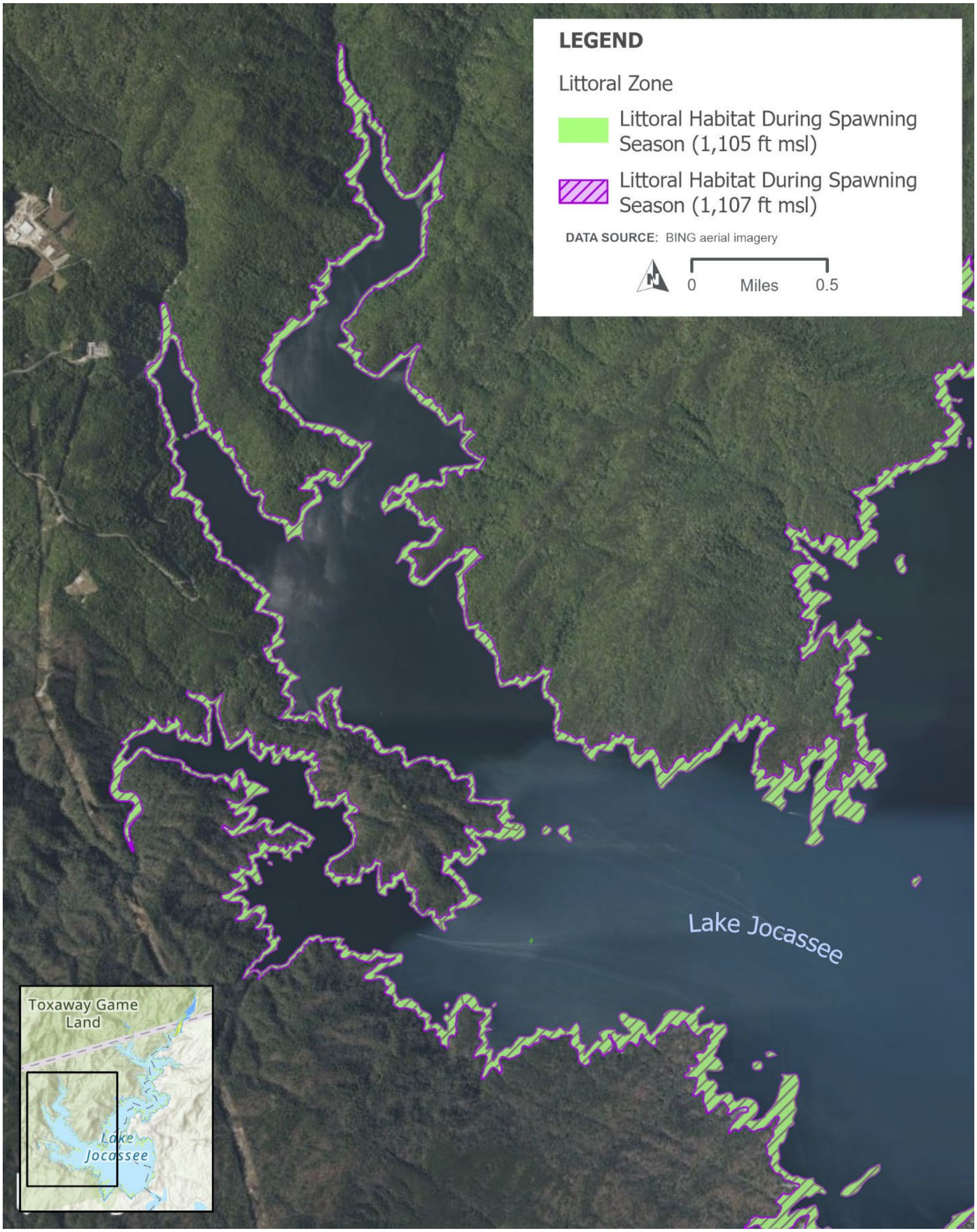
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Attachment 3

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

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1 Project Introduction and Background

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

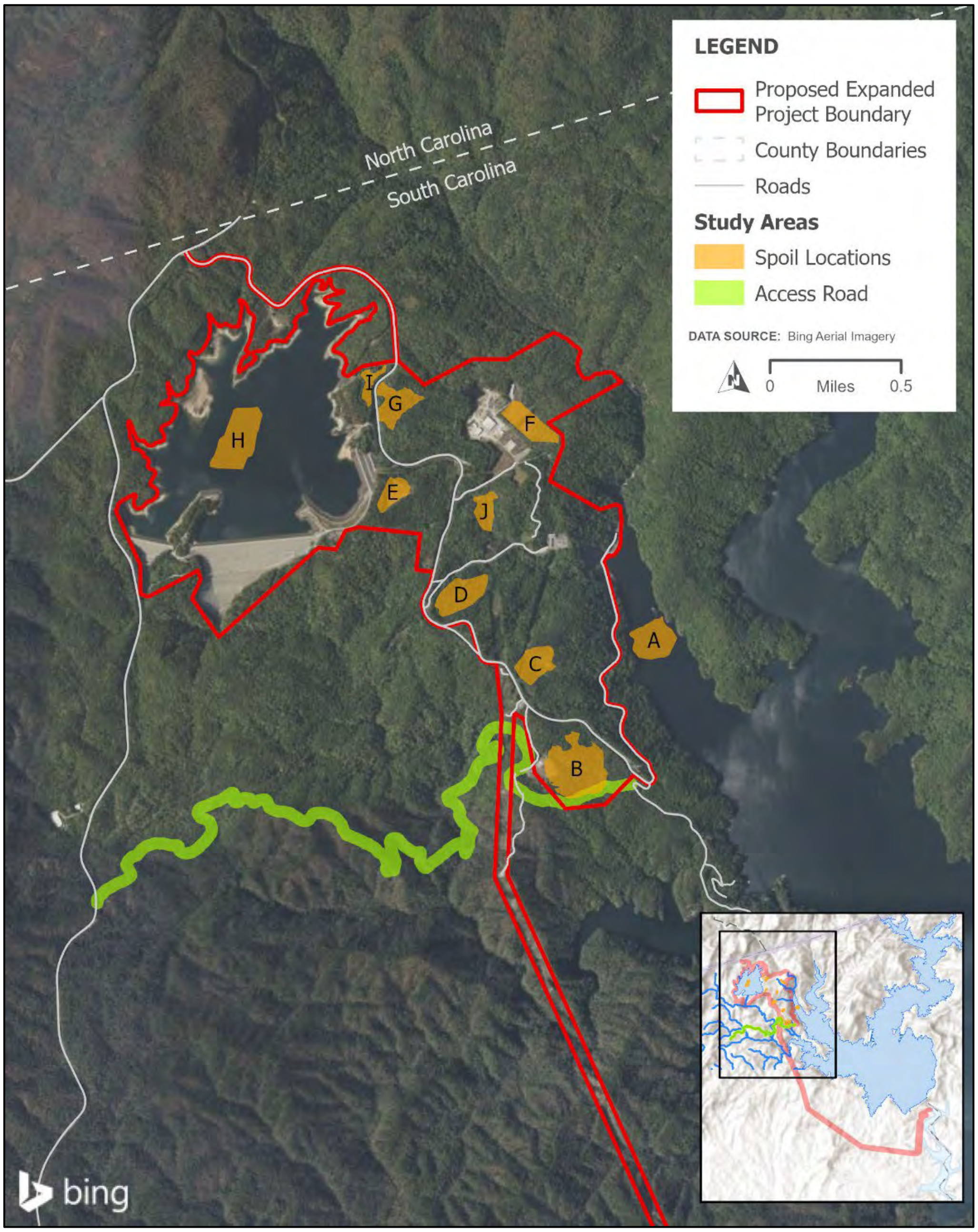

Figure 3-1. Potential Spoil Locations and Proposed Temporary Access Road Study Area

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 (Limber Pole Creek)	Upstream	9.5	405
	Downstream	10.5	223
Stream 7 (Howard Creek)	Upstream	12.3	142
	Downstream	8.5	121
Stream 12 (UT to Howard Creek)	Upstream	18.6	243
	Downstream	14.7	162
Stream 15 (UT to Devils Fork)	Upstream	8.2	101
	Downstream	9.6	223
Stream 16 (UT to Devils Fork)	Upstream	8.6	263
	Downstream	10.3	142
Stream 17 (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

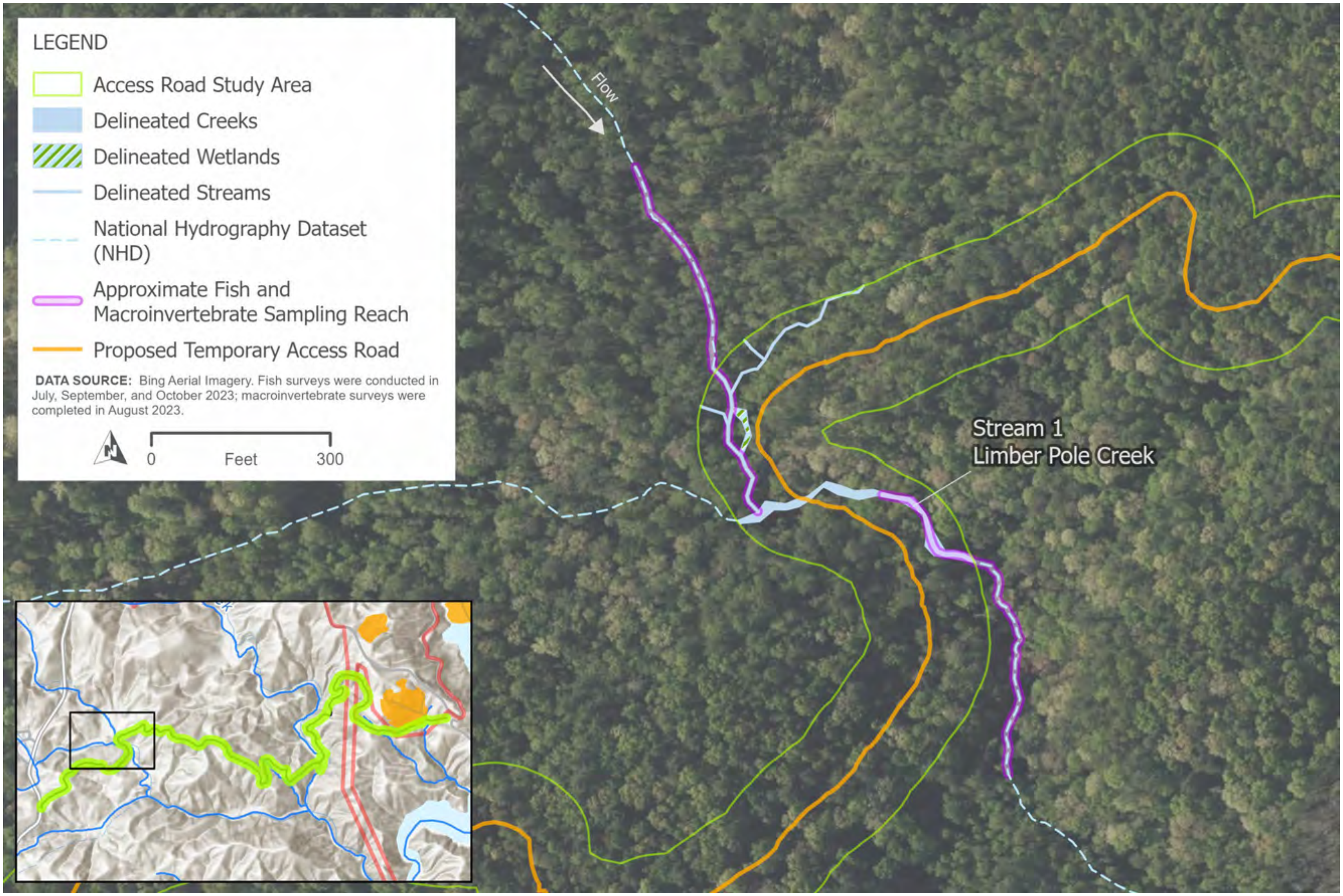
Stream/Creek	Reach	Entrenchment Ratio	Width/ Depth Ratio	Sinuosity	Slope	Bed Material (D50)	Rosgen Classification	Catchment Assessment	SQT Existing Condition Score	Maximum SQT Existing Condition Score	Percent Stream Functionality	Reach Description
												were present at the base of cascades. No 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

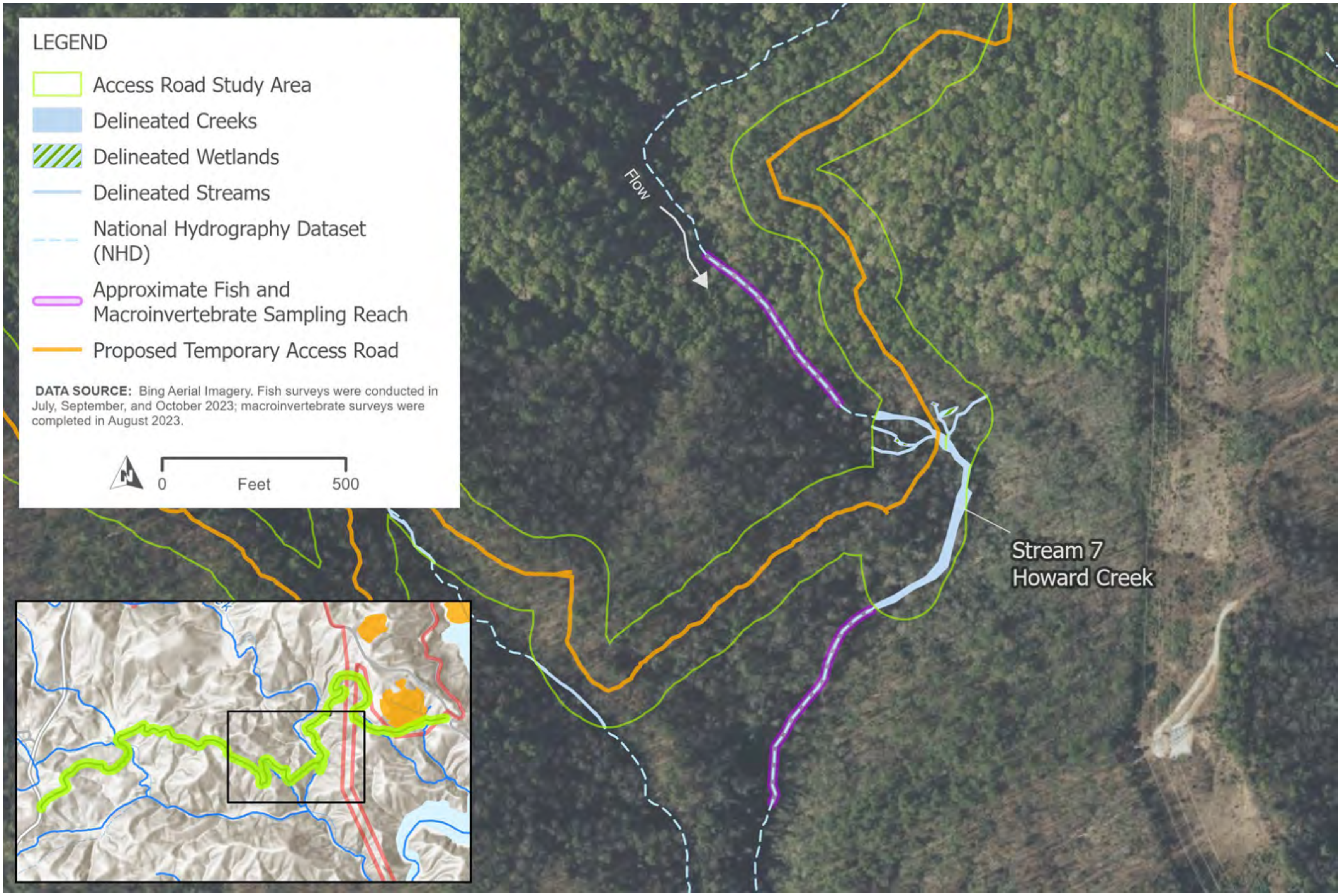
In accordance with the Protocol, one electrofishing unit and one netter was used for the upstream reach of Stream 1, and two electrofishing units and two netters were used at all other reaches. Surveys were completed upstream and downstream of the road crossings on July 25 and 26, September 5 and 6, 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.

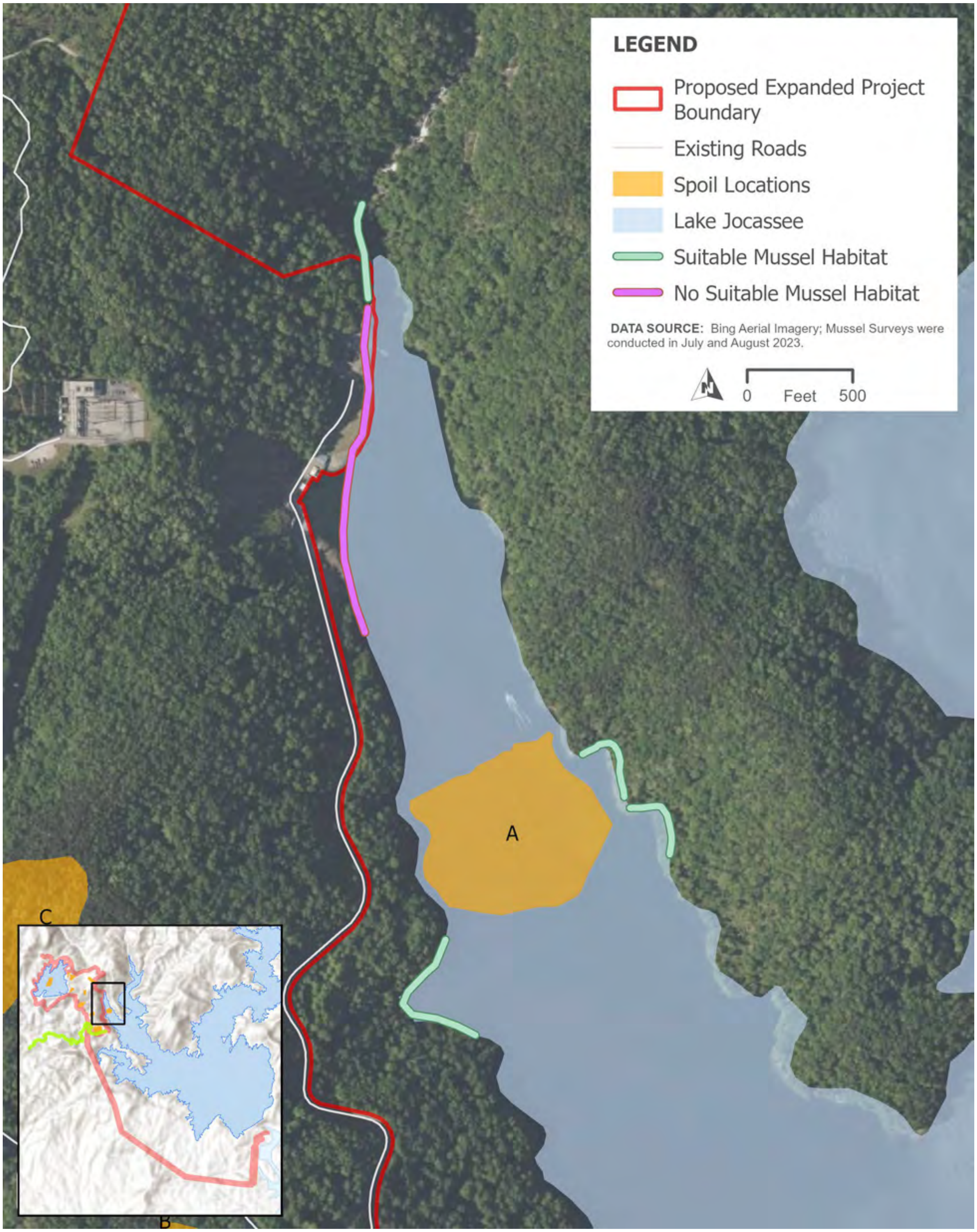


Figure 6-3. Mussel Habitat Survey Areas along Lake Jocassee Shoreline

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

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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.

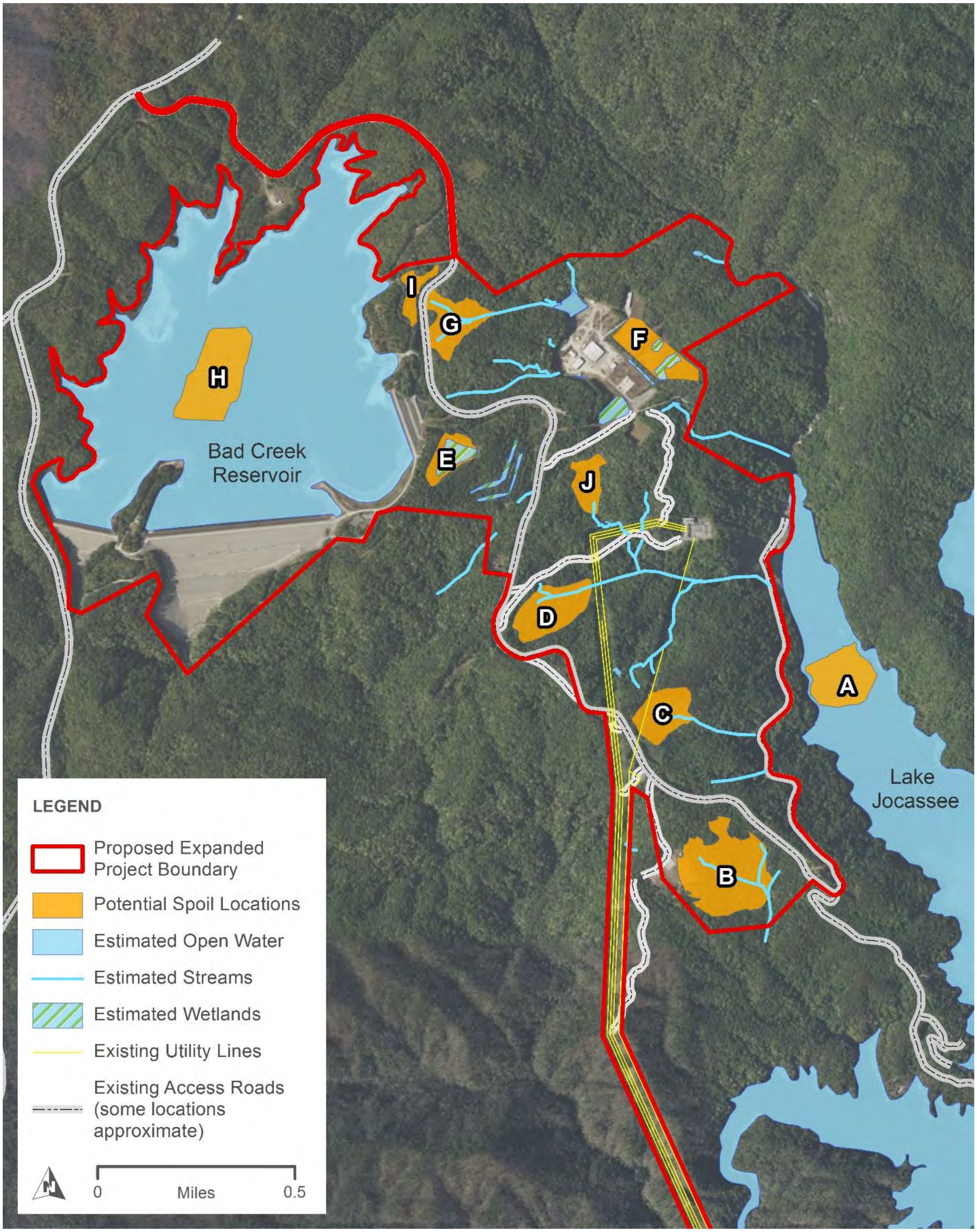
South Carolina Department of Natural Resources. 2022. Fish Sampling Guidance: Fish Collection Protocols for Streams. Accessed July 2023. [URL]: https://www.dnr.sc.gov/environmental/SCDNRSamplingProcedureFishes.pdf.

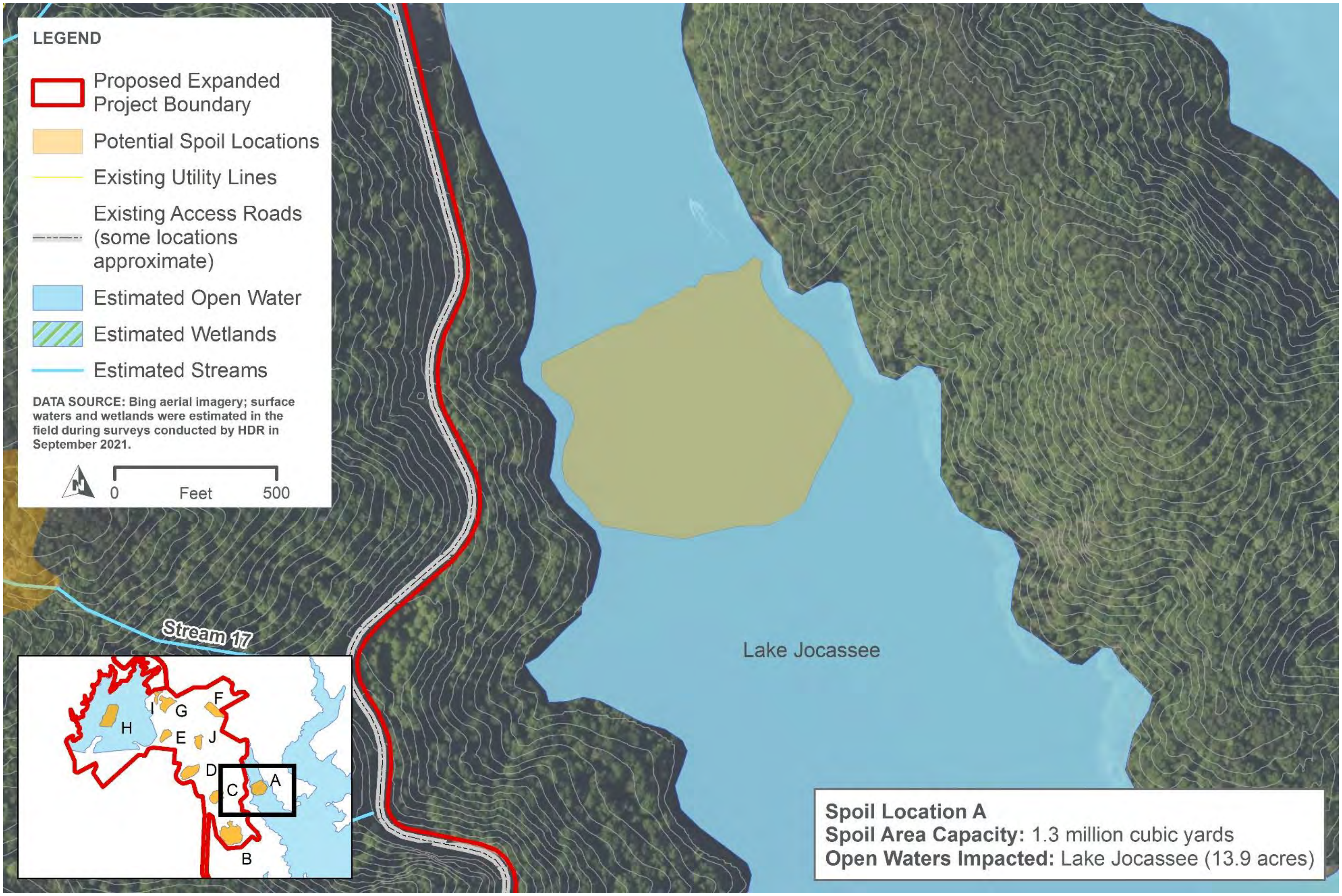
South Carolina Steering Committee. 2022. South Carolina Stream Quantification Tool: Data Collection and Analysis Manual, SC SQT v1.1. South Carolina Department of Natural Resources, Columbia, SC.

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

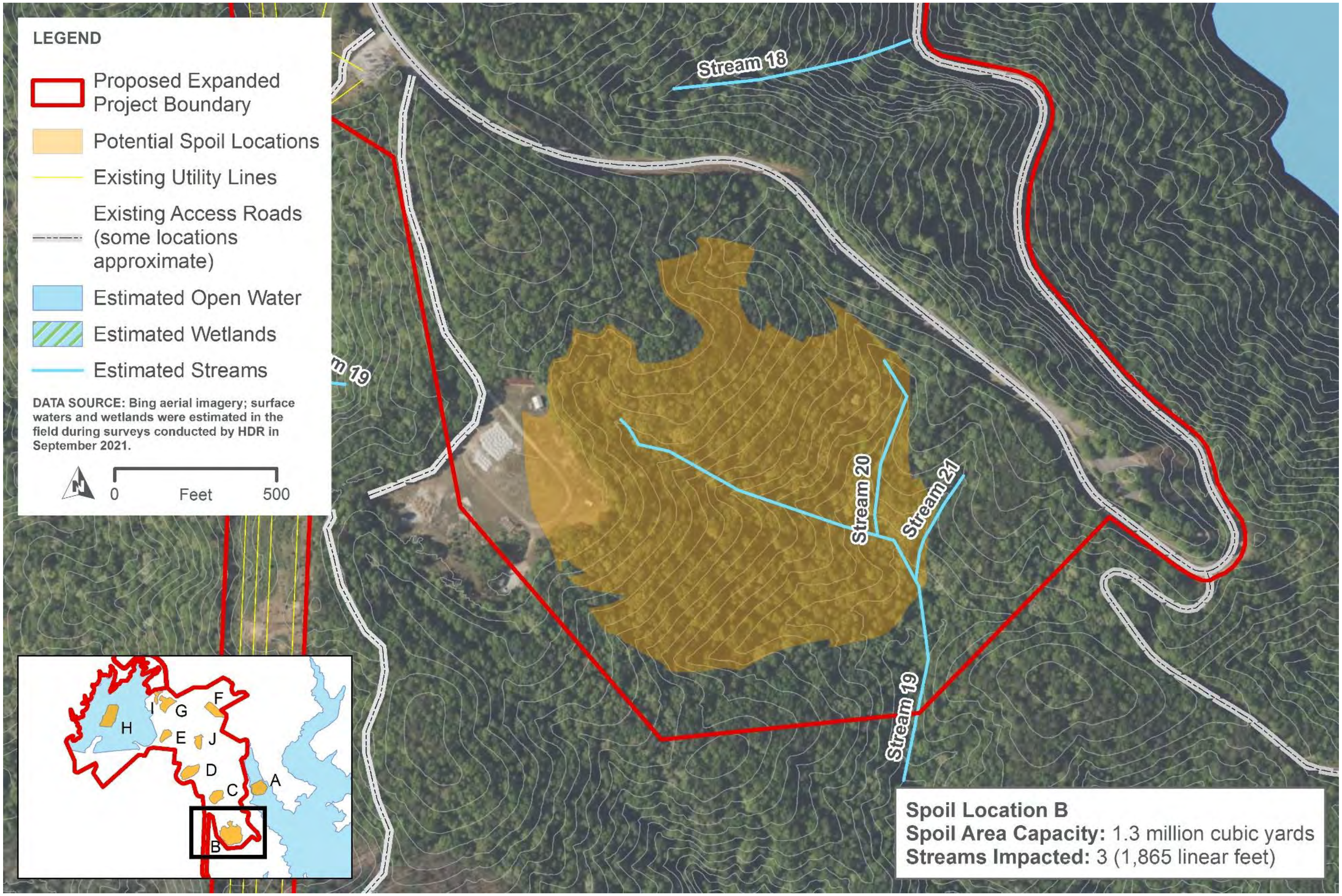
Attachment 1 – Streams and Wetlands within Potential Spoil Locations


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

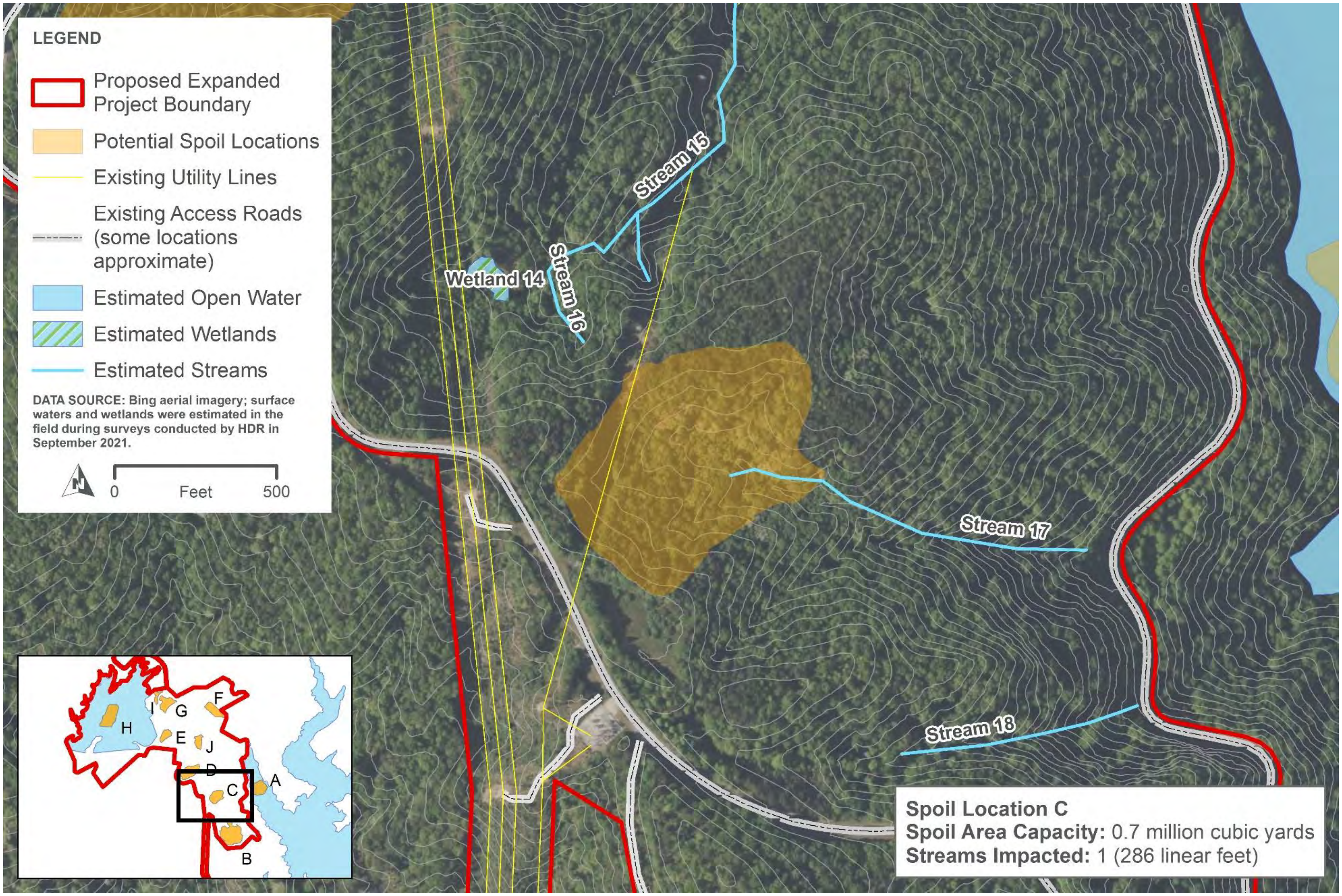


DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

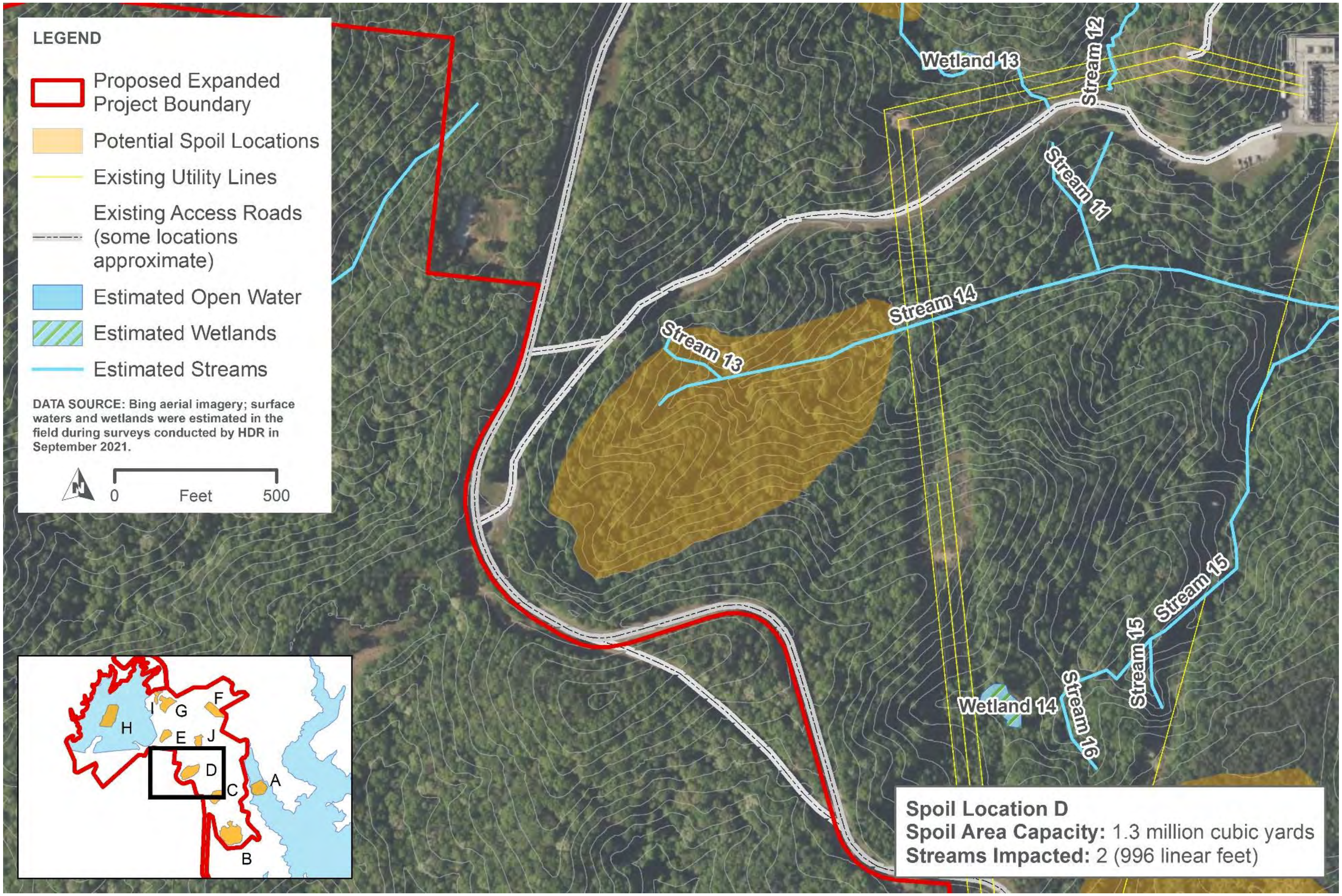
Spoil Location A
Spoil Area Capacity: 1.3 million cubic yards
Open Waters Impacted: Lake Jocassee (13.9 acres)



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

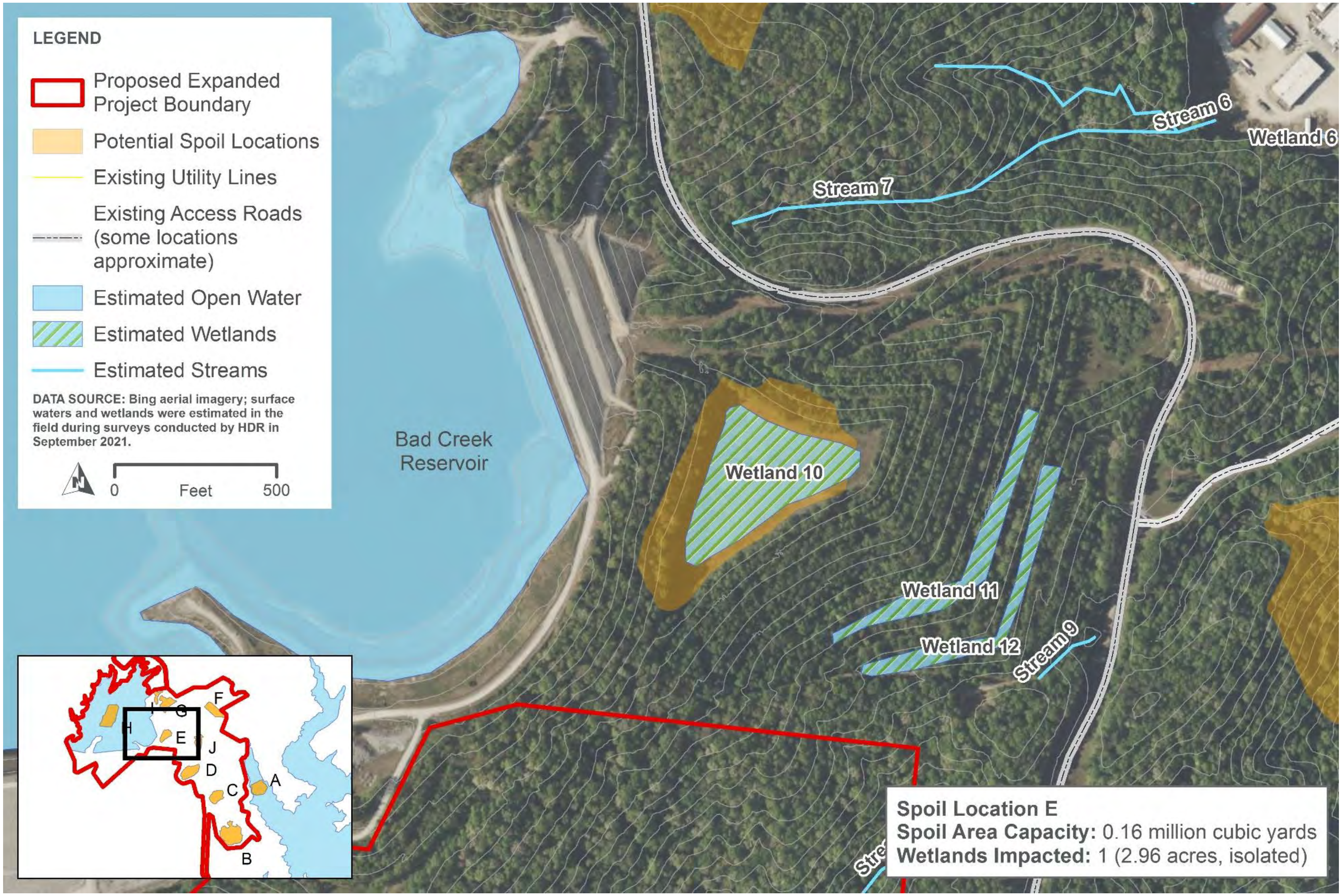


Spoil Location C
Spoil Area Capacity: 0.7 million cubic yards
Streams Impacted: 1 (286 linear feet)

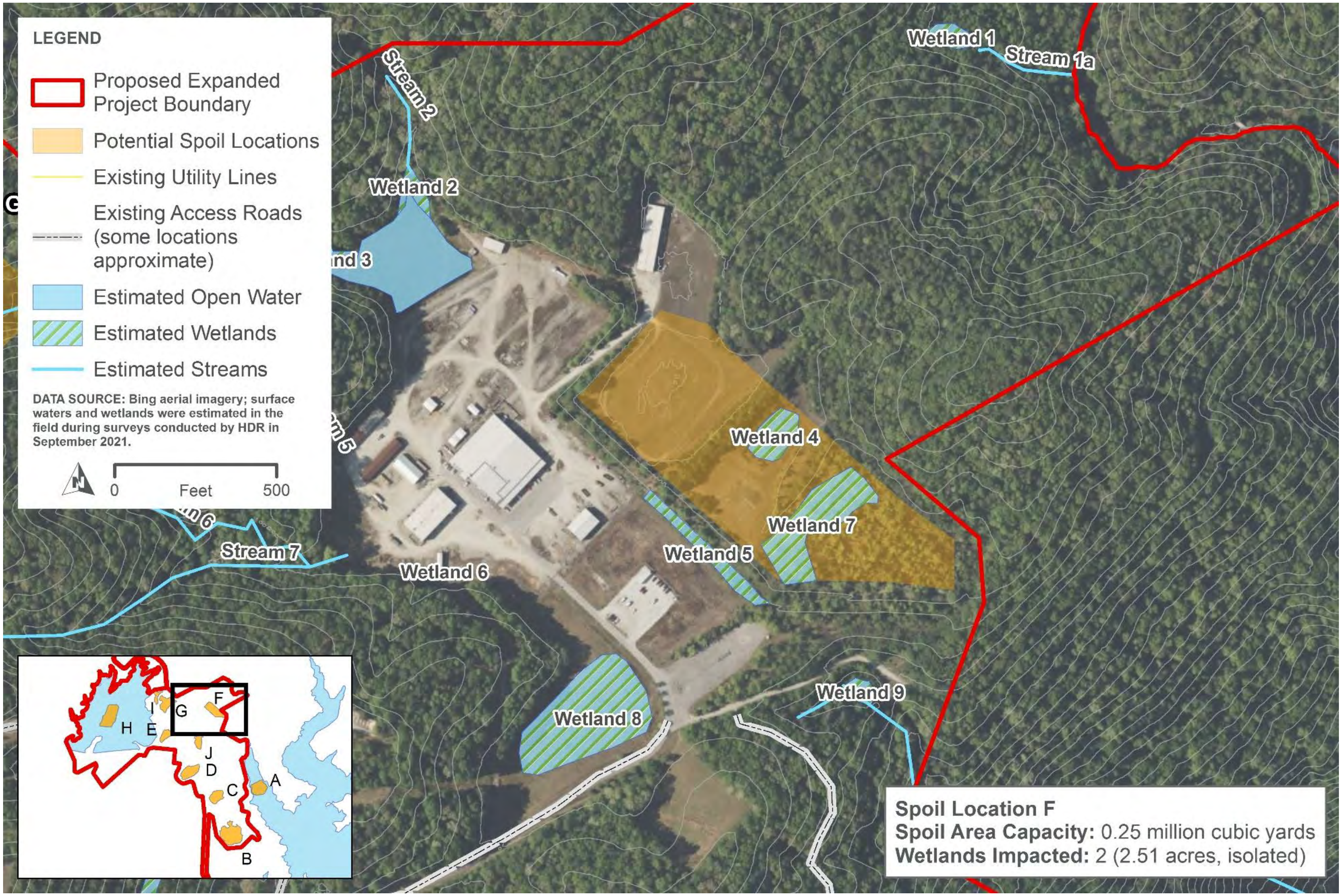


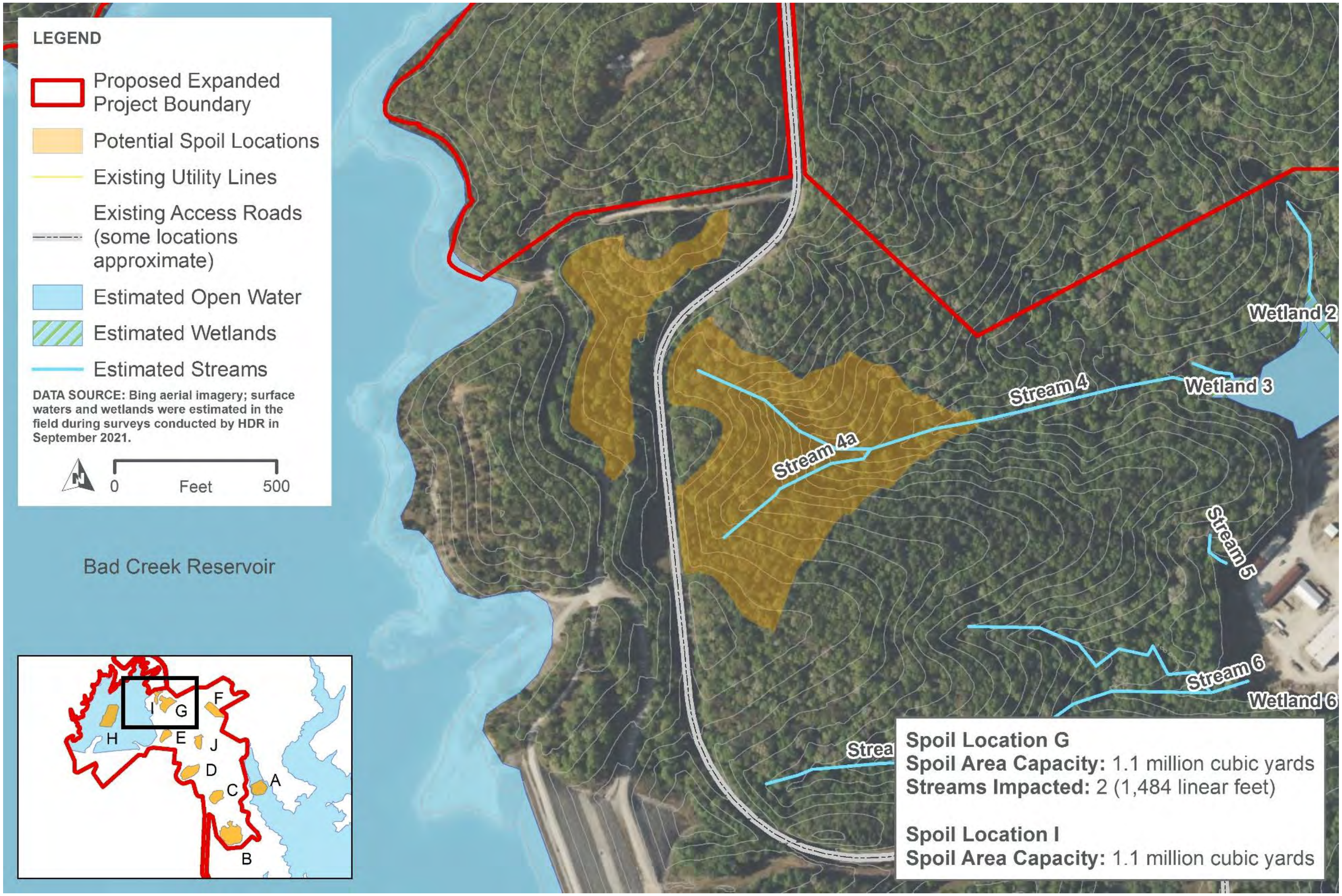
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

Spoil Location D
Spoil Area Capacity: 1.3 million cubic yards
Streams Impacted: 2 (996 linear feet)



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

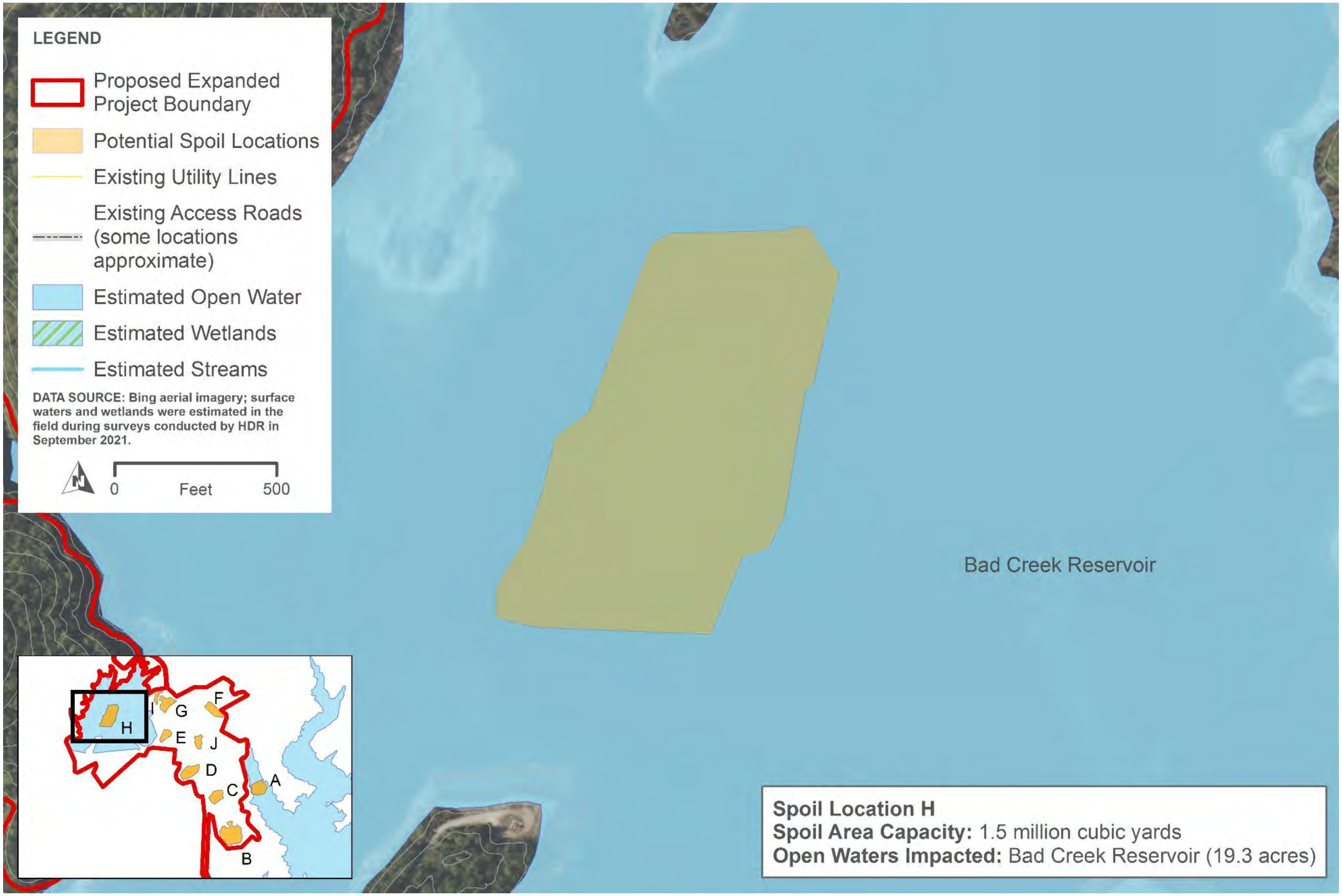

LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Utility Lines
Existing Access Roads (some locations approximate)
Estimated Open Water
Estimated Wetlands
Estimated Streams
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.
0
Feet
500
Wetland 1
Stream 1a
Stream 2
Wetland 2
Wetland 3
Stream 5
Wetland 4
Wetland 7
Wetland 5
Wetland 6
Stream 6
Stream 7
Wetland 8
Wetland 9
H
E
I
G
F
J
D
C
A
B
Spoil Location F
Spoil Area Capacity: 0.25 million cubic yards
Wetlands Impacted: 2 (2.51 acres, isolated)



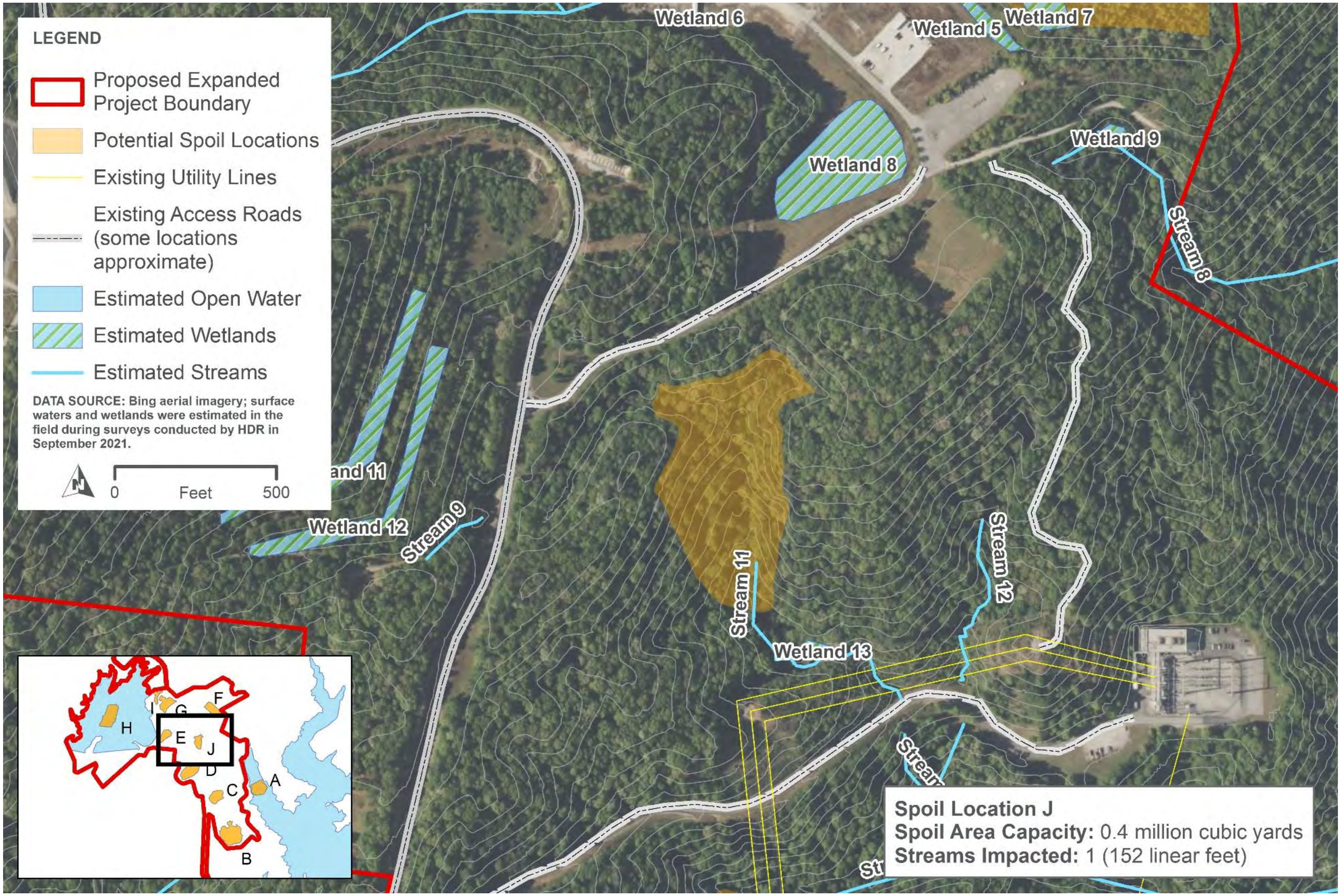
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

Spoil Location 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

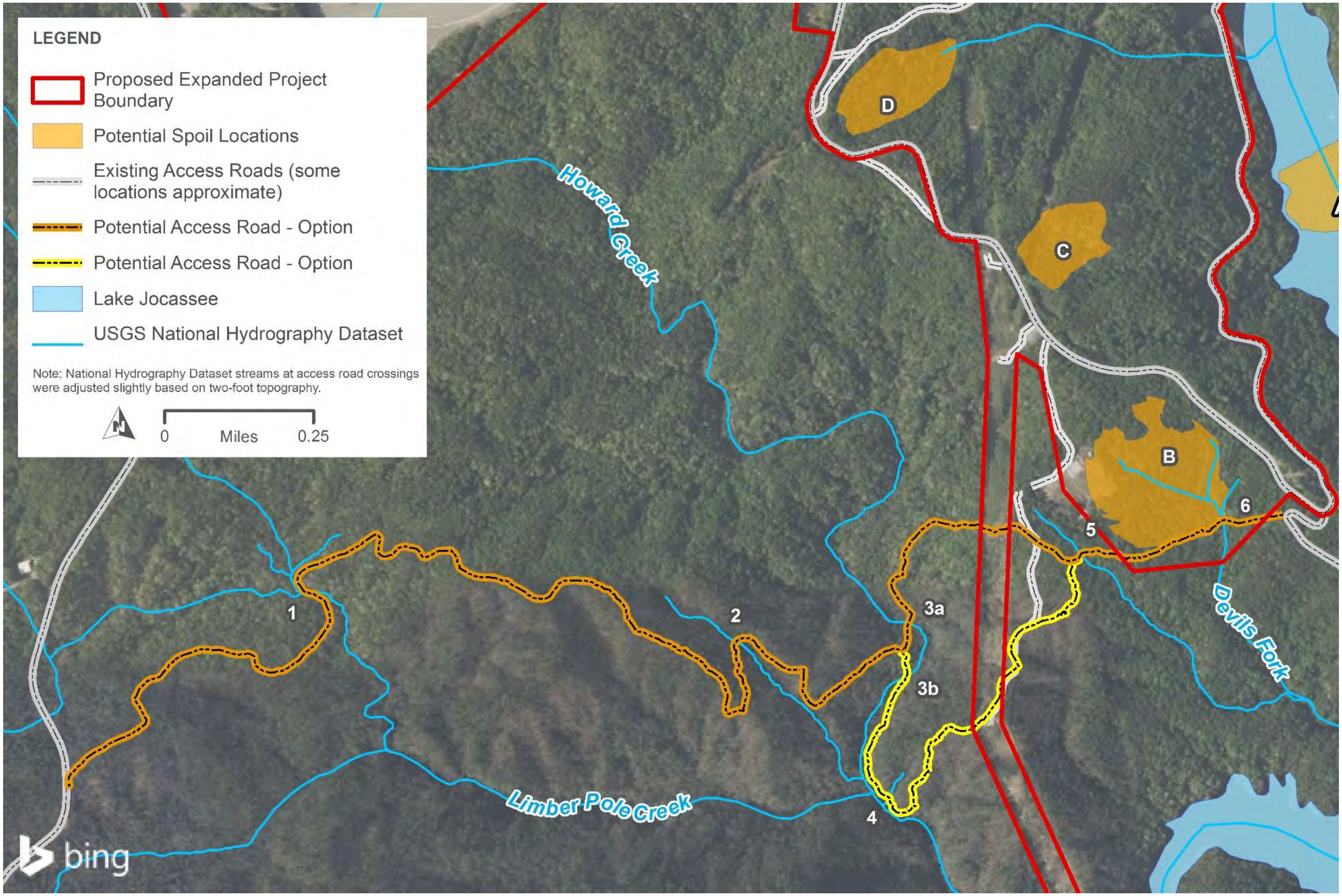


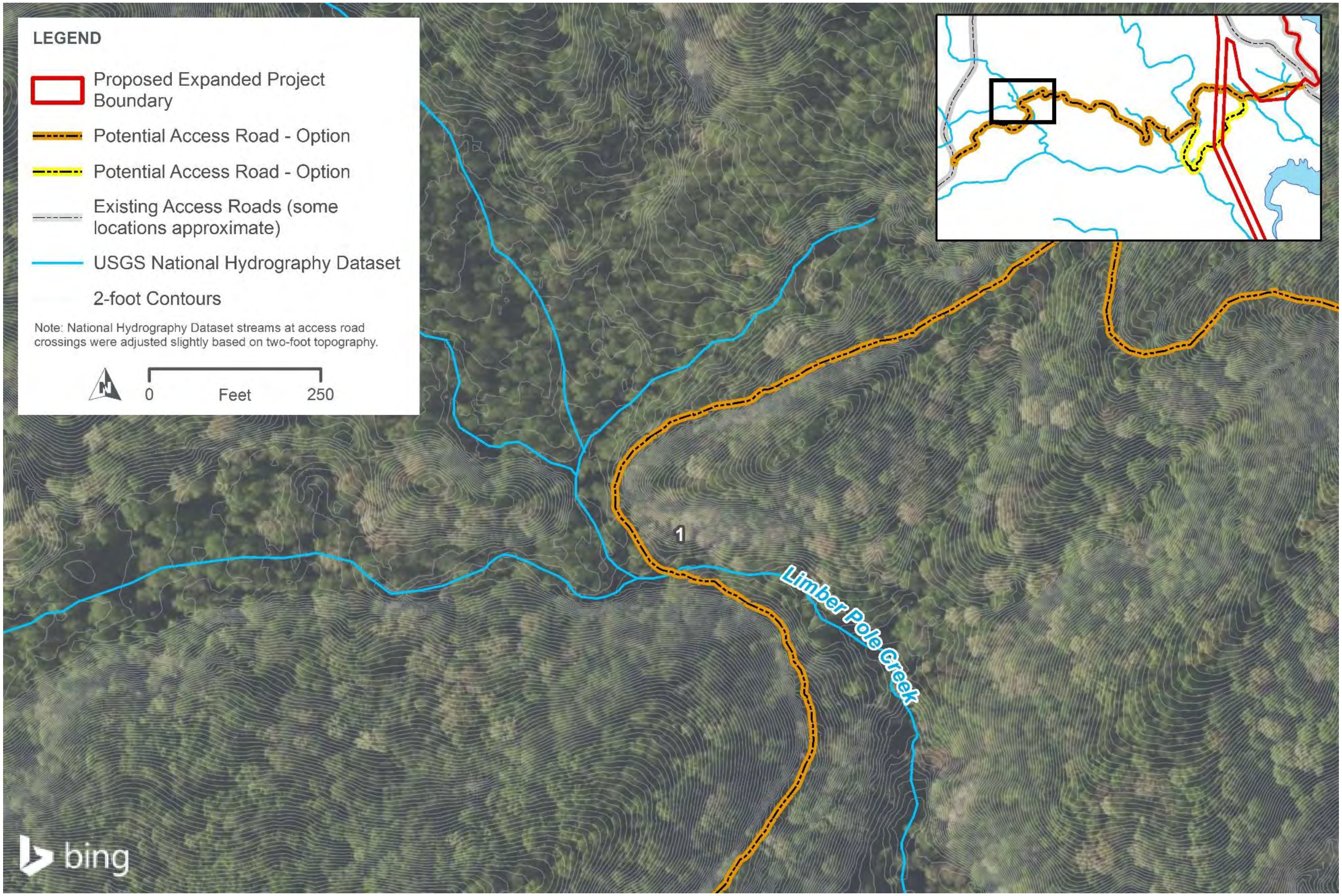
Spoil Location H
Spoil Area Capacity: 1.5 million cubic yards
Open Waters Impacted: Bad Creek Reservoir (19.3 acres)

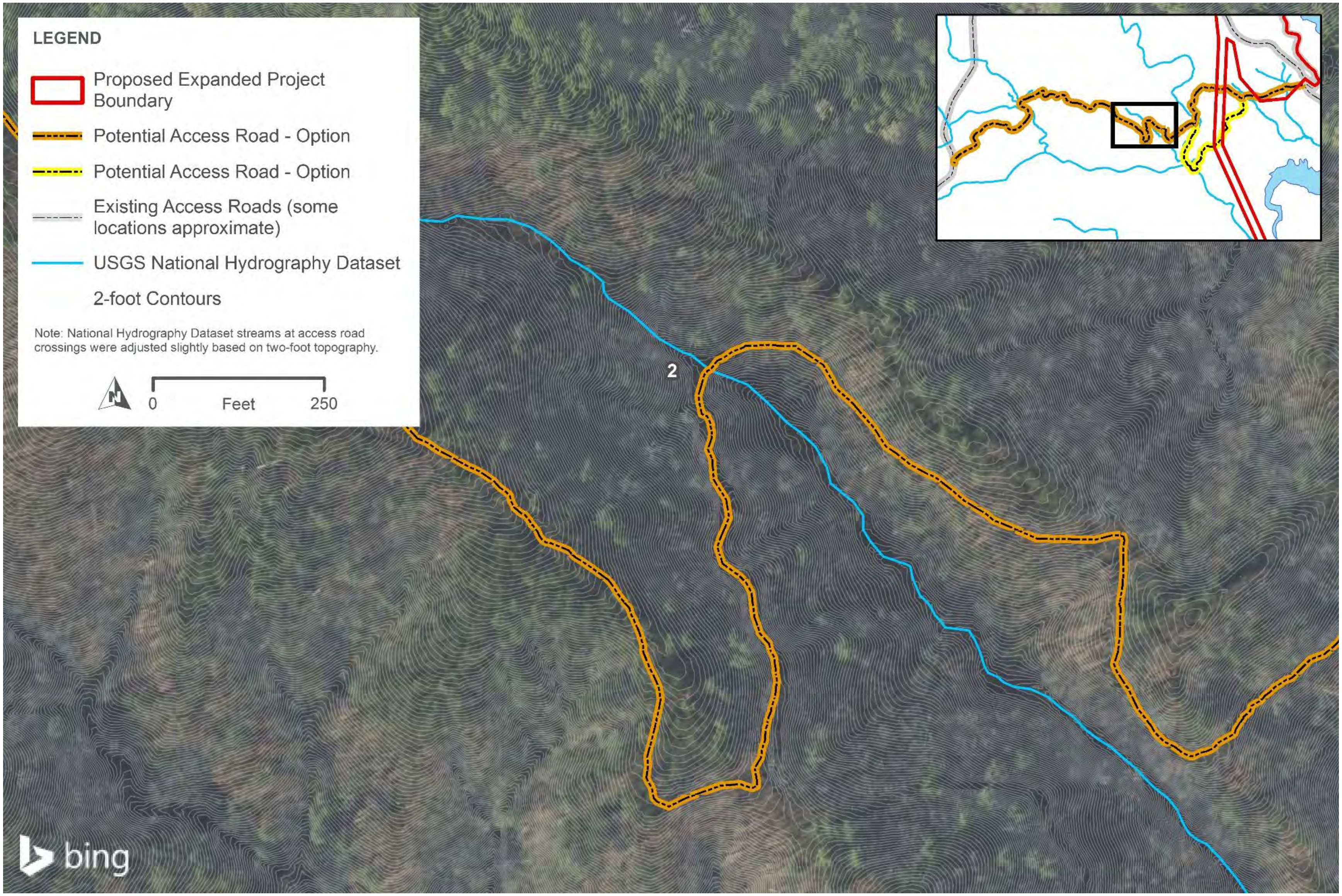

LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Utility Lines
Existing Access Roads (some locations approximate)
Estimated Open Water
Estimated Wetlands
Estimated Streams
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys 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
Strea
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)

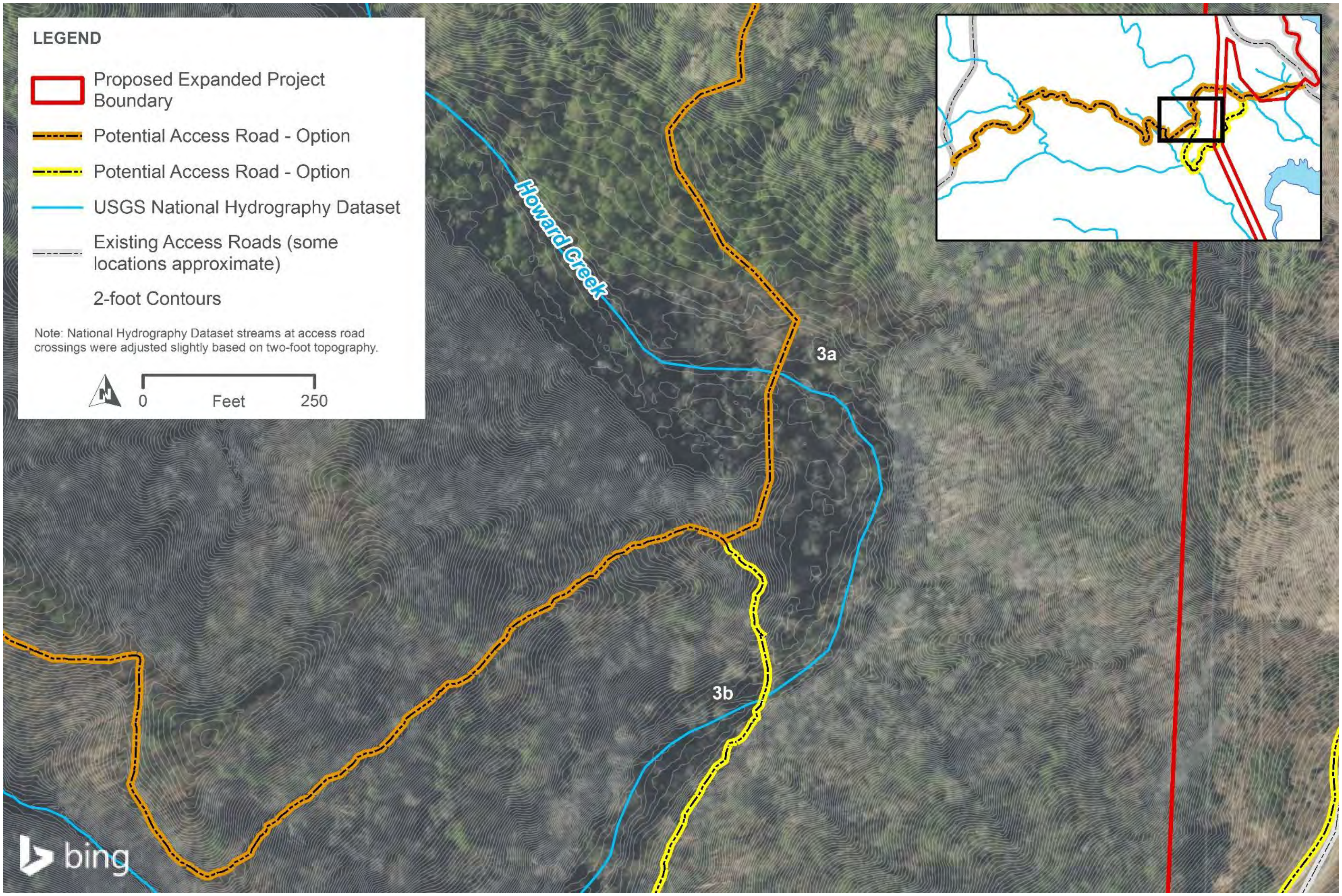
Attachment 2

Attachment 2 – Potential Access Road Stream Crossings

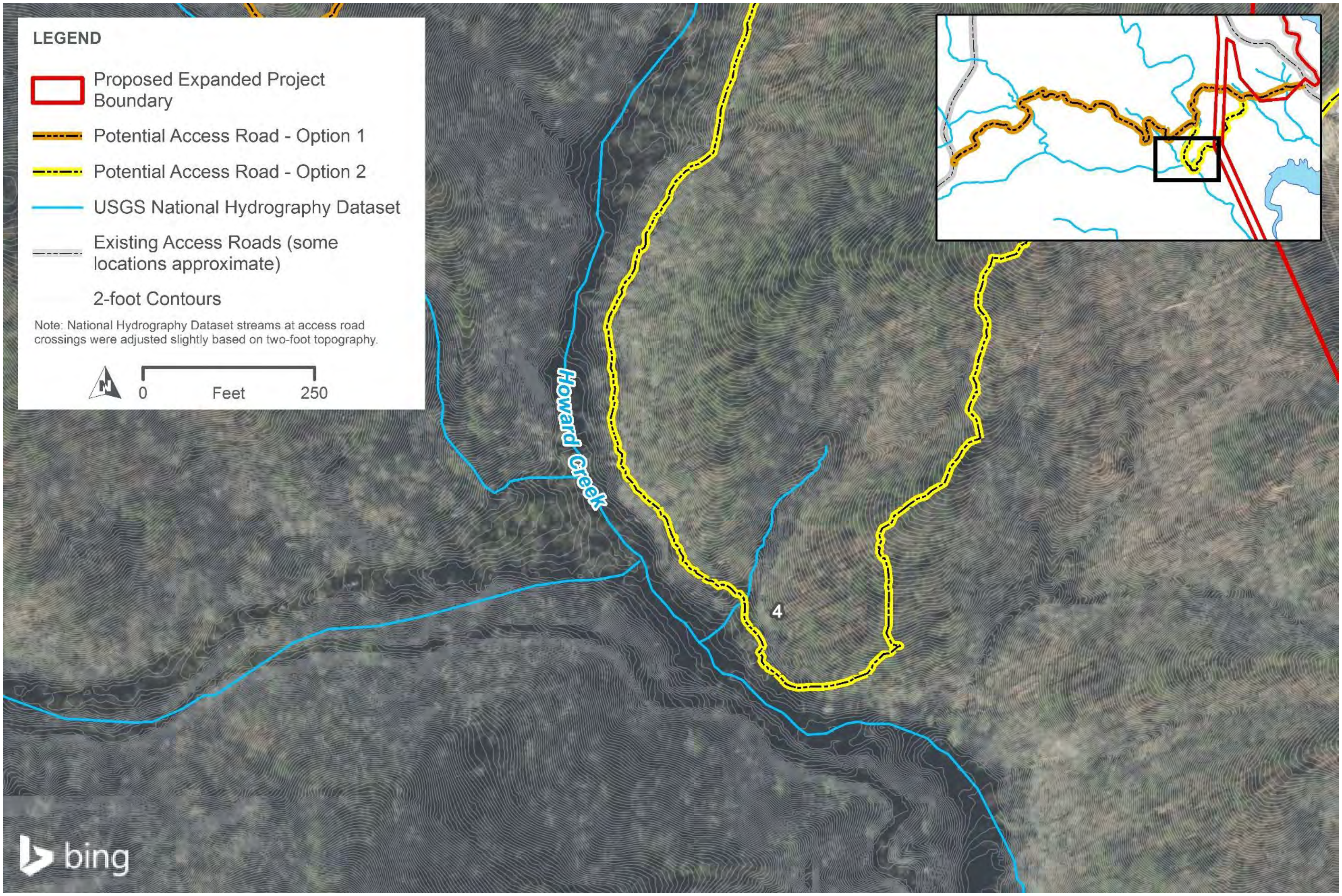

LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Access Roads (some locations approximate)
Potential Access Road - Option
Potential Access Road - Option
Lake Jocassee
USGS National Hydrography Dataset
Note: National Hydrography Dataset streams at access road crossings were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

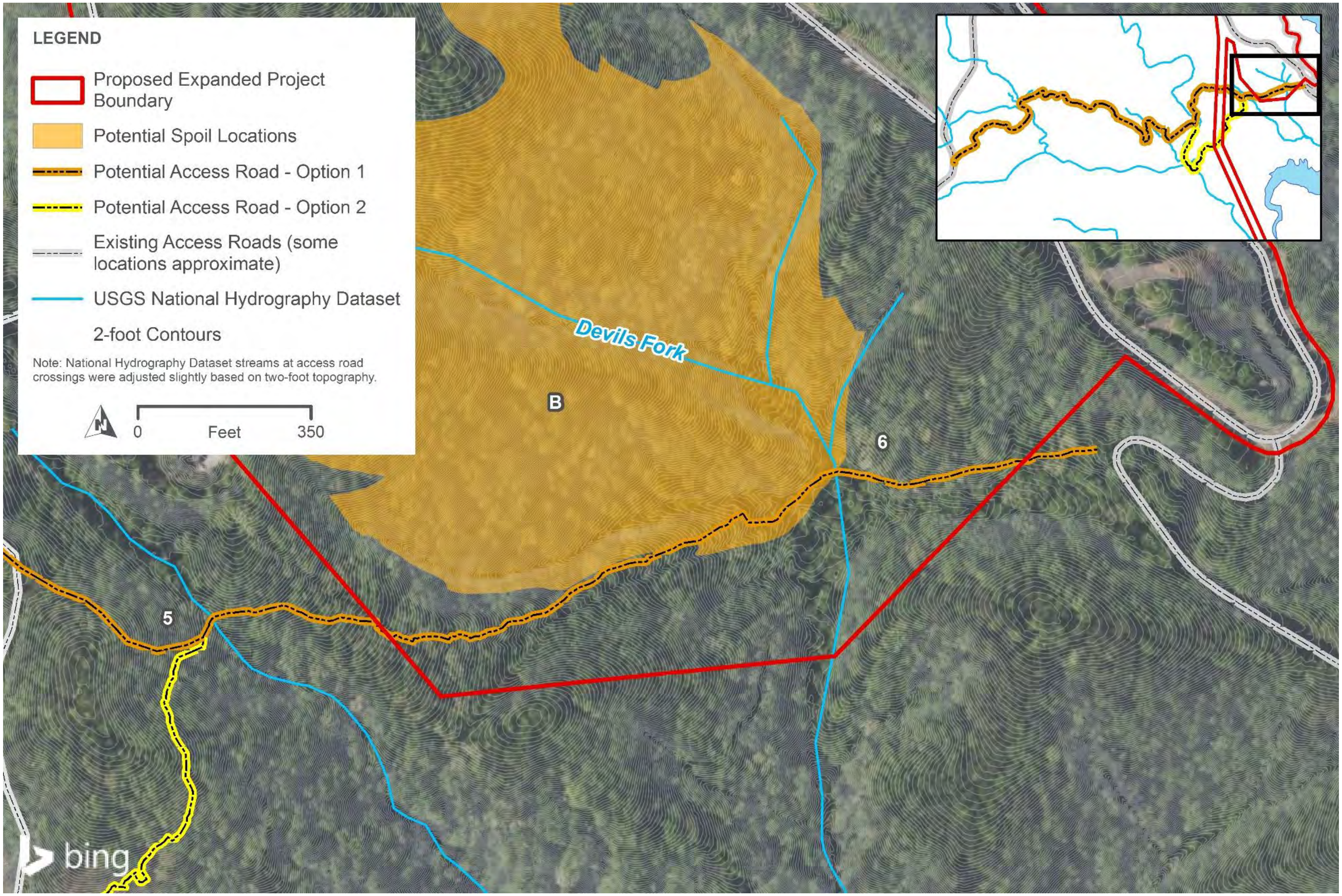

LEGEND
Proposed Expanded Project Boundary
Potential Access Road - Option
Potential Access Road - Option
Existing Access Roads (some locations approximate)
USGS National Hydrography Dataset
2-foot Contours
Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based 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



Note: National Hydrography Dataset streams at access road crossings were adjusted slightly based on two-foot topography.


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.
N
0
Feet
350
Devils Fork
B
5
6
bing

Attachment B

Attachment B - Natural Resources Assessment Figures

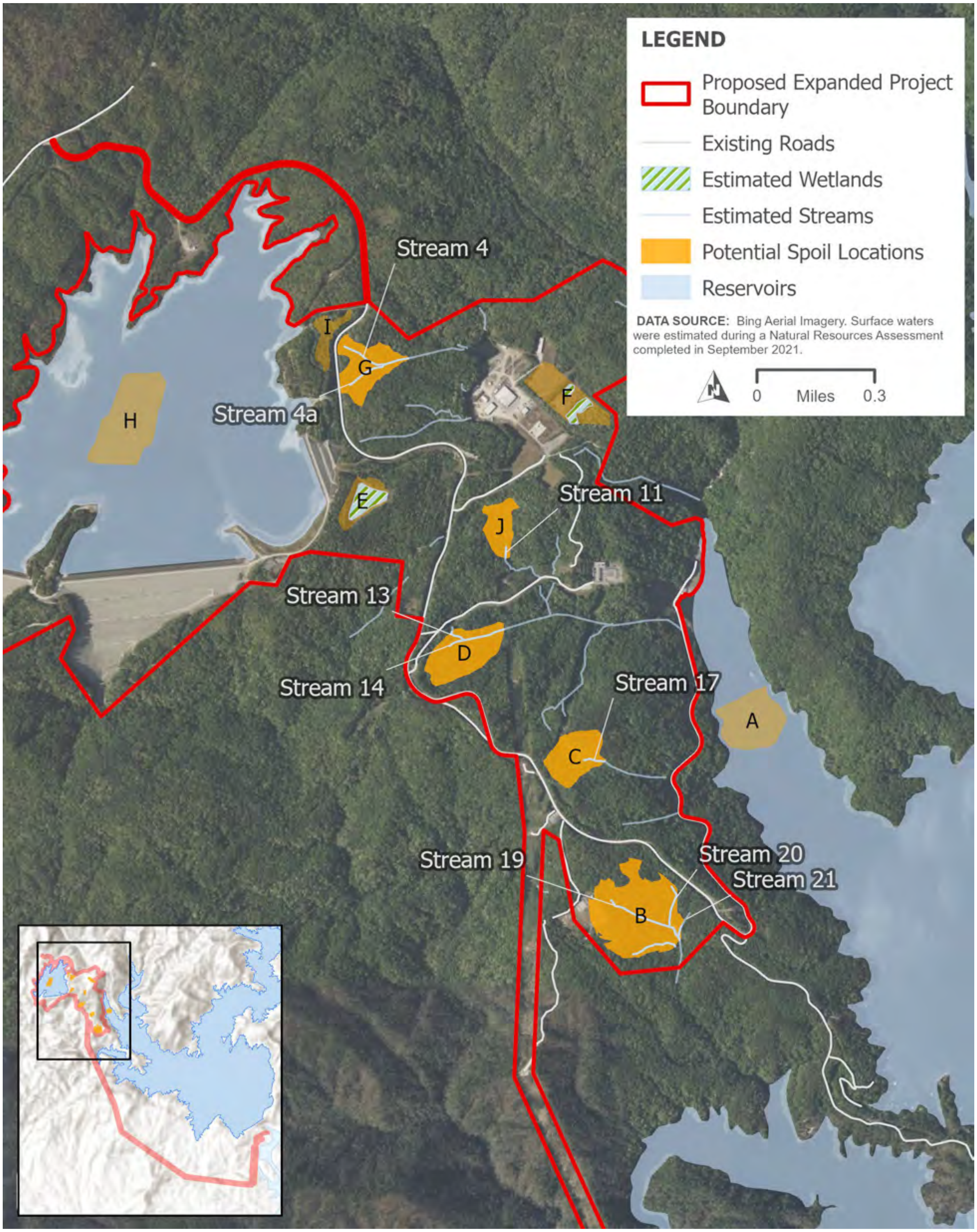


Figure 1. Estimated surface waters and wetlands within spoil locations

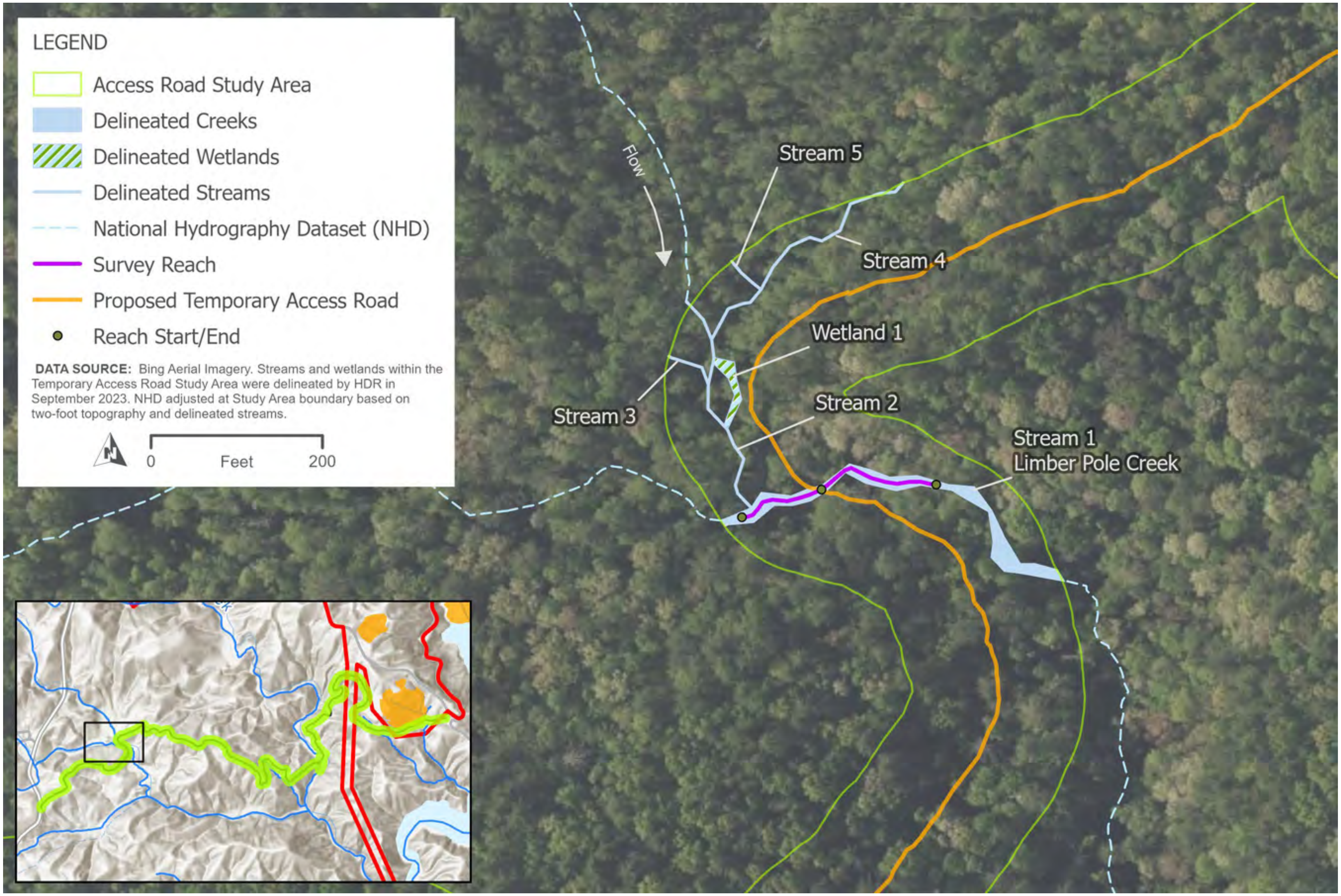


Figure 2. Streams and wetlands surveyed along the proposed temporary access road at the Stream 1 (Limber Pole Creek) crossing

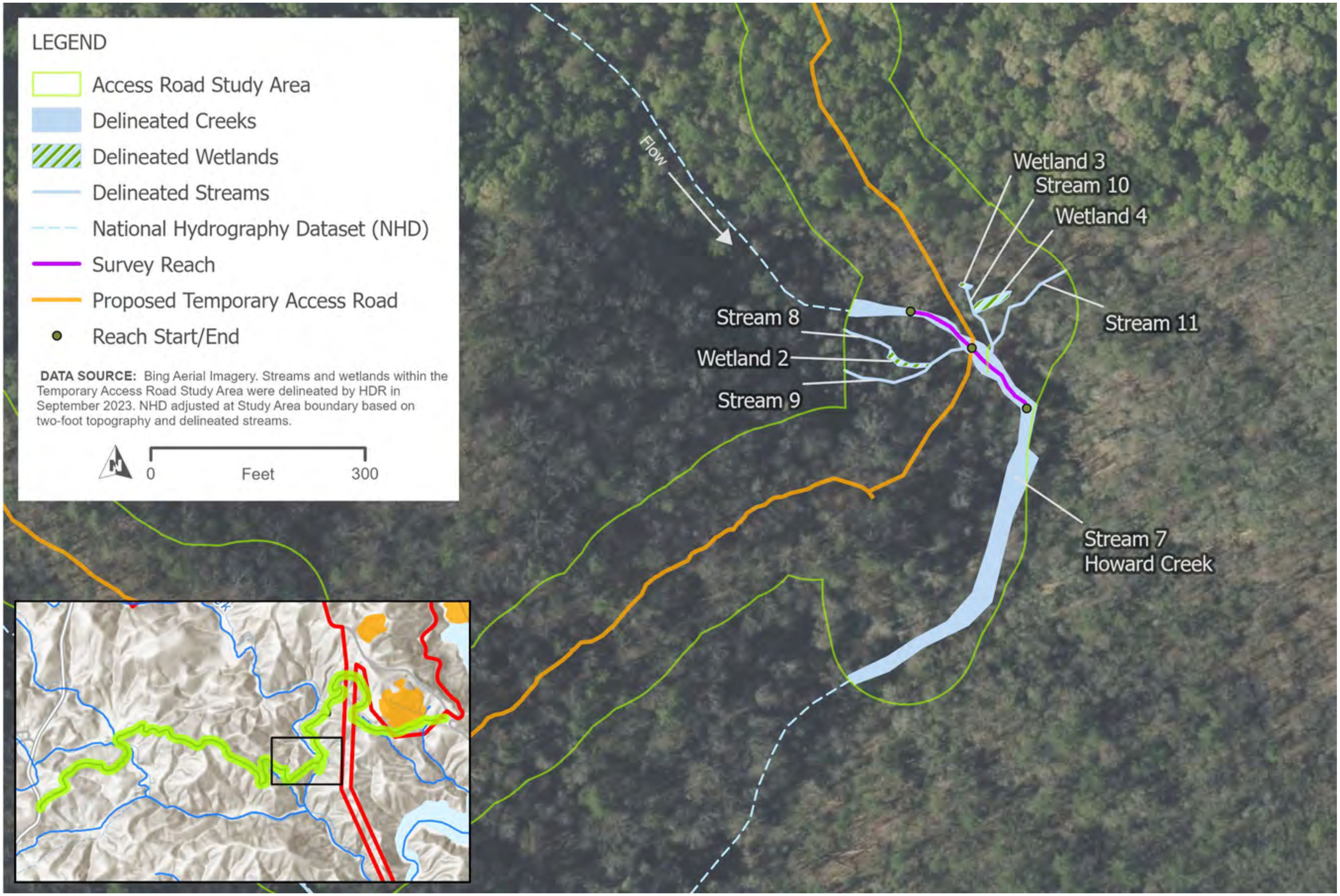


Figure 3. Streams and wetlands surveyed along the proposed temporary access road at the Stream 7 (Howard Creek) crossing

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

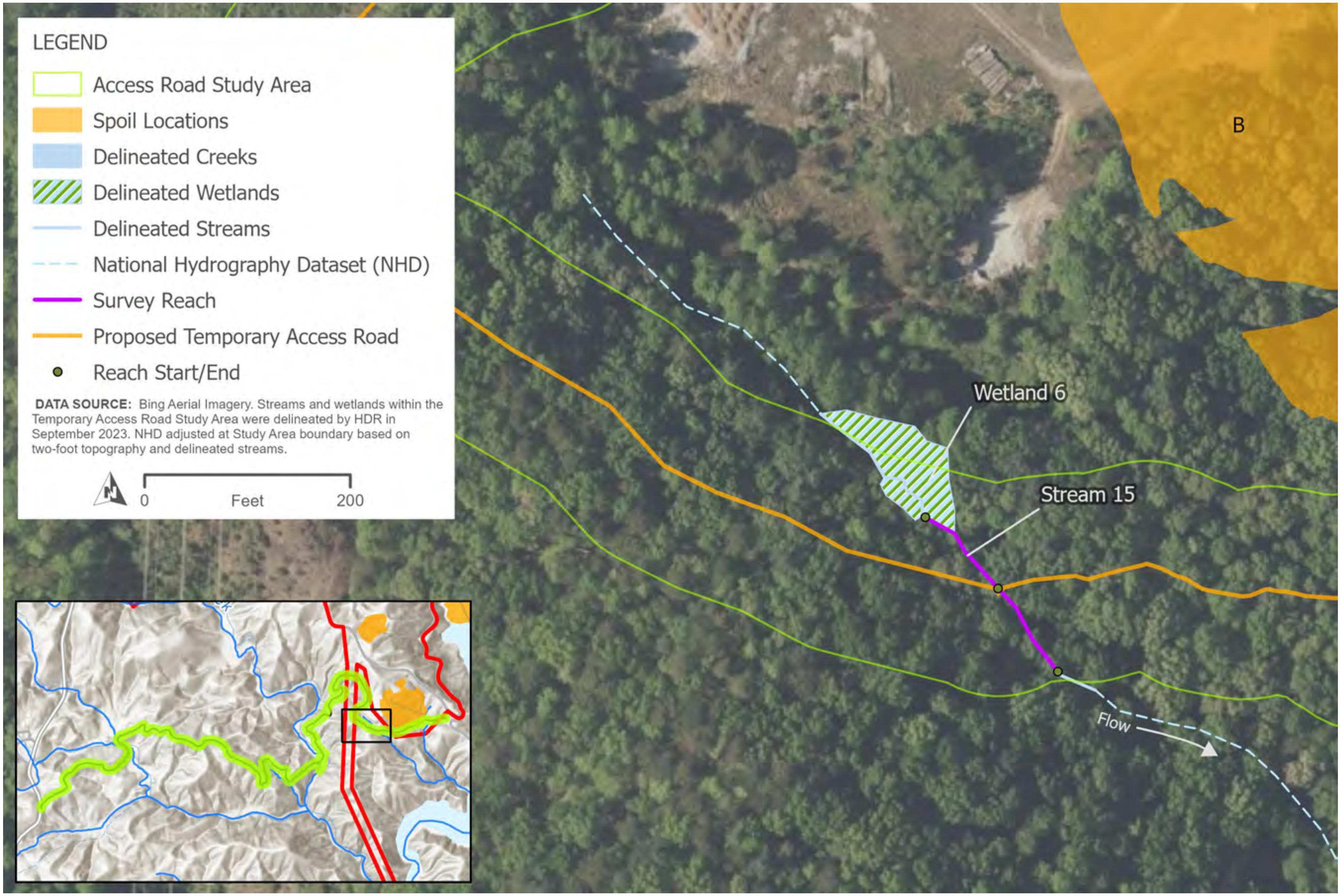


Figure 5. Streams and wetlands surveyed along the proposed temporary access road at the Stream 15 crossing

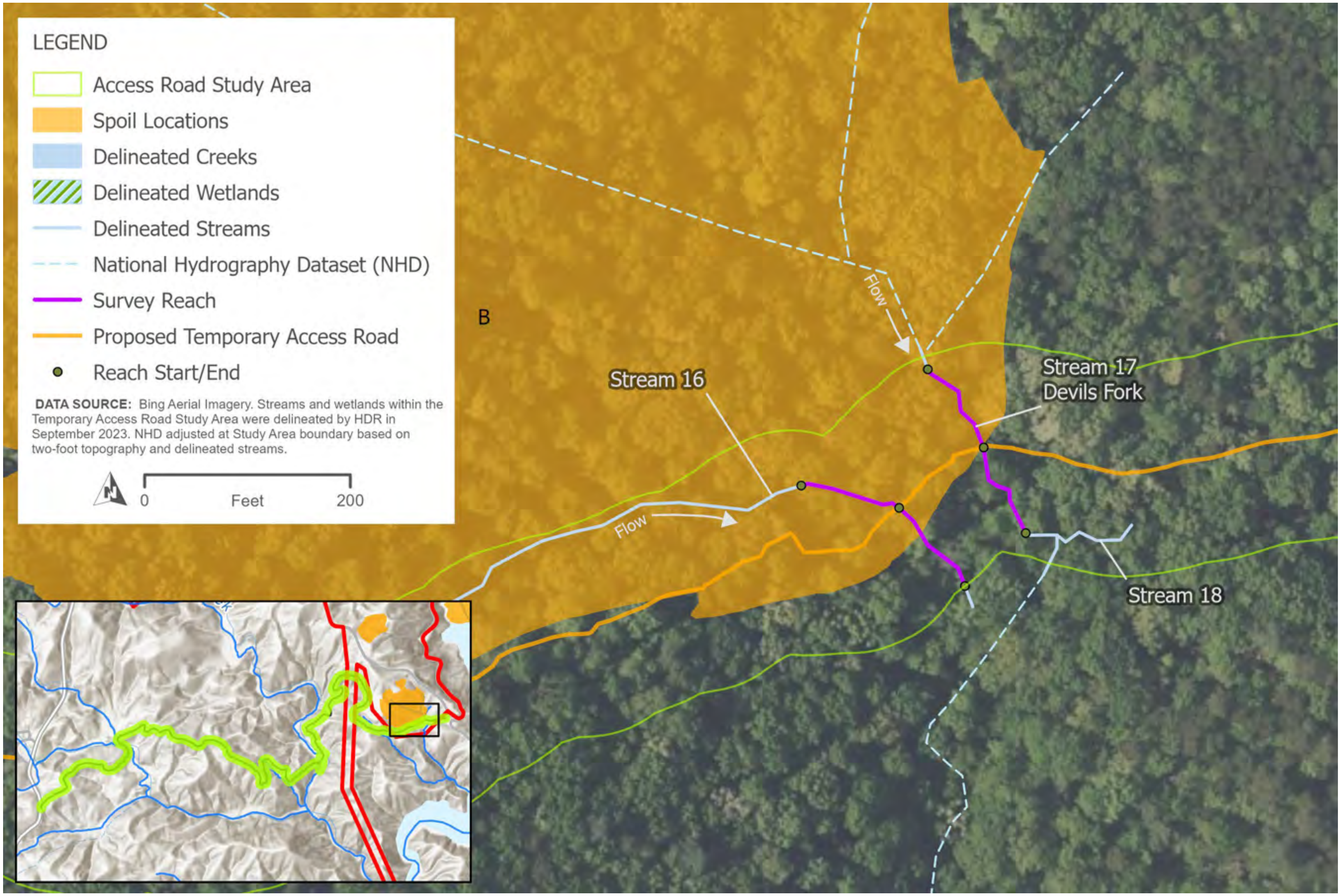


Figure 6. Streams and wetlands surveyed along the proposed temporary access road at the Stream 15 and 17 crossings

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 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 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) 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 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)

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 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) 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	
STORET #	AGENCY	
INVESTIGATORS Paul Bright / Brett Boone		
FORM COMPLETED BY Paul Bright	DATE 10/18/23 TIME 4:00 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 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) 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 Paul Bright

DATE 10/19/23

TIME 10:00 [✓ 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 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) 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 Paul Bright	DATE 10/19/23 TIME 3:00 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 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) 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

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 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 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) 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) 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 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)

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 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) 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 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 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) 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 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) 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
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 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)

	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 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) 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 on USGS 7.5-minute quad: Whitewater River
7. River basin: Savannah
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 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

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 <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

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 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 <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

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
7. River basin: Savannah on USGS 7.5-minute quad: Howard Creek
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 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 <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

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 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

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 <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 <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

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 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] <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

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 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

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 <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

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 <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

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**	

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

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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.

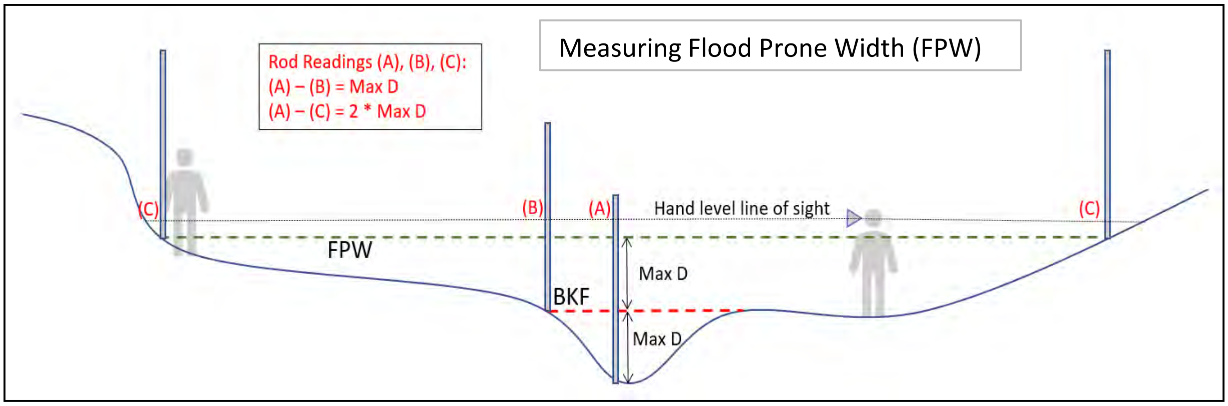
Difference between BKF stage and WS (ft)	Describe the bankfull indicator
0.82	Back of depositional feature

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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

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

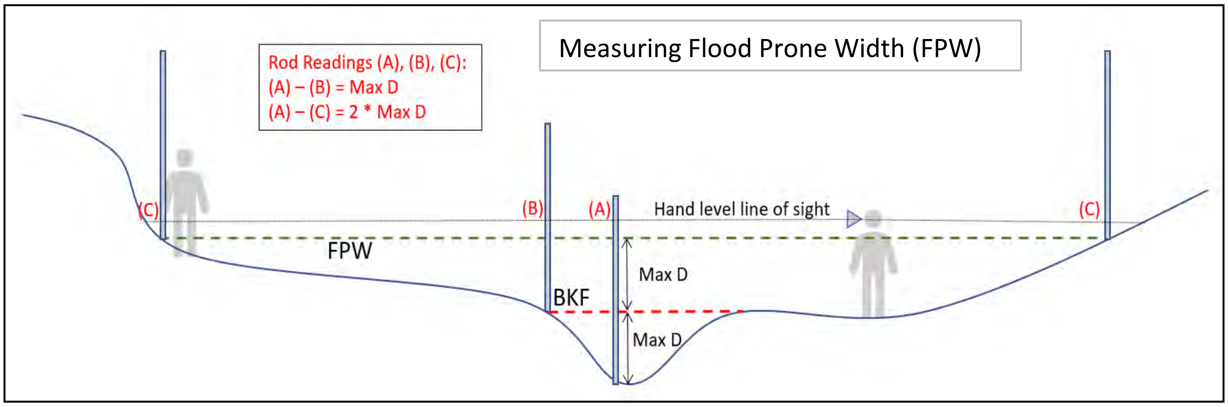
C.

Difference between BKF stage and WS (ft)	Describe the bankfull indicator
0.83	bottom of undercut, top of mid-channel depositional bar

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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 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 At maximum pool depth	24.1	66.6						
Geomorphic P-P Spacing (ft)								
Pool Depth (ft) 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											

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

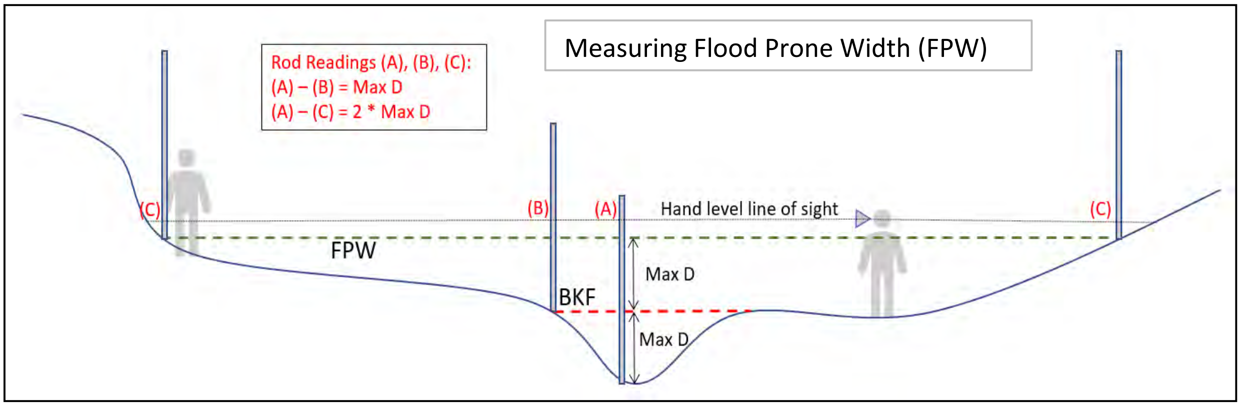
C.

Difference between BKF stage and WS (ft)	Describe the bankfull indicator
0.02	undercut bank, moss lines

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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 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 At maximum pool depth	23.2	40.5	72					
Geomorphic P-P Spacing (ft)		17.3	31.5					
Pool Depth (ft) 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

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

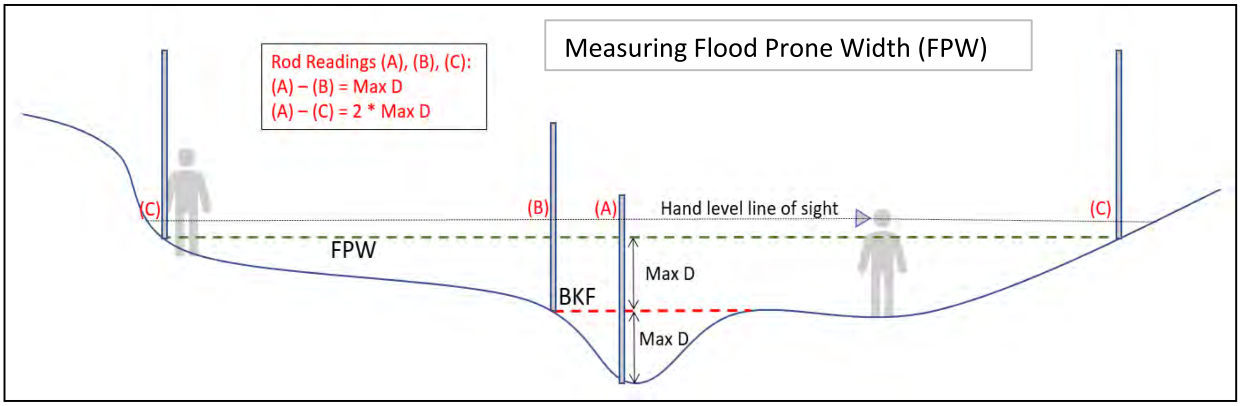
C.

Difference between BKF stage and WS (ft)	Describe the bankfull indicator
0.48	depositional bench w/veg - top

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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		



IV. Representative Sub-Reach

A.

Assessment Segment Length 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

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 12 - Upstream

SC SQT Rapid Method Form
Version 1.0

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.

Date: 10/2/2023
Investigators: EBS, KC, SP (HDR)

Stream 12 - Upstream

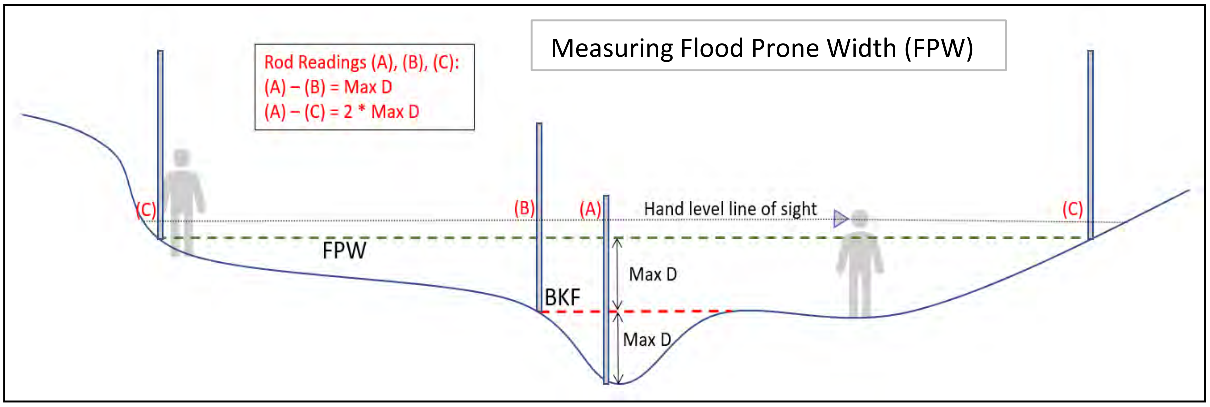
SC SQT Rapid Method Form
Version 1.0

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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		



IV. Representative Sub-Reach

A.

Assessment Segment Length 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 At maximum pool depth	10.9	31	44.1					
Geomorphic P-P Spacing (ft)		20.1	13.1					
Pool Depth (ft) 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												

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.

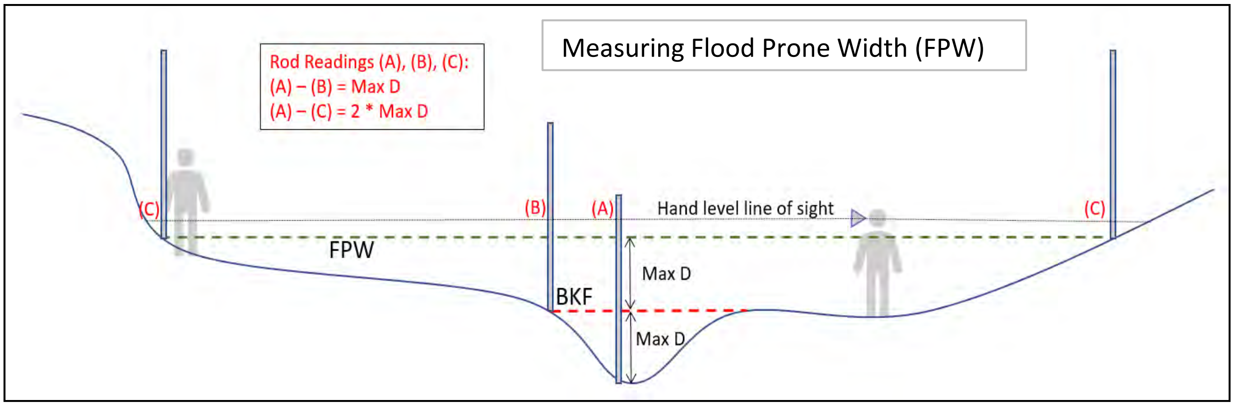
Difference between BKF stage and WS (ft)	Describe the bankfull indicator
0.75	Back of bench

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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
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		



IV. Representative Sub-Reach

A.

Assessment Segment Length 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 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) 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

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

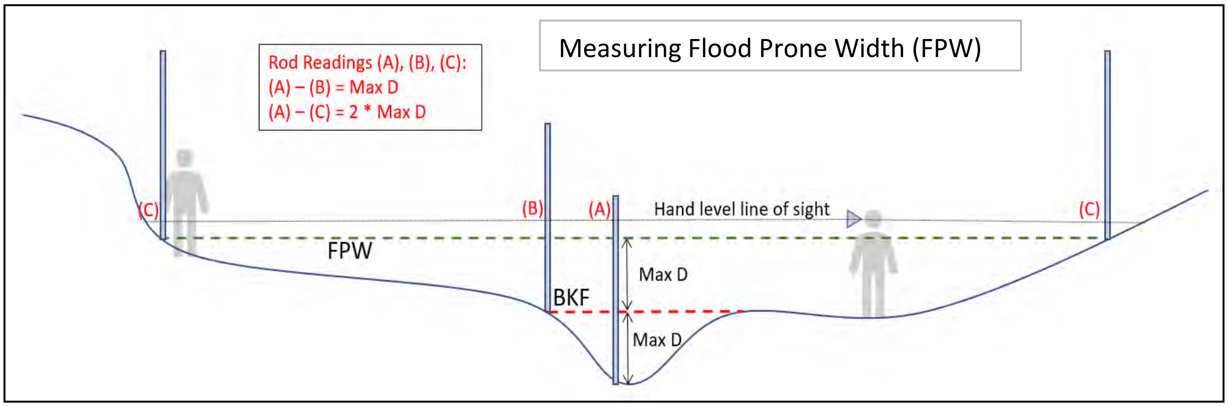
Date: 10/3/2023 Stream 15 - Upstream **SC SQT Rapid Method Form**

Investigators: EBS, KC, SP (HDR) Version 1.0

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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 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		



IV. Representative Sub-Reach

A.

Assessment Segment Length 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 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) 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

Stream 15 - Upstream

SC SQT

BEHI/NBS Field Form

Investigators: EBS, KC, SP (HDR)

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

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

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 15 - Downstream

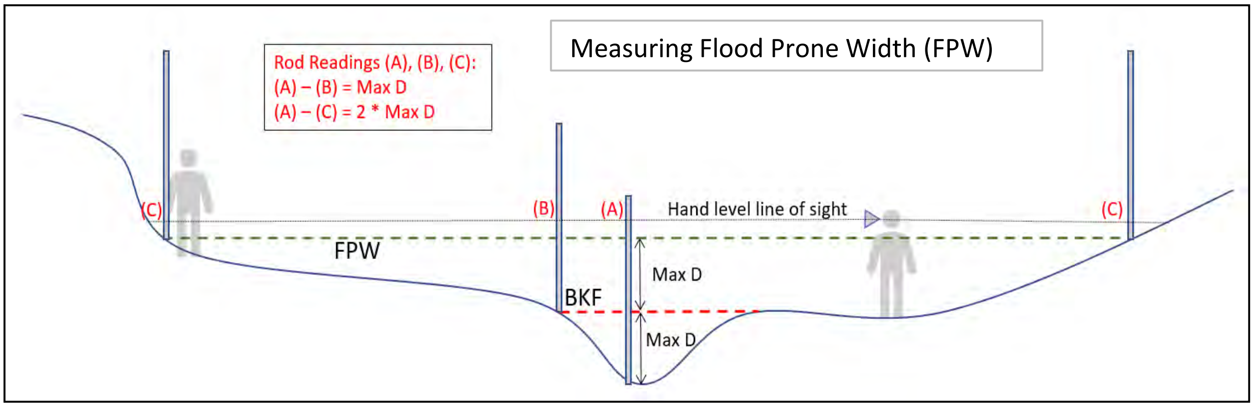
SC SQT Rapid Method Form
Version 1.0

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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		



IV. Representative Sub-Reach

A.

Assessment Segment Length 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 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) 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											

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 16 - Upstream

SC SQT Rapid Method Form
Version 1.0

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

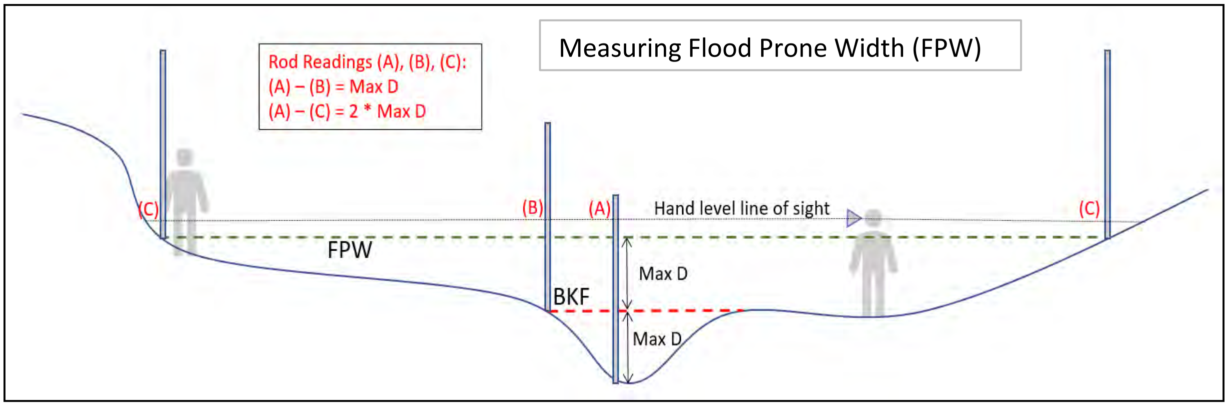
C.

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

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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		



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 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 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) 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

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

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 16 - Downstream

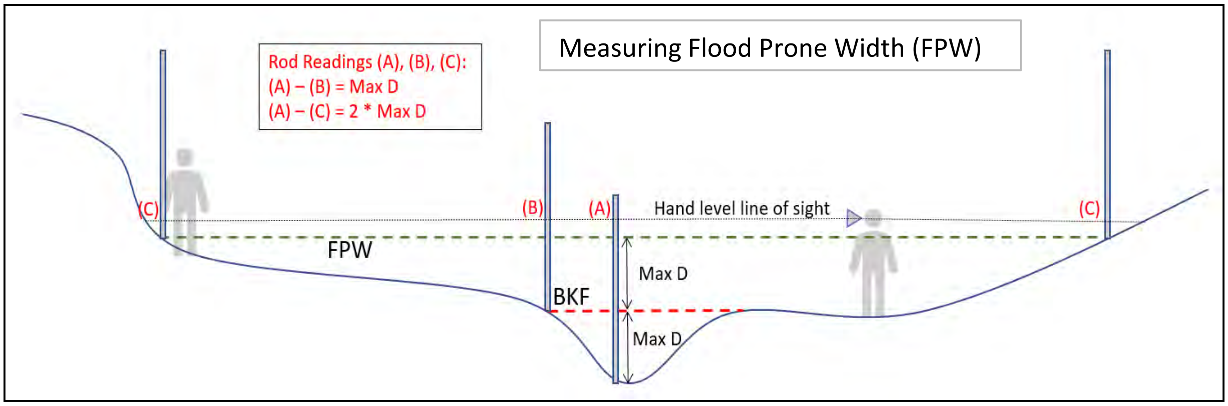
SC SQT Rapid Method Form
Version 1.0

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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		



Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 16 - Downstream

SC SQT Rapid Method Form
Version 1.0

IV. Representative Sub-Reach

A.

Assessment Segment Length 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 At maximum pool depth	31.5	41	56.4					
Geomorphic P-P Spacing (ft)		9.5	15.4					
Pool Depth (ft) 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

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.

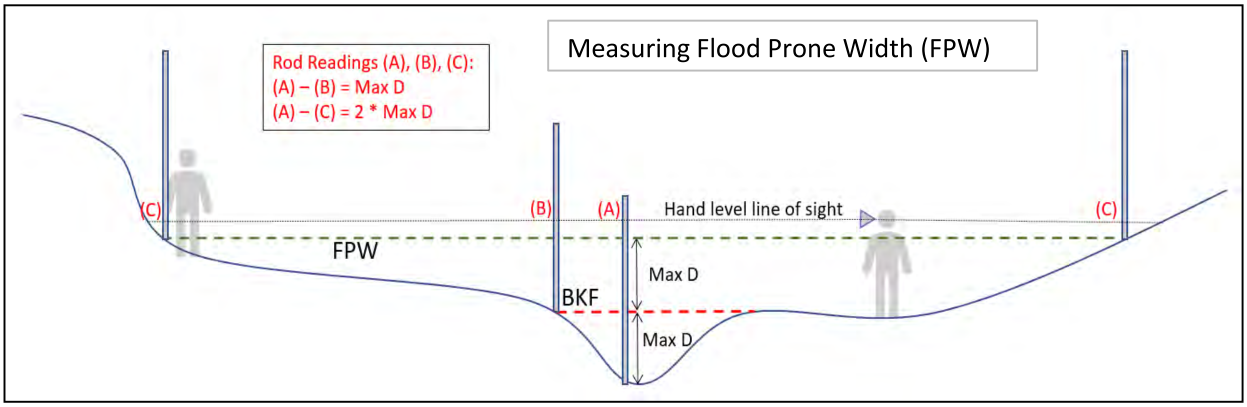
Difference between BKF stage and WS (ft)	Describe the bankfull indicator
0.58	undercut
0.44	bench

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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		



IV. Representative Sub-Reach

A.	Assessment Segment Length 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 At maximum pool depth	3							
Geomorphic P-P Spacing (ft)								
Pool Depth (ft) 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

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

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 17 (Devils Fork) - Downstream

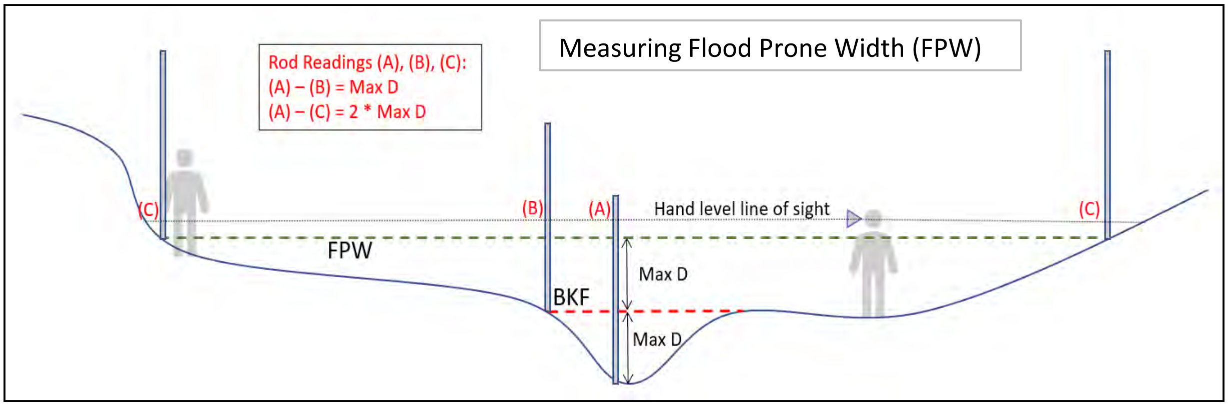
SC SQT Rapid Method Form
Version 1.0

III. Bankfull Verification and Stable Riffle Cross Section

A.	Difference between BKF stage and WS (ft) *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
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 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 At maximum pool depth	79							
Geomorphic P-P Spacing (ft)								
Pool Depth (ft) 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

Date: 10/3/2023
Investigators: EBS, KC, SP (HDR)

Stream 17 (Devils Fork) -
Downstream

SC SQT Rapid Method Form
Version 1.0

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												

Attachment G

Attachment G - Streams Photolog

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.

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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

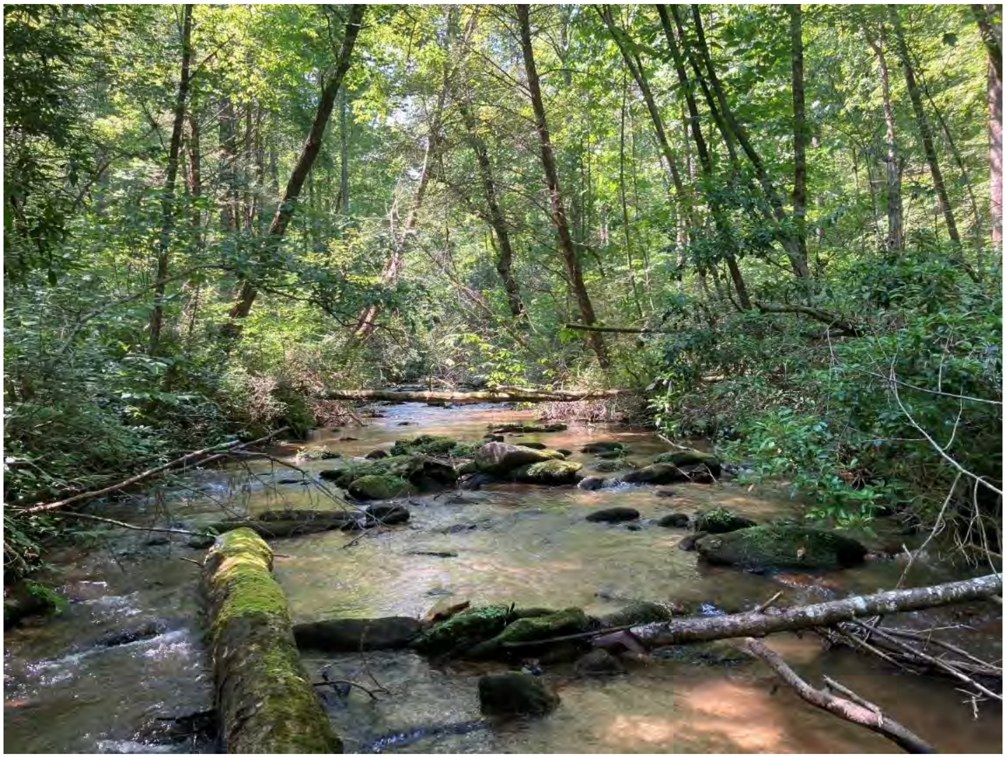

Photo 3. Stream 7 (Howard Creek) - Upstream Fish Sampling Location

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 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 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	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 (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.

Braided channel:	5 Multiple clear channels with water under most conditions. "Main" channel hard to distinguish.	4	3 Side channel(s) present but with less flow/water.	2	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:

---

1 dusky salamander
Several crayfish

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Attachment J

Attachment J - SQT Catchment Assessment and Matrix Summaries

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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 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	

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
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 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	

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): 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 (∆FF)	
Functional Yield (∆FF/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
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 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	tream 12 Downstrea	Downstream of temporary access road	Single reach from temporary access road, downstream	0.48	0.48	

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): 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 (∆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 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		**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:

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	

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 (∆FF)	
Functional Yield (∆FF/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 - Upstrean	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	

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 (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 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 - Upstrea	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	

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): 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 (∆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 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

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Wednesday, April 19, 2023 11:06 AM
To: Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; Lynn Quattro; Olds, Melanie J; amedeemd@dhec.sc.gov; Morgan Kern; Ross Self; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Alison Jakupca; Kevin Nebiolo; Jordan Johnson (Jordan.Johnson@KleinschmidtGroup.com)
Cc: Kulpa, Sarah; Salazar, Maggie; McCarney-Castle, Kerry
Subject: Bad Creek Relicensing Aquatics Resource Committee 4/6/2023 Meeting Summary and Information

Importance: High

Categories: Bad Creek

Bad Creek Relicensing Aquatic Resources Committee:

The meeting summary and slide deck from the Entrainment Consultation meeting held on April 6, 2023 has been uploaded to the Bad Creek Relicensing Project Resource Committees Sharepoint Site in the Aquatic Resources Committee folder.

As discussed during the meeting, Duke Energy proposes to use the NC Stream Assessment Method (NC SAM) to evaluate streams that will be assessed under Task 3 (Stream Habitat Quality Surveys) of the Aquatic Resources Study. The NC SAM field assessment form and user manual is also provided on the sharepoint site. Additional information can be found on the NC Department of Environmental Quality website: Wetland Information & Projects | NC DEQ

Please review the Stream Assessment Form and Tools and let us know if you have any comments by **Monday, May 17**.

Thank you for your time in attending the entrainment consultation meeting. Our team is working on the revisions and additional analyses discussed during the meeting, and we'll be in touch with an updated schedule for the distribution of the revised entrainment study report soon.

Please let Mike Abney, Alan Stuart or me know if you have any questions.

Thanks,

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

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Friday, May 5, 2023 12:30 PM
To: Abney, Michael A; Amy Breedlove; Dan Rankin; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; Lynn Quattro; Olds, Melanie J; amedeemd@dhec.sc.gov; Morgan Kern; Ross Self; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Alison Jakupca; Kevin Nebiolo; Jordan Johnson (Jordan.Johnson@KleinschmidtGroup.com)
Cc: Kulpa, Sarah; Salazar, Maggie; McCarney-Castle, Kerry
Subject: RE: Bad Creek Relicensing Aquatics Resource Committee Meeting - Follow Up Information Requested during April 6 Meeting

Categories: Bad Creek

Dear Bad Creek Aquatic Resources Committee Members:

Following up from the April 6, 2023 Entrainment Consultation meeting, we would like to provide some additional information from action items taken during the meeting. During study updates, William Wood (SCDNR) asked what the depth is between the minimum safety depth over the weir and low pool if the weir was increased in height. The minimum safety depth for Lake Jocassee is 50 feet, or elevation 1,060 ft msl at full pool. The crest of the submerged weir downstream of the Bad Creek powerhouse is approximately at this elevation (see the Pre-Application Document or Water Resources Revised Study Plan) Recall that expanding the existing weir elevation is not currently considered or planned if Bad Creek II is pursued.

An additional action item included determining the temperature range that Threadfin Shad and/or Blueback herring become stressed or moribund.

Please see the table below for a summary of temperatures reported by multiple resources.

Effects	**Threadfin Shad threshold**	**Blueback Herring threshold**
Sublethal effects (feeding cessation)	12°C	7°C
Inactivity	6-7°C	4-5°C
Death	4-5°C	2-3°C

Additionally, the **Keowee-Toxaway Fish Community Assessment Study FERC Required Fish Entrainment Modification** report (10/7/2013) stated,

> *"…The lower temperature tolerance of this species (TFS) has been reported as 7-14°C (Lee et al. 1980). Cold-induced mortality of threadfin shad has been observed at temperatures of 9-12°C; massive winter die-offs are not uncommon at the limits of this species' range. Mobility of threadfin shad may be impaired at temperatures below about 14°C, potentially increasing susceptibility to entrainment and predation (Griffith 1978; Burgess 1980; McLean et al. 1982, 1985; Etnier and Starnes 1993). Blueback herring have exhibited a preference for habitat with temperatures between*

> *13° and 24°C and oxygen concentrations exceeding 3 mg/L during the warmer months (Dennerline and Degan 1999; Goodrich 2002). In contrast to threadfin shad, blueback herring tolerate winter temperatures as low as 2°C (Lee et al. 1980; Page and Burr 1991)."*

For the purposes of updates to the entrainment study modeling, a threshold of 12°C will be used to represent the threshold for increased susceptibility of forage fish to entrainment.

Please let Mike Abney and me know if you have any questions regarding the provided information.

Regards,

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

Subject: FW: Bad Creek Relicensing Aquatics Resource Committee 4/6/2023 Meeting Summary and Information

---

From: Elizabeth Miller <MillerE@dnr.sc.gov>
Sent: Monday, May 8, 2023 5:24 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Abney, Michael A <Michael.Abney@duke-energy.com>; Amy Breedlove <BreedloveA@dnr.sc.gov>; Dan Rankin <RankinD@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Settevendemio, Erin <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; jhains@g.clemson.edu; Lynn Quattro <QuattroL@dnr.sc.gov>; Olds, Melanie J <melanie_olds@fws.gov>; 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>; Alison Jakupca <Alison.Jakupca@KleinschmidtGroup.com>; Kevin Nebiolo <Kevin.Nebiolo@KleinschmidtGroup.com>; Jordan Johnson (Jordan.Johnson@KleinschmidtGroup.com) <Jordan.Johnson@KleinschmidtGroup.com>
Cc: Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Salazar, Maggie <maggie.salazar@hdrinc.com>; McCarney-Castle, Kerry <Kerry.McCarney-Castle@hdrinc.com>
Subject: RE: Bad Creek Relicensing Aquatics Resource Committee 4/6/2023 Meeting Summary and Information

Hi John,

The SCDNR would like to request that Duke Energy use the South Carolina Stream Quantification Tool (SC-SQT) to evaluate streams to be assessed under Task 3 (Stream Habitat Quality Surveys) of the Aquatic Resources Study. The SC-SQT was developed to evaluate stream function and conditions. Duke Energy can find all the information needed here on the SC Stream Quantification Tool: https://dnr.sc.gov/environmental/streamrestoration.html

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: Wednesday, April 19, 2023 11:06 AM
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>; Alison Jakupca <Alison.Jakupca@KleinschmidtGroup.com>; Kevin Nebiolo <Kevin.Nebiolo@KleinschmidtGroup.com>; Jordan Johnson (Jordan.Johnson@KleinschmidtGroup.com)

<Jordan.Johnson@KleinschmidtGroup.com>
Cc: Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>
Subject: Bad Creek Relicensing Aquatics Resource Committee 4/6/2023 Meeting Summary and Information
Importance: High

Bad Creek Relicensing Aquatic Resources Committee:

The meeting summary and slide deck from the Entrainment Consultation meeting held on April 6, 2023 has been uploaded to the Bad Creek Relicensing Project Resource Committees Sharepoint Site in the Aquatic Resources Committee folder.

As discussed during the meeting, Duke Energy proposes to use the NC Stream Assessment Method (NC SAM) to evaluate streams that will be assessed under Task 3 (Stream Habitat Quality Surveys) of the Aquatic Resources Study. The NC SAM field assessment form and user manual is also provided on the sharepoint site. Additional information can be found on the NC Department of Environmental Quality website: Wetland Information & Projects | NC DEQ

Please review the Stream Assessment Form and Tools and let us know if you have any comments by **Monday, May 17**.

Thank you for your time in attending the entrainment consultation meeting. Our team is working on the revisions and additional analyses discussed during the meeting, and we'll be in touch with an updated schedule for the distribution of the revised entrainment study report soon.

Please let Mike Abney, Alan Stuart or me know if you have any questions.

Thanks,

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

Salazar, Maggie

From:	Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent:	Tuesday, May 9, 2023 6:06 AM
To:	Elizabeth Miller; Abney, Michael A; Amy Breedlove; Dan Rankin; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; Lynn Quattro; Olds, Melanie J; amedeemd@dhec.sc.gov; Morgan Kern; Ross Self; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Alison Jakupca; Kevin Nebiolo; Jordan Johnson (Jordan.Johnson@KleinschmidtGroup.com)
Cc:	Kulpa, Sarah; Salazar, Maggie; McCarney-Castle, Kerry
Subject:	RE: [EXTERNAL] RE: Bad Creek Relicensing Aquatics Resource Committee 4/6/2023 Meeting Summary and Information

Elizabeth: Thank you for your comments. We will review the SC-SQT methodology and SCDNR recommendation and respond back to the Committee.

All: Please let us know if you have any comments on the recommended SC-SQT methodology recommendation.

Regards,
John

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
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Please let me know if you have any questions.

Thank you,

Elizabeth

Elizabeth C. Miller
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Cc: Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>
Subject: Bad Creek Relicensing Aquatics Resource Committee 4/6/2023 Meeting Summary and Information
Importance: High

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Please review the Stream Assessment Form and Tools and let us know if you have any comments by **Monday, May 17**.

Thank you for your time in attending the entrainment consultation meeting. Our team is working on the revisions and additional analyses discussed during the meeting, and we'll be in touch with an updated schedule for the distribution of the revised entrainment study report soon.

Please let Mike Abney, Alan Stuart or me know if you have any questions.

Thanks,

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

Salazar, Maggie

Subject: FW: Bad Creek Relicensing Aquatic Resources - SCDNR SQT May 24 Meeting Minutes and Technical Memo
Attachments: 20230524 Bad Creek SCDNR SQT meeting summary.pdf; Bad Creek stream assessment approach memo_20230609.pdf

Importance: High

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Friday, June 9, 2023 8:26 AM
To: Elizabeth Miller <MillerE@dnr.sc.gov>; Lorianne Riggin <rigginl@dnr.sc.gov>
Cc: Abney, Michael A <Michael.Abney@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Settevendemio, Erin <erin.settevendemio@hdrinc.com>
Subject: RE: Bad Creek Relicensing Aquatic Resources - SCDNR SQT May 24 Meeting Minutes and Technical Memo
Importance: High

Elizabeth and Lorianne: The links provided below are an internal SharePoint site which you cannot access.

I have attached the referenced documents for your review.

Let me know if you have any questions.

Thanks, John

From: Crutchfield Jr., John U
Sent: Friday, June 9, 2023 6:38 AM
To: Elizabeth Miller <millere@dnr.sc.gov>; rigginl@dnr.sc.gov
Cc: Abney, Michael A <Michael.Abney@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Erin Settevendemio <erin.settevendemio@hdrinc.com>
Subject: Bad Creek Relicensing Aquatic Resources - SCDNR SQT May 24 Meeting Minutes and Technical Memo
Importance: High

Elizabeth and Lorianne:

Per discussion during our recent Bad Creek Relicensing Aquatic Resources meeting on May 24, please find attached Relicensing SharePoint links to two documents:

1) May 24, 2023 meeting minutes regarding discussion of the SCDNR Stream Quantitative Tool (SQT) 20230524 Bad Creek SCDNR SQT meeting summary.pdf

2) Duke Energy Technical Memo detailing the sampling methods approach for conducting the Bad Creek relicensing stream surveys Stream Survey Approach

Duke Energy would appreciate your review of these two documents and request comments be provided by COB, Friday, June 16.

Please reply to me if you have or don't have any comments on these documents.

After your review, Duke Energy will distribute these documents to the entire Aquatic Resources Committee for review.

Please let Mike, Alan or I know if you have any questions about these documents.

Thank you,

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

Salazar, Maggie

From: Maggie.Salazar@hdrinc.com
Subject: FW: Bad Creek Relicensing Aquatic Resources - SCDNR SQT May 24 Meeting Minutes and Technical Memo
Attachments: SC List of Metrics_v1.1.xlsx; SC_SQT_Data_Collection_and_Analysis_Manual.pdf; SC_SQT_RapidMethodForm (1).xlsx

---

From: Elizabeth Miller <MillerE@dnr.sc.gov>
Sent: Thursday, June 15, 2023 2:06 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Lorianne Riggin <RigginL@dnr.sc.gov>
Cc: Abney, Michael A <Michael.Abney@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Settevendemio, Erin <erin.settevendemio@hdrinc.com>
Subject: RE: Bad Creek Relicensing Aquatic Resources - SCDNR SQT May 24 Meeting Minutes and Technical Memo

Hi John,

Lorianne and I do not have any comments on the meeting minutes. However, we have a few comments on the memo.

Page 2: Under the SCDNR Stream Quantification Tool Approach header, first paragraph, last sentence needs to state ". . . 404 program, including assessing impacts (debits) and restoration/mitigation (credits)."

Page 2: The SQT would be applicable to all the streams proposed regardless of drainage area up to Level 3 Geomorphology of the tool. This would include Hydrology and Hydraulics as well. The data that is put into those reference curves is beyond the Jennings streams surveyed. The Jennings streams surveyed were additional data points to ensure that the existing hydraulic regional curves created for NC were also appropriate for SC within the same ecoregions and to identify publicly available reference streams for stream restoration design development. Additional data that supports the various metrics in the Hydrology, Hydraulics and Geomorphology categories is detailed in the attached spreadsheet (also found here: https://www.dnr.sc.gov/sqt/docs/SC_List_of_Metrics.xlsx) on the References tab. Where the SQT may not be appropriate will be for use of the macroinvertebrate reference curve and the fish biotic index reference curves. The Macroinvertebrate reference curves within the SQT are only applicable to perennial streams with a drainage area of 3 square miles or larger. The Fish Biotic Index reference curves within the SQT is only applicable in streams with drainage areas between 1.5 square miles and 63 square miles. 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. For fish, we can check with Mark Scott and Kevin Kubach to see if they could adapt our existing Fish BI framework and see if something could be made available for this project after baseline fish surveys are conducted during the appropriate time of year and then compare to post.

Page 3: Duke Energy discusses using the Debit Tool in addition to the SQT. Is the purpose of using the Debit Tool to monitor change of stream function and condition? If so, Duke Energy does not need to use the Debit Tool until it comes time to quantify how many credits are needed from the Corps. Since this debit tool is not yet adopted by the Corps (but it is forthcoming) we would recommend focusing the stream assessment for condition and function approach solely on the SQT. Also note, there is a rapid assessment under the SQT for a basic suite of metrics within the hydrology, hydraulics and geomorphology functional categories. See Appendix A in the SC SQT Data Collection and Analysis Manual and the rapid method form (both attached). The rapid method would be good to use on all the streams.

Please let us know if you have any additional 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, June 9, 2023 8:26 AM
To: Elizabeth Miller <MillerE@dnr.sc.gov>; Lorianne Riggin <RigginL@dnr.sc.gov>
Cc: Abney, Michael A <Michael.Abney@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Erin Settevendemio <erin.settevendemio@hdrinc.com>
Subject: RE: Bad Creek Relicensing Aquatic Resources - SCDNR SQT May 24 Meeting Minutes and Technical Memo
Importance: High

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Please reply to me if you have or don't have any comments on these documents.

After your review, Duke Energy will distribute these documents to the entire Aquatic Resources Committee for review.

Please let Mike, Alan or I know if you have any questions about these documents.

Thank you,

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

From: Huff, Jen
Sent: Friday, June 23, 2023 9:00 AM
To: Crutchfield Jr., John U; Elizabeth Miller; Lorianne Riggin; Abney, Michael A; Stuart, Alan Witten; Settevendemio, Erin; Wahl, Nick; Kulpa, Sarah
Subject: RE: Bad Creek Relicensing - Discuss SC-SQT methodology
Attachments: 2023 06 21 sqt meeting summary.docx

Follow Up Flag: Follow up
Flag Status: Flagged

Attached please find the summary of our discussion on Wednesday. Please provide comments by the end of next week (6/30/2023) if possible.

Have a great weekend.

Jen Huff
D 980.337.5041 **M** 980.309.5491

hdrinc.com/follow-us

-----Original Appointment-----
From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Monday, June 19, 2023 9:04 AM
To: Crutchfield Jr., John U; Elizabeth Miller; Lorianne Riggin; Abney, Michael A; Stuart, Alan Witten; Settevendemio, Erin; Wahl, Nick; Kulpa, Sarah
Cc: Huff, Jen
Subject: Bad Creek Relicensing - Discuss SC-SQT methodology
When: Wednesday, June 21, 2023 11:00 AM-12:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: Microsoft Teams Meeting

Meeting to discuss SCDNR's comments on Bad Creek stream assessment methodology.

Microsoft Teams meeting

Join on your computer, mobile app or room device
Click here to join the meeting

Meeting ID: 254 195 123 338
Passcode: QUgJKR
Download Teams | Join on the web

Join with a video conferencing device
duke-energy@m.webex.com

Meeting Summary

Project: Bad Creek Pumped Storage Project Relicensing

Subject: SCDNR’s Stream Quantification Tool (SQT) for Aquatic Habitat Analysis

Date: Wednesday, June 21, 2023

Location: Virtual Meeting

Attendees

Mike Abney, Duke Energy
John Crutchfield, Duke Energy
Alan Stuart, Duke Energy
Nick Wahl, Duke Energy
Jen Huff, HDR
Sarah Kulpa, HDR
Erin Settevendemio, HDR
Elizabeth Miller, SC Department of Natural Resources (SCDNR)
Lorianne Riggin, SCDNR

Discussion

John Crutchfield opened the meeting and proposed the group use SCDNR’s email response to Duke Energy’s stream assessment approach technical memo dated June 9, 2023, to guide the conversation. Elizabeth Miller and Lorianne Riggin agreed.

J. Crutchfield stated Duke Energy has no questions regarding SCDNR’s first comment about page 2 of the memo and will incorporate the change in the stream assessment description. He then asked L. Riggin and E. Miller to expand on their second comment.

L. Riggin provided additional background on the development of the SQT. She referred to the references tab on the “SC List of Metrics_v1.1” SCDNR provided with its comments. That tab explains each metric and the source of each. She further explained there is no minimum stream size for the hydrology, hydraulics, and geomorphology Threshold Index Values. The only Functional Categories with minimum stream size are the Physicochemical and Biology levels (i.e., yellow and green rows). L. Riggin also noted there is both a rapid and detailed assessment up to Level 3 in the SQT.

Mike Abney asked how ephemeral and intermittent streams are evaluated under the SQT. L. Riggin replied SQT doesn’t apply to ephemeral streams but does apply to intermittent streams. M. Abney stated some of the streams in the spoil disposal areas haven’t been field checked, but some have and some don’t have water even after heavy rain.

J. Crutchfield asked if SCDNR would be willing to participate in field reconnaissance of the streams (or representative streams). L. Riggin stated she would be interested.

Alan Stuart asked how to score Riparian Vegetation Buffer Width if the proposed activity isn’t listed in the Description. L. Riggen recommended using the Single Family Residential, x Slope values. A. Stuart asked if there are other metrics with stratification. L. Riggin stated the other stratifications are based on the Rosgen stream classification. Perennial streams could be evaluated up to Level 5, regardless of stream size; intermittent streams could be analyzed to Level 3 (i.e., Geomorphology). She will check the SQT tool for ephemeral stream analysis level.

Nick Wahl shared photos from a June 20, 2023, site visit of Stream 14 in Spoil Area G. The area experienced heavy rain during the previous two days, but other than sheet flow, there was no stream channel. L. Riggin asked for the Rosgen stream classification. N. Wahl stated he has limited experience with Rosgen stream classifications, but he estimated it would be classified as AA+, which are high-gradient streams, usually in colluvial valleys. Erin Settevendemio added A-type streams are often headwater streams and are not deeply entrenched.

M. Abney asked how the stream feature would be evaluated using SQT. L. Riggin stated we would still use SQT to evaluate using the correct reference curve. E. Settevendemio asked if SQT can be used on D-type streams. L. Riggin responded it cannot; SQT is used solely for single-thread streams.

A. Stuart asked how much of Stream 14 would be surveyed under the SQT methodology. L. Riggin responded that a representative reach should be surveyed. The manual describes how to determine the amount to survey. Chapter 3 of the SQT manual describes how to delineate survey reaches based on stream length and functional changes. If thousands of feet of stream are functioning the same, just a representative sample would be surveyed.

E. Settevendemio stated Eric Mularski estimated up to 10 stream reaches would need to be surveyed and according to the SQT manual, each rapid assessment would require 2-4 hours. She asked which Functional Categories were included in that time estimate. L. Riggin replied the 2-4 hour estimate includes the first three levels (i.e., through Geomorphology).

E. Settevendemio stated she believes using the SQT for the streams in the disposal areas will result in measure of the feet of functional yield. L. Riggin confirmed that is correct and that information can then be used with the Debit tool for calculating USACE mitigation credit needs. The SQT will evaluate how well the stream is functioning or not functioning.

M. Abney asked how SQT would be used for the streams that would be filled for spoil disposal. L. Riggin stated there wouldn’t be a post-fill survey, but would instead use the Debit tool since all stream functions would be eliminated after filling. The Debit tool would identify the delta between pre- and post-construction stream function.

M. Abney asked about using SQT for temporary road stream crossings. Since the crossings will be temporary, he expects minimal effects and the Debit tool delta could be zero. L. Riggin agreed it’s possible but the debit calculator manual includes impact severity tiers to quantify functions that are lost or diminished.

A. Stuart asked if the tool accounts for the decreased effects associated with bottomless culverts. L. Riggin referred to the USACE Charleston District guidance for impacts. Bridges have less impact than bottomless culverts, which have less impact than culvert/low water crossing.

E. Settevendemio referred to Appendix A of debit calculator manual and the Reach 1 example with 1st and 2nd order streams. In that example, there was not fieldwork because it was assumed the streams had the highest quality functions. She asked if the same process was used here (i.e., assume all streams are at their highest function), would they need to be surveyed. L. Riggin stated the goal of SQT was to give applicants options. If the field reconnaissance indicates all the streams are high functioning, surveys aren't needed (i.e., Debit Option 1). However, that would maximize the debits that would be needed since stream impacts would be based on the highest standard score. L. Riggin will find where those standard scores are located and share with E. Settevendemio.

E. Settevendemio ask if SCDNR or the USACE is scheduling training for the SQT tool. L. Riggin stated it will be incorporated into existing scheduled workshops. There are plans to have an SQT field camp, but it hasn't been scheduled yet. Rosgen training will be a prerequisite to training specific to the SQT tool.

L. Riggin reiterated the first step of the process is to assess stream functions; the Debit Tool is used after that step. L. Riggin noted that one of SCDNR's goals for creating the SQT tool was to give permit applicants options, especially where impacts are proposed to poorly functioning streams. She encouraged Duke Energy representatives to contact her with questions.

J. Crutchfield stated Duke Energy will revise the stream assessment technical memo based on today's conversation and send it to SCDNR for review as well as provide a summary of the meeting discussion.

M. Abney said he is planning to schedule the field reconnaissance the week of 7/10 or 7/17 with surveys scheduled for the week of 7/24. L. Riggin said she is available on 7/12.

Action Items

1) M. Abney: Schedule field reconnaissance to look at streams in the potential spoil disposal areas.
2) L. Riggin: Review SQT for treatment of ephemeral streams.
3) L. Riggin: Provide standard scores for Debit Tool.
4) Duke Energy will prepare a meeting summary for the relicensing consultation record, revised the stream assessment technical memo and provide both documents to SCDNR for review and comment.

From:	Lorianne Riggin <RigginL@dnr.sc.gov>
Sent:	Friday, June 23, 2023 10:27 AM
To:	Huff, Jen; Crutchfield Jr., John U; Elizabeth Miller; Abney, Michael A; Stuart, Alan Witten; Settevendemio, Erin; Wahl, Nick; Kulpa, Sarah
Subject:	RE: Bad Creek Relicensing - Discuss SC-SQT methodology
Attachments:	SC_SQT v1.1.xlsx; Denison etal 2021 Integrating_Regional_Frameworks_and_Local_Variabil.pdf
Categories:	Bad Creek

Thanks all!

Here are some comments on the notes.

1. Bottom of page 1/top of page 2: It states that perennial stream can be evaluated up to Level 4, regardless of stream size. To clarify, perennial streams can go up to Level 5 Biology, but Level 5 does have thresholds of applicability based on the function-based parameters of Macroinvertebrates (applicable to perennial streams with a drainage area of at least 3 square miles) and Fish (applicable to perennial streams with drainage areas between 1.5 and 63 square miles). Please see the Parameter and Metric Selection spreadsheet in the attached SQT Workbook. This should help provide a visual of what applies and where.

   Additionally to Alan's question regarding stratification, there are other stratifications in the tool outside of the Rosgen stream types, such as those based on adjacent land use and slope, whether you choose to use LWD piece count versus LWD Index and what ecoregion for macroinvertebrates and stream bioassessment class for fishes the stream is located. To determine your fish bioassessment class – you can use the viewer here: https://dnr.sc.gov/environmental/streamrestoration.html. The fish bioassessment classes are based on the attached published paper by Denison et.al.

   You can view all the reference curves associated with these stratifications on the Reference Curve worksheet of the attached SQT. You can also read more detail about how these are used in the SC SQT User Manual Section 6.1 and Appendix A. Additionally, Section 6.2 of the SC SQT User Manual explains in further detail how the stratification process works within the tool. The Reference Curve Stratification can also be seen on the Reference Curve Thresholds tab (Columns D and E) of the SC List of Metrics I provided prior to our recent meeting.

2. Bottom of page 2 regarding bottomless culverts – Just an additional comment to note that this is a similar scenario as discussed with the temporary crossings. If using a bottomless arched culvert, you would just need to take into account what stream functions are impacted. See the discussion of Impact Severity Tiers in Section 2.5 of the Debit Calculator Manual.

3. Page 3: Note there are plans to have a SQT Field Camp in South Carolina. Existing field camps scheduled can be found here: https://stream-mechanics.com/workshops/

In regards to my tasks –

Ephemeral Stream Question
The overall score output by the SQT is related to stream size (Strahler stream order) and flow type (perennial, intermittent, and ephemeral) to potentially match impacted stream types to mitigation stream types. In the SC SQT Workbook attached, on the parameter and metric selection tab you will see which metrics for the various function-based parameters are applicable to ephemeral streams, but to summarize here, it includes the following Function-Based Parameters: Reach Runoff, Large Woody Debris, and Riparian Vegetation. Note the Lateral Migration Parameter is not appropriate for ephemeral channels as they are systems that are naturally in disequilibrium.

Debit Standard Scores
As I mentioned briefly on the call, the working group that developed the Debit Tool Calculator decided to keep the reference standards for the standard scores assumed hidden to prevent misuse of the Debit Tool Calculator (this is also noted in Chapter 3 of the Debit Calculator User Manual). However, Section 3.5.1 of the Debit Calculator User Manual gives you an overview of what values are assumed and in more detail Section 3.5.1.2. Debit Options 1, 2a, and 2b assign standard scores to function-based parameters for the existing condition when the metric is NOT measured/assessed and the standard score is assigned based on priority category. Priority category is a factor that recognizes the importance of aquatic resources that provide valuable functions and services on a watershed scale, that occupy important positions in the landscape, or that are considered important because of their rarity. See section 2.4.1 of the Debit Calculator User Manual to distinguish what priority the streams in question may be. Section 3.4 of the Debit Calculator User Manual explains under the various debit options which parameters assume standard scores based on those priorities.

In summary – stream classified as primary priority are going to assume an existing condition standard score of 1.0, secondary priority as 0.8 and tertiary priority as 0.7.

Metrics in the SQT and Debit Calculator are linked to reference curves that relate measured field values to a function index scale ranging from 0.00 to 1.00. The function index scale rates field values relative to departure from the reference condition in the region. The function index value range is standardized across metrics by determining how field values relate to functional capacity (i.e., functioning, functioning-at-risk, and not functioning conditions; Table 6 of the Debit Calculator Manual). The Debit Calculator and SQT use the same reference curves to score metrics; to see the reference curves see the Reference Curve spreadsheet in the attached Workbook.

Let me know if you have any other questions.

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

From: Huff, Jen <Jen.Huff@hdrinc.com>
Sent: Friday, June 23, 2023 9:00 AM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Elizabeth Miller <MillerE@dnr.sc.gov>; Lorianne Riggin <RigginL@dnr.sc.gov>; Abney, Michael A <Michael.Abney@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Settevendemio, Erin <Erin.Settevendemio@hdrinc.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Kulpa, Sarah <sarah.kulpa@hdrinc.com>
Subject: RE: Bad Creek Relicensing - Discuss SC-SQT methodology

Attached please find the summary of our discussion on Wednesday. Please provide comments by the end of next week (6/30/2023) if possible.

Have a great weekend.

Jen Huff
D 980.337.5041 **M** 980.309.5491

hdrinc.com/follow-us

-----Original Appointment-----
From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Monday, June 19, 2023 9:04 AM
To: Crutchfield Jr., John U; Elizabeth Miller; Lorianne Riggin; Abney, Michael A; Stuart, Alan Witten; Settevendemio, Erin; Wahl, Nick; Kulpa, Sarah
Cc: Huff, Jen
Subject: Bad Creek Relicensing - Discuss SC-SQT methodology
When: Wednesday, June 21, 2023 11:00 AM-12:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: Microsoft Teams Meeting

Meeting to discuss SCDNR’s comments on Bad Creek stream assessment methodology.

Microsoft Teams meeting

Join on your computer, mobile app or room device
Click here to join the meeting

Meeting ID: 254 195 123 338
Passcode: QUgJKR
Download Teams | Join on the web

Join with a video conferencing device

duke-energy@m.webex.com
Video Conference ID: 113 267 448 9
Alternate VTC instructions

Or call in (audio only)

+1 704-659-4701,,997829859#   United States, Charlotte

Phone Conference ID: 997 829 859#
Find a local number | Reset PIN

Learn More | Help | Meeting options

Bad Creek Pumped Storage Project No. 2740

Joint Aquatic and Water Resources Committee Meeting

DUKE ENERGY

BUILDING A SMARTER ENERGY FUTURE®

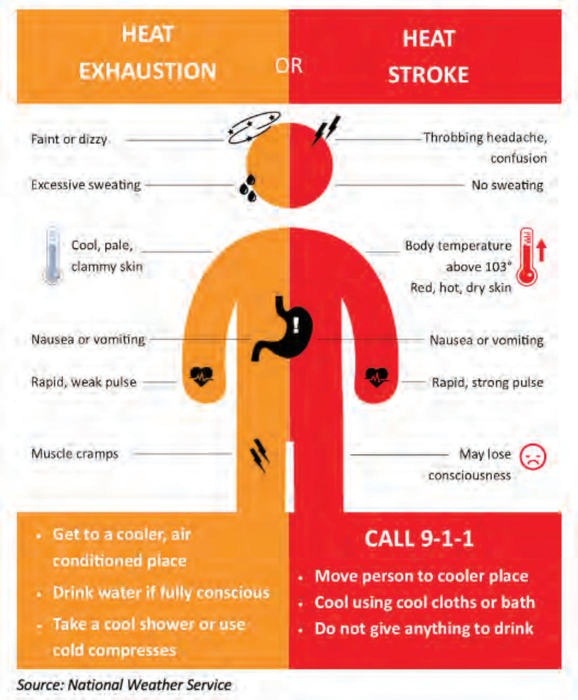
JULY 27, 2023

Meeting Agenda

- Welcome and Meeting Purpose
- Safety Moment
- Introductions and FERC ILP Schedule
- Water Resources Study Update
  - Overview of Tasks
  - CFD Model Discussion
  - Preliminary Results
- *Break (15 min)*
- CHEOPS Discussion and Performance Measures
- Aquatic Resources Study Update
  - Revised Entrainment Study Report
  - Mussel & Stream Habitat Quality Surveys
- Action Items

Safety Moment – Heat Safety

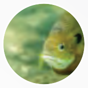
- **Tips for Keeping Cool**
  - Drink **water** (even if you aren't thirsty). Rule of thumb when working in heat is 1 gallon per 4 hours!
  - Avoid alcohol and caffeine
  - Wear sunscreen (even a mild sunburn can affect the body's ability to cool properly!)
  - Try to schedule outdoor *optional* outdoor activities for the early morning or evening; if you must work during the day, rest and find shade **often**.
  - Wear loose, light-colored clothing.
- Know the difference between Heat Exhaustion and Heat Stroke.
- Heat Stroke is a MEDICAL EMERGENCY that can lead to death if not treated quickly.



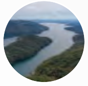
Source: National Weather Service

Resource Committees

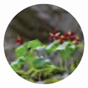
Lead Technical Manager
- John Crutchfield



Aquatic Resources
- Mike Abney
- Nick Wahl



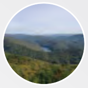
Water Resources
- Maverick Raber



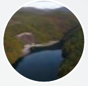
Wildlife & Botanical Resources
- Scott Fletcher
- Mike Abney

Project Manager
- Alan Stuart

Cultural Resources
- Christy Churchill



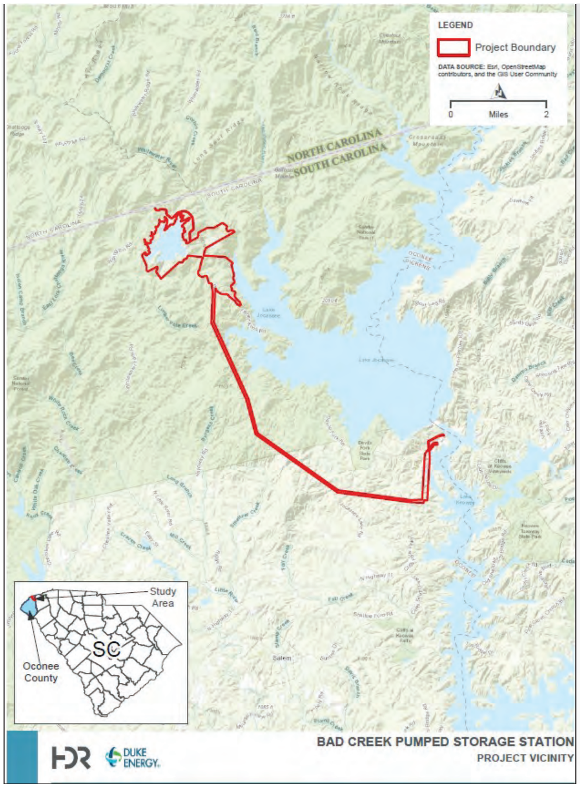
Recreation & Aesthetics
- Alan Stuart
- Ethan Pardue



Operations
- Lynne Dunn
- Ed Bruce

FERC ILP Schedule

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



Bad Creek Pumped Storage Project Location and FERC Project Boundary

Water Resources Study

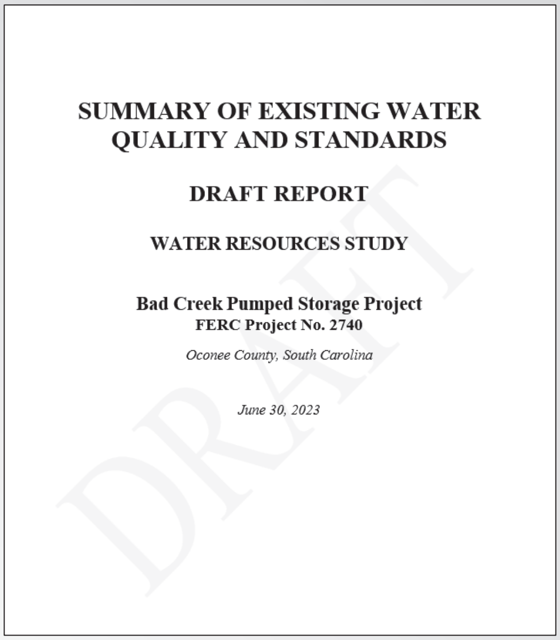
Water Resources Study

Task Refresher

- Task 1 – Summary of Existing Water Quality Data And Standards
- Task 2 – Water Quality Monitoring in Whitewater River Arm
- Task 3 – Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse (CFD Modeling)
- Task 4 – Water Exchange Rates and Lake Jocassee Reservoir Levels (CHEOPS Modeling)
- Task 5 – Future Water Quality Monitoring Plan Development

Water Resources Study

- Task 1 – Summary of Existing Water Quality Data and Standards
  - **Objective:** Compile previously collected water quality data and provide a summary of existing data from Lake Jocassee and Howard Creek under current Project operations and prior to Project operations, while addressing stakeholder concerns.
  - **Status:** The draft report was uploaded to the SharePoint site on June 30 for a 60-day review period.



SUMMARY OF EXISTING WATER QUALITY AND STANDARDS

DRAFT REPORT

WATER RESOURCES STUDY

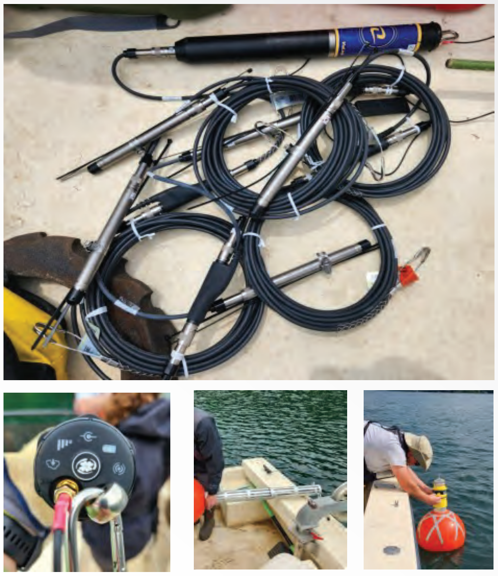
Bad Creek Pumped Storage Project
FERC Project No. 2740
Oconee County, South Carolina

June 30, 2023

Water Resources Study

- Task 2 – Water Quality Monitoring in Whitewater River Arm
  - **Objective:** Collect continuous temperature data and periodic DO (bi-weekly) from three historical locations in the Whitewater River Cove to gather current-day representative (i.e., baseline) water quality information in Summer 2023 and 2024.
  - **Status:** Ongoing.
  - Dataloggers were deployed May 22nd and 23rd.
    - Four data collection trips have been made and will continue every two weeks through September.

Task 2 - Water Quality Monitoring in Whitewater River Arm

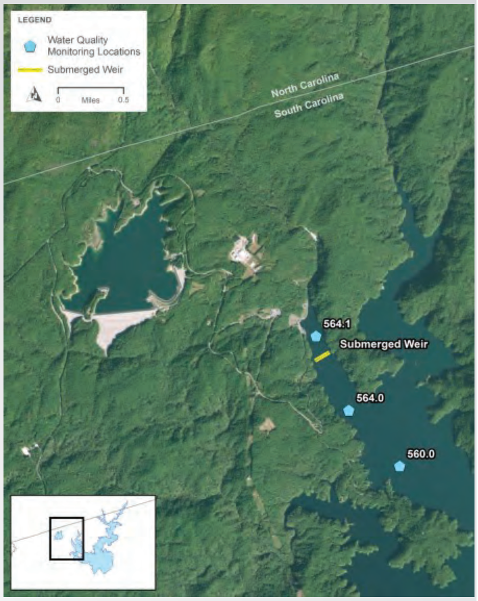


Task 2 - Water Quality Monitoring in Whitewater River Arm

Station 564.1

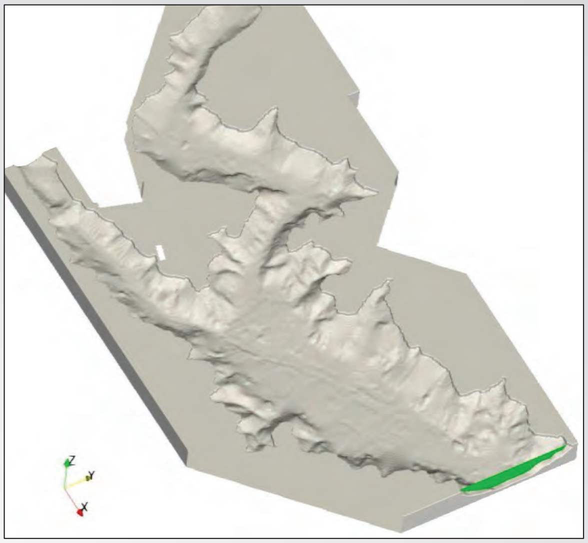
Station 560.0

Station 564.0



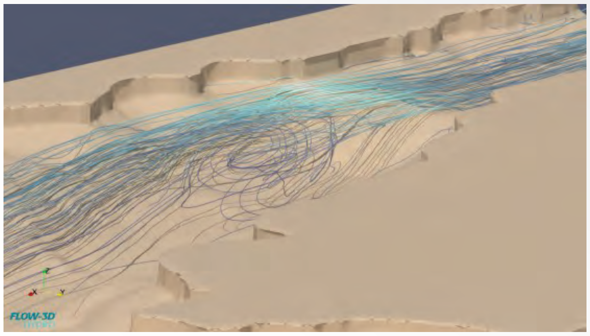
Water Resources Study

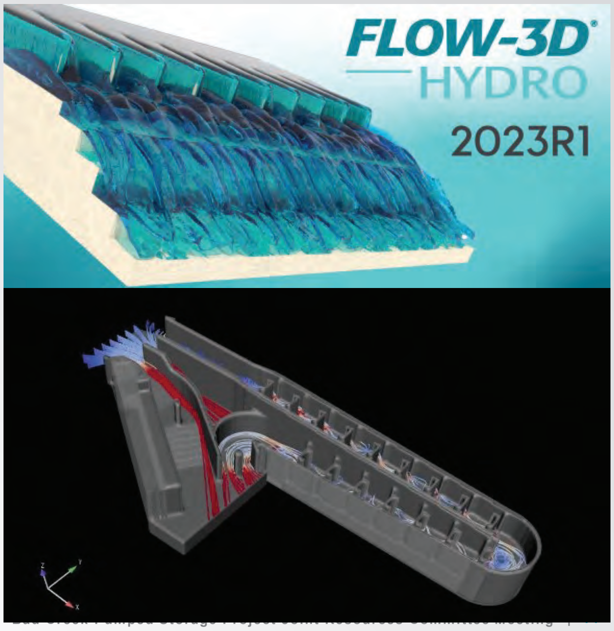
- **Task 3 – Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse (CFD Modeling)**
  - **Objectives**
    - Use a two-dimensional (2-D) hydraulic model to determine the downstream extent of potential effects (i.e., mixing) in the Whitewater River Cove due to an additional powerhouse (Bad Creek II).
    - Develop CFD model to evaluate flows and extent of vertical mixing in the Whitewater River arm and downstream of the submerged weir due to the addition of Bad Creek II.
  - **Status:** Ongoing.
    - Simulations are complete and analyses are ongoing.
    - Velocity data were collected in mid-July along 5 transects in the Whitewater River cove with boat-mounted ADCP for ongoing model validation.



Task 3 – Introduction to **Computational Fluid Dynamics**

- Modeling software capable of solving complex hydraulics in three dimensions.
- CFD models solve the three-dimensional form of the Navier-Stokes equations that govern fluid momentum in conjunction with conservation of mass (continuity).
- Commercially available Flow-3D software used for the Bad Creek analysis.



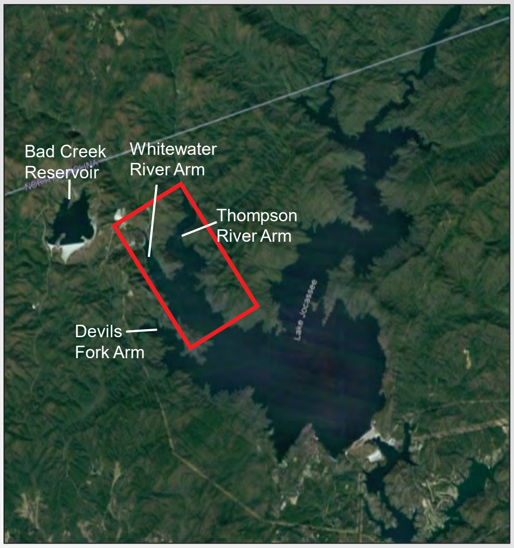


Task 3 – Modeling Steps and Take-Home Message

1. 2-D hydraulic model (Innovyze) was developed to help determine the downstream modeling extent (model domain) required for the CFD model.
2. CFD model was developed to evaluate hydraulic effects (depth, velocity, flow patterns) of Bad Creek II operations on vertical mixing in the Whitewater River cove.
3. Sixteen scenarios were evaluated using pumping and generating modes under existing and proposed conditions (including potentially expanded weir).

Take home message: Of the “bookend” scenarios analyzed, combined Bad Creek and Bad Creek II operations (39,200 cfs) with Lake Jocassee at minimum pond elevation (1,080 ft msl) was found to have the greatest effect on Whitewater River Cove hydraulics, however at the downstream model boundary **<u>that effect was negligible</u>**.

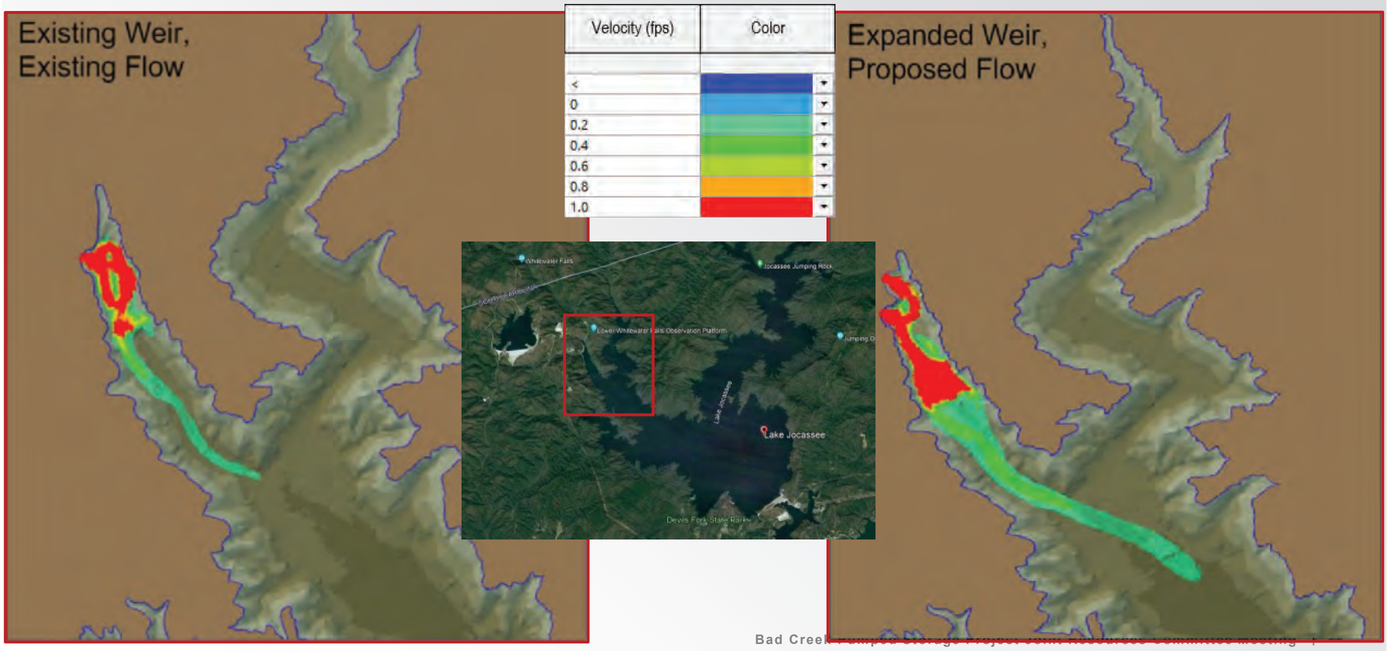
Lake Jocassee Area (full pond): 7,980 acres
Modeled Area (full pond): 2,840 acres



Task 3 – 2-D Modeling [Innovyze ICM]

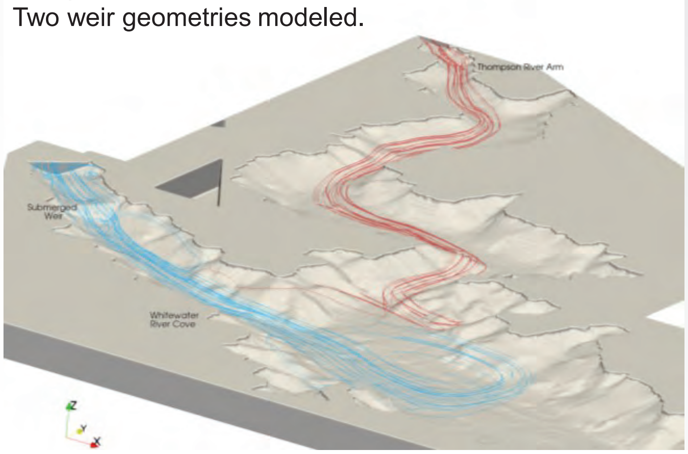
- CFD modeling requires lengthy computing time, therefore 2-D model was used to quickly determine the approximate CFD modeling extent (modeling boundary).
- 2-D model terrain based on previously gathered Lake Jocassee bathymetry and SC State lidar.
- Scenarios assume full generation/pumping capacity for the entirety of the simulation.
- Simulation length was determined by the time it takes to drain/fill Bad Creek from full pond to maximum drawdown.
- 2-D modeling is depth-averaged.

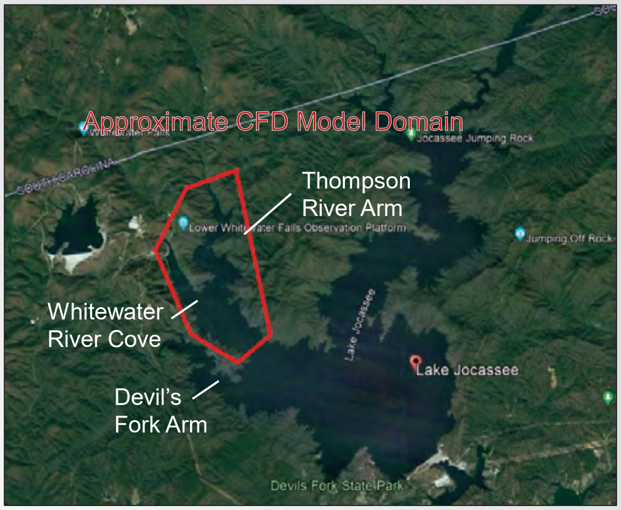
Task 3 – 2-D Modeling Results: Velocity Vectors, Minimum Pond (1,080 ft)



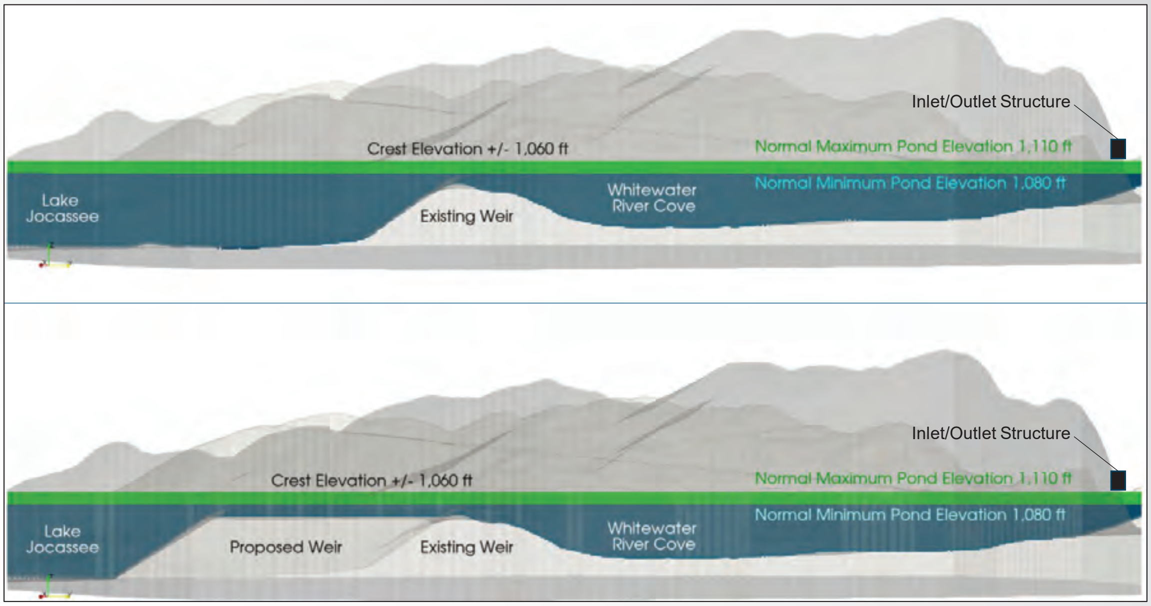
Task 3 – CFD Model Development

- Model domain extends just upstream of confluence with Devil's Fork Arm.
- Inflows and water surface elevations held constant at the inflow boundary.
- Maximum generating/pumping capacity simulated.
- Thompson River flow included (long term average flow).
- Two pond levels modeled.
- Two weir geometries modeled.





Task 3 – CFD Model Geometries & Scenarios

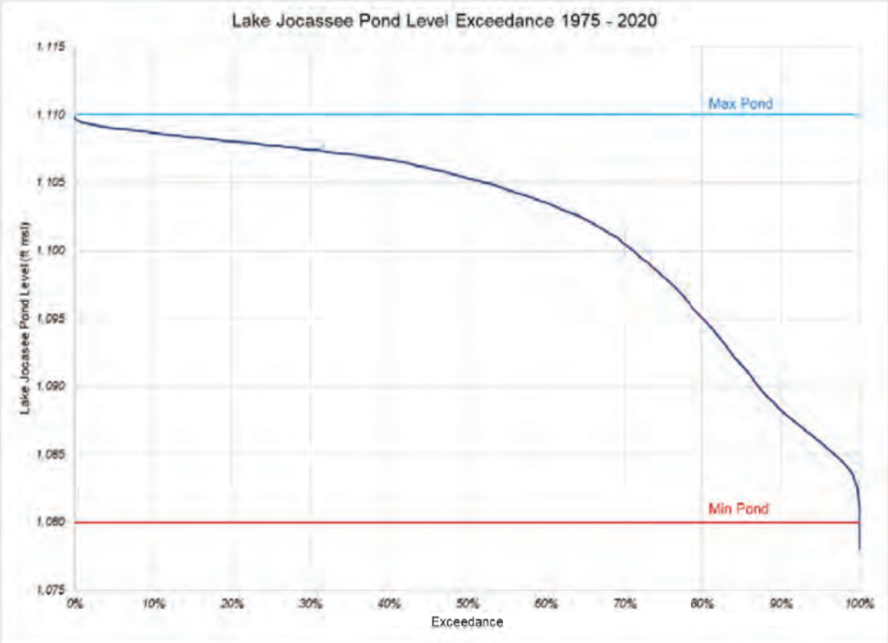


Task 3 – CFD Modeled Scenarios

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

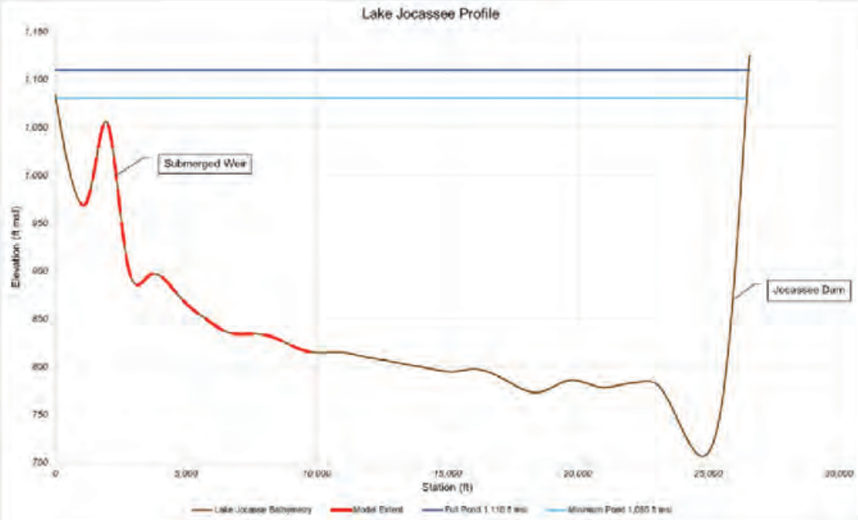
Task 3 – Lake Jocassee Pond Level Exceedance Curve

Note: all modeled scenarios are either at min or max pond elevation.

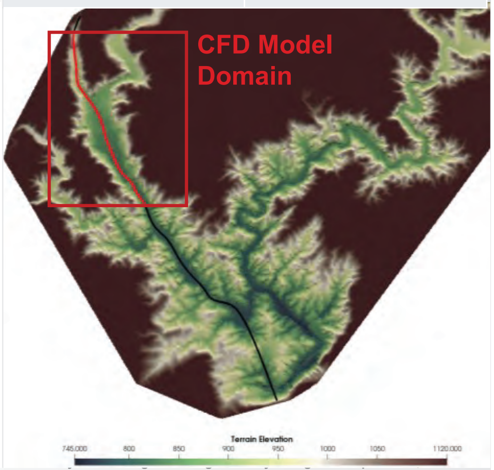


Task 3 – CFD Model Domain

Model Domain – Profile View from Weir to Jocassee Dam

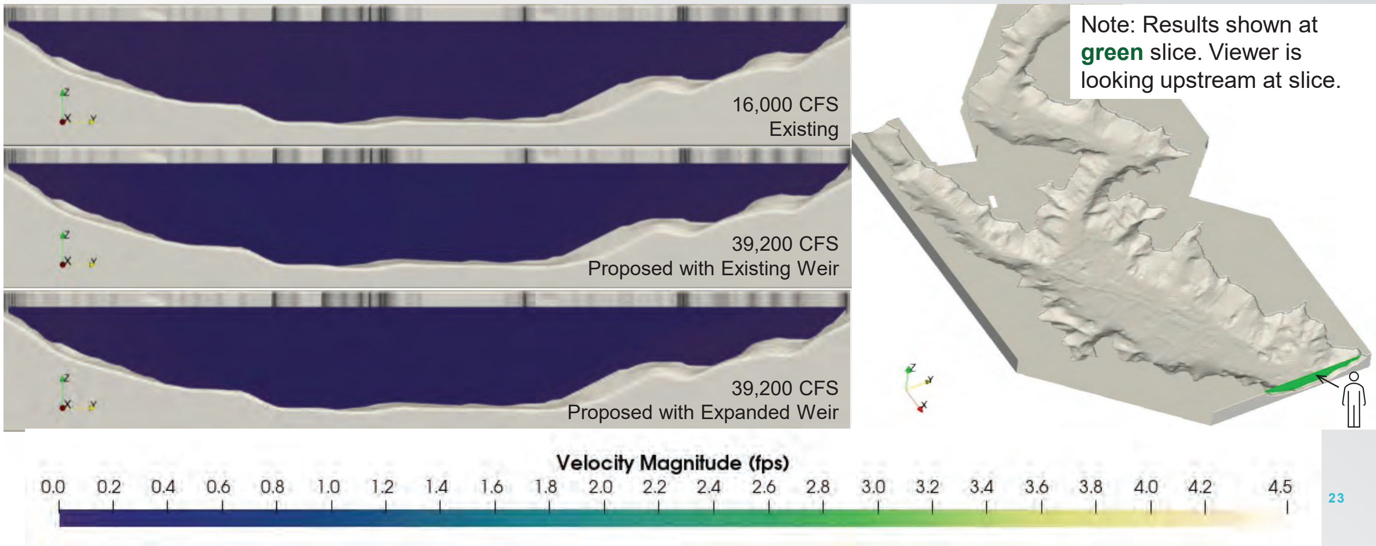


Lake Jocassee Volumes at 1,110 ft msl	
Entire Lake (ac-ft)	Modeled Area (ac-ft)
1,200,000	133,000



Task 3 – CFD Model Domain

Model Domain Confirmation: Minimum Pond 1,080 ft msl - Generation Mode



Note: Results shown at **green** slice. Viewer is looking upstream at slice.

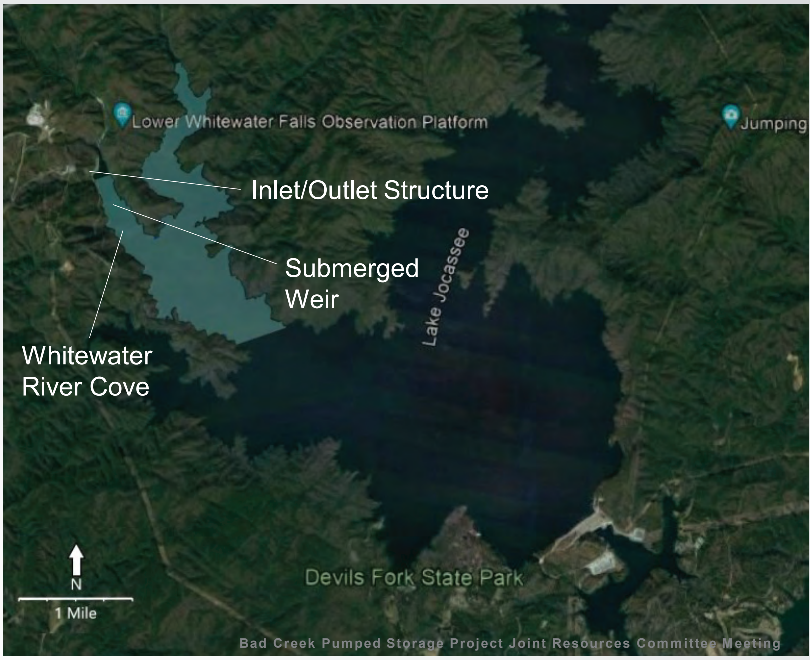
CFD Results – Existing Generation Operations

Task 3 – Velocity Effects and Vertical Mixing; Existing Generation

Results – Existing Generation at **Full Pond**

- Max velocity approx. 0.6 fps
- Teal: < 1.0 fps

(Teal shading indicates model extent.)

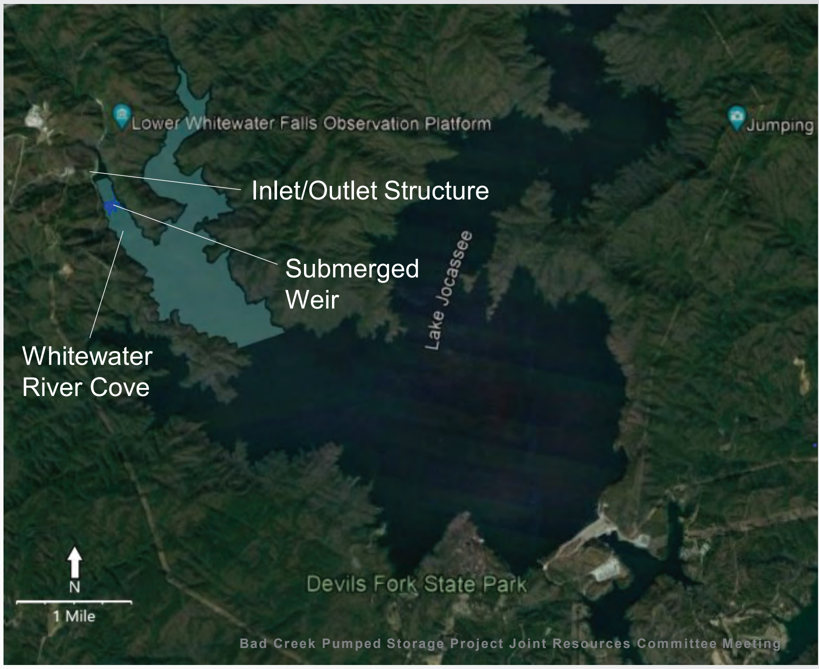


Task 3 – Velocity Effects and Vertical Mixing; Existing Generation

Results – Existing Generation at **Minimum Pond**

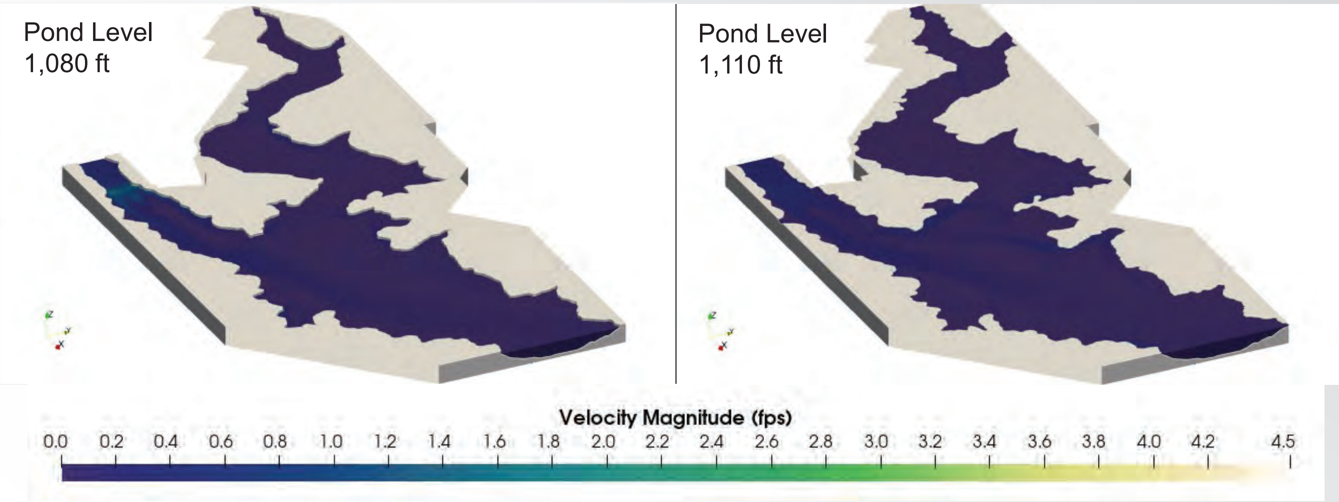
- Max velocity approx. 2.9 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps
- Green: 2.0 – 3.0 fps

(Teal shading indicates model extent.)



Task 3 – Velocity Effects and Vertical Mixing; Existing Generation

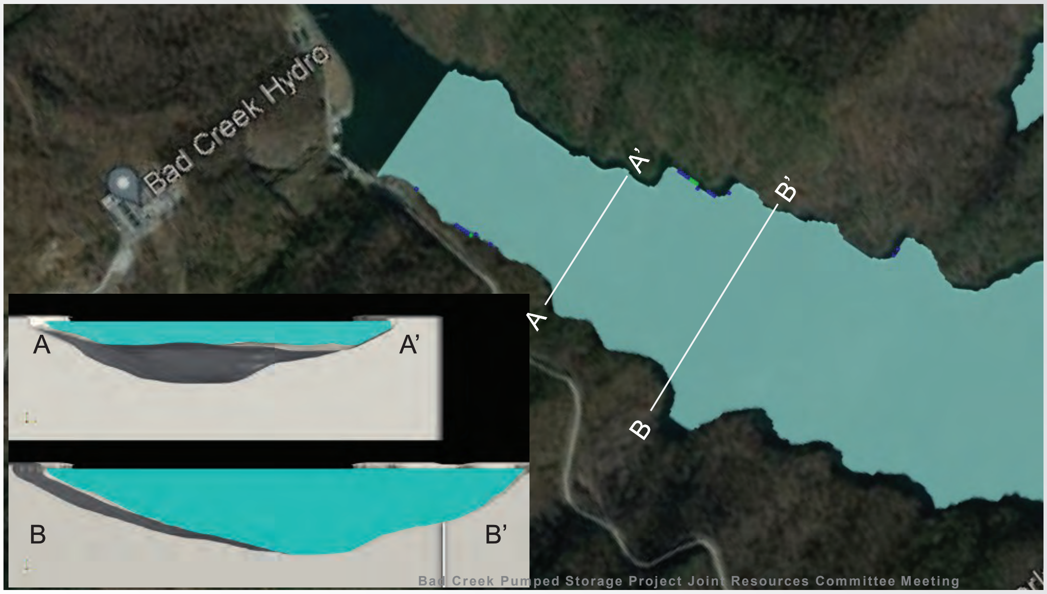
Results – Existing Generation at Minimum and Full Pond



Task 3 – Velocity Effects and Vertical Mixing; Existing Generation

Results – Existing Generation at **Full Pond**

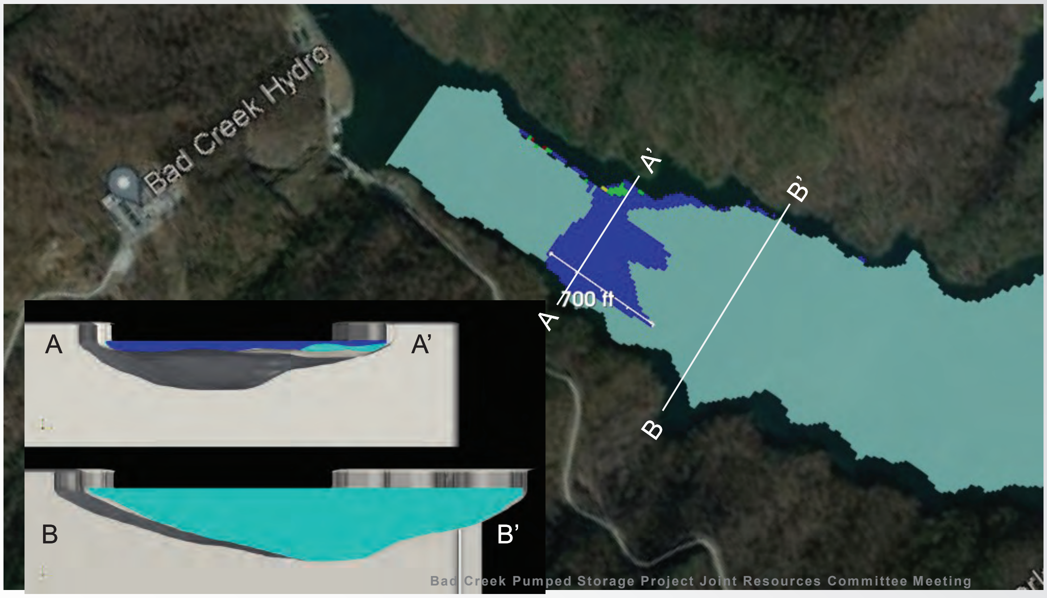
- Max velocity approx. 0.6 fps
- Teal: < 1.0 fps



Task 3 – Velocity Effects and Vertical Mixing; Existing Generation

Results – Existing Generation at **Minimum Pond**

- Max velocity approx. 2.9 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps
- Green: 2.0 – 3.0 fps



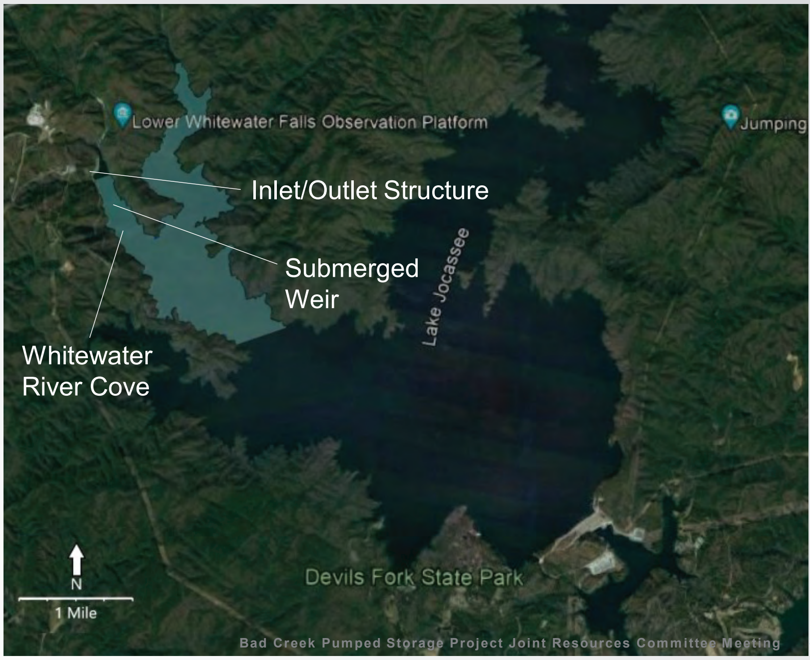
CFD Results – Existing Pumping Operations

Task 3 – Velocity Effects and Vertical Mixing; Existing Pumping

Results – Existing Pumping at **Full Pond**

- Max velocity approx. 0.5 fps
- Teal: < 1.0 fps

(Teal shading indicates model extent.)

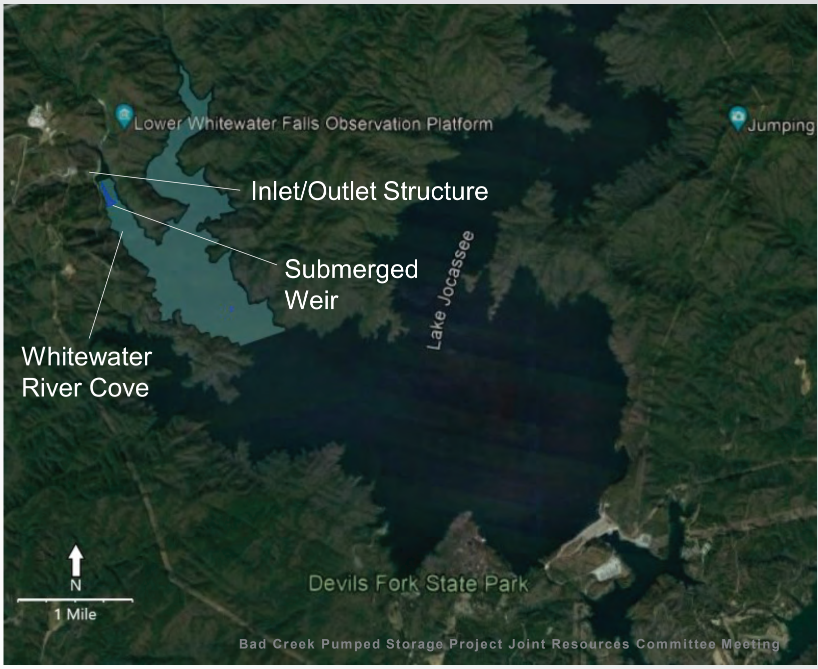


Task 3 – Velocity Effects and Vertical Mixing; Existing Pumping

Results – Existing Pumping at **Minimum Pond**

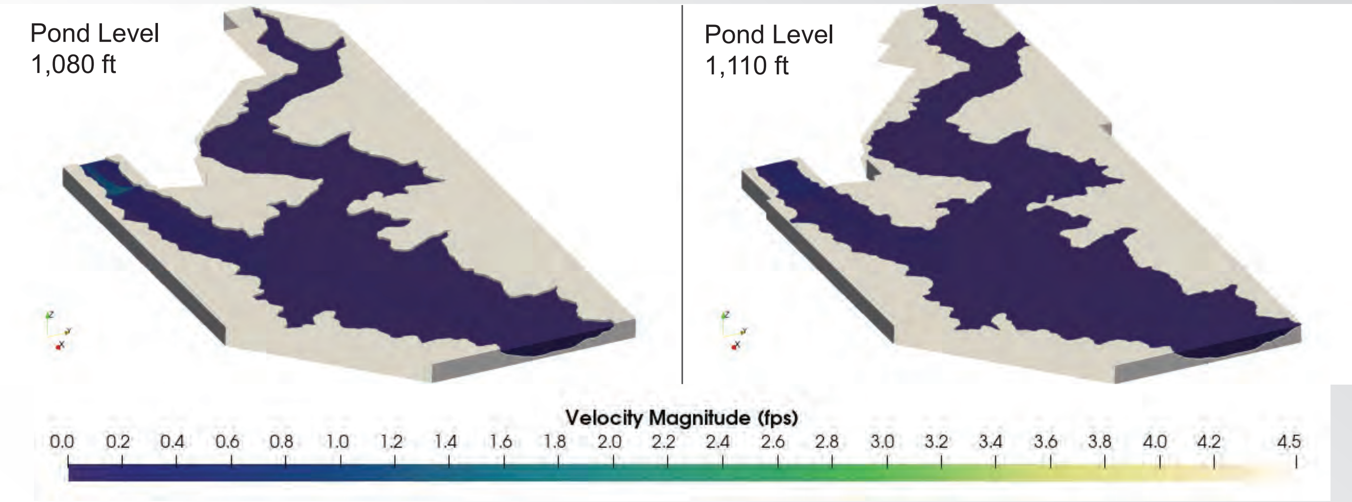
- Max velocity approx. 1.4 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps

(Teal shading indicates model extent.)



Task 3 – Velocity Effects and Vertical Mixing; Existing Pumping

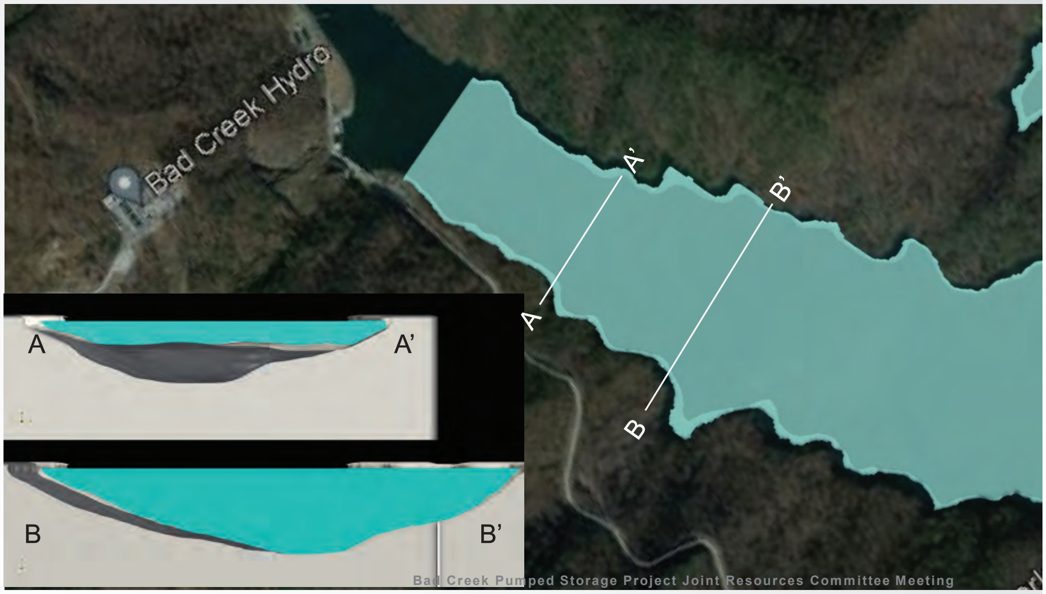
Results – Existing Pumping at Minimum and Full Pond



Task 3 – Velocity Effects and Vertical Mixing; Existing Pumping

Results – Existing Pumping at **Full Pond**

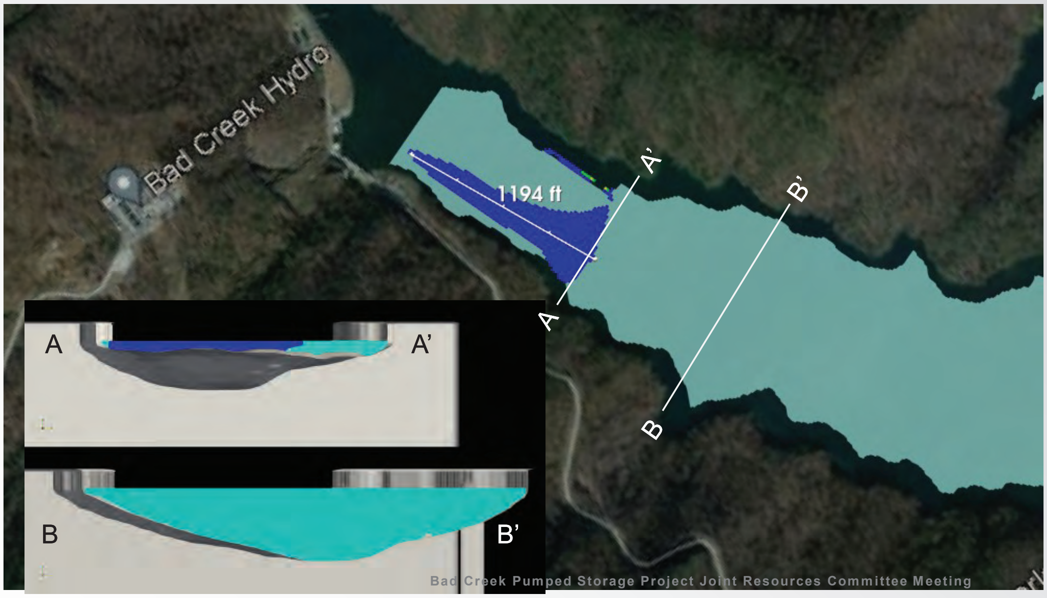
- Max velocity approx. 0.5 fps
- Teal: < 1.0 fps



Task 3 – Velocity Effects and Vertical Mixing; Existing Pumping

Results – Existing Pumping at **Minimum Pond**

- Max velocity approx. 2.9 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps



CFD Results – Proposed Generation Operations

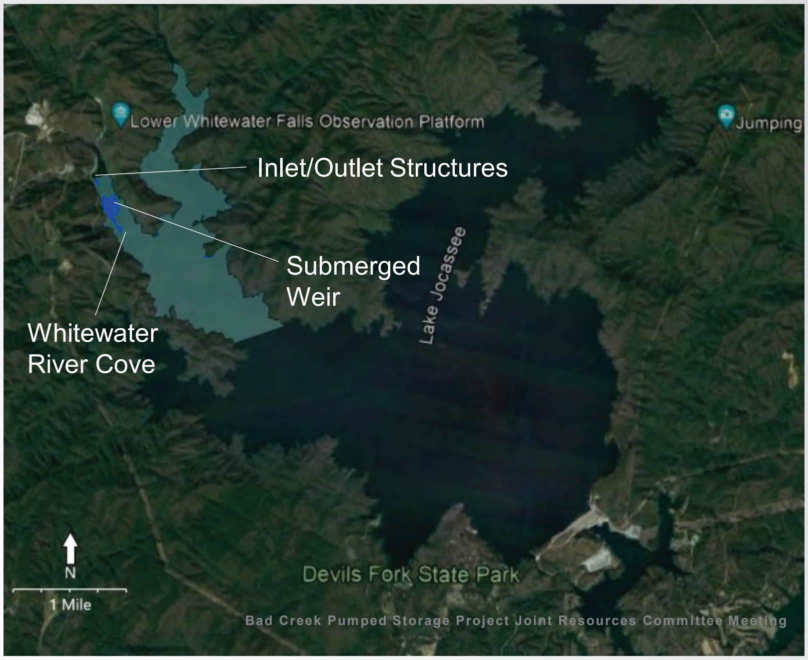
Task 3 – Velocity Effects and Vertical Mixing; Proposed Generation

Results – Proposed Generation at **Full Pond**

3-D Contours of Velocity

- Max velocity approx. 1.3 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps

(Teal shading indicates model extent.)

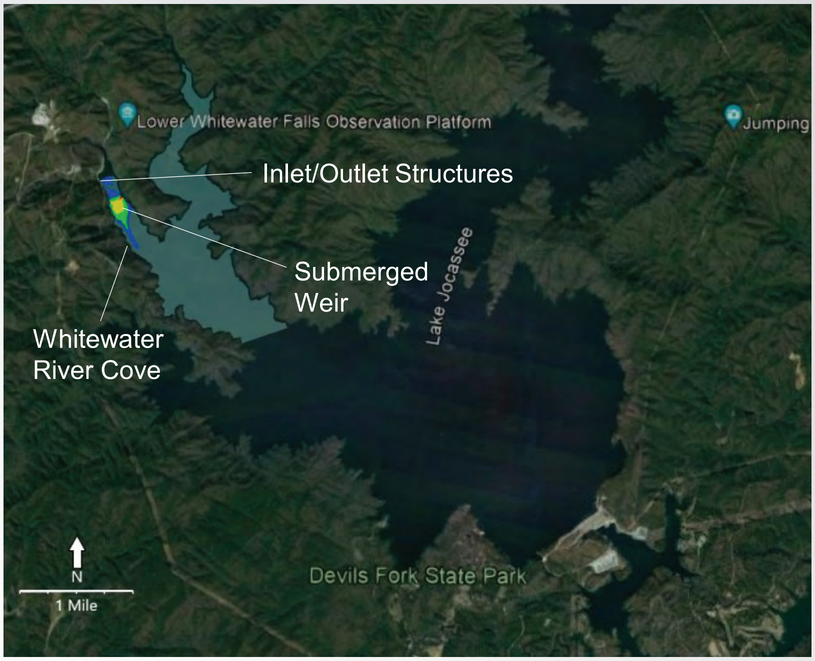


Task 3 – Velocity Effects and Vertical Mixing; Proposed Generation

Results – Proposed Generation at **Minimum Pond**

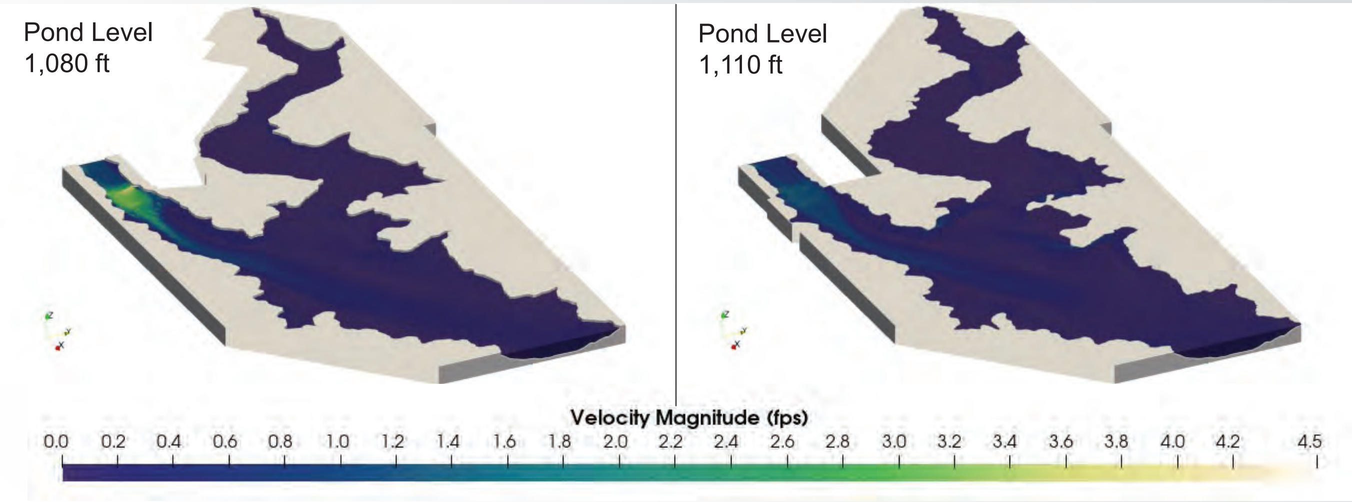
- Max velocity approx. 4.5 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps
- Green: 2.0 – 3.0 fps
- Yellow: 3.0 – 4.0 fps
- Red: > 4.0 fps

(Teal shading indicates model extent.)



Task 3 – Velocity Effects and Vertical Mixing; Proposed Generation

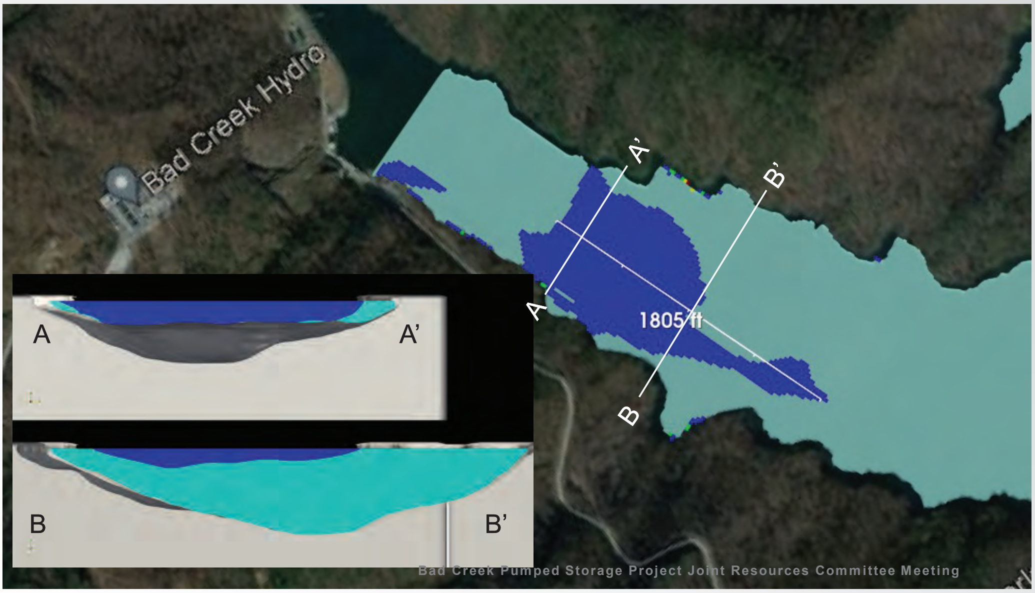
Results – Proposed Generation at Minimum and Full Pond



Task 3 – Velocity Effects and Vertical Mixing; Proposed Generation

Results – Proposed Generation at **Full Pond**

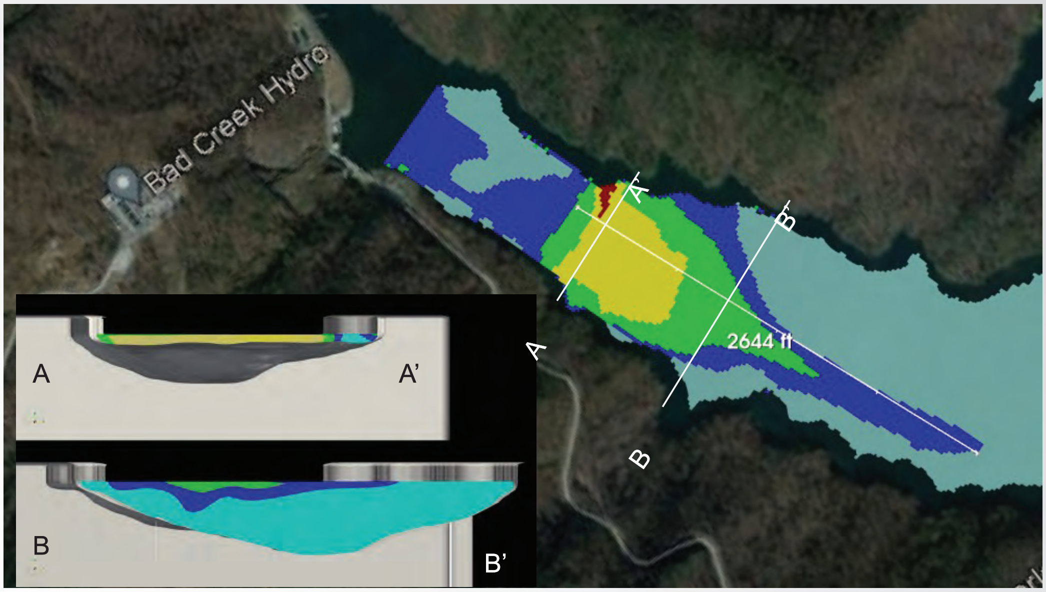
- Max velocity approx. 1.3 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps



Task 3 – Velocity Effects and Vertical Mixing; Proposed Generation

Results – Proposed Generation at **Minimum Pond**

- Max velocity approx. 4.5 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps
- Green: 2.0 – 3.0 fps
- Yellow: 3.0 – 4.0 fps
- Red: > 4.0 fps



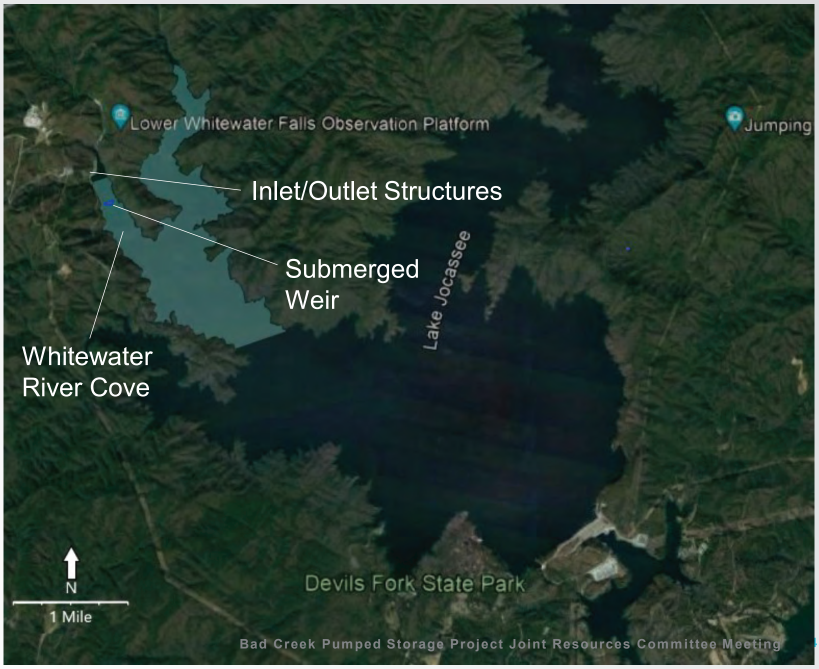
CFD Results – Proposed Pumping Operations

Task 3 – Velocity Effects and Vertical Mixing; Proposed Pumping

Results – Proposed Pumping at **Full Pond**

- Max velocity approx. 1.1 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps

(Teal shading indicates model extent.)

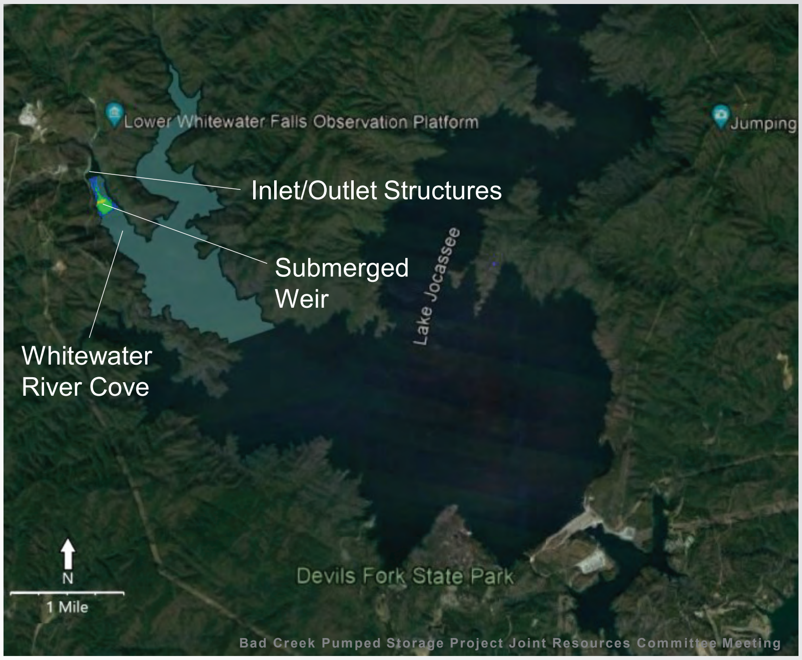


Task 3 – Velocity Effects and Vertical Mixing; Proposed Pumping

Results – Proposed Pumping at **Minimum Pond**

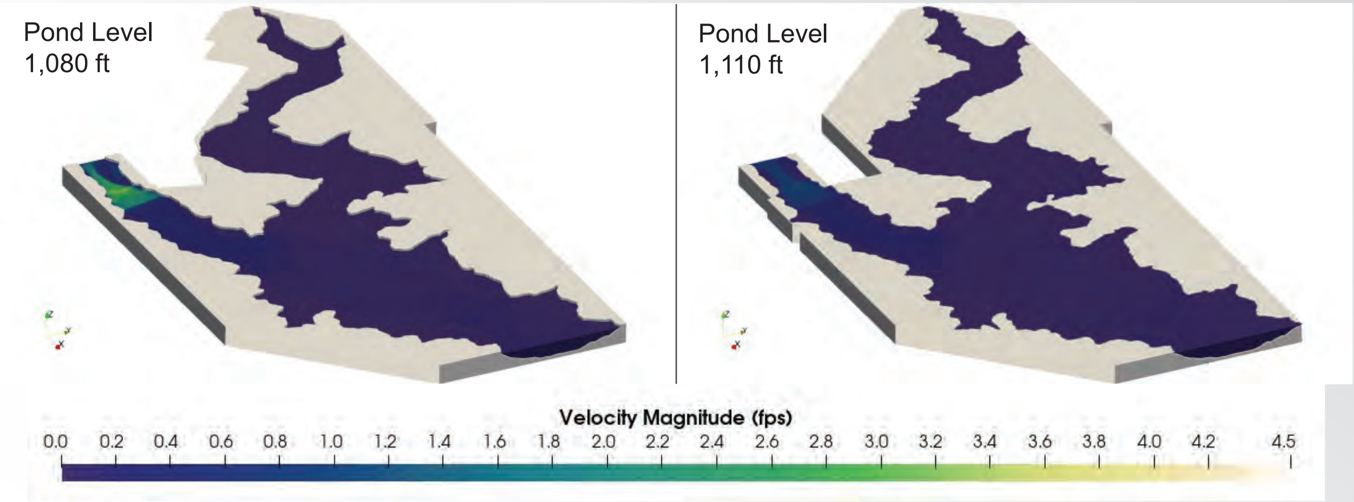
- Max velocity approx. 3.3 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps
- Green: 2.0 – 3.0 fps
- Yellow: 3.0 – 4.0 fps

(Teal shading indicates model extent.)



Task 3 – Velocity Effects and Vertical Mixing; Proposed Pumping

Results – Proposed Pumping at Minimum and Full Pond



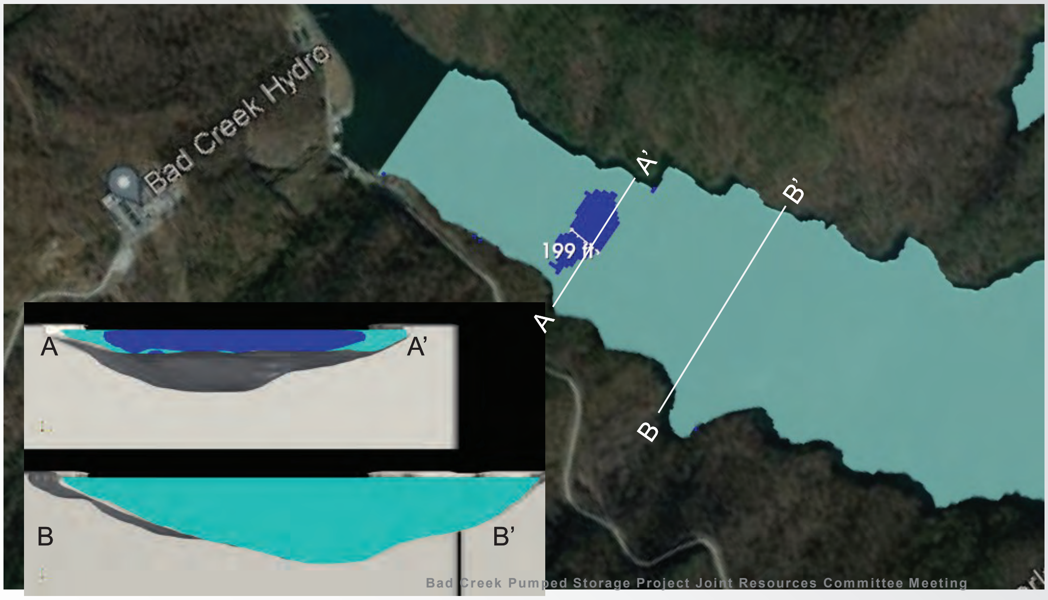
Pond Level 1,080 ft

Pond Level 1,110 ft

Task 3 – Velocity Effects and Vertical Mixing; Proposed Pumping

Results – Proposed Pumping at **Full Pond**

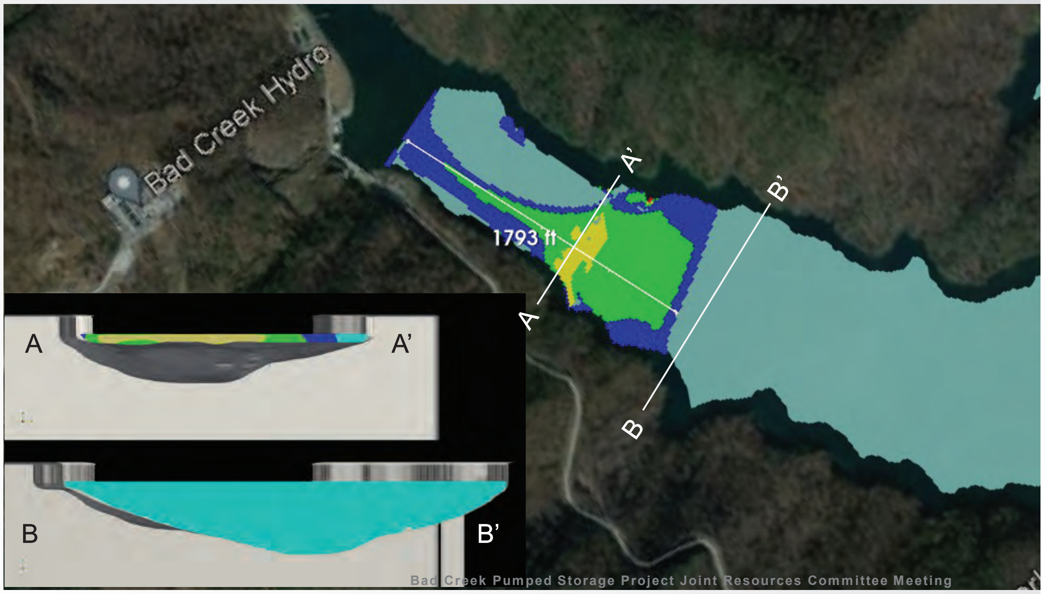
- Max velocity approx. 1.1 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps



Task 3 – Velocity Effects and Vertical Mixing; Proposed Pumping

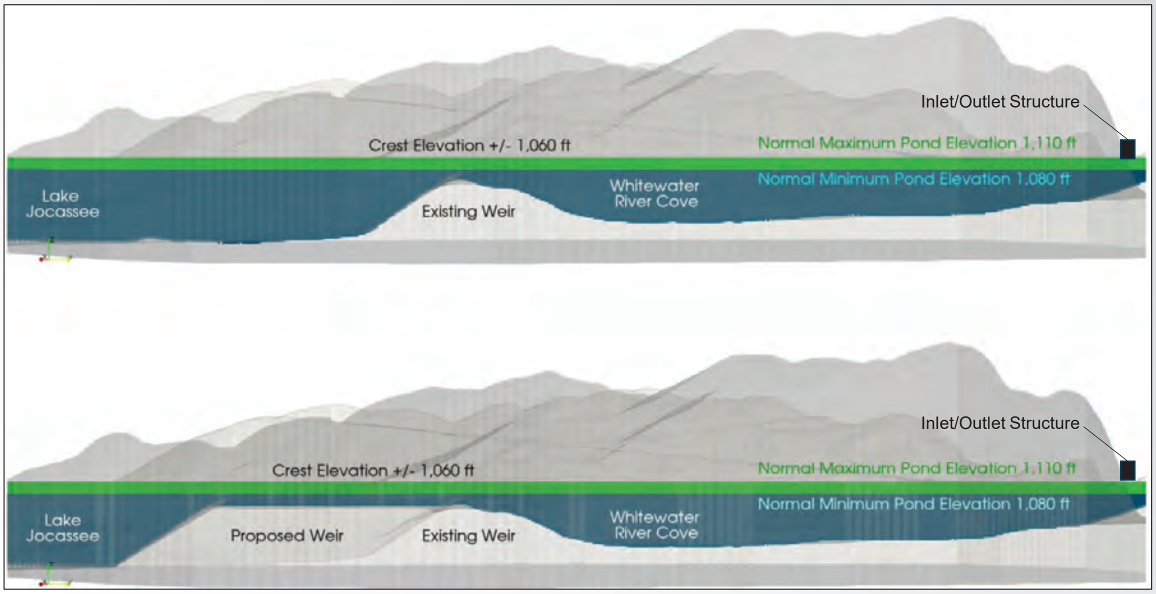
Results – Proposed Pumping at **Minimum Pond**

- Max velocity approx. 3.3 fps
- Teal: < 1.0 fps
- Blue: 1.0 – 2.0 fps
- Green: 2.0 – 3.0 fps
- Yellow: 3.0 – 4.0 fps

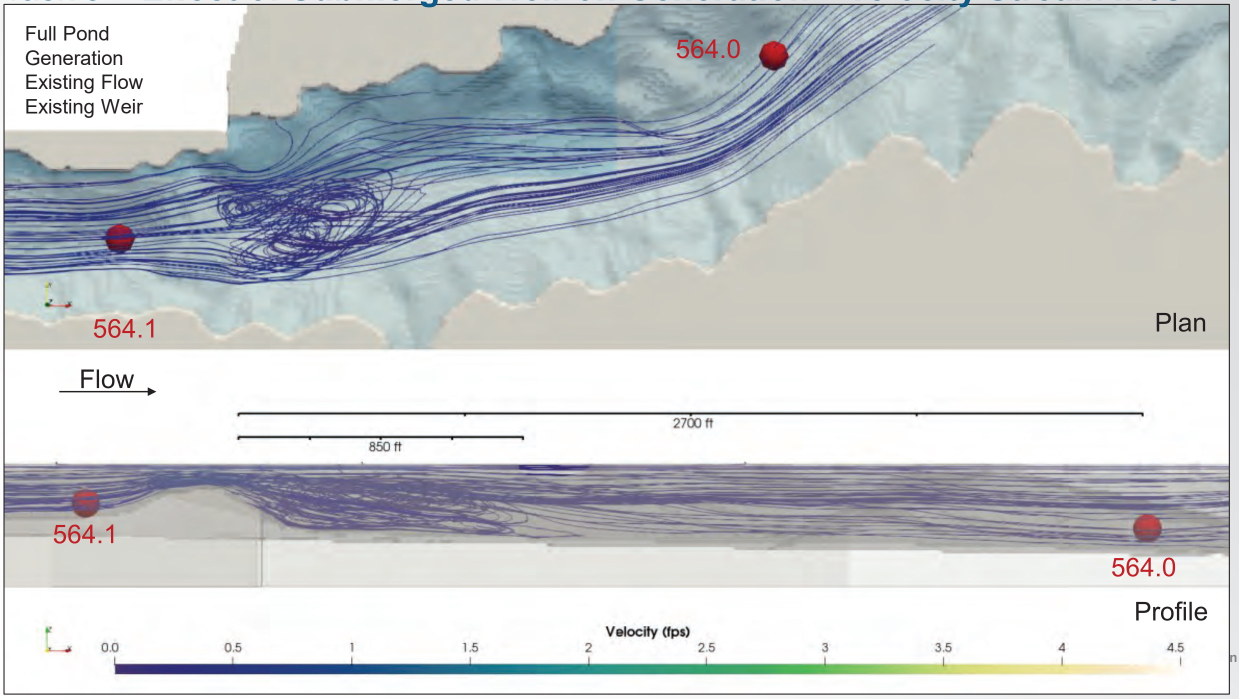


Effect of Submerged Weir Geometry during Generation

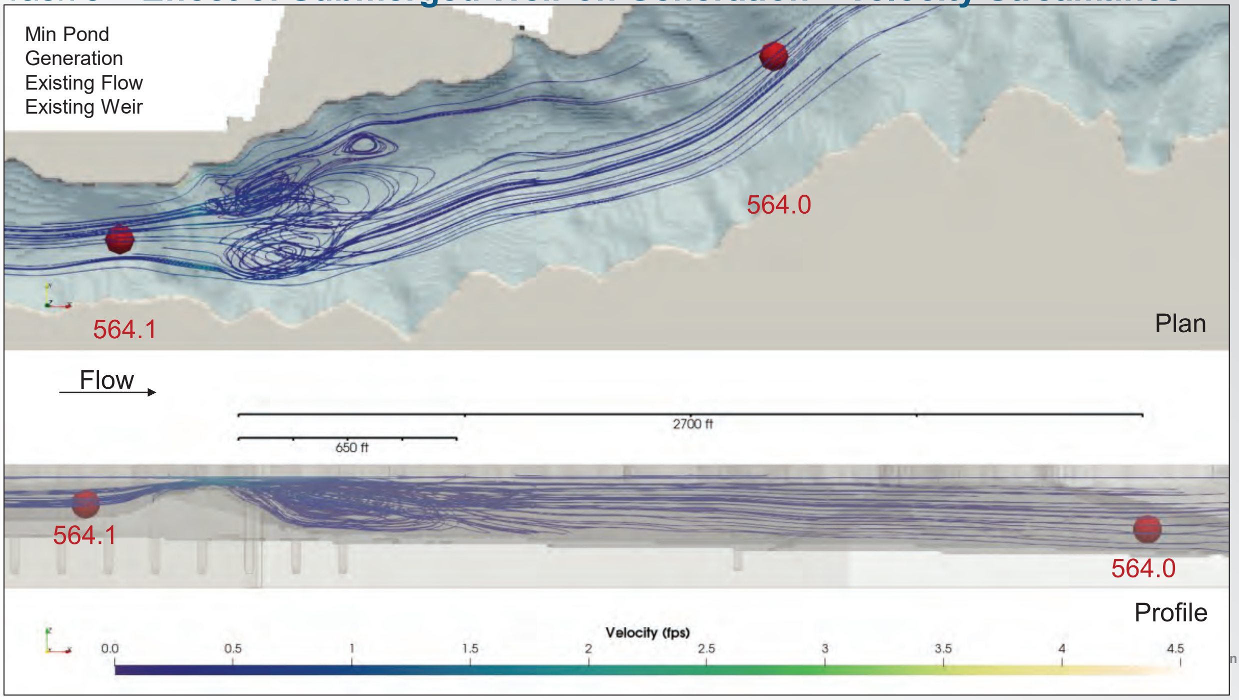
Task 3 – Weir Comparison



Task 3 – **Effect of Submerged Weir on Generation – Velocity Streamlines**

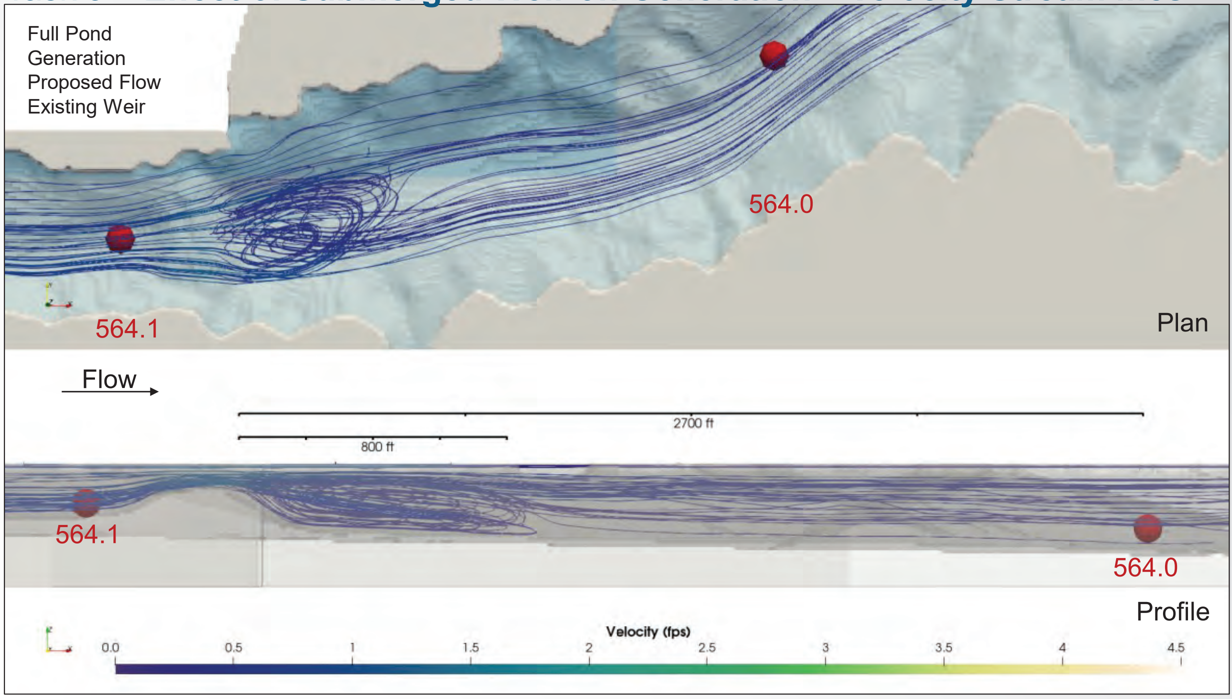


Task 3 – **Effect of Submerged Weir on Generation – Velocity Streamlines**

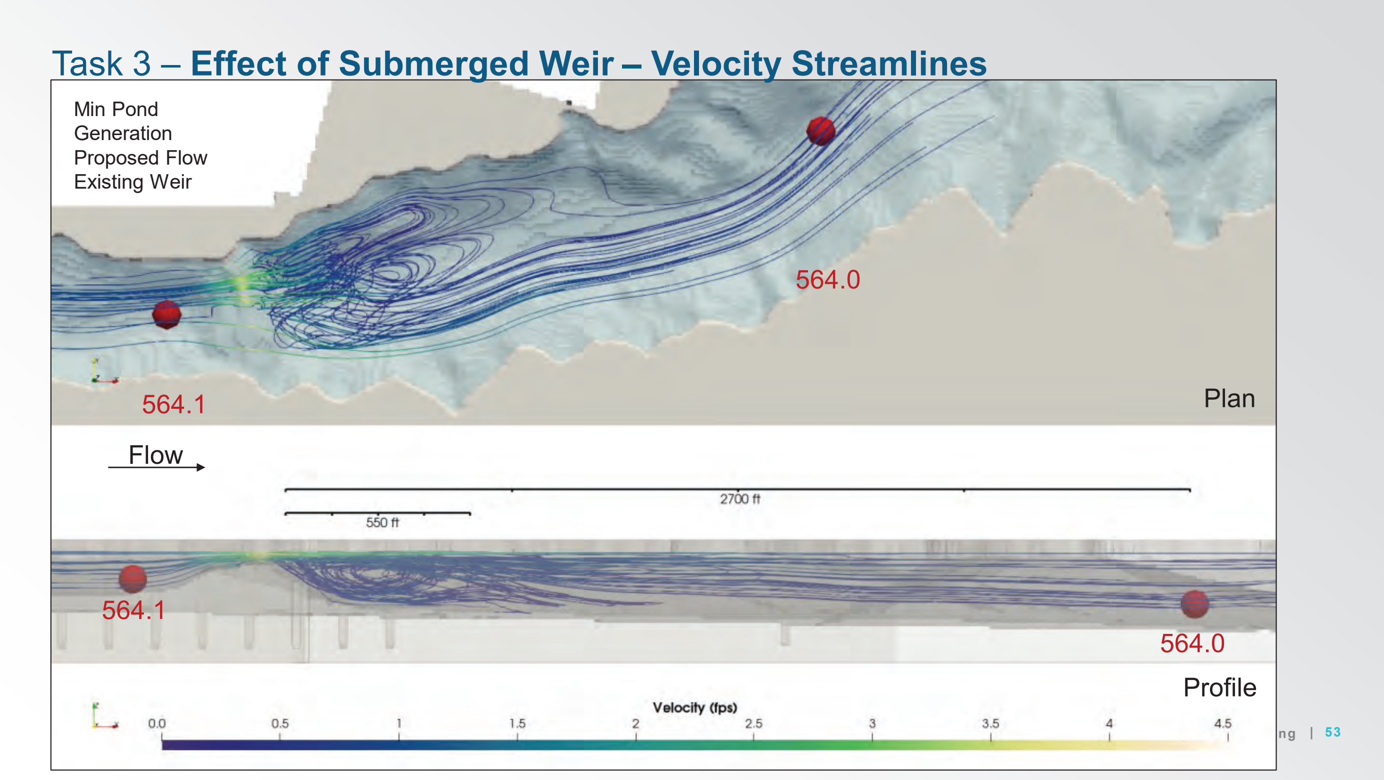


Min Pond
Generation
Existing Flow
Existing Weir

Task 3 – **Effect of Submerged Weir on Generation – Velocity Streamlines**

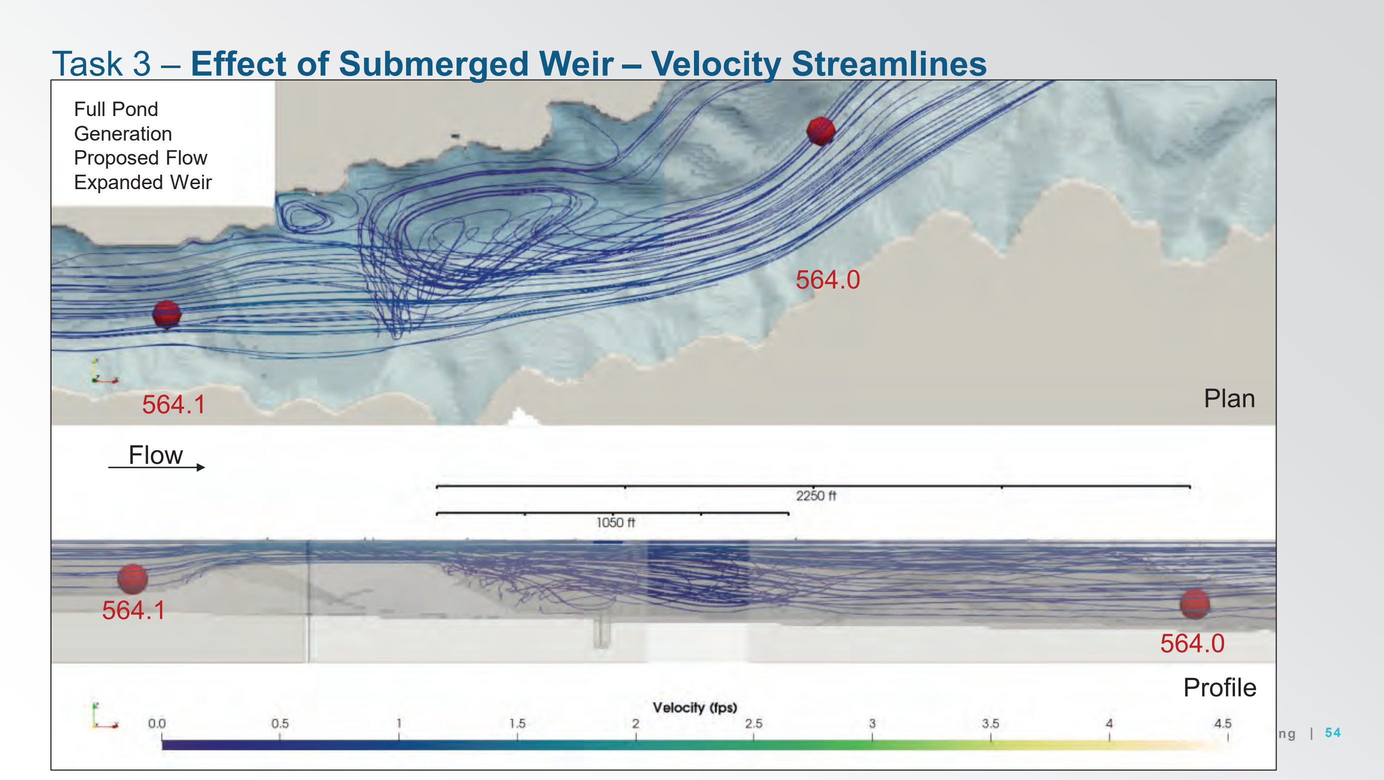


Full Pond
Generation
Proposed Flow
Existing Weir



Task 3 – **Effect of Submerged Weir – Velocity Streamlines**

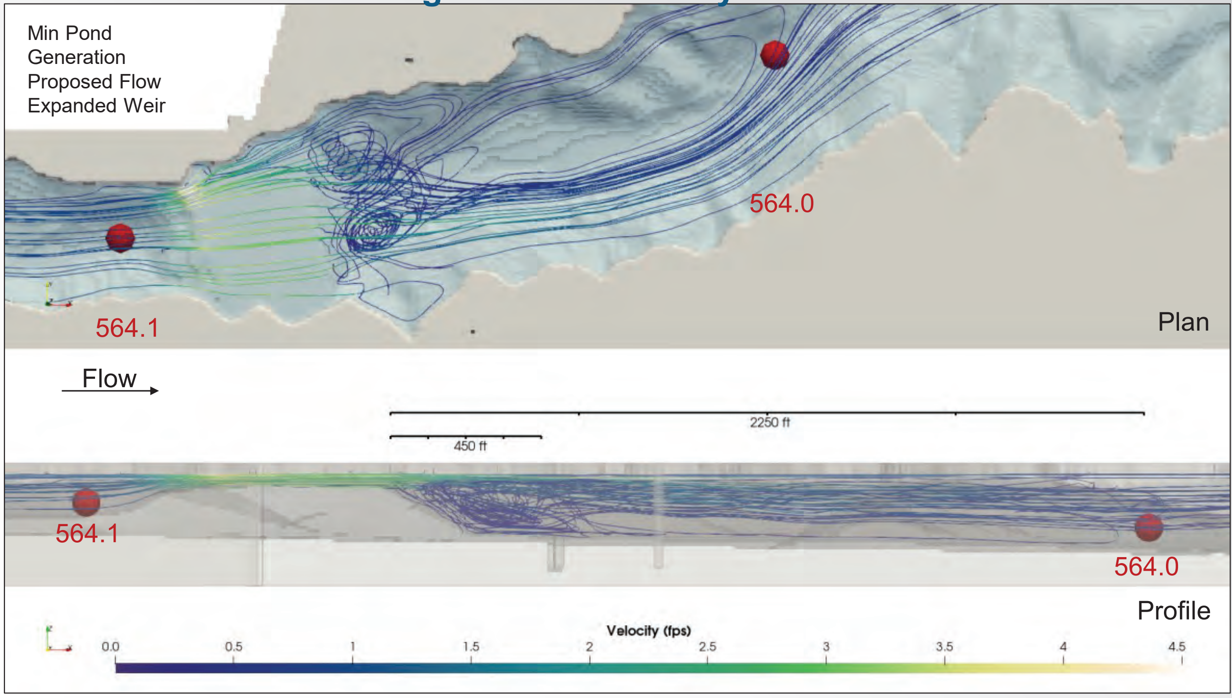
Min Pond
Generation
Proposed Flow
Existing Weir



Task 3 – **Effect of Submerged Weir – Velocity Streamlines**

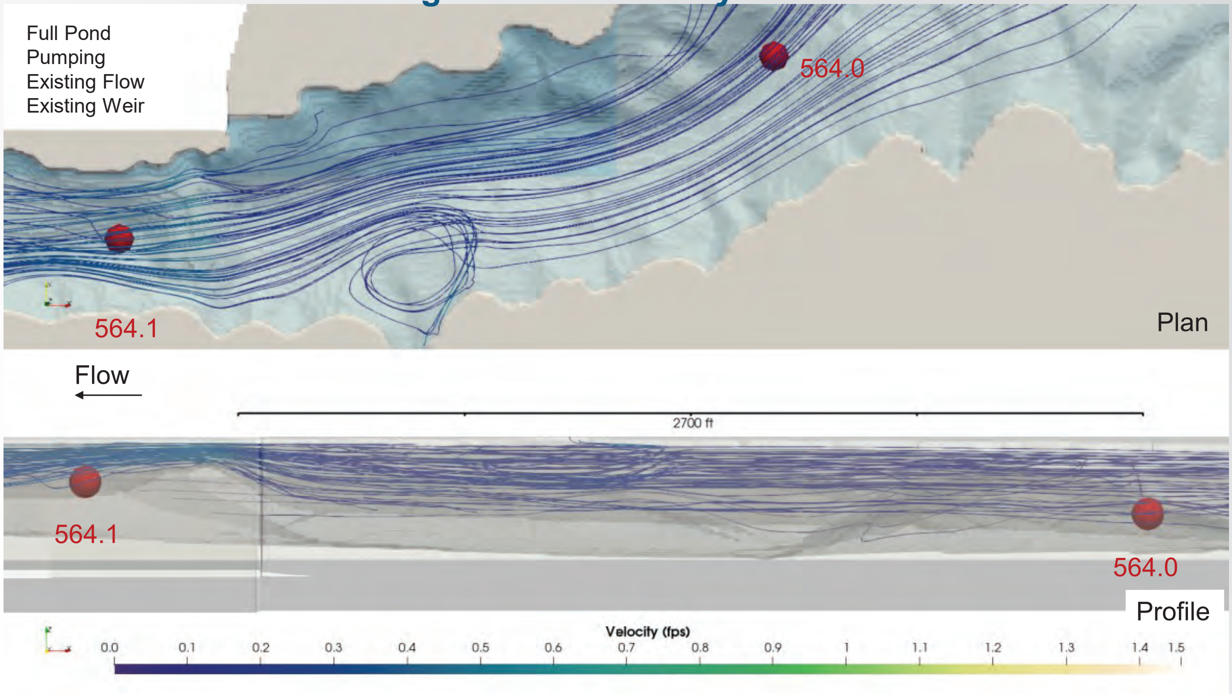
Full Pond
Generation
Proposed Flow
Expanded Weir

Task 3 – **Effect of Submerged Weir – Velocity Streamlines**



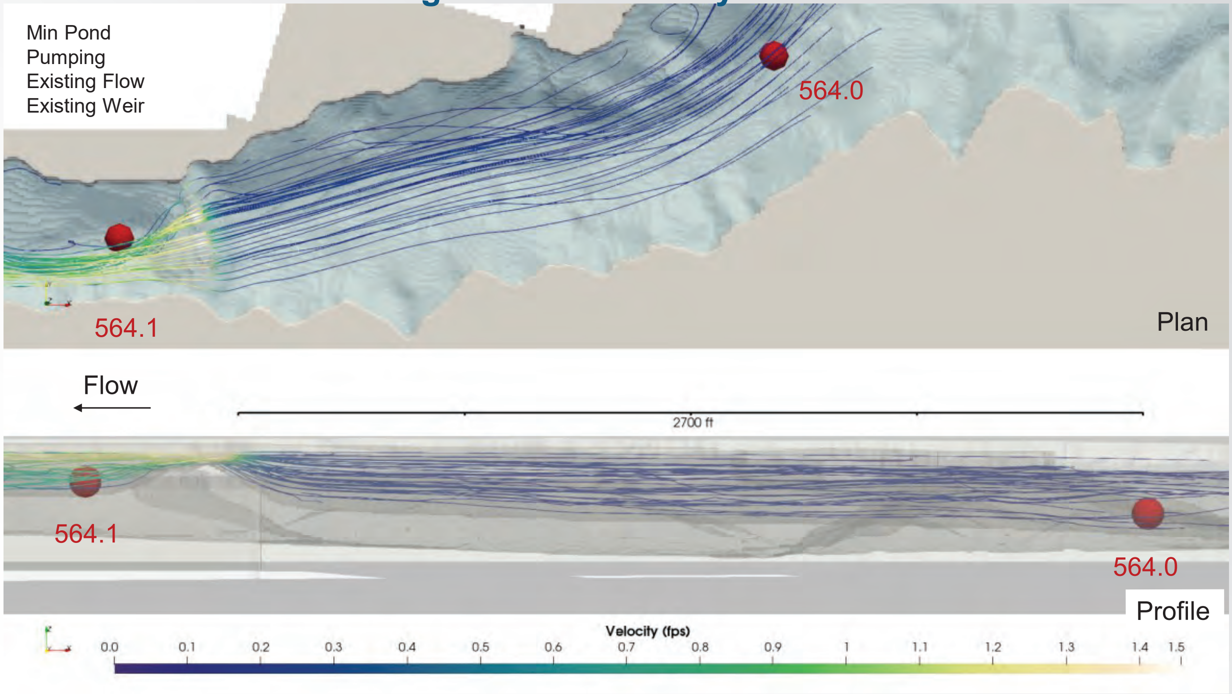
Effect of Submerged Weir during Pumping

Task 3 – Effect of Submerged Weir – Velocity Streamlines



Full Pond
Pumping
Existing Flow
Existing Weir

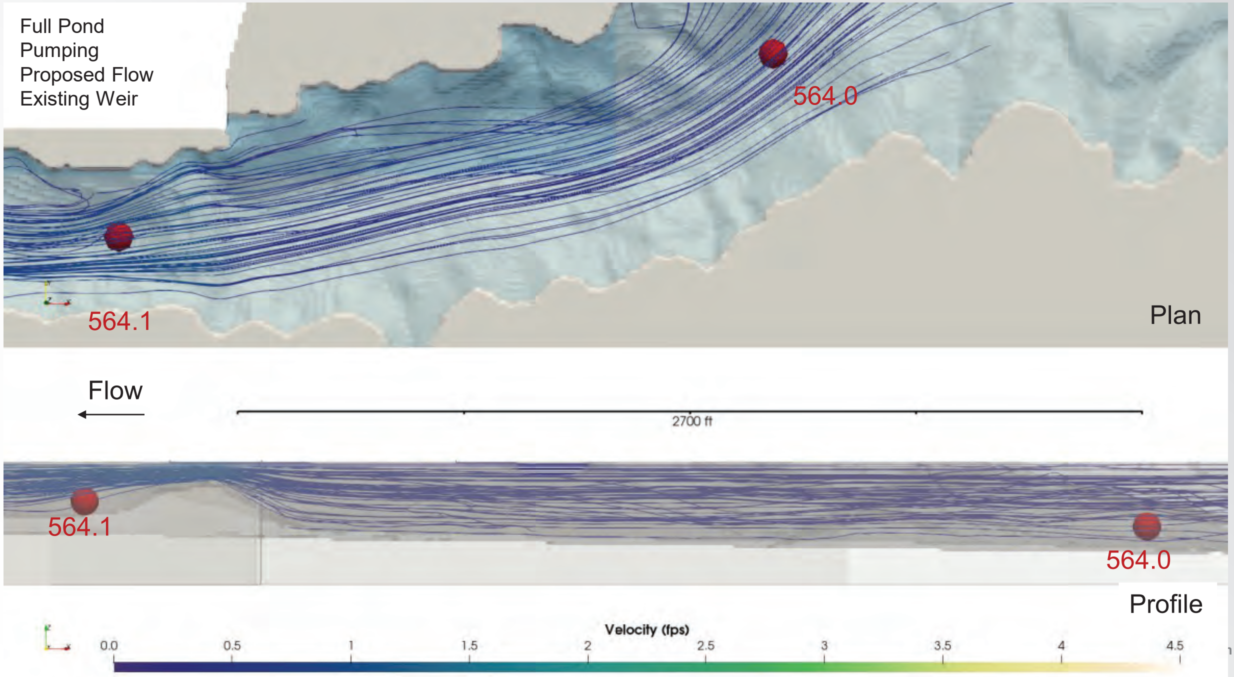
Task 3 – Effect of Submerged Weir – Velocity Streamlines



Min Pond
Pumping
Existing Flow
Existing Weir

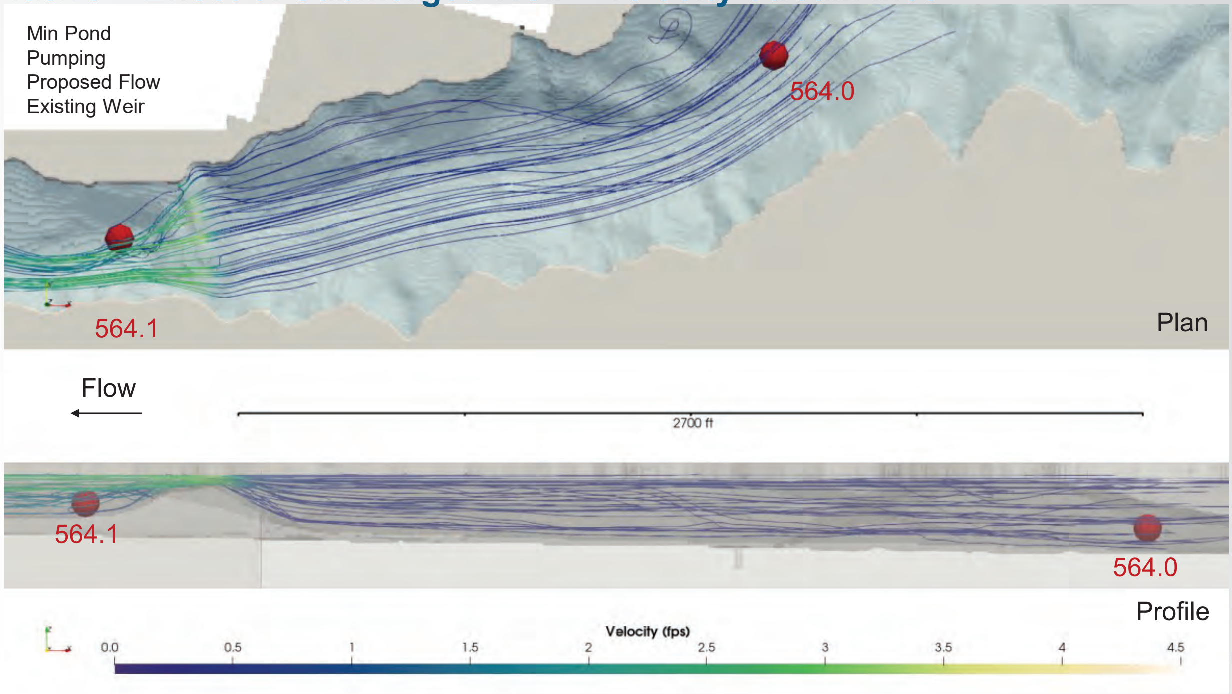
Task 3 – **Effect of Submerged Weir – Velocity Streamlines**

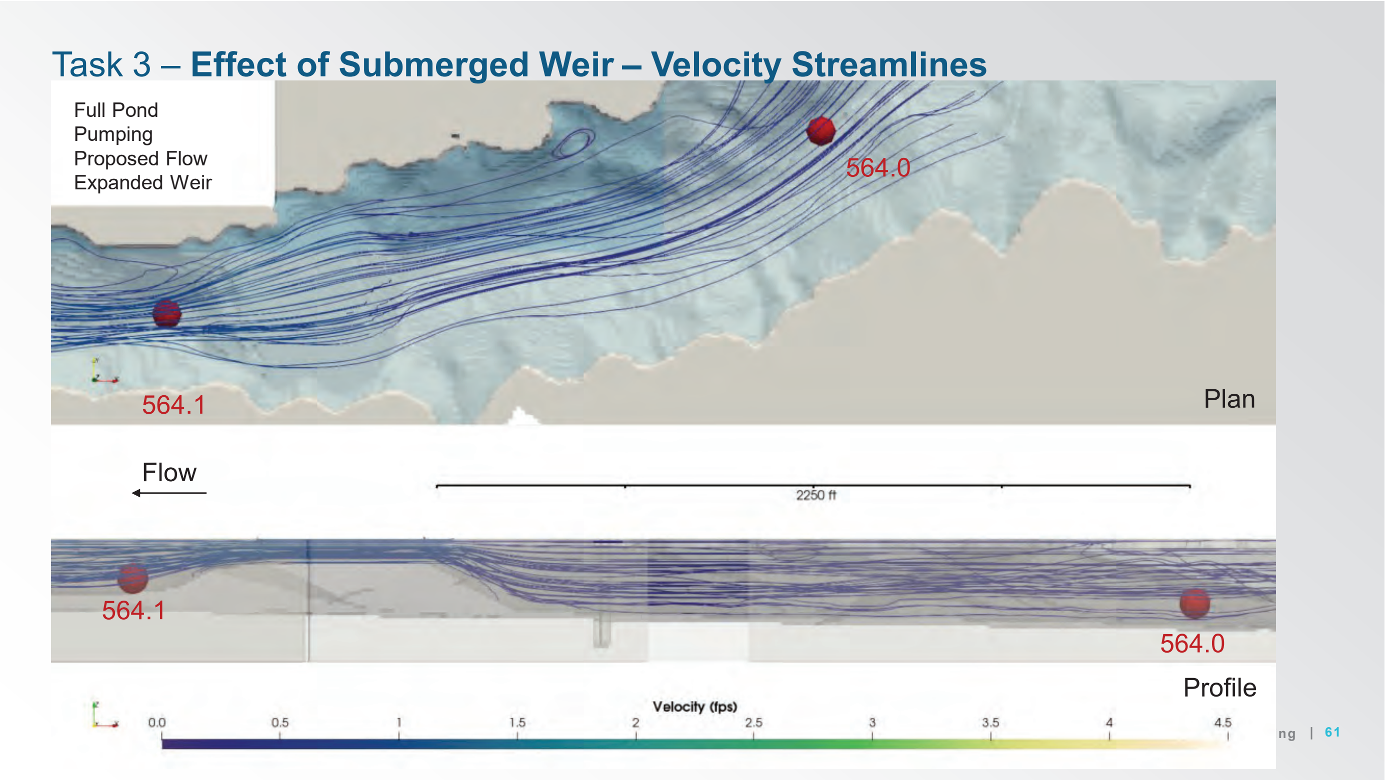
Full Pond
Pumping
Proposed Flow
Existing Weir



Task 3 – **Effect of Submerged Weir – Velocity Streamlines**

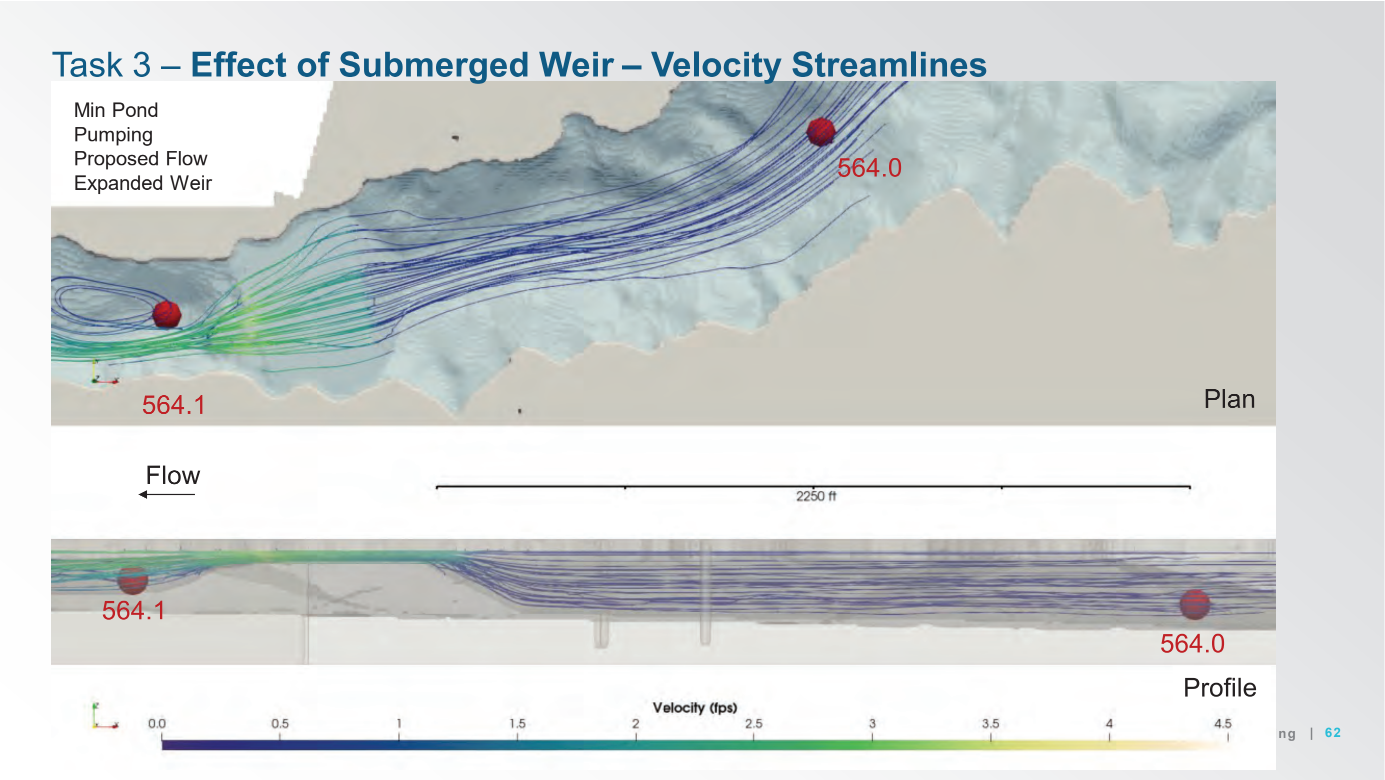
Min Pond
Pumping
Proposed Flow
Existing Weir





Task 3 – Effect of Submerged Weir – Velocity Streamlines

Full Pond
Pumping
Proposed Flow
Expanded Weir



Task 3 – Effect of Submerged Weir – Velocity Streamlines

Min Pond
Pumping
Proposed Flow
Expanded Weir

Task 3 – Initial Conclusions from CFD Modeling

Generation

- The energy of the water discharged from Bad Creek is dissipated as it’s forced up and over the existing submerged weir.
- Similar vertical mixing and flow patterns result from flows over existing and expanded weir.
- Similar vertical mixing and flow patterns result from Bad Creek II powerhouse operations.
- Results indicate Bad Creek II powerhouse operations will not alter existing stratification patterns observed at Station 564.0 (downstream of weir).

Pumping

- Hydraulic impacts due to Bad Creek II pumping impacts limited to Whitewater River Cove upstream of submerged weir.
- Pumping in any configuration does not create mixing downstream of submerged weir.

***Draft Report will be distributed in the fall for Resource Committee review*

Water Resources Study

Task 4 – Water Exchange Rates and Lake Jocassee Reservoir Levels (CHEOPS Modeling)

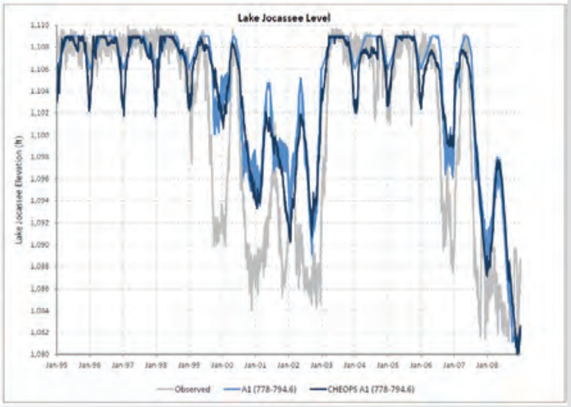
Task 4 – Water Exchange Rates and Lake Jocassee Reservoir Levels (CHEOPS Modeling)

Goals for today:
- Initial CHEOPS performance measures
- Modeling scenarios
- Update on model refinement

CHEOPS™
Operations and Planning Model

Task 4 – Performance Measures

- **Objectives:**
  - Use the existing CHEOPS model to evaluate the difference in water **exchange rate, frequency, and magnitude** between Bad Creek Reservoir and Lake Jocassee due to the addition of a second powerhouse.
  - Identify and evaluate impacts, if any, to Lake Keowee as a result of operating an additional powerhouse at the Project.
- **Status:** Ongoing.



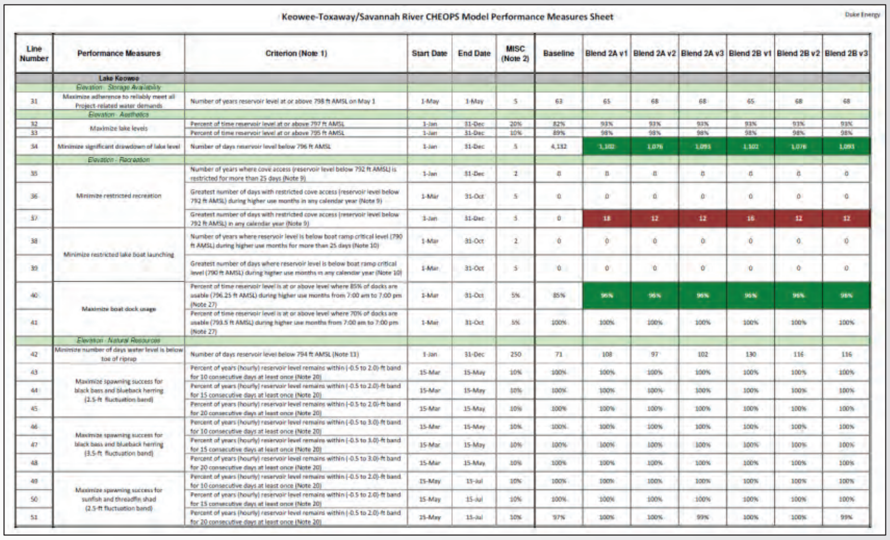
Task 4 – CHEOPS Scenarios

Baseline:
- Existing Bad Creek powerhouse
- Existing Bad Creek license
- KT license
- Updated demand curve (Bad Creek and Jocassee)
- Updated pumping dispatch curves (Bad Creek and Jocassee)
- Updated weekly drawdown cycle (30,000 ac-ft)

Bad Creek II:
- Baseline plus:
  - 4 Bad Creek II units (identical to existing units)
  - Pumping dispatch curve (Bad Creek II)
  - Assumption: Bad Creek II available for the entire scenario run

Task 4 – Bad Creek Performance Measures

Performance Measures Worksheet
- Minimum Increment of Significant Change (MISC)
- Side-by-side comparison
- Color coded



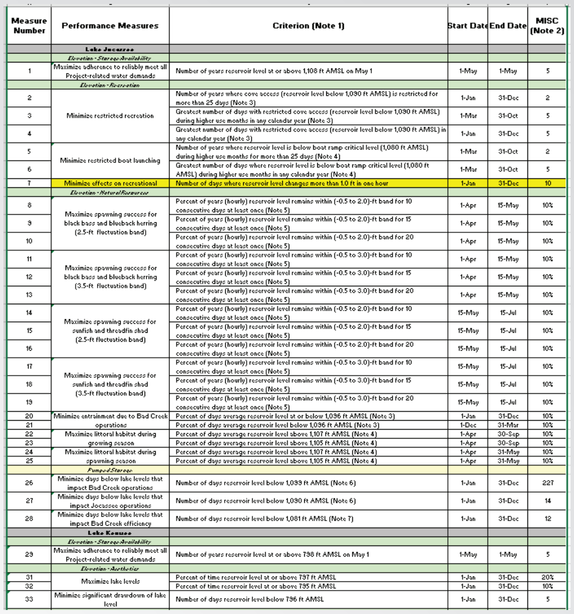
Keowee-Toxaway/Savannah River CHEOPS Model Performance Measures Sheet

Duke Energy

Line Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)	Baseline	Blend 2A v1	Blend 2A v2	Blend 2A v3	Blend 2B v1	Blend 2B v2	Blend 2B v3
	Lake Keowee											
	Elevation - Storage Availability											
31	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 798 ft AMSL on May 1	1-May	1-May	5	63	65	68	68	65	68	68
	Elevation - Aesthetics											
32	Maximize lake levels	Percent of time reservoir level at or above 797 ft AMSL	1-Jan	31-Dec	20%	82%	93%	93%	93%	93%	93%	93%
33		Percent of time reservoir level at or above 795 ft AMSL	1-Jan	31-Dec	10%	89%	98%	98%	98%	98%	98%	98%
34	Minimize significant drawdown of lake level	Number of days reservoir level below 796 ft AMSL	1-Jan	31-Dec	5	4,132	1,102	1,076	1,093	1,102	1,076	1,093
	Elevation - Recreation											
35	Minimize restricted recreation	Number of years where cove access (reservoir level below 792 ft AMSL) is restricted for more than 25 days (Note 9)	1-Jan	31-Dec	2	0	0	0	0	0	0	0
36		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) during higher use months in any calendar year (Note 9)	1-Mar	31-Oct	5	0	0	0	0	0	0	0
37		Greatest number of days with restricted cove access (reservoir level below 792 ft AMSL) in any calendar year (Note 9)	1-Jan	31-Dec	5	0	18	12	12	16	12	12
38	Minimize restricted lake boat launching	Number of years where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months for more than 25 days (Note 10)	1-Mar	31-Oct	2	0	0	0	0	0	0	0
39		Greatest number of days where reservoir level is below boat ramp critical level (790 ft AMSL) during higher use months in any calendar year (Note 10)	1-Mar	31-Oct	5	0	0	0	0	0	0	0
40	Maximize boat dock usage	Percent of time reservoir level is at or above level where 85% of docks are usable (796.25 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 27)	1-Mar	31-Oct	5%	85%	96%	96%	96%	96%	96%	98%
41		Percent of time reservoir level is at or above level where 70% of docks are usable (793.5 ft AMSL) during higher use months from 7:00 am to 7:00 pm (Note 27)	1-Mar	31-Oct	5%	100%	100%	100%	100%	100%	100%	100%
	Elevation - Natural Resources											
42	Minimize number of days water level is below toe of riprap	Number of days reservoir level below 794 ft AMSL (Note 13)	1-Jan	31-Dec	250	71	108	97	102	130	116	116
43	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 20)	15-Mar	15-May	10%	100%	100%	100%	100%	100%	100%	100%
44		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 20)	15-Mar	15-May	10%	100%	100%	100%	100%	100%	100%	100%
45		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 20)	15-Mar	15-May	10%	100%	100%	100%	100%	100%	100%	100%
46	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 20)	15-Mar	15-May	10%	100%	100%	100%	100%	100%	100%	100%
47		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 20)	15-Mar	15-May	10%	100%	100%	100%	100%	100%	100%	100%
48		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 20)	15-Mar	15-May	10%	100%	100%	100%	100%	100%	100%	100%
49	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 20)	15-May	15-Jul	10%	100%	100%	100%	100%	100%	100%	100%
50		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 20)	15-May	15-Jul	10%	100%	100%	100%	100%	100%	100%	100%
51		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 20)	15-May	15-Jul	10%	97%	100%	100%	99%	100%	100%	99%

Task 4 – Bad Creek Performance Measures

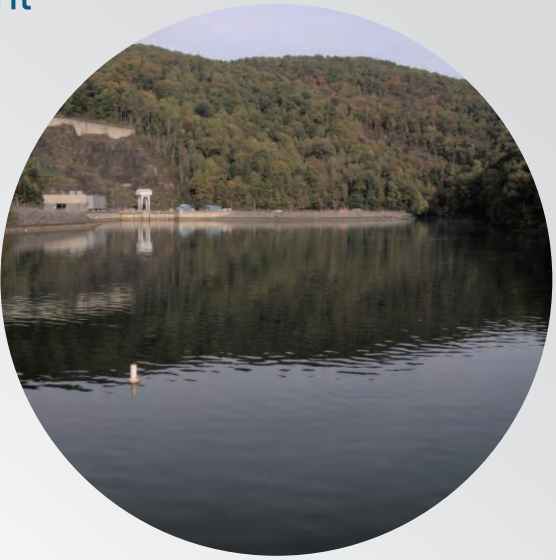
- **Starting Point:** KT Relicensing Performance Measures
  - All Jocassee and Keowee lake level measures & LIP Stages
  - New measure: Measure 7 – Number of days where Jocassee reservoir level changes more than 1.0 ft in one hour
  - **Revised measures**
    - Measure 59 – Number of days where Keowee level below critical level (790.0 ft msl) for thermal power operation
    - Measures 61-66 – Number of days in LIP Stages; added MISC



Measure Number	Performance Measures	Criterion (Note 1)	Start Date	End Date	MISC (Note 2)
	Lake Jocassee				
	Elevation - Storage Availability				
1	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 1,108 ft AMSL on May 1	1-May	1-May	5
	Elevation - Recreation				
2	Minimize restricted recreation	Number of years where cove access (reservoir level below 1,090 ft AMSL) is restricted for more than 25 days (Note 3)	1-Jan	31-Dec	2
3		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) during higher use months in any calendar year (Note 3)	1-Mar	31-Oct	5
4		Greatest number of days with restricted cove access (reservoir level below 1,090 ft AMSL) in any calendar year (Note 3)	1-Jan	31-Dec	5
5	Minimize restricted boat launching	Number of years where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months for more than 25 days (Note 4)	1-Mar	31-Oct	2
6		Greatest number of days where reservoir level is below boat ramp critical level (1,080 ft AMSL) during higher use months in any calendar year (Note 4)	1-Mar	31-Oct	5
7	Minimize effects on recreational	Number of days where reservoir level changes more than 1.0 ft in one hour	1-Jan	31-Dec	10
	Elevation - Natural Resources				
8	Maximize spawning success for black bass and blueback herring (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	15-May	10%
9		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 5)	1-Apr	15-May	10%
10		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 5)	1-Apr	15-May	10%
11	Maximize spawning success for black bass and blueback herring (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	1-Apr	15-May	10%
12		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 5)	1-Apr	15-May	10%
13		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 5)	1-Apr	15-May	10%
14	Maximize spawning success for sunfish and threadfin shad (2.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	10%
15		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 15 consecutive days at least once (Note 5)	15-May	15-Jul	10%
16		Percent of years (hourly) reservoir level remains within (-0.5 to 2.0)-ft band for 20 consecutive days at least once (Note 5)	15-May	15-Jul	10%
17	Maximize spawning success for sunfish and threadfin shad (3.5-ft fluctuation band)	Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 10 consecutive days at least once (Note 5)	15-May	15-Jul	10%
18		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 15 consecutive days at least once (Note 5)	15-May	15-Jul	10%
19		Percent of years (hourly) reservoir level remains within (-0.5 to 3.0)-ft band for 20 consecutive days at least once (Note 5)	15-May	15-Jul	10%
20	Minimize entrainment due to Bad Creek operations	Percent of days average reservoir level at or below 1,096 ft AMSL (Note 3)	1-Jan	31-Dec	10%
21		Percent of days average reservoir level below 1,096 ft AMSL (Note 3)	1-Dec	31-Mar	10%
22	Maximize littoral habitat during growing season	Percent of days average reservoir level above 1,107 ft AMSL (Note 4)	1-Apr	30-Sep	10%
23		Percent of days average reservoir level above 1,105 ft AMSL (Note 4)	1-Apr	30-Sep	10%
24	Maximize littoral habitat during spawning season	Percent of days average reservoir level above 1,107 ft AMSL (Note 4)	1-Apr	31-May	10%
25		Percent of days average reservoir level above 1,105 ft AMSL (Note 4)	1-Apr	31-May	10%
	Pumped Storage				
26	Minimize days below lake levels that impact Bad Creek operations	Number of days reservoir level below 1,099 ft AMSL (Note 6)	1-Jan	31-Dec	227
27	Minimize days below lake levels that impact Jocassee operations	Number of days reservoir level below 1,090 ft AMSL (Note 6)	1-Jan	31-Dec	14
28	Minimize days below lake levels that impact Bad Creek efficiency	Number of days reservoir level below 1,081 ft AMSL (Note 7)	1-Jan	31-Dec	12
	Lake Keowee				
	Elevation - Storage Availability				
29	Maximize adherence to reliably meet all Project-related water demands	Number of years reservoir level at or above 798 ft AMSL on May 1	1-May	1-May	5
	Elevation - Aesthetics				
31	Maximize lake levels	Percent of time reservoir level at or above 797 ft AMSL	1-Jan	31-Dec	20%
32		Percent of time reservoir level at or above 795 ft AMSL	1-Jan	31-Dec	10%
33	Minimize significant drawdown of lake level	Number of days reservoir level below 796 ft AMSL	1-Jan	31-Dec	5

Aquatic Resources Study

Task 1 – Consultation on Entrainment



Draft Entrainment Study Report

- Meeting with the Aquatic Resources RC in April 2023
- Entrainment study evaluating additional parameters affecting entrainment scenarios
  - Lake surface elevation (+/- 1,099 ft msl; 89 ft)
  - Water temperature
  - Hours of pumping (day vs night operations)
- Distribute draft study report by November 2023

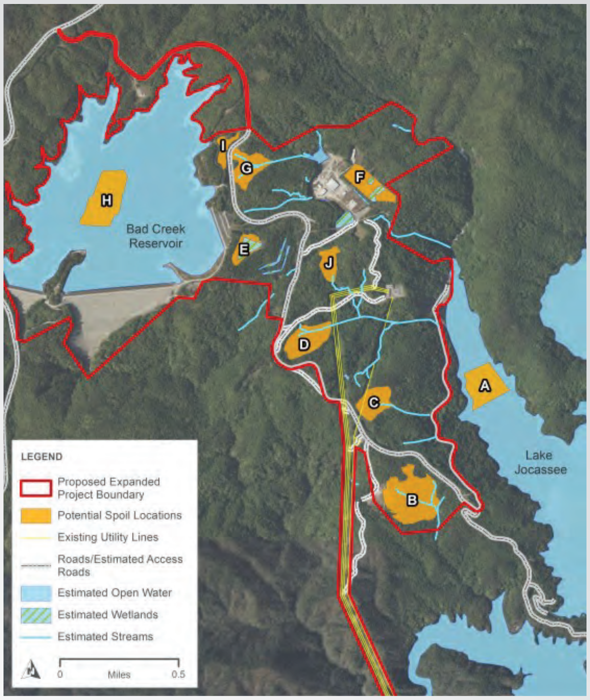
Task 2 – Desktop Studies on Potential Effects to Pelagic and Littoral Habitat

- Meeting with the Water Resources RC in July 2023 (today)
- Water Resources Study modeling results
  - 2-D hydraulic model
  - CFD model
  - CHEOPS model
- Discuss desktop study results in early spring 2024

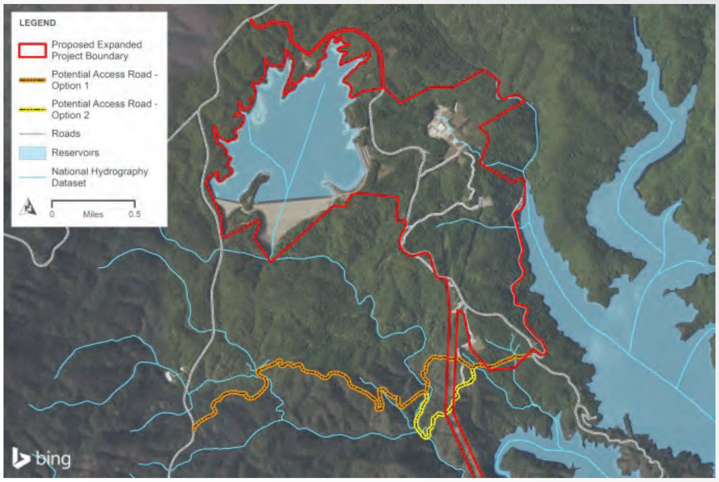
Task 3 – Mussel Surveys and Stream Habitat Quality Surveys

Potential Spoil Locations

- Mussel surveys
  - Late July: survey of Lake Jocassee shoreline in the vicinity of Bad Creek inlet/outlet and submerged weir
  - Mussel habitat is not present at upland potential spoil locations
- Stream habitat assessments
  - NC Stream Assessment Method (NCSAM) and USEPA Rapid Bioassessment Protocol (RBP) will be completed for all streams within potential spoil locations

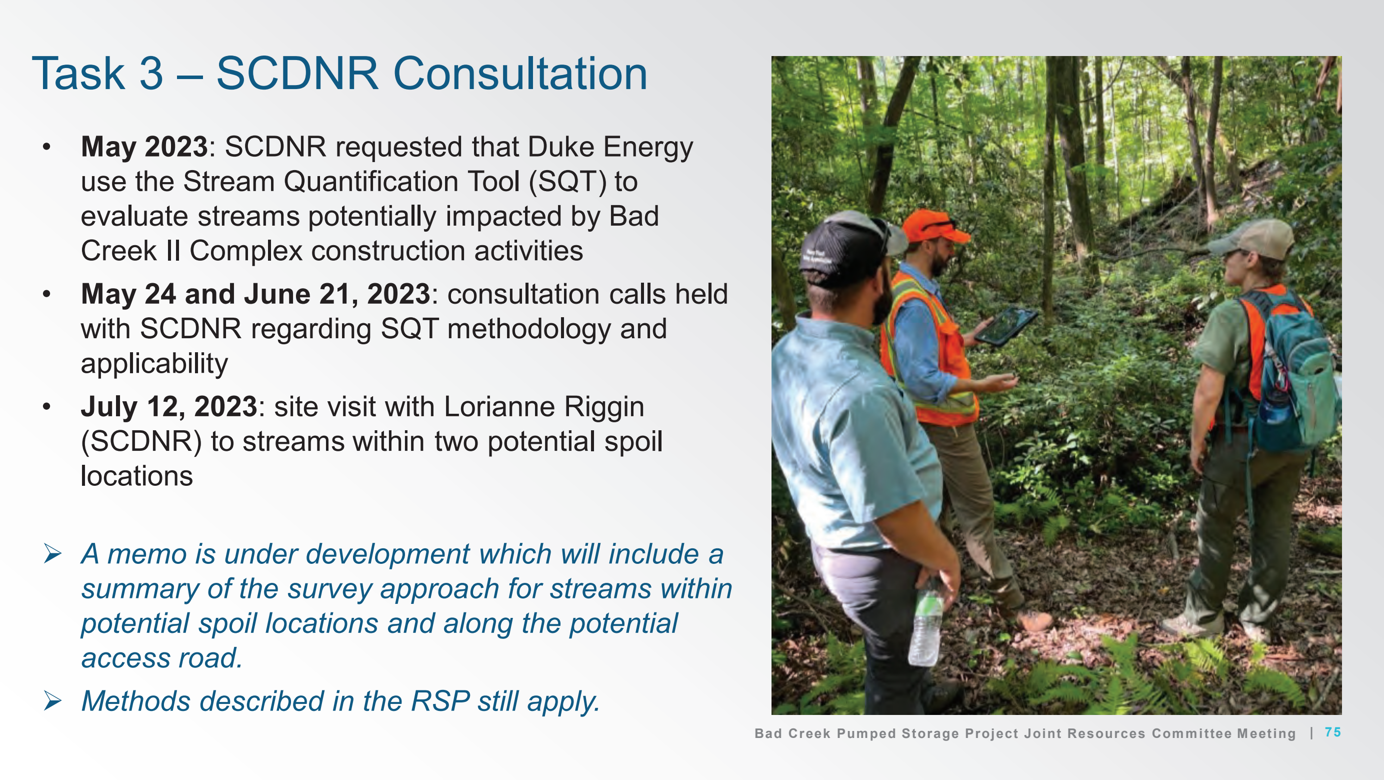


Task 3 – Mussel Surveys and Stream Habitat Quality Surveys



Potential Access Road

- Fish Community & Mussel surveys
  - Howard Creek
  - Limber Pole Creek
- Stream habitat assessments
  - All streams crossed by the potential access road
  - NCSAM + USEPA RBP
  - SCDNR Stream Quantification Tool (SQT)

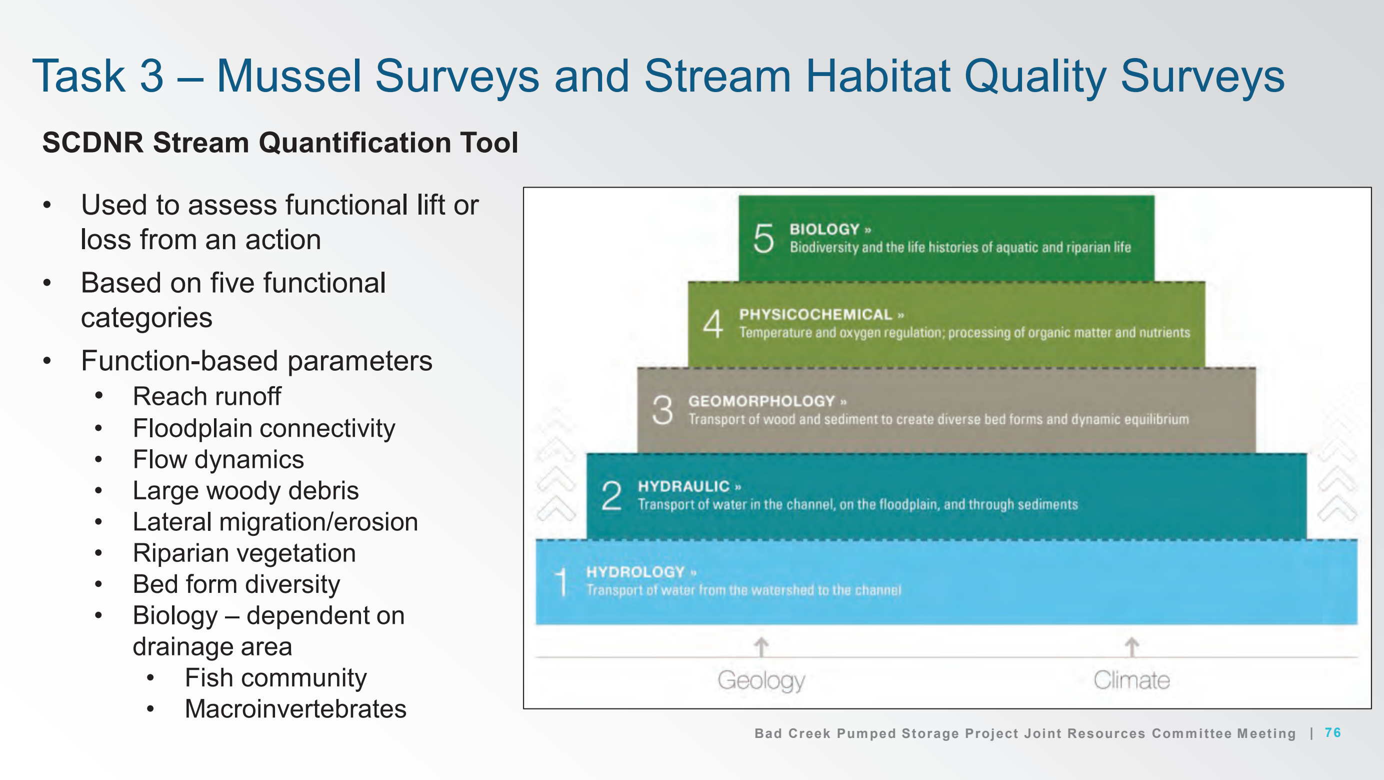


Task 3 – SCDNR Consultation

- **May 2023**: SCDNR requested that Duke Energy use the Stream Quantification Tool (SQT) to evaluate streams potentially impacted by Bad Creek II Complex construction activities
- **May 24 and June 21, 2023**: consultation calls held with SCDNR regarding SQT methodology and applicability
- **July 12, 2023**: site visit with Lorianne Riggin (SCDNR) to streams within two potential spoil locations

➢ *A memo is under development which will include a summary of the survey approach for streams within potential spoil locations and along the potential access road.*

➢ *Methods described in the RSP still apply.*



Task 3 – Mussel Surveys and Stream Habitat Quality Surveys

SCDNR Stream Quantification Tool

- Used to assess functional lift or loss from an action
- Based on five functional categories
- Function-based parameters
  - Reach runoff
  - Floodplain connectivity
  - Flow dynamics
  - Large woody debris
  - Lateral migration/erosion
  - Riparian vegetation
  - Bed form diversity
  - Biology – dependent on drainage area
    - Fish community
    - Macroinvertebrates

5 **BIOLOGY »** Biodiversity and the life histories of aquatic and riparian life

4 **PHYSICOCHEMICAL »** Temperature and oxygen regulation; processing of organic matter and nutrients

3 **GEOMORPHOLOGY »** Transport of wood and sediment to create diverse bed forms and dynamic equilibrium

2 **HYDRAULIC »** Transport of water in the channel, on the floodplain, and through sediments

1 **HYDROLOGY »** Transport of water from the watershed to the channel

Task 3 – Mussel Surveys and Stream Habitat Quality Surveys

Field Studies Schedule

Task	Location(s)	Timeframe
Fish community sampling*	Potential access road	Late July - October (3 events)
Mussel surveys*	Lake Jocassee & Potential access road	Late July
Macroinvertebrate sampling*	Potential access road	Early August
Stream habitat assessments (NCSAM + USEPA RBP)*	Potential spoil locations & potential access road	Early-mid October
Stream geomorphic surveys and riparian vegetation assessments	Potential access road	Early-mid October

*Incidental observations of amphibians and reptiles will be documented.

Task 3 – Mussel Surveys and Stream Habitat Quality Surveys

Limber Pole Creek

Howard Creek

Questions and Action Items

Meeting Summary

Project:	Bad Creek Pumped Storage Project Relicensing
Subject:	Bad Creek Water and Aquatic Resources Joint Resource Committee Meeting
Date:	Thursday, July 27, 2023
Location:	Duke Energy Operations Center, Greenville, SC

Attendees (in-person)

John Crutchfield, Duke Energy
Alan Stuart, Duke Energy
Jeff Lineberger, Duke Energy
Ethan Pardue, Duke Energy
Paul Keener, Duke Energy
Mike Abney, Duke Energy
Maverick Raber, Duke Energy
Kelly Kirven, Kleinschmidt Assoc.
Alison Jakupka, Kleinschmidt Assoc.
Elizabeth Miller, SCDNR
Amy Chastain, SCDNR
William Wood, SCDNR
Dan Rankin, SCDNR
Erika Hollis, Upstate Forever
Sarah Kulpa, HDR
Joe Dvorak, HDR
Jen Huff, HDR
Kerry McCarney-Castle, HDR
Eric Mularski, HDR

Attendees (virtual)

Lynne Dunn, Duke Energy
Scott Fletcher, Duke Energy
Alex Pellett, SCDNR
Jeff Phillips, Greenville Water
Melanie Olds, U.S. Fish and Wildlife Service
John Hains, Friends of Lake Keowee Society
Kevin Nebiolo, Kleinschmidt Assoc.
Ty Ziegler, HDR

Introduction

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

Water Resources Study Update

Tasks 1 and 2

M. Raber provided an update on Water Resources Study tasks and summarized topics for discussion during the morning meeting.

- Task 1 – “Summary of Existing Water Quality Data and Standards” report was submitted to the Water Resources Study Resource Committee (RC) on June 30th for a 60-day turn-around.
- Task 2 – “Water Quality Monitoring in the Whitewater River Arm” is ongoing; M. Raber summarized instrumentation deployment in late May and data collection (every 2 weeks and

every 2 meters vertical profile). Continuous temperature monitoring is underway in the Whitewater River arm at stations 564.1, 564.0, and 560.0. Four elevations are being monitored for dissolved oxygen and temperature to determine flow patterns and how flow/mixing is affected by the existing submerged weir. Water quality data in the Whitewater River cove will be collected during summer 2023 and 2024 to represent conservative (higher temps) conditions under current operations (2023) and planned upgrades at the existing Bad Creek Project (2024).

Task 3

Joe Dvorak introduced modeling efforts for Task 3 of the Water Resources Study “Velocity Effects and Vertical Mixing in Lake Jocassee Due to a Second Powerhouse” (CFD Modeling in the Whitewater River Cove), the objectives of the study, and noted results are preliminary. He described how a 2-D model was developed first to determine the model extent for CFD modeling; he described CFD model assumptions and domain as well as existing and proposed weir configurations and typical exceedance water elevations for Lake Jocassee over the period of record. J. Dvorak noted all effects of the additional powerhouse are limited to the model domain which accounts for about 11 percent of the total volume of Lake Jocassee. He provided slides showing figures of preliminary CFD modeling results and indicated full results will be provided in the report to be provided this fall.

Participant Discussion and Questions Tasks 1 - 3

- John Hains (via chat) asked, “What are the criteria for “negligible”? This is in reference to language on Slide 15: “*Of the “bookend” scenarios analyzed, combined Bad Creek and Bad Creek II operations (39,200 cfs) with Lake Jocassee at minimum pond elevation (1,080 ft msl) was found to have the greatest effect on Whitewater River Cove hydraulics, however at the downstream model boundary **that effect was negligible***.” J. Dvorak replied there are no stated criteria for “negligible” as it is subjective, but today’s discussion will include more about the actual results and the effect of the second powerhouse and conclusions will support this statement.
- Elizabeth Miller asked about the orientation of Slide 17. J. Dvorak explained where the I/O structure was and orientation to the lake.
- Alan conveyed a question from Erika Hollis, who asked if this information has yet been presented anywhere. J. Dvorak responded that this is the first time these results are being presented. A draft report will be issued soon which will provide detail on the overview covered during the presentation.
- Dan Rankin commented that from the results we are seeing (i.e., no effect at the downstream model domain due to expanding the weir or adding a second powerhouse), the main purpose of the weir is primarily to provide a place to dispose of excavation material. J. Dvorak agreed expanding the weir would have limited effects on velocities. D. Rankin then asked if any consideration has been given to creating another weir? J. Dvorak responded that has not been considered but the model has the capability to evaluate other designs.
- Joh Hains (via chat) asked, “Is there any reason that the expanded weir could be expected to change the velocity field at that downstream location?” J. Dvorak indicated we would get into that specifically later in the slides.
- Gerry Yantis asked if water temperature affects CFD modeling or if temperature/other criteria were considered. J. Dvorak indicated there are other parameters CFD model can evaluate like temperature, but we have not done that – the focus here is solely on hydraulics. M. Raber added ongoing data collection efforts in the Whitewater River cove for water quality

parameters (Task 2) supports the modeling effort to help determine mixing effects upstream and downstream.

- William Wood asked about water flow effects from the Thompson River. J. Dvorak indicated even at minimum pond, as you get further into the main body of the lake (downstream of Thompson River), flow from the Thompson River has a negligible effect on overall flow patterns in the lake.
- Ty Ziegler (via chat): "There are some very minor differences in flow patterns/velocities from the existing weir to the expanded weir (mostly at maximum drawdown), but by the time you get to WQ monitoring location 564.0, the results are similar. Therefore, we shouldn't see any differences in vertical mixing/stratification at location 564.0. Joe will have some figures to demonstrate."
- Alex Pellet (via chat): "This is off-topic at the moment, but perhaps we can circle back. I'm curious to understand one of the questions, I believe was from Dan Rankin. If disposing of the rock material is a goal of this, and there are only marginal benefits to weir expansion, then we might prefer other configurations of the material which provide superior aquatic habitat? Is that correct?"
    - J. Dvorak discussed the shape of the proposed expanded weir is simplified in the model. The length of the crest of the weir drives model results, not the composition of the weir. He deferred to M. Raber to discuss habitat effects of different materials. M. Raber noted that due to temperature density, when water comes across the weir, flow is laminar across the top, and stratification is not affected downstream of the weir (not affected by mixing upstream of the weir) so the geometry of the weir shape wouldn't change that. Would there be a configuration that would provide more/better fish habitat provided? J. Dvorak indicated there is at minimum 20 feet of water over top of the weir keeping flow at the top – therefore, roughness of the surface of the crest of the weir would not affect anything.
- A. Stuart stated all Duke Energy lakes have an established minimum clearance for lake structures due to recreation, however, he does not know the exact depth for Lake Jocassee. Dan Rankin asked how often lake was at that minimum depth.
    - Mike Abney confirmed Duke Energy Lake Services has a minimum required depth between a structure placed in a lake (e.g., for fish habitat) and the normal minimum lake elevation. That minimum depth varies by lake and is 50 feet from full pool for Lake Jocassee).
- D. Rankin (Slide 55) asked if the size of the mixing zone downstream of the weir simply would double in length (downstream) by expanding the weir. J. Dvorak replied it's not possible to compare full to minimum pond in these mixing scenarios; it's actually an additional 200 feet downstream due to the expanded weir, not doubled.
- E. Miller (Slide 55) asked if flowlines were forming a loop downstream of the weir? J. Dvorak said it's possible but there are about 500 flow lines so it would be impossible to determine; the reason for the flow path (shown on Slides 50 through 55) is due to the natural thalweg of the flow through Whitewater River cove. M. Raber indicated the flow there is about 0.5 fps in the water column, even under worst case conditions (i.e., minimum pond, generation, two powerhouses, expanded weir).
- Lynne Dunne (virtual): Will there be additional operations requests for Bad Creek for ADCP validations for CFD modeling? A. Stuart answered we will not know if additional schedule changes will be necessary until HDR confirms if the data collected under generating and pumping at the five transects is good. (HDR collected ADCP flow data at 5 transects two weeks prior to the meeting, therefore validation data analysis is forthcoming).

Task 4 - CHEOPS

Ed Bruce opened the Task 4 “Water Exchange Rates and Lake Jocassee Reservoir Levels [CHEOPS Modeling])” discussion, summarizing study objectives and goals for today.

A. Stuart clarified there is no proposed change in the volume/capacity of Lake Jocassee associated with Bad Creek II; E. Bruce noted a good analogy is putting a bigger faucet on a bathtub, but it’s still the same bathtub.

E. Bruce reviewed the CHEOPS scenarios (baseline and with Bad Creek II). He noted that as an assumption, the second powerhouse would be available immediately (in the model runs), looking at maximum possible change scenarios and determining if there are any effects noticeable statistically and over time. The performance measures will run for X amount of years and determine any long-term effects and handed over the presentation to Jen Huff to explain more about performance measures.

J. Huff distributed a proposed performance measures spreadsheet to the group (emailed to virtual attendees) and described what performance measures are (i.e., statistical summary of how the model performs for a particular measure), provided definitions of terms, and went through individual performance measures considered in this effort.

Erika Hollis asked about the “MISC” (minimum increment of significant change). J. Huff indicated the MISC is a value that was determined by the Operations Resource Committee (RC) formed for Keowee-Toxaway (KT) relicensing. The MISC for each measure indicates what variance from the baseline result for that measure great enough to represent a statistical difference in results. Using output from KT relicensing, J. Huff walked through what each color meant: cells with no color are not significantly different from baseline, green cells have better results than the baseline, and red performed poorer than baseline conditions. For Bad Creek, Duke Energy is proposing to use the measures used for KT relicensing for Jocassee and Keowee (i.e., nothing further downstream).

J. Crutchfield mentioned the performance measures spreadsheet will be on SharePoint for comments; J. Huff asked for comments by August 15 (comments include any proposed new measures) and requests for those proposing new measures, provide details on the measures requested.

Sarah Kulpa asked if the MISC is for the license year or just the number of times something occurs during the entire period of record. E. Bruce noted it could be for either, depending on the measure. S. Kulpa asked J. Huff to describe the philosophy of developing the MISC and asked if there is a benefit to using the same MISC that was developed for KT relicensing. J. Huff indicated the period of record that will be used for Bad Creek runs is the same as was used for KT relicensing (unimpaired flow data from same days and modeled over same number of days), so believes the MISCs to be appropriate. She also stated there was a lot of time and effort dedicated to developing the measures and MISCs during KT relicensings. E. Bruce indicated if stakeholders believe there should be a change to the MISC, the RC is welcome to suggest revisions. J. Huff reiterated the model cannot be run until performance measures are assigned.

E. Miller noted the SCDNR would like to see performance measures 8-19 and (maximum spawning success for black bass and blueback herring) and 42-53 (maximize spawning success for sunfish and threadfin shad) revised. Measures 8-13 and 42-47 should extend through the end of May (currently extend from April 1 through May 15).

A. Stuart asked for clarification on the MISC – would SCDNR want to keep the MISC at 10%. E. Miller indicated 5% might be better for the MISC (5% of the years over the period of record). W. Wood asked for clarification on the MISC – J. Huff indicated 10% means 10% of years where it remains within the prescribed range. SCDNR proposed changing the MISC to 5% for measures 8-25 and 42-57.

J. Huff reviewed performance measure example of spawning elevation - using KT example on Slide 68. Difference between baseline/scenario calculation and the MISC (variance).

D. Rankin sought clarification that Bad Creek cannot change the KT license and J. Huff confirmed. D. Rankin noted the PMs may not be adequate to represent fish spawning due to the spawning period having a bell-shaped curve with peak success occurring in the middle of the season. He indicated the measure would more accurately capture success with a tighter time period, not longer, to capture this.

J. Huff indicated the thinking is that if there is at least one X-day period in spawning season, there would be some spawning success. Spawning seasons shift year-to-year and will continue to do so with climate change. Jeff Lineberger noted the same conversation occurred during KT relicensing.

J Lineberger reminded the group that the CHEOPS model does not address water quality or factors other than lake levels. E. Bruce and J. Lineberger further described parameters for CHEOPS and future with Bad Creek exchanging water differently than occurred 15 years ago.

J. Huff asked if it would be helpful to provide the performance measures from KT out from the spreadsheet. E. Hollis indicated it might be helpful.

A. Stuart noted if an RC member would like to suggest a performance measure but is not sure exactly how to provide that information, Duke Energy will help. J. Huff agreed.

D. Rankin asked for time to think about parameters for this project vs. SCDNR/Army Corps of Engineers previous parameters for KT relicensing; SCDNR also requests time to review performance measures. J. Huff offered to have a conversation offline if that would be helpful.

A. Stuart asked D. Rankin if his concerns are related to both Jocassee and Keowee. D. Rankin indicated there was only one year of recruitment issues at Keowee and that was during a maintenance drawdown so he does not believe recruitment issues would extend downstream to Lake Keowee. However, he feels it would be more conservative to include and would like Keowee considered.

J. Crutchfield and A. Stuart asked if the RC agreed with and could provide confirmation/comments on performance measures by August 15th. Erika Hollis asked if comments need to be formal; J. Huff indicated it could be in any format, including comment bubbles on the spreadsheet provided on SharePoint or simply an email.

A. Pellett (via chat): “When natural resources performance measures "maximize spawning success", are we saying the fluctuation bands and numbers of consecutive days are sufficient to maximize spawning? Or, should I understand these to be "tolerable" or "sufficient to maintain populations?" I'm not suggesting that we necessarily need to maximize this specific factor (lake elevation) for spawning, I just want to understand the metric as well as I can. I'm not a fish expert… I think Dan just clarified that a bit actually...”

A. Pellett indicated (via phone) his concern had been answered during the discussion.

J. Huff thanked the group for the discussion and closed the Water Resources Study discussion.

<<15-Minute Break>>

Aquatic Resources Study Update

Mike Abney provided an overview of study status including updates on the entrainment study (Task 2 – Consultation on Entrainment) as well as Task 3 (Mussel Surveys and Stream Habitat Quality Surveys). M. Abney mentioned that Nick Wahl and others from Duke Energy are currently in the field for Task 3 efforts. He then introduced the two options for the potential access road proposed by Duke Energy for access to the Fisher Knob community during construction, showed the potential spoil locations (to store spoil from excavations for new structures, and briefly introduce the methodology that will be undertaken in response to requests from the SCDNR (i.e., use of SC Stream Quantification Tool [SQT]).

E. Miller asked about SQT for small streams near spoil sites. M. Abney briefly stated there was a recent field visit with Duke Energy/HDR/SCDNR to inspect two of the representative spoil locations and discussions during the presentation will circle back to the SQT. Mussel surveys will be carried out at stream crossings but not spoil areas. Streams in spoil areas and crossed by the access road were evaluated for potential mussel habitat, however, only Howard Creek and Limber Pole Creek were determined to potentially support habitat with concurrence by the SCNDR during the July 12 site visit. Only those two creeks will be surveyed for mussels in addition to the shoreline of Lake Jocassee. M. Abney indicated surveying methods stated in the approved Study Plan will still be carried out, but the SC SQT will be implemented for the larger streams (e.g., Howard Creek, Limber Pole Creek) at potential stream crossings; he then showed field studies schedule.

D. Rankin asked if roads would be temporary and what would they be constructed with (i.e., gravel?) and asked for clarification on use. A. Stuart indicated they would be temporary, and the hope is to gravel as much as possible, however some slopes may require a hardpan treatment. The primary reason for the road would be to provide access to the Fisher Knob community to their homes during construction.

W. Wood asked for confirmation that the bridges would be removed following construction and the roads/area blocked off so people cannot continue to access areas (for off-roading). A. Stuart confirmed.

D. Rankin asked about the design of the road crossings as there are significant differences on aquatic resources in the design of road crossings. A. Stuart acknowledged there could be different effects based on the two road route options given Option 2 (Slide 74) parallels Howard Creek, potentially resulting in more impacts. Duke Energy is leaning towards Option 1 to minimize impacts to the extent feasible. A. Stuart stated the road is still being designed, but he would ask the team for additional details about the design.

D. Rankin asked if there have been field surveys conducted along the potential road routes. A. Stuart indicated the routes follow old logging roads to minimize impacts. Eric Mularski indicated a wildlife survey will be carried out for potentially listed species along the potential access road routes, so there will be a more complete dataset available of natural resources in these areas.

J. Crutchfield asked Alison Jakupka and Kevin Nebiolo (Kleinschmidt Associates) to provide an update on the entrainment study. Kleinschmidt has worked with Duke Energy to obtain water quality and operations data from 1991-1993. The entrainment report draft has now been revised to remove the swim speed analysis as suggested during earlier meetings and incorporate new data. K. Nebiolo reviewed progress that has been made on the entrainment task in light of new data. He noted that entrainment increases with a decrease in Jocassee elevation.

A. Stuart asked for clarification that entrainment discussions are focused on pumpback (not generation). K. Nebiolo agreed that is the case.

D. Rankin and W. William asked for clarification on which units are upstream/downstream first/on first off. A. Stuart clarified the Bad Creek units are numbered 1-4 moving from upstream to downstream.

A. Stuart asked A. Jakupka when the RC can expect the revised entrainment report. K. Nebiolo responded – he projects end of August for new report (to Duke Energy for review) with an RC review comment period following.

E. Miller asked about relocation of the existing wastewater settling ponds. A Stuart indicated the ponds will be replaced separate from relicensing. E. Miller asked if impacts would be assessed prior to clearing a new location. A. Stuart indicated he did not think the location for the new treatment system will require clearing for new basins.

J. Crutchfield concluded the meeting by thanking attendees for their participation and reviewing the action items.

Action Items

- HDR/Duke Energy will post meeting notes, recording, and presentation to SharePoint site and distribute the link to Water Resources and Aquatic Resources RCs.
- HDR/Duke Energy to provide a SharePoint link to the CHEOPS model performance measures; requested deadline for RC comments is August 15. [If needed, HDR/Duke Energy will schedule a follow-up meeting with RC regarding potential revisions to performance measures].
- Potential revisions to CHEOPS performance measures include measures 8-19 and 42-53 and would include changing MISC from 10% to 5% and extending the date from May 15 to May 31. Suggested revisions (by the SCDNR) are on hold subject to further review; SCDNR (and others) to have a closer look and provide comments and feedback by August 15.
- HDR/Duke Energy to post KT performance measures to the SharePoint site and distribute link to RCs.
- HDR/Duke Energy is currently preparing a technical memo regarding stream surveys and will post to the SharePoint site.
- Duke Energy to discuss and provide clarification on road and bridge design for access road.

From: maggie.salazar@hdrinc.com
Subject: FW: Bad Creek Relicensing - Stream Survey Assessment Approach Technical Memo
Attachments: Bad Creek Hydroelectric Project - Approach to Stream Assessments Post-Consultation.pdf

Importance: High

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Thursday, August 3, 2023 8:43 AM
To: Abney, Michael A <Michael.Abney@duke-energy.com>; Amy Breedlove <BreedloveA@dnr.sc.gov>; RankinD <RankinD@dnr.sc.gov>; Elizabeth Miller <MillerE@dnr.sc.gov>; Erika Hollis <ehollis@upstateforever.org>; Settevendemio, Erin <Erin.Settevendemio@hdrinc.com>; Gerry Yantis <gcyantis2@yahoo.com>; jhains@g.clemson.edu; quattrol <quattrol@dnr.sc.gov>; Olds, Melanie J <melanie_olds@fws.gov>; amedeemd@dhec.sc.gov; kernm <kernm@dnr.sc.gov>; SelfR <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: Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Huff, Jen <Jen.Huff@hdrinc.com>; McCarney-Castle, Kerry <Kerry.McCarney-Castle@hdrinc.com>; Salazar, Maggie <maggie.salazar@hdrinc.com>; Mularski, Eric <Eric.Mularski@HDRInc.com>; Fletcher, Scott T <Scott.Fletcher@duke-energy.com>
Subject: Bad Creek Relicensing - Stream Survey Assessment Approach Technical Memo
Importance: High

Dear Bad Creek Relicensing Aquatic Resources Committee:

Please find attached the Stream Survey Assessment Technical Memo which specifies the sampling approach for streams and spoil areas discussed during the July 27, 2023, Resource Committee meeting.

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
526 S. Church Street, EC12Q | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

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.

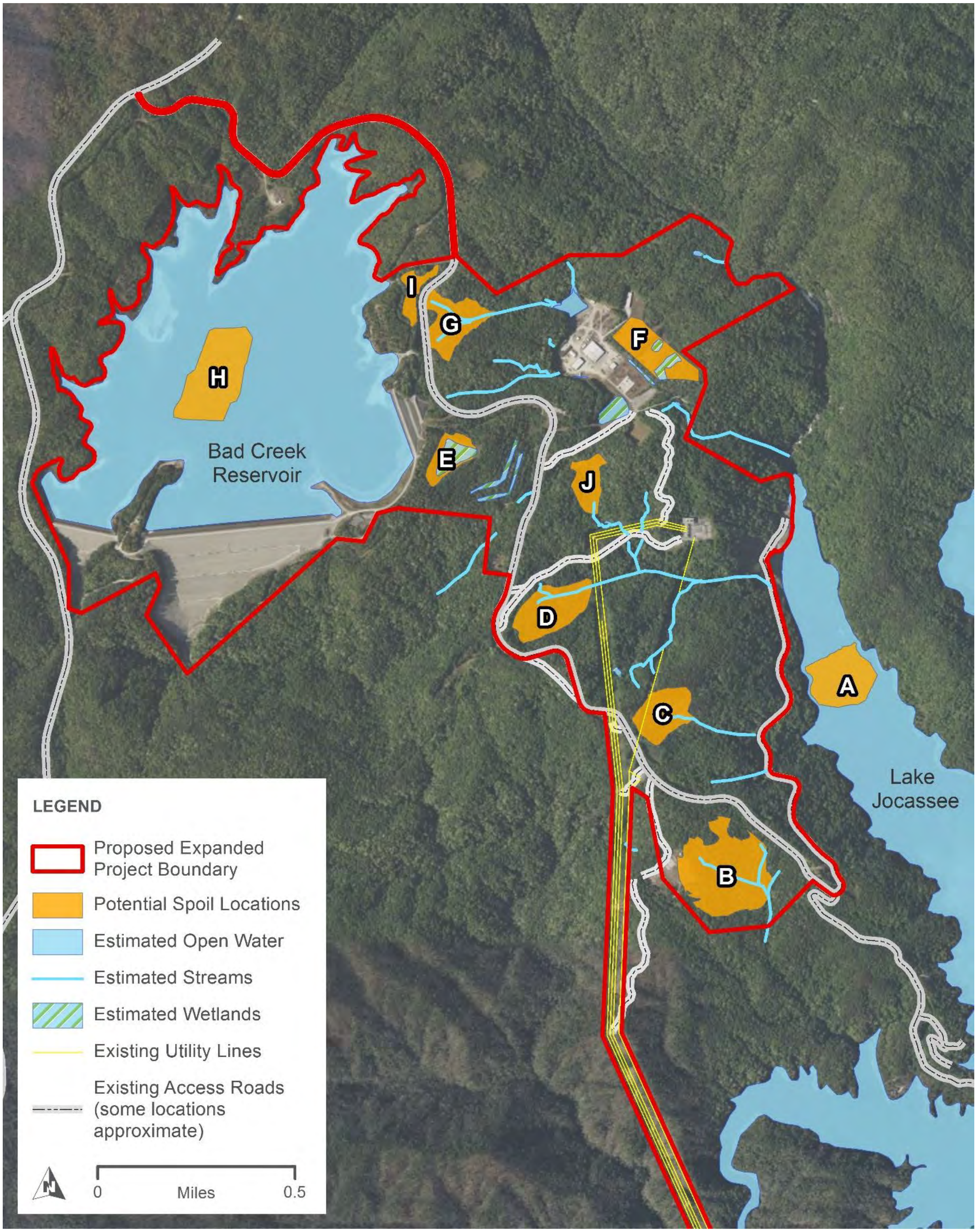
South Carolina Department of Natural Resources. 2022. Fish Sampling Guidance: Fish Collection Protocols for Streams. Accessed July 2023. [URL]: https://www.dnr.sc.gov/environmental/SCDNRSamplingProcedureFishes.pdf.

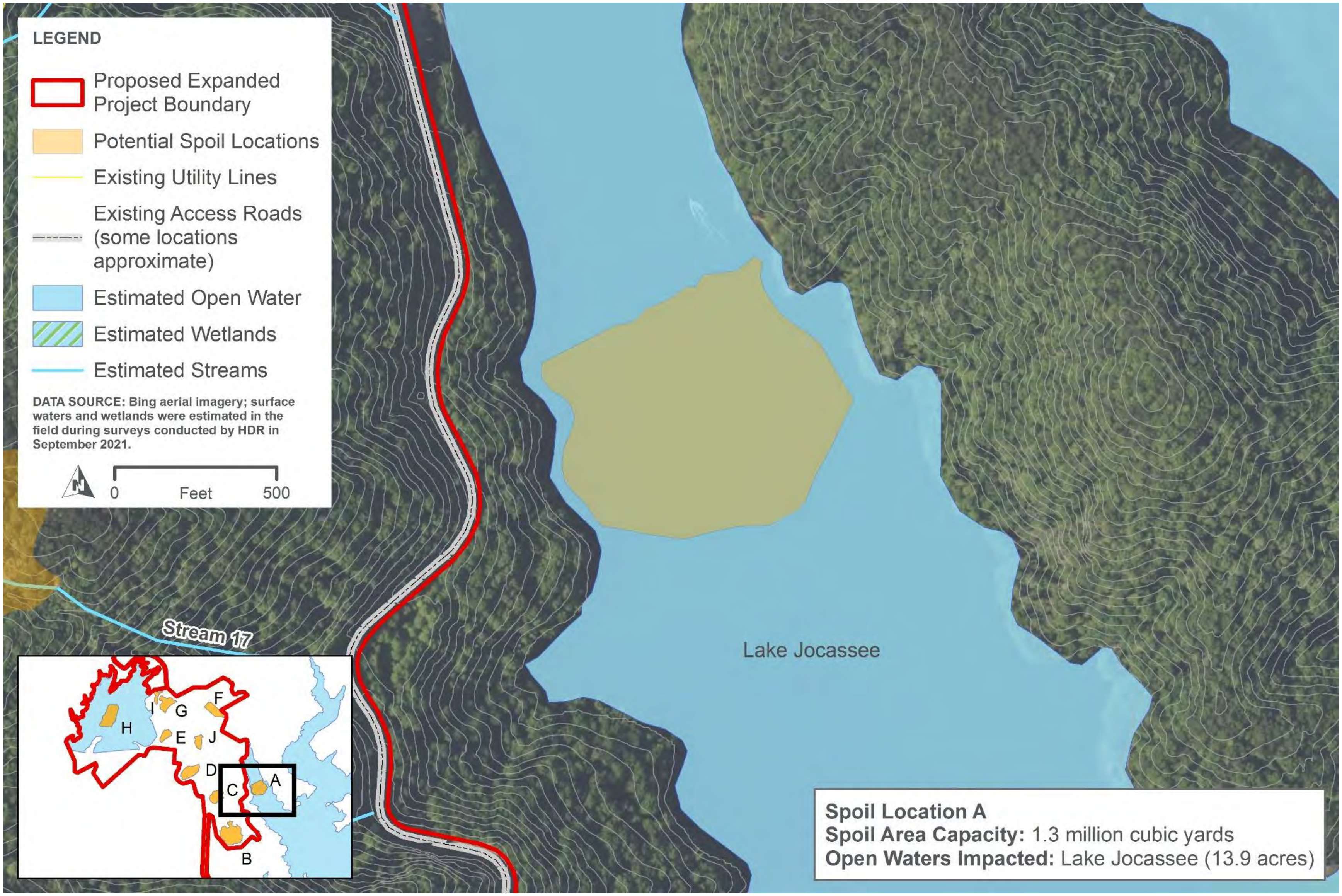
South Carolina Steering Committee. 2022. South Carolina Stream Quantification Tool: Data Collection and Analysis Manual, SC SQT v1.1. South Carolina Department of Natural Resources, Columbia, SC.

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

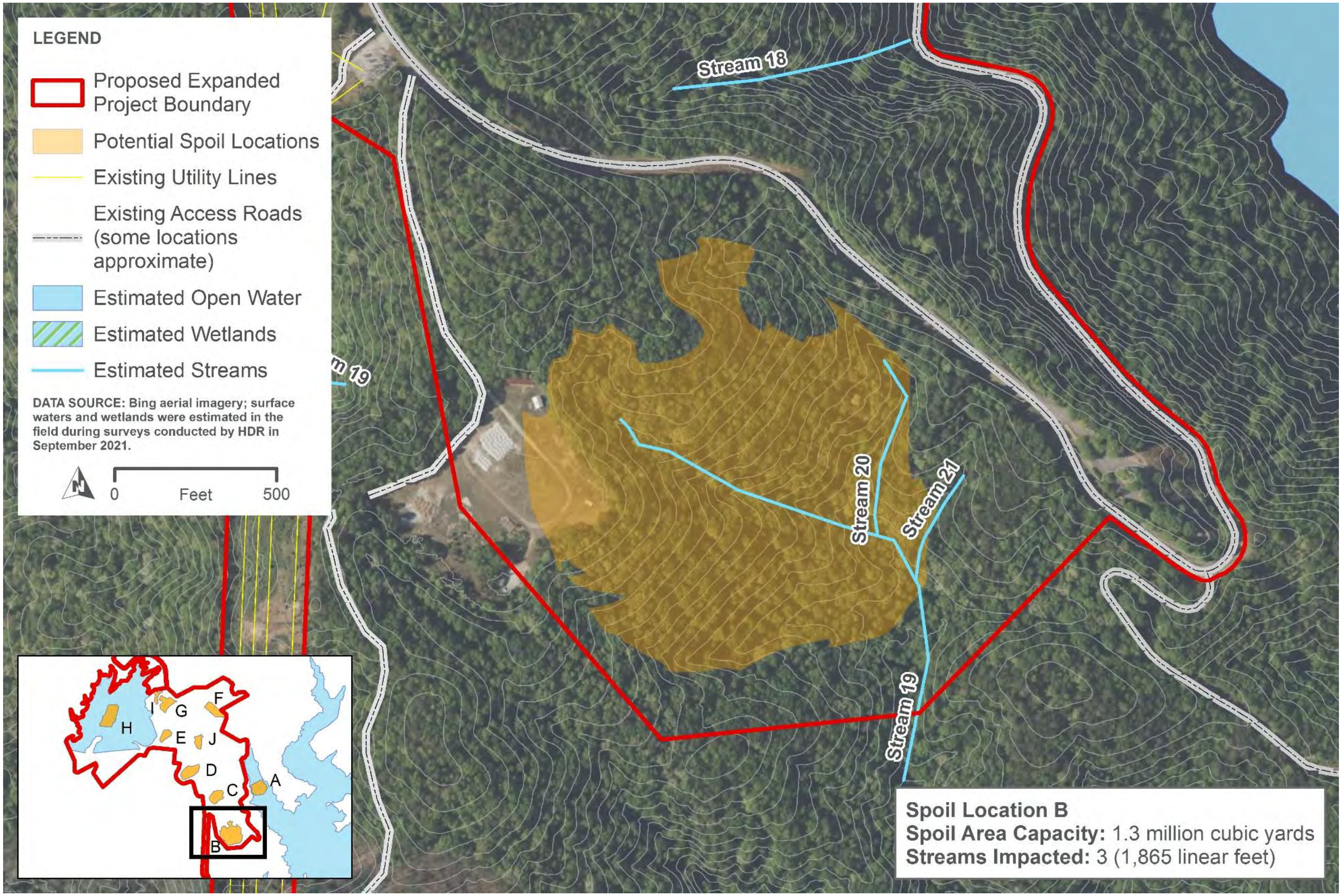
Attachment 1 – Streams and Wetlands within Potential Spoil Locations

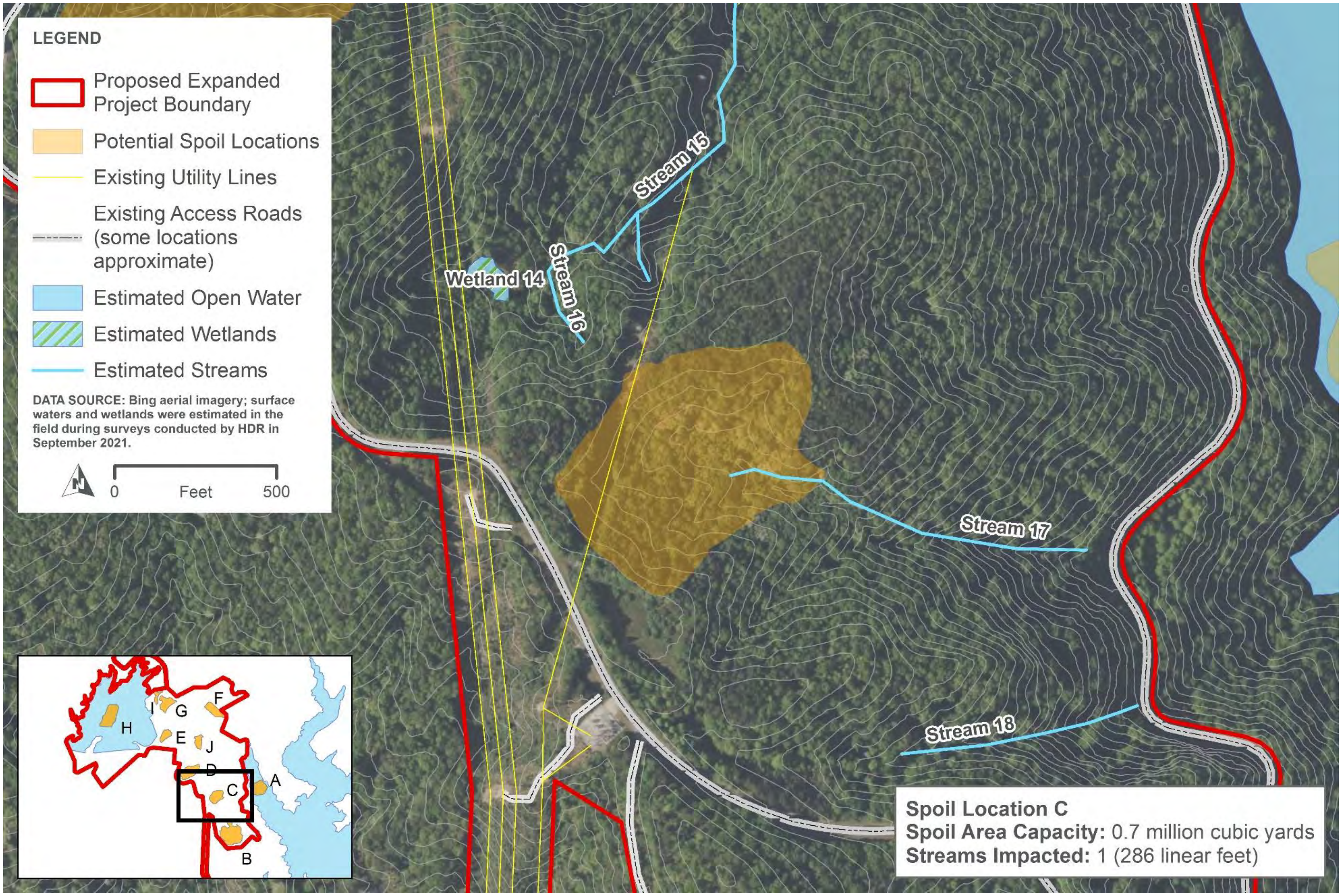

I
G
F
H
Bad Creek Reservoir
E
J
D
C
A
Lake Jocassee
B
LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Estimated Open Water
Estimated Streams
Estimated Wetlands
Existing Utility Lines
Existing Access Roads (some locations approximate)
N
0
Miles
0.5



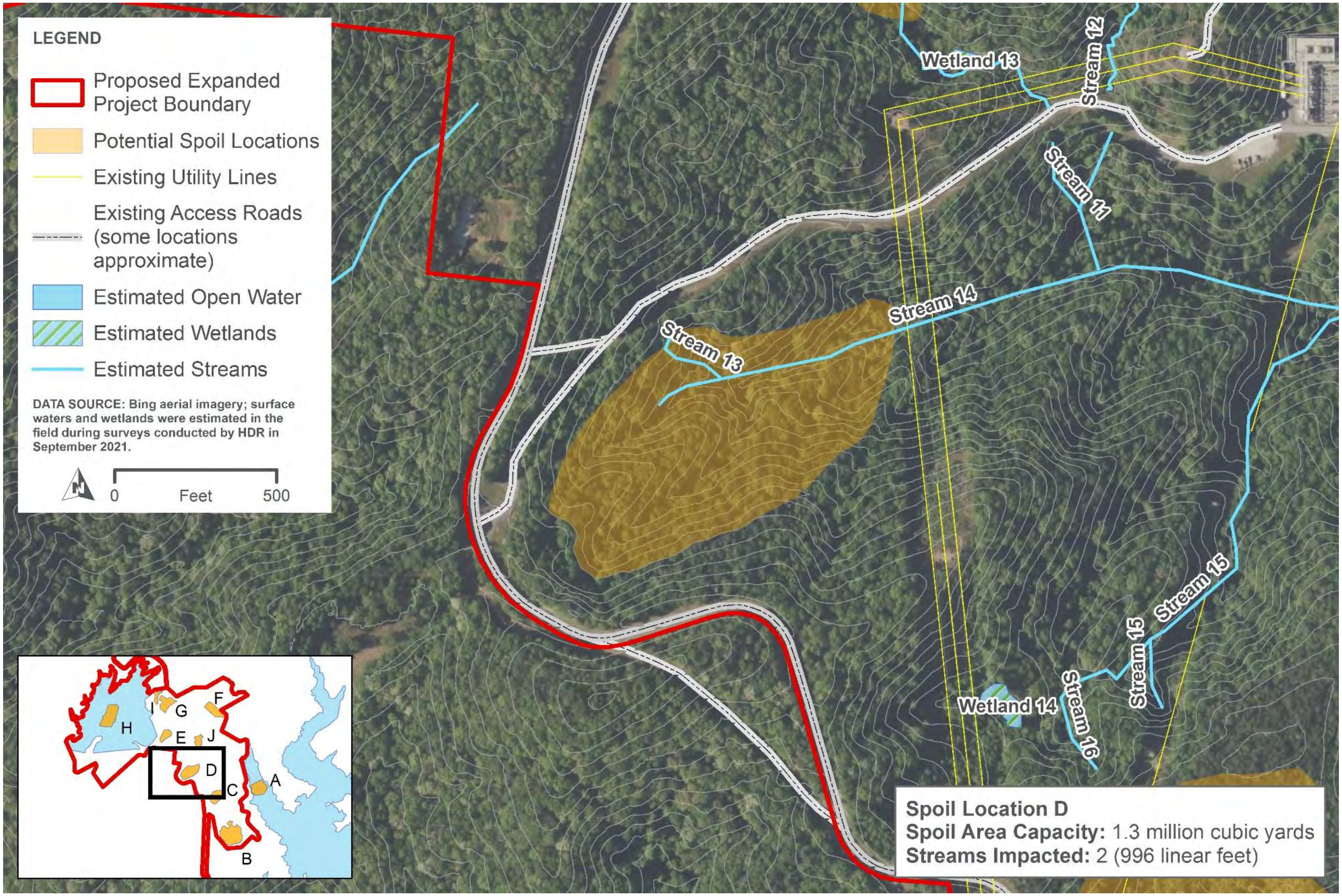
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

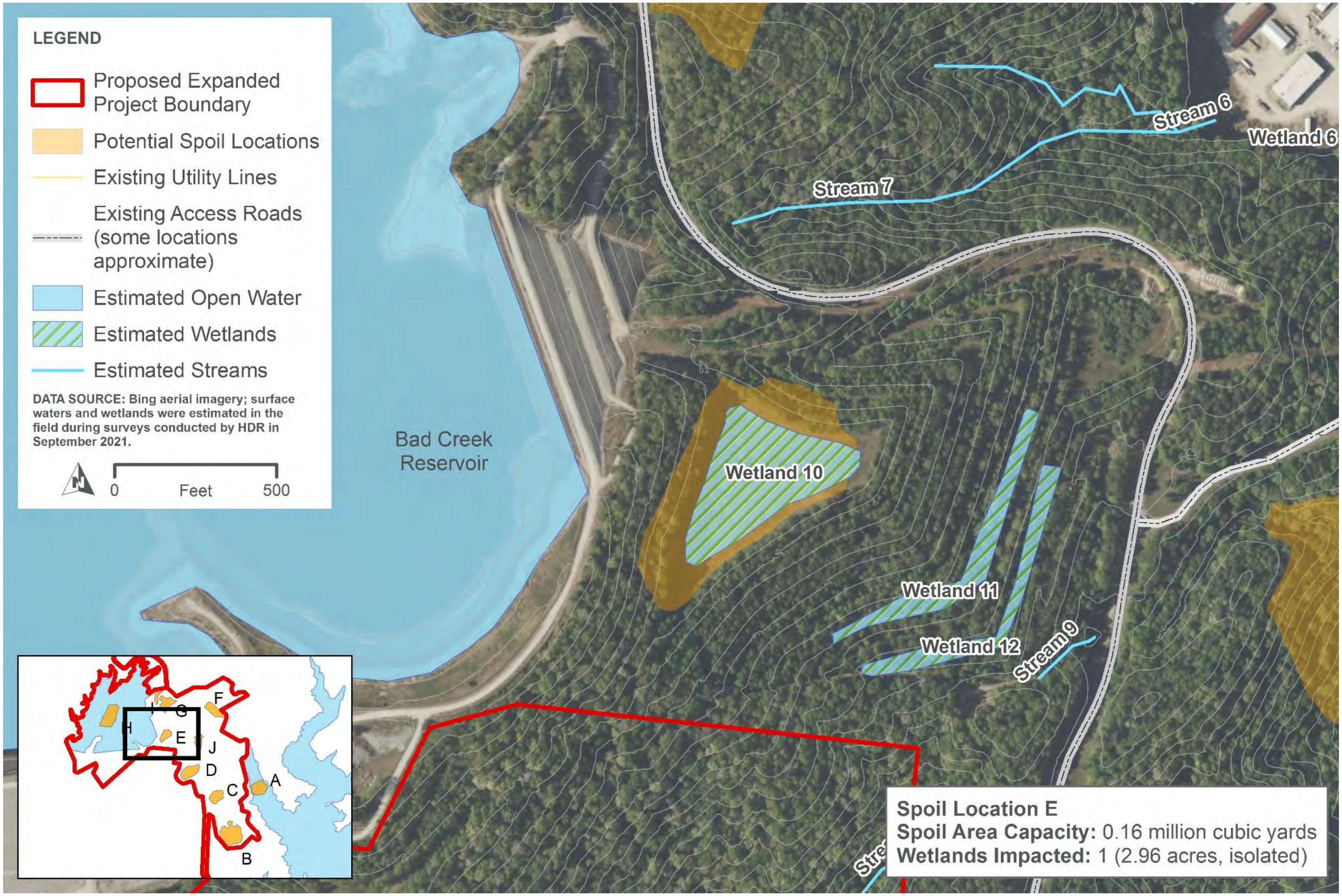
Spoil Location A
Spoil Area Capacity: 1.3 million cubic yards
Open Waters Impacted: Lake Jocassee (13.9 acres)


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
Stream 18
Stream 19
Stream 20
Stream 21
Stream 19
H
I
G
F
E
J
D
C
A
B
Spoil Location B
Spoil Area Capacity: 1.3 million cubic yards
Streams Impacted: 3 (1,865 linear feet)

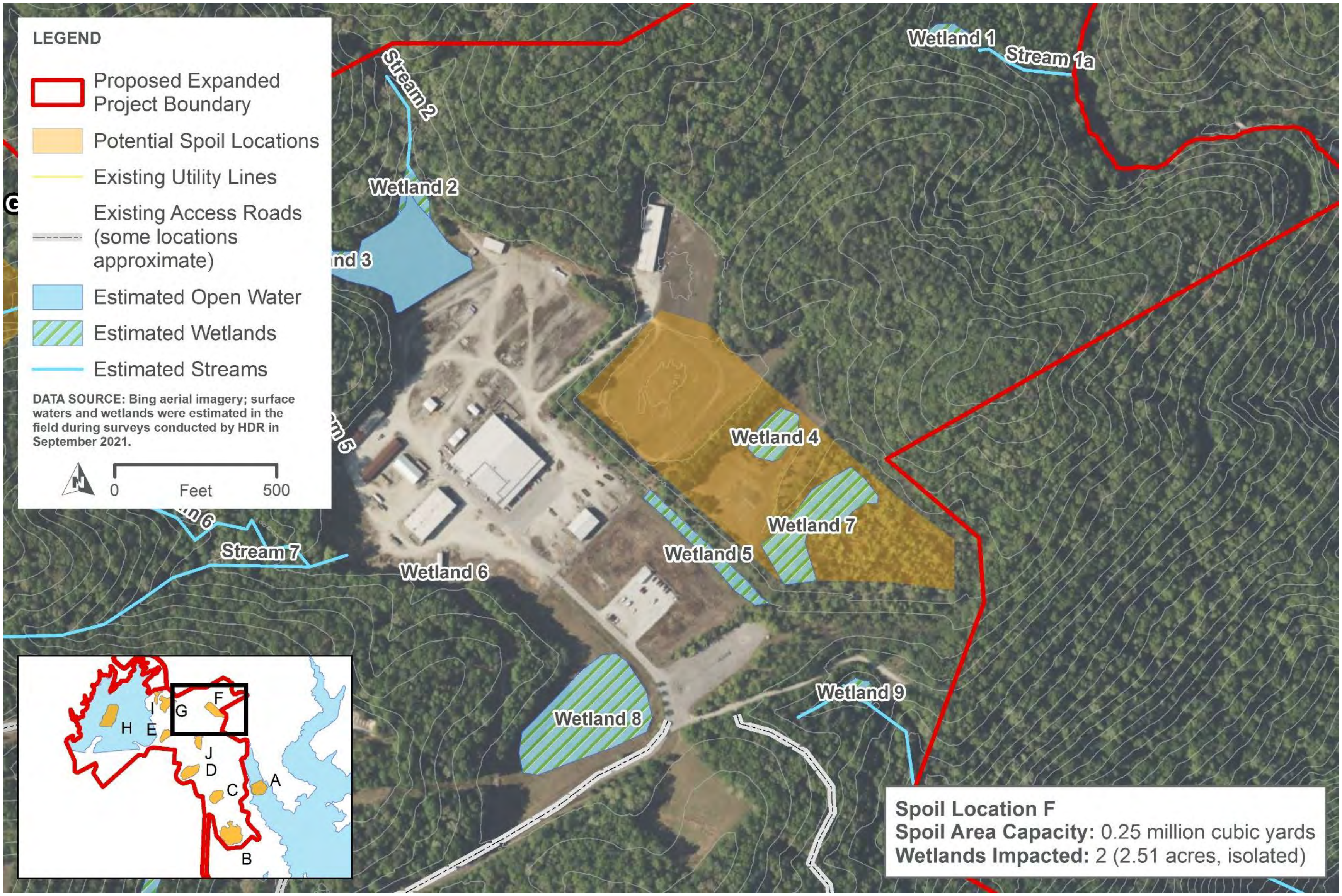


Spoil Location C
Spoil Area Capacity: 0.7 million cubic yards
Streams Impacted: 1 (286 linear feet)


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.
N
0
Feet
500
Wetland 13
Stream 12
Stream 11
Stream 14
Stream 13
Stream 15
Wetland 14
Stream 16
Stream 15
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)

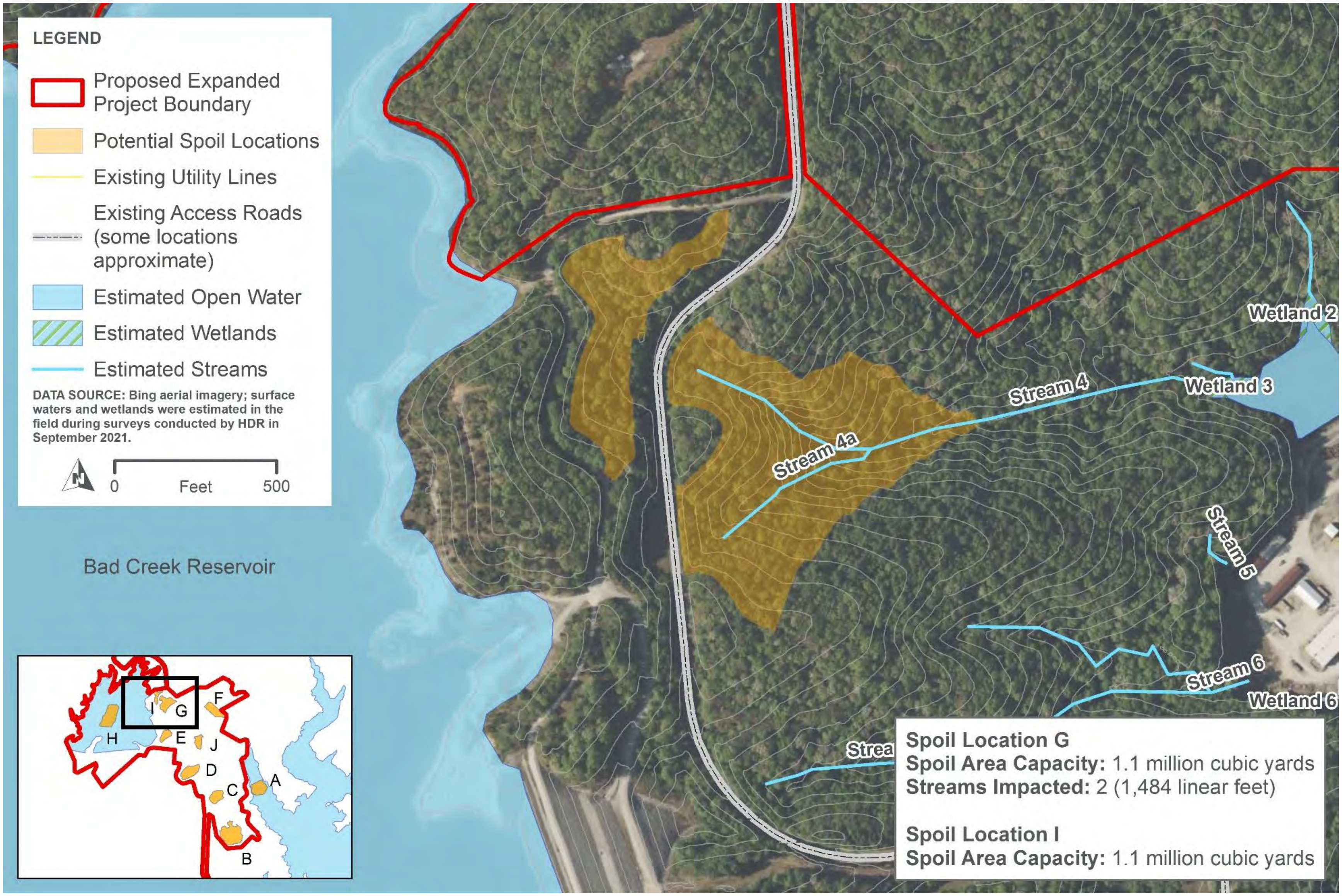


Spoil Location E
Spoil Area Capacity: 0.16 million cubic yards
Wetlands Impacted: 1 (2.96 acres, isolated)



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

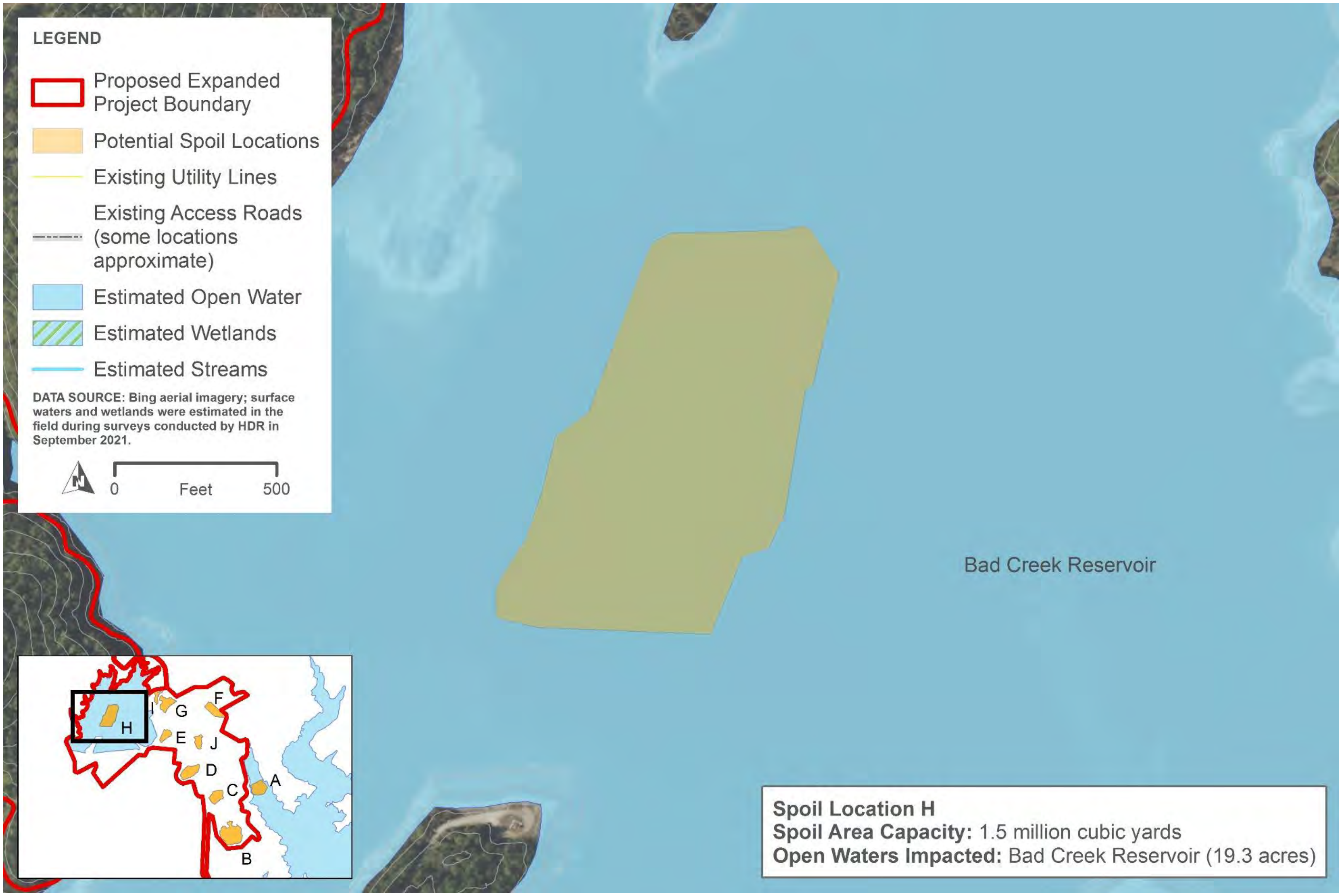
Spoil Location F
Spoil Area Capacity: 0.25 million cubic yards
Wetlands Impacted: 2 (2.51 acres, isolated)

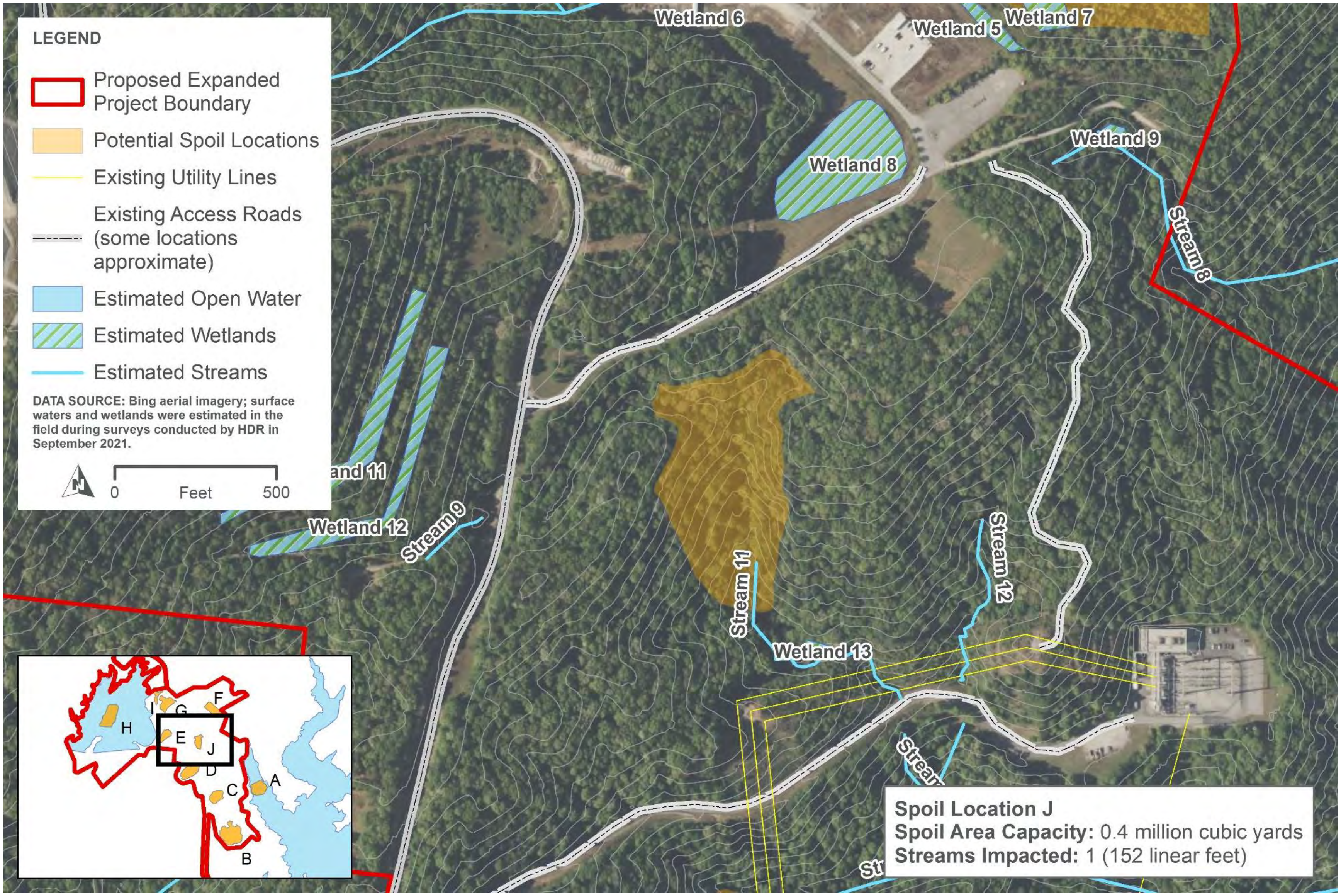


DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

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.
N
0
Feet
500
Bad Creek Reservoir
A
B
C
D
E
F
G
H
I
J
Spoil Location H
Spoil Area Capacity: 1.5 million cubic yards
Open Waters Impacted: Bad Creek Reservoir (19.3 acres)

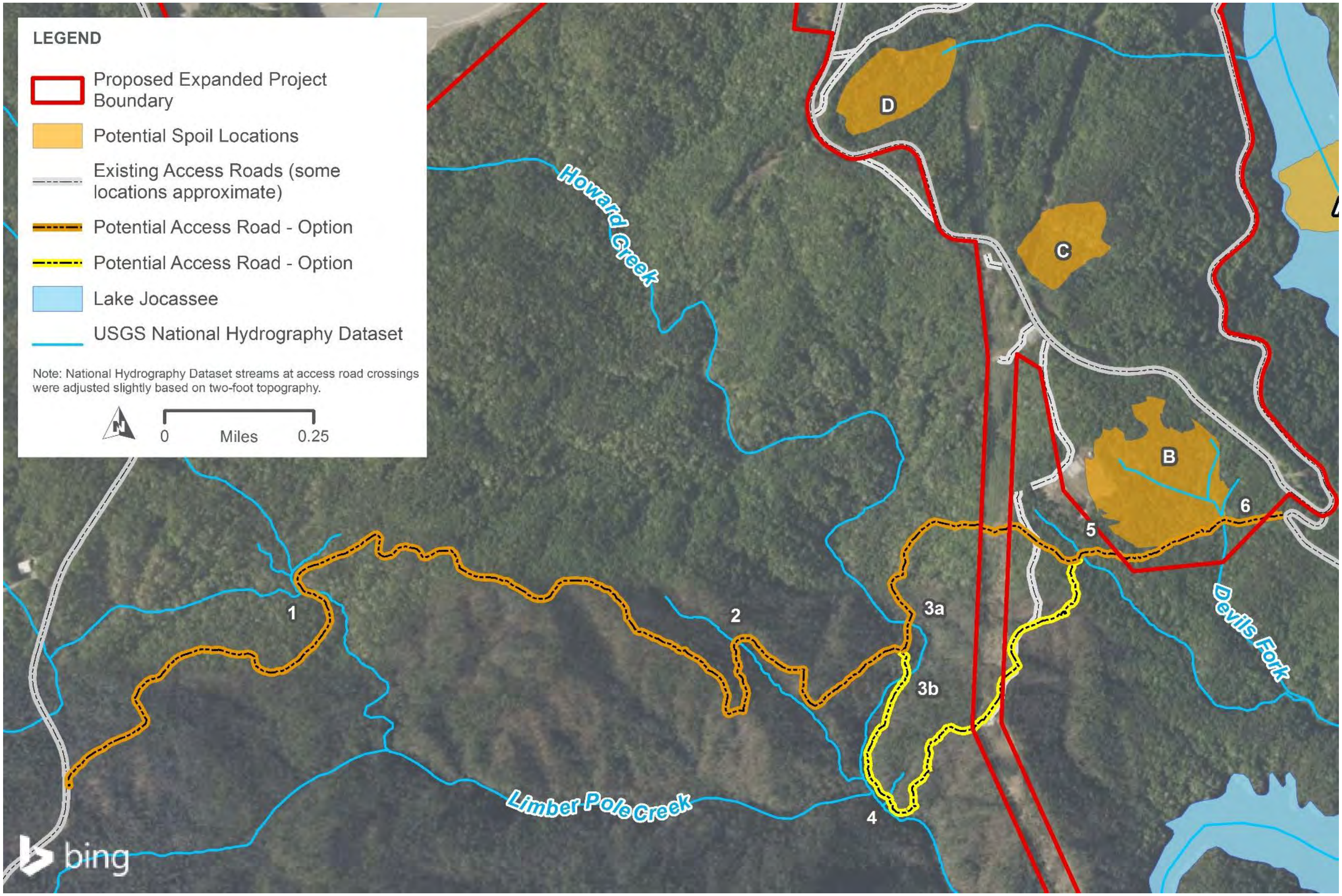


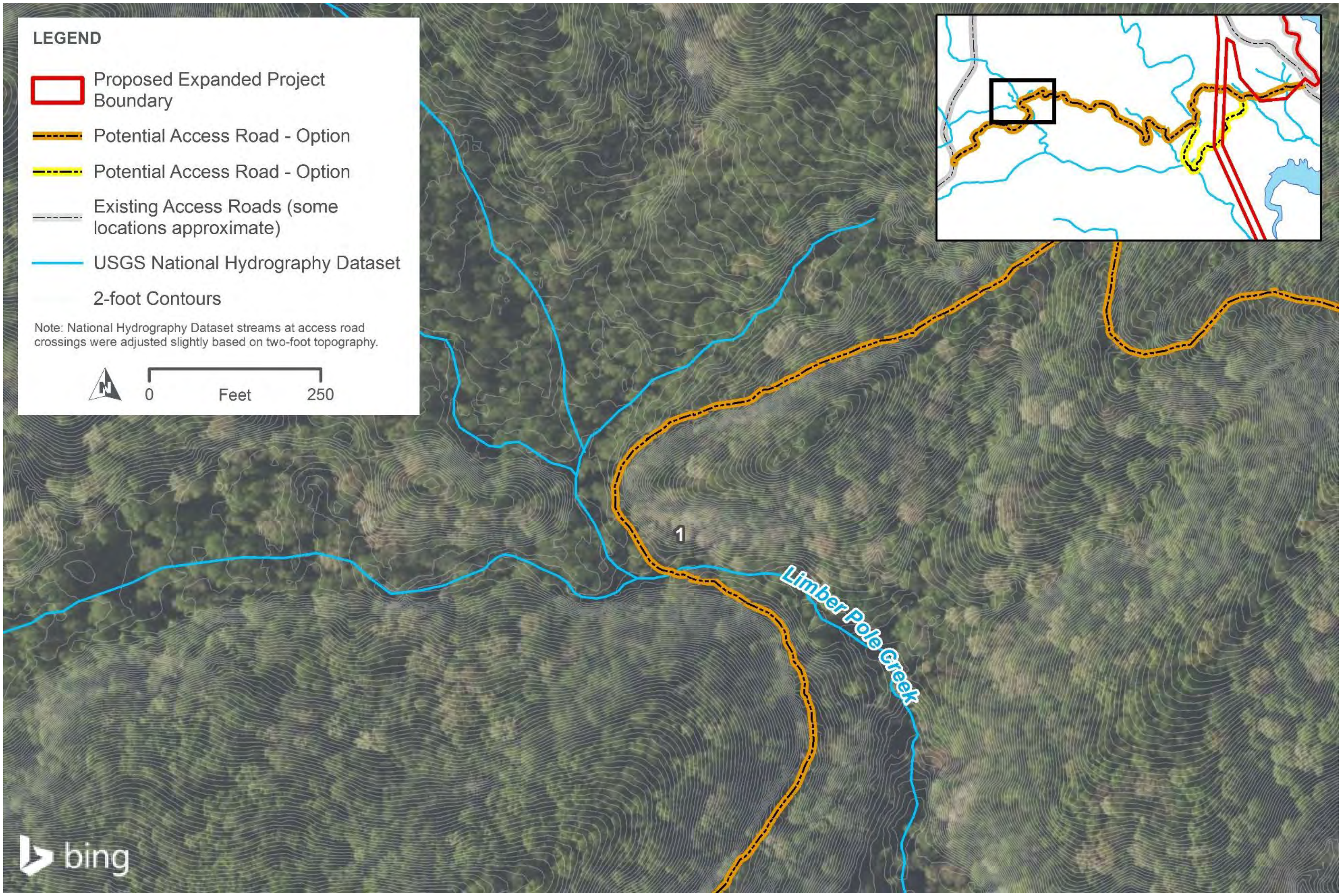
DATA SOURCE: Bing aerial imagery; surface waters and wetlands were estimated in the field during surveys conducted by HDR in September 2021.

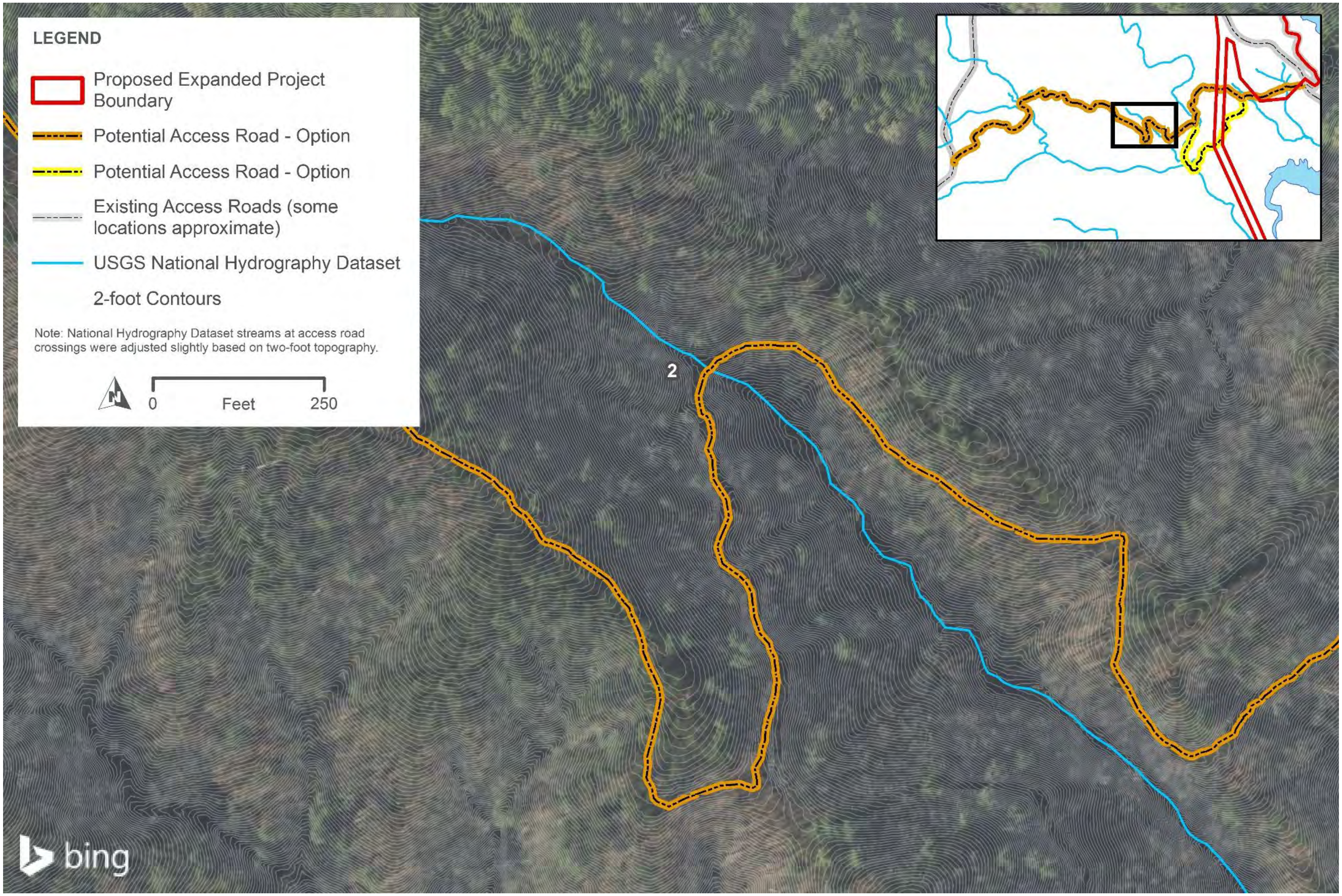
Spoil Location J
Spoil Area Capacity: 0.4 million cubic yards
Streams Impacted: 1 (152 linear feet)

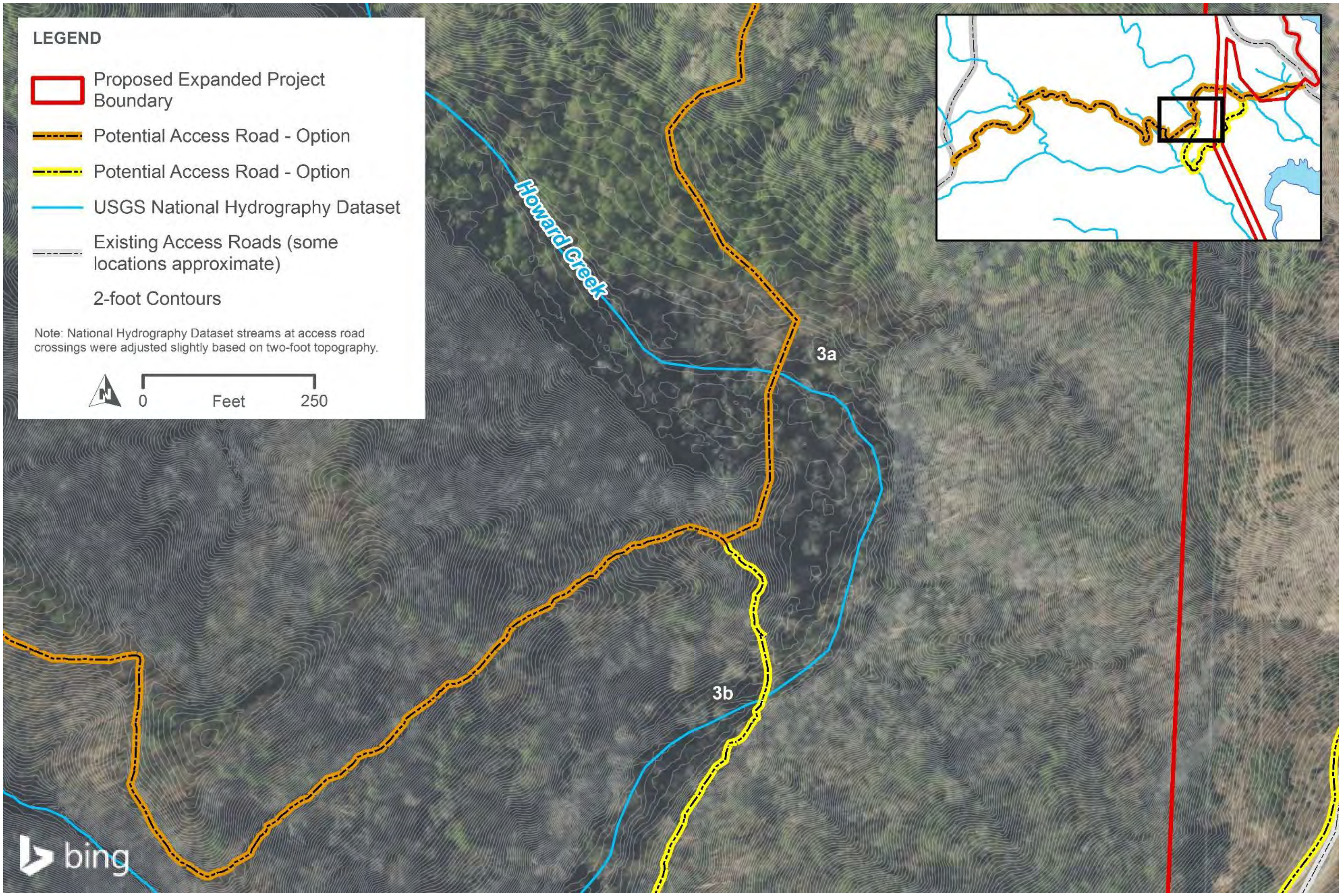
Attachment 2

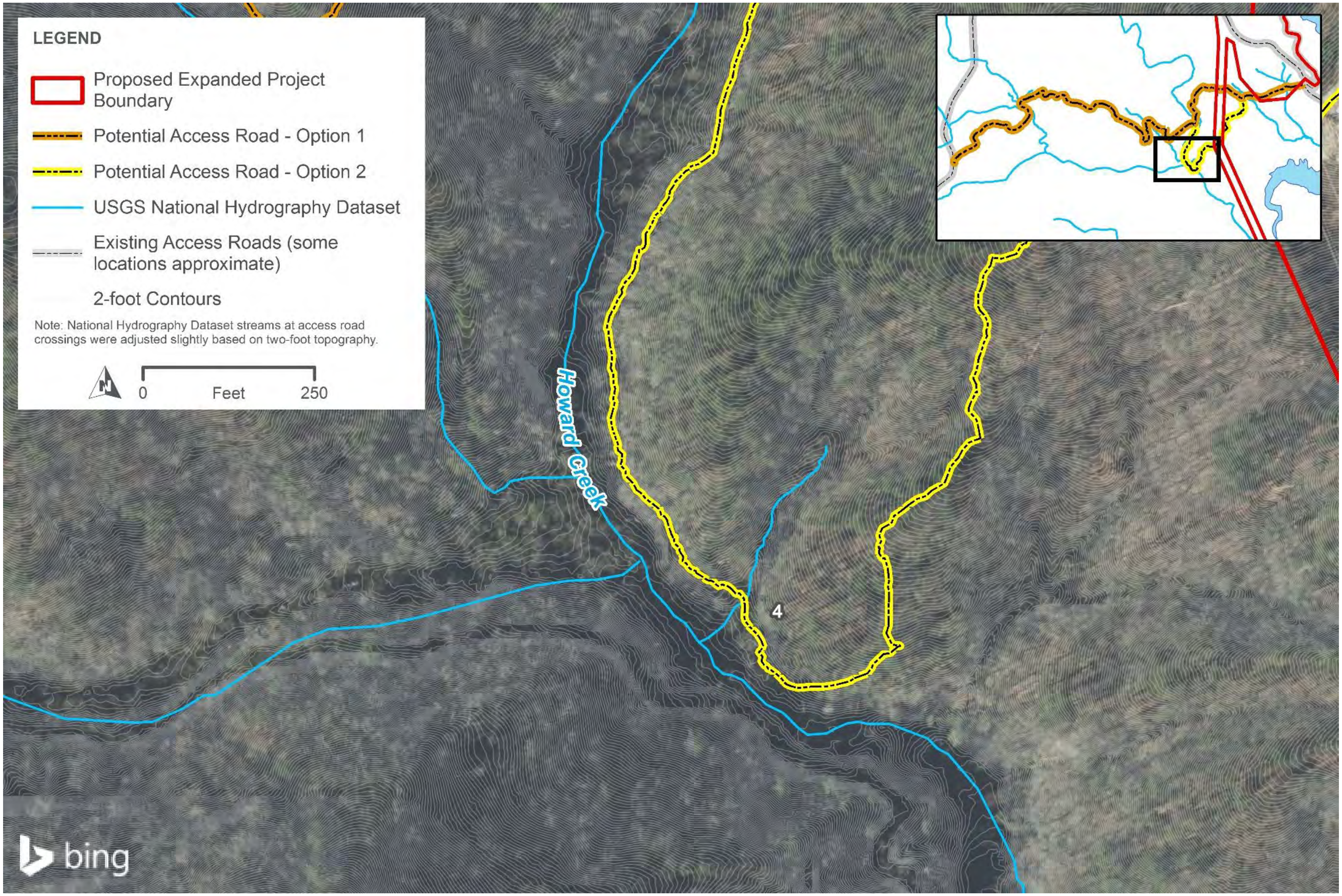
Attachment 2 – Potential Access Road Stream Crossings

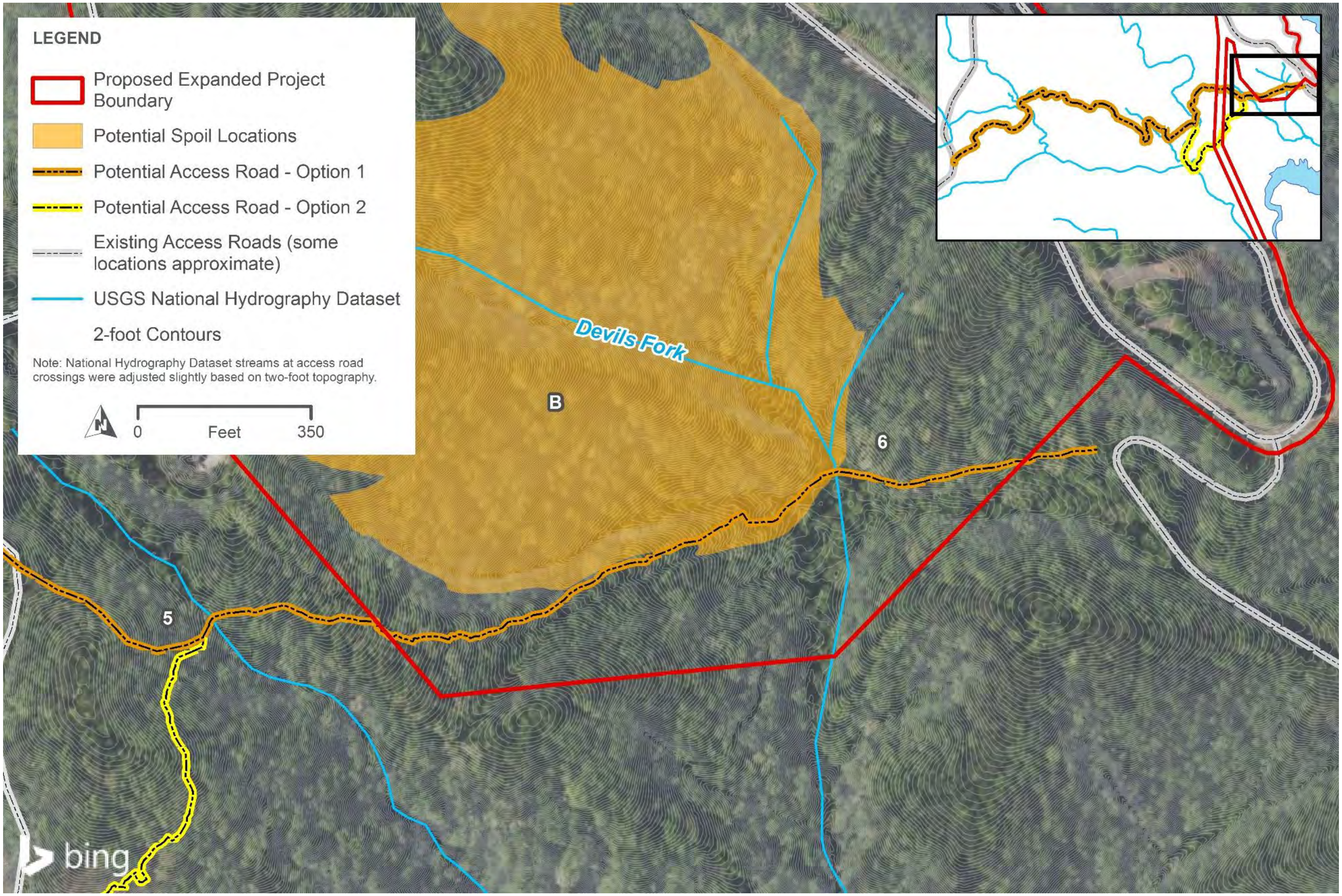

LEGEND
Proposed Expanded Project Boundary
Potential Spoil Locations
Existing Access Roads (some locations approximate)
Potential Access Road - Option
Potential Access Road - Option
Lake Jocassee
USGS National Hydrography Dataset
Note: National Hydrography Dataset streams at access road crossings were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

Subject: FW: Bad Creek Relicensing - Draft Herpetological Survey Study Plan of Spoil Sites (Request for Review)
Attachments: DukeEnergy_BadCreekRelicensing_SpoilArea_HerpStudyplan_08152023_DRAFT.docx

Importance: High

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Thursday, August 17, 2023 8:12 AM
To: Elizabeth Miller <MillerE@dnr.sc.gov>
Cc: Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Fletcher, Scott T <Scott.Fletcher@duke-energy.com>; Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; McCarney-Castle, Kerry <Kerry.McCarney-Castle@hdrinc.com>; Mularski, Eric <Eric.Mularski@HDRInc.com>; Huff, Jen <Jen.Huff@hdrinc.com>; Salazar, Maggie <maggie.salazar@hdrinc.com>; Abney, Michael A <Michael.Abney@duke-energy.com>
Subject: Bad Creek Relicensing - Draft Herpetological Survey Study Plan of Spoil Sites (Request for Review)
Importance: High

Elizabeth: As discussed during the July 31, 2023, Wildlife & Botanical Resources Committee meeting, Duke Energy plans to conduct a herpetological survey of the identified spoil disposal sites at Bad Creek to support the Project 404 permitting process.

I have attached the draft study plan and request SCDNR review and provide any comments on the plan.

Duke Energy will conduct the survey beginning September 11 so we would appreciate an expedited review with comments provided by no later than August 31. We appreciate SCDNR's attention to this request.

I will let you distribute the draft survey study plan to the appropriate SCDNR personnel for review. You can provide collective comments via email and on the attached document.

Please respond back that you received the draft study plan so I will know you are in receipt.

Again, thank you for your attention to the request.

Regards,

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

Subject: FW: Bad Creek Relicensing - Draft Herpetological Survey Study Plan of Spoil Sites (Request for Review)

From: Elizabeth Miller <MillerE@dnr.sc.gov>
Sent: Friday, September 1, 2023 11:21 AM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Cc: Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Fletcher, Scott T <Scott.Fletcher@duke-energy.com>; Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; McCarney-Castle, Kerry <Kerry.McCarney-Castle@hdrinc.com>; Mularski, Eric <Eric.Mularski@HDRInc.com>; Huff, Jen <Jen.Huff@hdrinc.com>; Salazar, Maggie <maggie.salazar@hdrinc.com>; Abney, Michael A <Michael.Abney@duke-energy.com>
Subject: RE: Bad Creek Relicensing - Draft Herpetological Survey Study Plan of Spoil Sites (Request for Review)

Hi John,

Sorry for the delayed response. I've been out the past couple of days due to Hurricane Idalia. The SCDNR has reviewed draft Herpetological Habitat Survey Study Plan and has no comments to offer. Thank you for the opportunity to review.

Elizabeth

Elizabeth C. Miller
SCDNR
Office: 843-953-3881
Cell: 843-729-4636

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Thursday, August 17, 2023 8:12 AM
To: Elizabeth Miller <MillerE@dnr.sc.gov>
Cc: Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Fletcher, Scott T <Scott.Fletcher@duke-energy.com>; Sarah Kulpa <Sarah.Kulpa@hdrinc.com>; Kerry McCarney-Castle <Kerry.McCarney-Castle@hdrinc.com>; Mularski, Eric -HDRInc <Eric.Mularski@HDRInc.com>; Huff, Jen <Jen.Huff@hdrinc.com>; Maggie Salazar <maggie.salazar@hdrinc.com>; Abney, Michael A <Michael.Abney@duke-energy.com>
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Duke Energy
526 S. Church Street, EC12Q | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

Subject: FW: Bad Creek SQT - riparian vegetation plots

From: Settevendemio, Erin <Erin.Settevendemio@hdrinc.com>
Sent: Monday, September 18, 2023 12:10 PM
To: Lorianne Riggin <RigginL@dnr.sc.gov>
Cc: Elizabeth Miller <millere@dnr.sc.gov>; Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Abney, Michael A <Michael.Abney@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Mularski, Eric <eric.mularski@hdrinc.com>; Kulpa, Sarah <sarah.kulpa@hdrinc.com>; Salazar, Maggie <Maggie.Salazar@hdrinc.com>; McCarney-Castle, Kerry <Kerry.McCarney-Castle@hdrinc.com>; Huff, Jen <Jen.Huff@hdrinc.com>
Subject: Bad Creek SQT - riparian vegetation plots

Good Afternoon Lorianne,

During preparations for fieldwork associated with the Stream Quantification Tool, we calculated the number plots needed for each stream reach according to the 2% area coverage requirement. Based on an average reach length of 600 feet and plot size of 100 m^2, we would need 1 plot per stream reach. However, in the Data Collection and Analysis Manual, it is stated that there is a 4-plot minimum. In the example provided in the manual, the stream reaches are four times the size than those at Bad Creek. Assuming a 50-foot riparian buffer, a 4-plot minimum would result in 7.2% of the riparian buffer surveyed.

In a review of the CVS-EEP Protocol for Level 2, it states that the number of vegetation plots would be calculated separately for stream enhancement, stream restoration, and wetland mitigation. Obviously, none of these categories apply to the streams at Bad Creek since we are primarily using this tool to monitor for any effects of the temporary access road. The Protocol also states that you can use the data entry tool to “aid in calculating the necessary number of plots”, however I was unable to get the tool to work on my computer (I am assuming some of the macros were blocked due to our security settings). How was the 4-plot minimum decided for the SQT?

We know of three named streams and potentially up to three additional streams that will require survey along the access road. For upstream and downstream reaches, this amounts to up to 48 vegetation plots to be surveyed (consisting of 7.2% of riparian buffer per stream reach, as stated above). This seems very comprehensive for the limited area under evaluation. Is there any flexibility in the number of plots to be surveyed? We would like to propose **two vegetation plots per stream reach**. Based on initial observations in the field, the riparian buffer vegetation community is consistent across the stream reaches and, given that this information is not intended to be used to support restoration efforts, we feel this would sufficiently characterize the natural and undisturbed riparian vegetation community that exists at the site.

We welcome your thoughts and are happy to jump on the phone to discuss.

Thanks,

Erin Settevendemio

Erin Bradshaw Settevendemio, M.S., FP-C
Aquatic Sciences Team Lead

HDR

From: Lorianne Riggin
To: Settevendemio, Erin
Cc: Elizabeth Miller; Crutchfield Jr., John U; Stuart, Alan Witten; Abney, Michael A; Wahl, Nick; Mularski, Eric; Kulpa, Sarah; Salazar, Maggie; McCarney-Castle, Kerry; Huff, Jen
Subject: RE: Bad Creek SQT - riparian vegetation plots
Date: Saturday, September 23, 2023 7:05:32 PM
Attachments: image001.png

Evening Erin,

For the purpose of evaluating change at Bad Creek, I think it would be okay to limit to two plots versus the required four considered for 404 compensatory mitigation purposes; however, I defer to Elizabeth as the lead for the agency coordinating this information.

From a will the SQT still work perspective, the SQT Data Collection Manual does note "Fewer plots may be evaluated if the representative sub-reach is short or if the riparian vegetation is very uniform in structure and composition throughout the sub-reach." I feel the scenario you have here applies to that.

Hope this helps,
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

From: Settevendemio, Erin <Erin.Settevendemio@hdrinc.com>
Sent: Monday, September 18, 2023 12:10 PM
To: Lorianne Riggin <RigginL@dnr.sc.gov>
Cc: Elizabeth Miller <MillerE@dnr.sc.gov>; Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Abney, Michael A <Michael.Abney@duke-energy.com>; Wahl, Nick <Nick.Wahl@duke-energy.com>; Mularski, Eric <eric.mularski@hdrinc.com>; Kulpa, Sarah <sarah.kulpa@hdrinc.com>; Salazar, Maggie <Maggie.Salazar@hdrinc.com>; McCarney-Castle, Kerry <Kerry.McCarney-Castle@hdrinc.com>; Huff, Jen <Jen.Huff@hdrinc.com>

Subject: Bad Creek SQT - riparian vegetation plots

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We welcome your thoughts and are happy to jump on the phone to discuss.

Thanks,

Erin Settevendemio

Erin Bradshaw Settevendemio, M.S., FP-C
Aquatic Sciences Team Lead

HDR
440 S. Church Street, Suite 900
Charlotte, NC 28202-2075
D 704.973.6869 **M** **518.534.2798**
Erin.BradshawSettevendemio@hdrinc.com

hdrinc.com/follow-us

From: Crutchfield Jr., John U
To: Abney, Michael A; Amy Breedlove; RankinD; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; kernm; SelfR; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Alex Pellett; Dale Wilde; bereskind; Jeff Phillips; McCarney-Castle, Kerry; More, Priyanka; Raber, Maverick James; Scott Harder; William T. Wood; Ziegler, Ty; Dvorak, Joe; Alison Jakupca; Kevin Nebiolo; Bruce, Ed; Dunn, Lynne; Huff, Jen
Cc: Kulpa, Sarah; Salazar, Maggie; Lineberger, Jeff
Subject: Bad Creek Relicensing - ILP Study Plans and Reports Schedule Update
Date: Tuesday, October 31, 2023 12:02:43 PM
Importance: High

Dear Bad Creek Relicensing Water and Aquatic Resources Committees:

I hope this email finds you well and that you have been able to get out and enjoy the fantastic weather we are having this fall. It is hard to believe it is nearly November, and as we all know, the days start slipping by quickly as the year wraps up.

Duke Energy and our consultants have been working diligently to complete the first year ILP studies and advance the study reports. I wanted to take this opportunity to provide you with a preview of Resource Committee reviews that will be requested over the next month and the upcoming FERC ILP process milestones.

1. **Initial Study Report (ISR)** – We expect to file the ISR on or just before the FERC ILP deadline of January 4, 2024.

2. **ISR Meeting** – The ISR meeting is to be held within 15 days of the ISR filing. Duke Energy is coordinating availability with FERC staff, and we are presently planning to conduct the ISR Meeting at the Duke Energy Wenwood Operations Center (Greenville, SC) on Wednesday, January 17th. Please note this meeting date is subject to change depending up FERC staff availability and if it shifts to another date in January, we will let you know so you can plan accordingly. Your attendance at this meeting is greatly appreciated and encouraged, but a Teams meeting will be made available for participants who are unable to travel.

3. **Water Resources Study Reports**
   a. **Task 2** study report "Whitewater River Cove Water Quality Field Study":
      i. Will not be completed until the end of the 2024 (2nd) ILP study season.
      ii. A summary of Year 1 results will be provided in the ISR.
   b. **Task 3** study report "Velocity Effects and Vertical Mixing in

Lake Jocassee Due to a Second Powerhouse”:

   i. The Resource Committee comment period on this report is closed. Thank you to RC members who provided comments.

   ii. We are developing an addendum to that report to include field verification results (ADCP velocity measurements in the Whitewater River Cove) as discussed at the July 27th Joint RC Meeting. This addendum will be submitted to the Water Resources RC (via the SharePoint Site) by November 10 for a 30-day review and will be submitted with the ISR.

   iii. The Task 3 study report (in entirety) will be filed with FERC with the ISR. This filing will include documentation of consultation with the RC and response to comments received. (Responses to comments will also be posted separately to the SharePoint site).

c. **Task 4** study report “Water Exchange Rates and Lake Jocassee Reservoir Levels":

   i. The Duke Energy relicensing team continues to work through CHEOPS model updates, calibration, and simulations of the designated operating scenarios for Bad Creek II. We presently expect to include a status update in the ISR and distribute the draft report to the Water and Aquatics Resources RCs in Q1 2024.

4. **Aquatic Resources Study Reports**

   a. **Task 1** study report "Entrainment Report (Revised)" will be shared with the Aquatics RC by November 3 for a final 30-day review period.

   b. **Task 2** study report “Desktop Studies on Pelagic and Littoral Habitat Effects” requires input from the Water Resources Task 4 study report described above. We presently expect to include a status update in the ISR and distribute the draft report to the Aquatics RC in Q1 2024.

   c. **Task 3** study report “Mussel Surveys and Stream Habitat Quality Surveys” will be submitted to the Aquatics RC as a draft for review and we are targeting submittal to the RC by November 17. Duke Energy will be requesting an expedited (3-week) review period by the RC, due to the coming holidays.

If you have any questions at all about any of the activities described above or the process in general, please do not hesitate to reach out to me or Alan Stuart directly.

Thank you for your continued participation in this process, and on behalf of Duke Energy, we look forward to a productive quarter and advancing the Bad Creek Project relicensing in collaboration with this group and other stakeholders.

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: Kulpa, Sarah; McCarney-Castle, Kerry
Subject: FW: [EXTERNAL] Re: Bad Creek Relicensing - ILP Study Plans and Reports Schedule Update
Date: Tuesday, October 31, 2023 1:01:34 PM

FYI.

From: John Hains <jhains@g.clemson.edu>
Sent: Tuesday, October 31, 2023 12:42 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Dale Wilde <dwilde@keoweefolks.org>
Subject: [EXTERNAL] Re: Bad Creek Relicensing - ILP Study Plans and Reports Schedule Update

I will be out of the country for the entire month of January. If I have internet access where I am during the meeting I will try to connect virtually.
Thanks for letting us know the overall plan.
John Hains

On Tue, Oct 31, 2023 at 12:02 PM Crutchfield Jr., John U <John.Crutchfield@duke-energy.com> wrote:

> Dear Bad Creek Relicensing Water and Aquatic Resources Committees:
>
> I hope this email finds you well and that you have been able to get out and enjoy the fantastic weather we are having this fall. It is hard to believe it is nearly November, and as we all know, the days start slipping by quickly as the year wraps up.
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525 South Tryon Street, DEP-35B | Charlotte, NC 28202
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From: Crutchfield Jr., John U
To: Abney, Michael A; Amy Breedlove; RankinD; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; quattrol; Olds, Melanie J; Amedee, Morgan D.; kernm; SelfR; Stuart, Alan Witten; Wahl, Nick; William T. Wood
Cc: Kulpa, Sarah; Huff, Jen; McCarney-Castle, Kerry; Salazar, Maggie; Mularski, Eric; Raber, Maverick James
Subject: Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review
Date: Friday, November 3, 2023 10:19:46 AM
Attachments: image001.png
image002.png

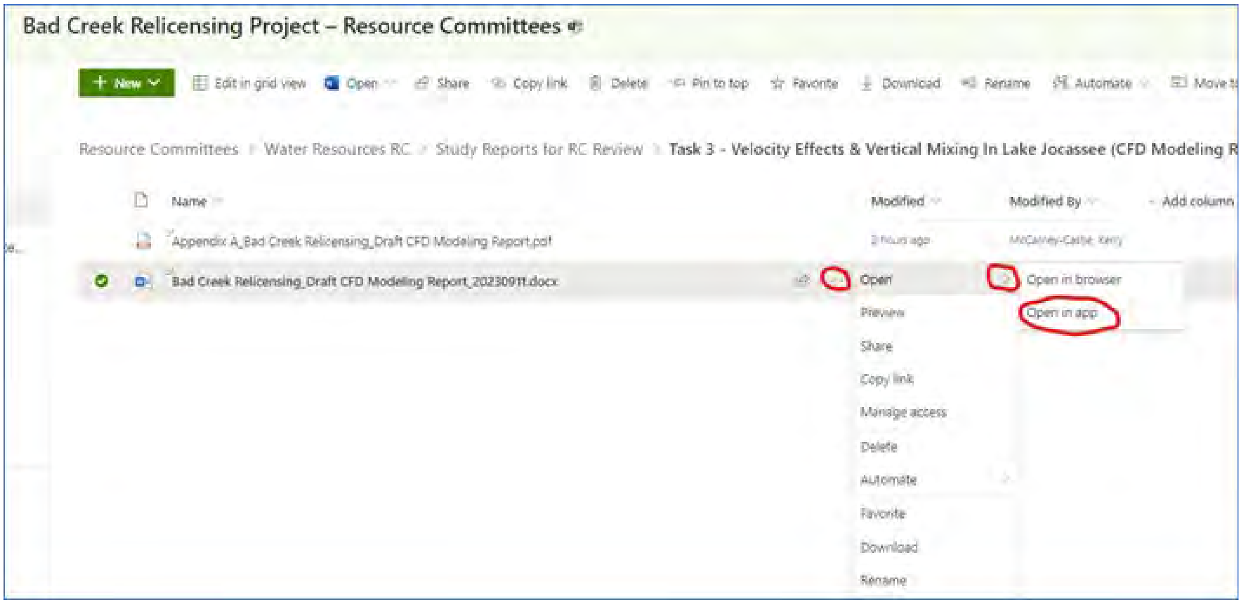
Dear Bad Creek Relicensing Aquatic Resources Committee:

Duke Energy is pleased to distribute the Desktop Entrainment Analysis draft report for Resource Committee review. This draft report satisfies Task 1 of the Bad Creek Relicensing Aquatic Resources Study. The deliverable is available on the Bad Creek Relicensing SharePoint site at the following link: Task 1 - Entrainment Report. Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **December 4th**. 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!*])



Name	Modified	Modified By	Add column
Appendix A_Bad Creek Relicensing_Draft CFD Modeling Report.pdf	2 hours ago	McCatney-Caribe, 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; RankinD; 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
Cc:	Kulpa, Sarah; Huff, Jen; McCarney-Castle, Kerry; Salazar, Maggie; Mularski, Eric
Subject:	Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)
Date:	Friday, November 17, 2023 1:50:17 PM
Attachments:	image001.png image002.png
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).

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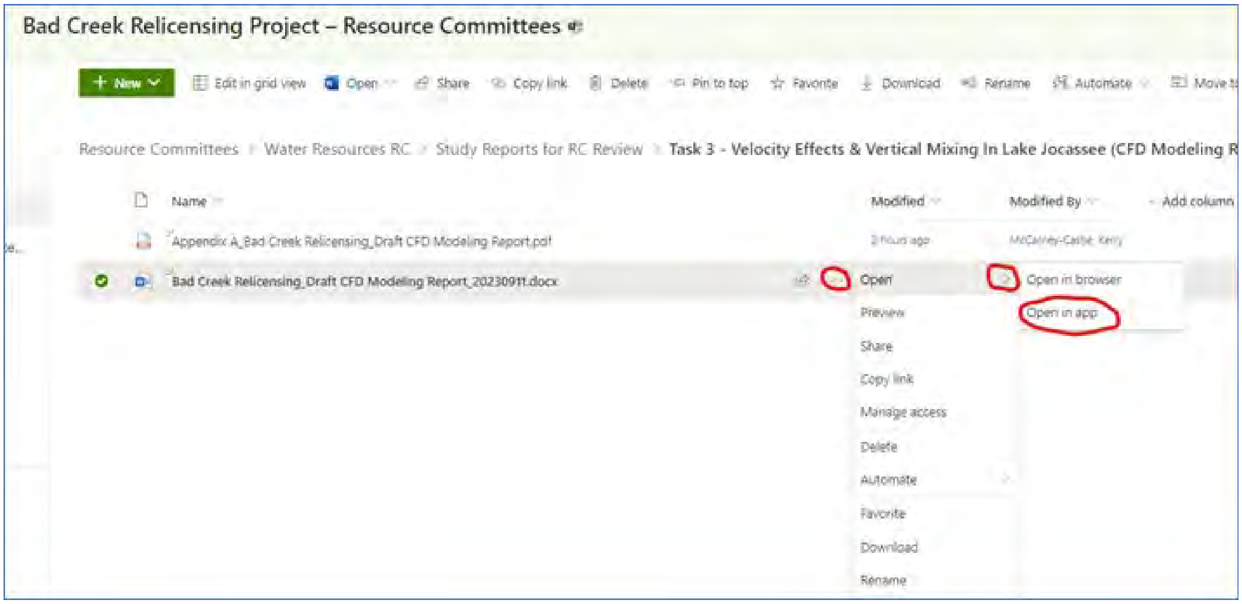

If you have any questions, please contact Alan Stuart or me.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From: Crutchfield Jr., John U
To: Abney, Michael A; Wahl, Nick; Alison Jakupca; Settevendemio, Erin; McCarney-Castle, Kerry
Cc: Stuart, Alan Witten; Kulpa, Sarah
Subject: FW: [EXTERNAL] Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review
Date: Thursday, November 30, 2023 2:45:36 PM
Attachments: image001.png
image002.png
Outlook-cuuxmhcg.png
Outlook-ny5mhzjb.png

FYI.

From: Olds, Melanie J <melanie_olds@fws.gov>
Sent: Thursday, November 30, 2023 2:40 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Subject: Re: [EXTERNAL] Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review

John,

The Service has reviewed the Entrainment Analysis report and does not have any 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, November 3, 2023 10:19 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>; 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>
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>; Raber, Maverick James <Maverick.Raber@duke-energy.com>
Subject: [EXTERNAL] Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review

Dear Bad Creek Relicensing Aquatic Resources Committee:

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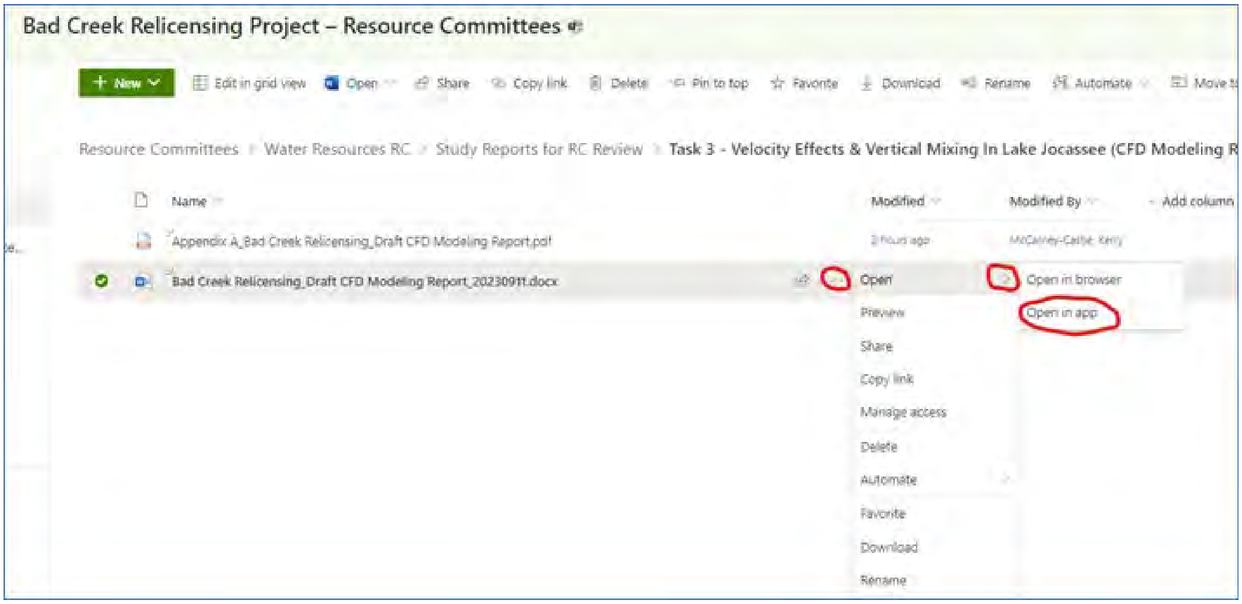

If you have any questions, please contact Alan Stuart or me.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From: Crutchfield Jr., John U
To: Stuart, Alan Witten; Kulpa, Sarah; Abney, Michael A; Wahl, Nick; Alison Jakupca; Settevendemio, Erin; McCarney-Castle, Kerry
Subject: Fwd: [EXTERNAL] RE: Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review
Date: Sunday, December 3, 2023 5:32:01 PM
Attachments: image003.png
image004.png

FYI.

Get Outlook for iOS

From: gcyantis2@yahoo.com <gcyantis2@yahoo.com>
Sent: Sunday, December 3, 2023 5:06 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Cc: 'Sue Williams' <suewilliams130@gmail.com>
Subject: [EXTERNAL] RE: Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review

John,
I've reviewed the document and have not questions or recommendations.
Thank you,
Gerry Yantis
AQD

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Wednesday, November 29, 2023 8:51 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>
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>; Raber, Maverick James <Maverick.Raber@duke-energy.com>
Subject: RE: Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review

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Regards,

John Crutchfield

From: Crutchfield Jr., John U
Sent: Friday, November 3, 2023 10:20 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>
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>; Raber, Maverick James <Maverick.Raber@duke-energy.com>
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Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From: Crutchfield Jr., John U
To: McCarney-Castle, Kerry; Settevendemio, Erin
Subject: FW: [EXTERNAL] Re: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)
Date: Monday, December 4, 2023 5:53:05 PM
Attachments: image001.png
image002.png

From: Erika Hollis <ehollis@upstateforever.org>
Sent: Monday, December 4, 2023 2:23 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Subject: [EXTERNAL] Re: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)

Hello John,

I have reviewed the draft “Desktop Entrainment Analysis Report” and have no comments to offer. I did however make a comment in the sharepoint document on the “Impacts to the Surface Waters and Associated Aquatic Fauna Draft Report”.

Contact me with any questions.

Thank you,

Erika

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 <John.Crutchfield@duke-energy.com>
Date: Friday, November 17, 2023 at 1:50 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>, alan.stuart@duke-energy.com <alan.stuart@duke-energy.com>, Wahl, Nick <Nick.Wahl@duke-energy.com>, William 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)

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).

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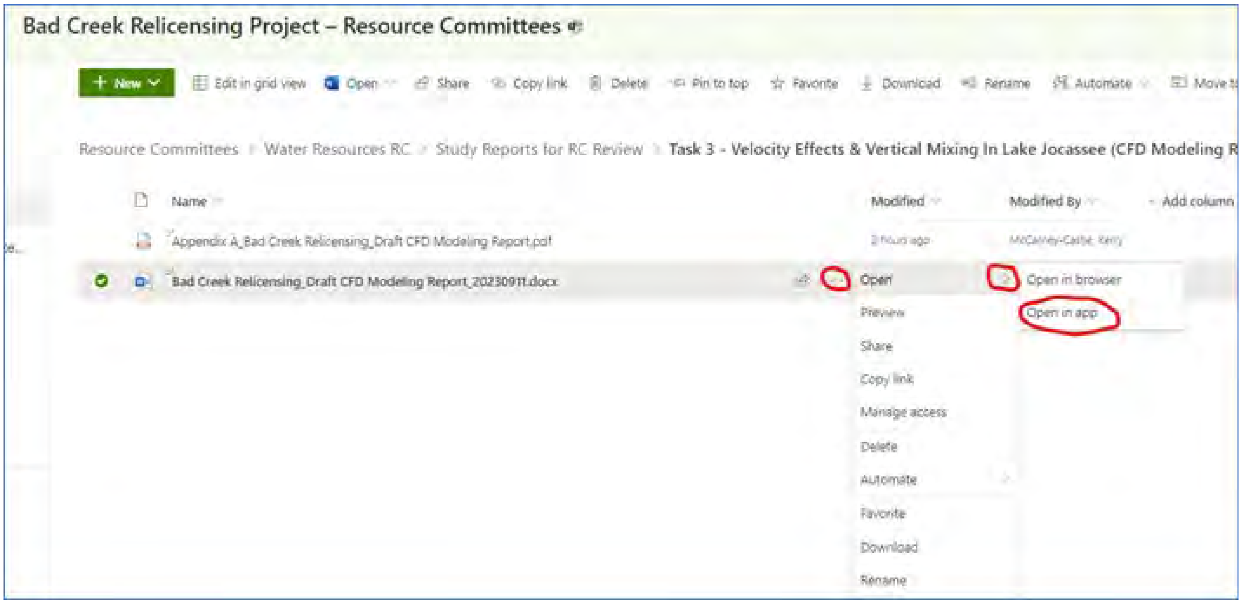

Bad Creek Relicensing Project – Resource Committees

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:	John Hains
To:	Crutchfield Jr., John U
Cc:	Abney, Michael A; Amy Breedlove; RankinD; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; quattrol; Olds, Melanie J; Amedee, Morgan D.; Morgan Kern; SelfR; Stuart, Alan Witten; Wahl, Nick; William T. Wood; Kulpa, Sarah; Huff, Jen; McCarney-Castle, Kerry; Salazar, Maggie; Mularski, Eric; Raber, Maverick James
Subject:	Re: Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review
Date:	Monday, December 4, 2023 5:58:25 PM
Attachments:	image001.png image002.png

To John Crutchfield, Jr.
Re: Desktop Entrainment Analysis Report
On Behalf of FOLKS

I have read the Desktop Entrainment Analysis Report and with regard to the entrainment impacts to both blueback herring and threadfin shad, I have no concerns for either species. Blueback herring populations exist in Lake Jocassee as a result of an accidental introduction and should be considered an invasive species. They have obviously 'naturalized' to this system but Duke was not the agency responsible for their introduction and in fairness Duke Energy therefore should not be tasked with their 'protection'.
I concur with dismissal of concerns regarding T. shad because it is improbable that entrainment at Bad Creek can have any significant impact on a population with such a high intrinsic rate of increase. I concur with this aspect of the analysis.
However, as this project goes forward, I believe that the changes in the velocity field during the various operational scenarios should be viewed more rigorously and that the question of entrainment should also be linked to the hydrodynamic behavior, the subject of a separate set of studies.
John Hains
Friends of Lake Keowee Society

On Wed, Nov 29, 2023 at 8:50 AM Crutchfield Jr., John U <John.Crutchfield@duke-energy.com> wrote:

> Dear Bad Creek Relicensing Aquatic Resources Committee:
>
> Just a reminder comments on due on the draft Desktop Entrainment Analysis Report on December 4th.
>
> Regards,
>
> John Crutchfield
>
> ---
>
> **From:** Crutchfield Jr., John U
> **Sent:** Friday, November 3, 2023 10:20 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>
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>; Raber, Maverick James <Maverick.Raber@duke-energy.com>
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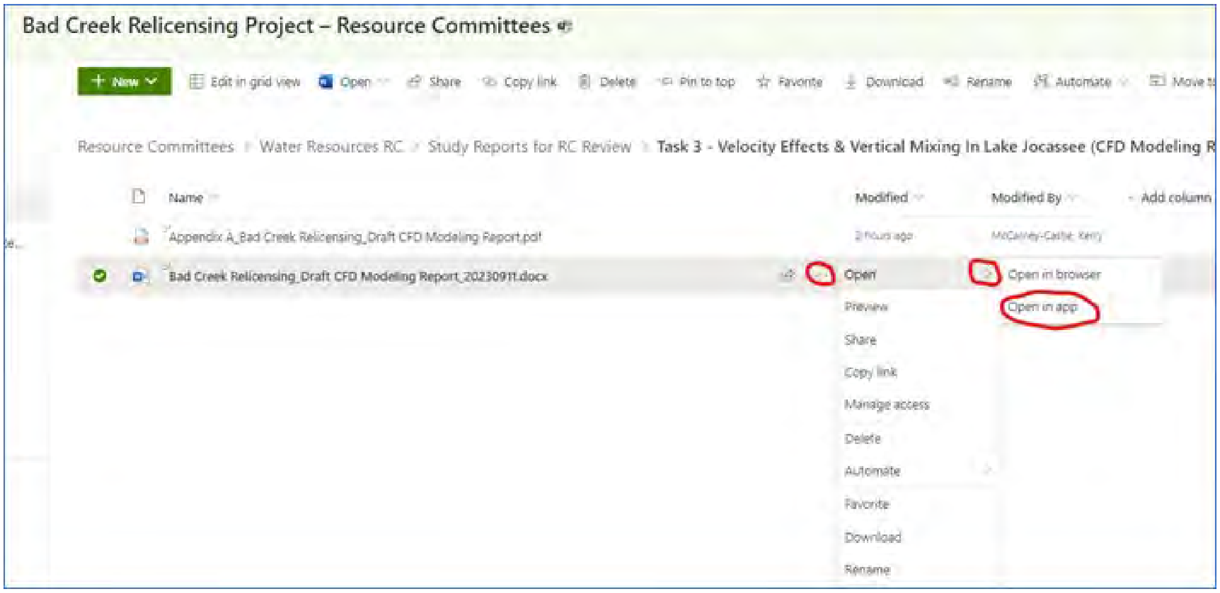

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Regards,

John Crutchfield

Project Manager II

Water Strategy, Hydro Licensing & Lake Services

Regulated & Renewable Energy

Duke Energy

525 South Tryon Street, DEP-35B | Charlotte, NC 28202

Office 980-373-2288| Cell 919-757-1095

From: Elizabeth Miller
To: Crutchfield Jr., John U; Abney, Michael A; Amy Breedlove; RankinD; 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
Cc: Kulpa, Sarah; Huff, Jen; McCarney-Castle, Kerry; Salazar, Maggie; Mularski, Eric; Raber, Maverick James
Subject: RE: Bad Creek Relicensing - Desktop Entrainment Analysis Report Ready for Resource Committee Review
Date: Monday, December 4, 2023 2:10:46 PM
Attachments: image001.png
image002.png

Hi John,

Staff with the South Carolina Department of Natural Resources have reviewed the draft Desktop Entrainment Analysis Report and have no comments to offer.

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 3, 2023 10:20 AM
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>; Raber, Maverick James <Maverick.Raber@duke-energy.com>
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To: Stuart, Alan Witten; Kulpa, Sarah; Settevendemio, Erin; McCarney-Castle, Kerry; Huff, Jen
Subject: FW: [EXTERNAL] RE: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)
Date: Wednesday, December 6, 2023 6:06:37 AM
Attachments: image003.png
image004.png

From: gcyantis2@yahoo.com <gcyantis2@yahoo.com>
Sent: Tuesday, December 5, 2023 4:28 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Cc: 'Sue Williams' <suewilliams130@gmail.com>
Subject: [EXTERNAL] RE: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)

Hello John,
AQD has no suggestions for the Aquatic Fauna Draft Report.
I do have one question: was there any assessment of the terrain around the spoils areas and the temporary roads that would identify higher risk area (e.g., extremely steep drops and/or channels that would cause high velocity of water risking erosion and silt entering the streambeds)? For such high risk area, would there be additional measures installed to prevent disturbance or damage to the streambeds and the aquatic life?
Thank you,
Gerry

From: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Sent: Monday, December 4, 2023 6:21 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>
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: RE: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)

Dear Bad Creek Relicensing Aquatic Resources Committee:

Just a reminder that comments on the Task 3 – Impacts to Surface Waters and Associated Aquatic Fauna Draft Report is **due December 8th**.

Thanks,
John

From: Crutchfield Jr., John U
Sent: Friday, November 17, 2023 1:50 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>
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.
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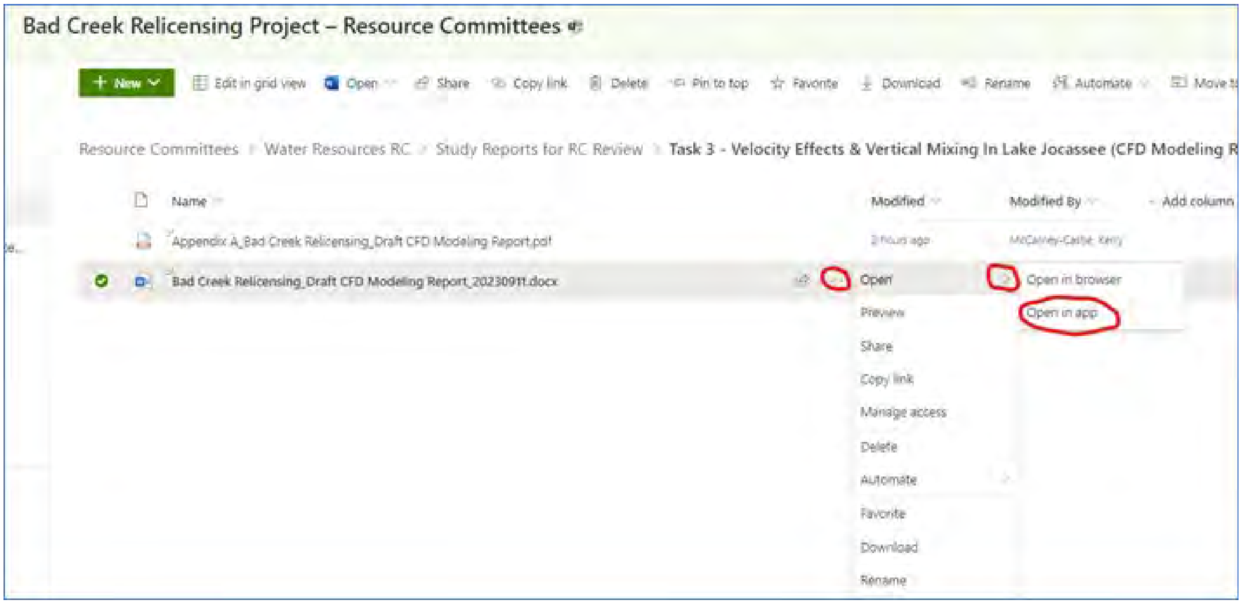
  (Note: If you are new to SharePoint, a very brief tutorial with screenshots is available on the home page of the Resource Committees tab called **“**Editing a Document in SharePoint”. This is the same tutorial that was presented during the kick-off meeting. [*The tutorial provides an alternative way 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	McCalney-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:	Elizabeth Miller
To:	Crutchfield Jr., John U; Abney, Michael A; Amy Breedlove; RankinD; 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
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)
Date:	Thursday, December 7, 2023 10:51:21 AM
Attachments:	image001.png image002.png

Hi John,

Due to the extensive and detailed nature of the document, the SCDNR expects to complete the review and submit comments by December 15, rather than the three-week review period ending by December 8 requested by Duke Energy.

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.
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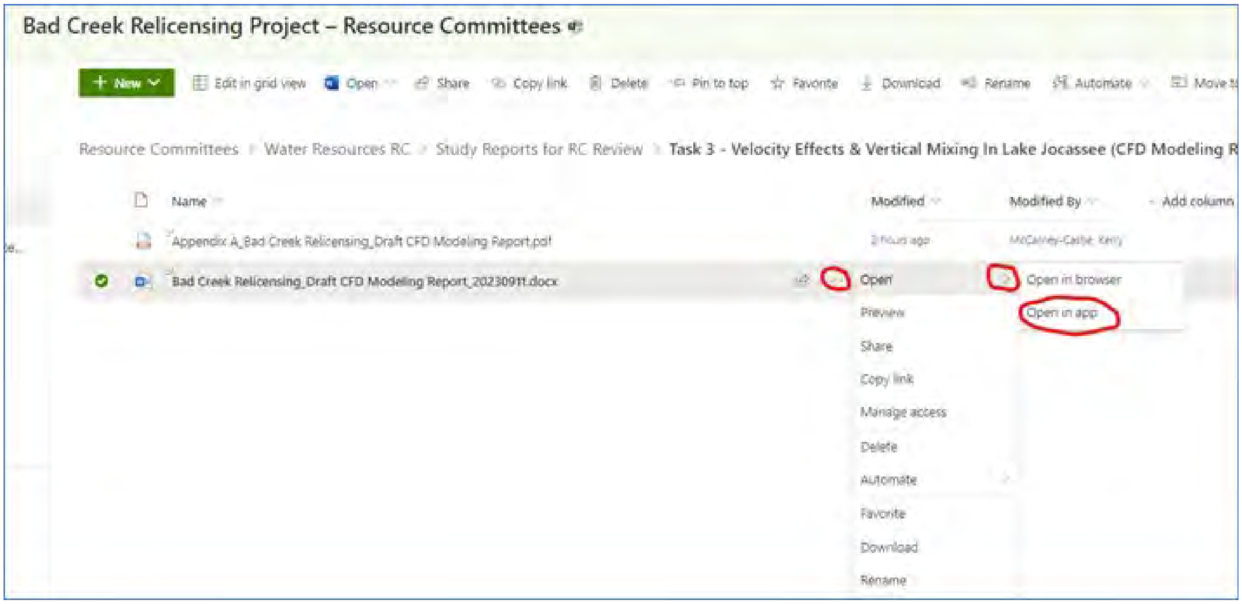
> (Note: If you are new to SharePoint, a very brief tutorial with screenshots is available on the home page of the Resource Committees tab called **"**Editing a Document in SharePoint". This is the same tutorial that was presented during the kick-off meeting. [*The tutorial provides an alternative way to open the document in Word – either technique works!]*)



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: Stuart, Alan Witten; Kulpa, Sarah; Settevendemio, Erin; McCarney-Castle, Kerry; Abney, Michael A; Wahl, Nick; Huff, Jen
Subject: FW: [EXTERNAL] Re: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)
Date: Friday, December 8, 2023 7:22:32 AM
Attachments: image001.png
image002.png

From: John Hains <jhains@g.clemson.edu>
Sent: Thursday, December 7, 2023 8:06 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>
Subject: [EXTERNAL] Re: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)

Hello John,

I have reviewed the draft report: Impacts to Surface Waters and Associated Aquatic Fauna

I find the efforts to establish baselines for assessment of impacts to be comprehensive and good. I appreciate the time and effort that was invested into these studies and look forward to the final assessments if Bad Creek II goes forward. My only suggestion is that if Duke has the results from earlier studies related to the original creation of the Bad Creek Project, a comparison of these latest results to earlier ones might yield insights to the resilience of these streams in response to construction impacts. I'm not sure if such analyses have a regulatory requirement but they might be of interest for purposes of perspective....that is....if they were impacted by construction back then and recovered, that might be a clue as to how quickly they would recover from the impacts, if any, of BC II. Just a thought.

John Hains

FOLKS

On Fri, Nov 17, 2023 at 1:50 PM Crutchfield Jr., John U <John.Crutchfield@duke-energy.com> wrote:

> 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.

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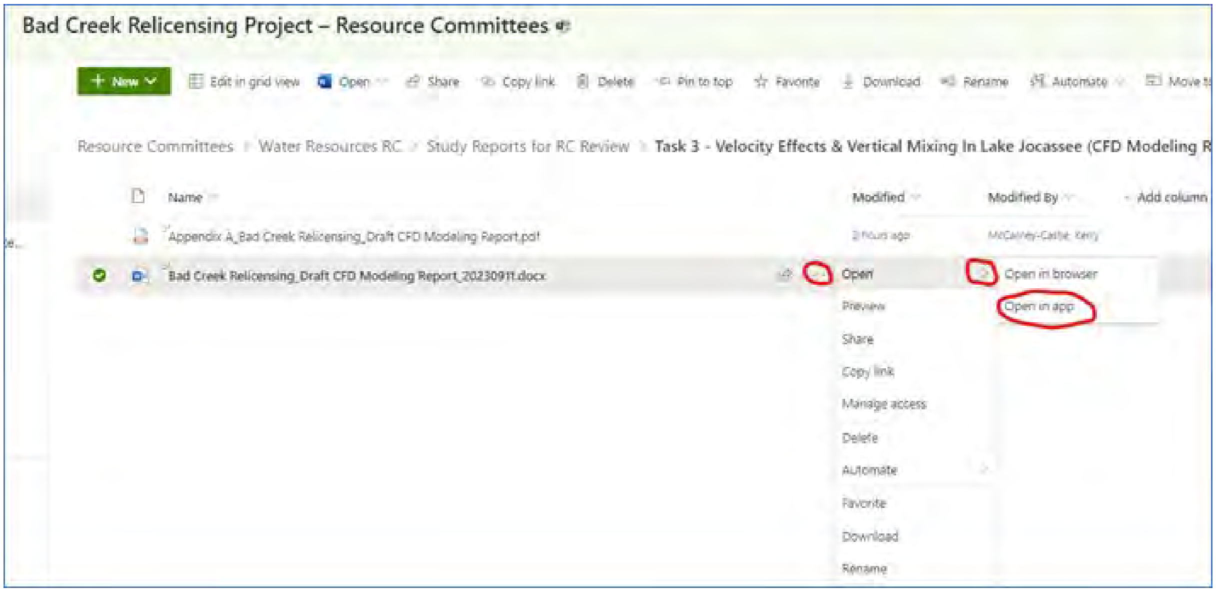

If you have any questions, please contact Alan Stuart or me.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From: Olds, Melanie J
To: Crutchfield Jr., John U; Abney, Michael A; Amy Breedlove; RankinD; Elizabeth Miller; Erika Hollis; Settevendemio, Erin; Gerry Yantis; jhains@g.clemson.edu; quattrol; Amedee, Morgan D.; Morgan Kern; SelfR; Stuart, Alan Witten; Wahl, Nick; William T. Wood
Cc: Kulpa, Sarah; Huff, Jen; McCarney-Castle, Kerry; Salazar, Maggie; Mularski, Eric
Subject: Re: [EXTERNAL] Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)
Date: Monday, December 11, 2023 10:22:01 AM
Attachments: image001.png
image002.png
Outlook-l2fdzsup.png
Outlook-zxlevec4.png

John,

The USFWS has reviewed the draft Impacts to Surface Waters and Associated Aquatic Fauna 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, November 17, 2023 1:50 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>
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: [EXTERNAL] Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)

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!

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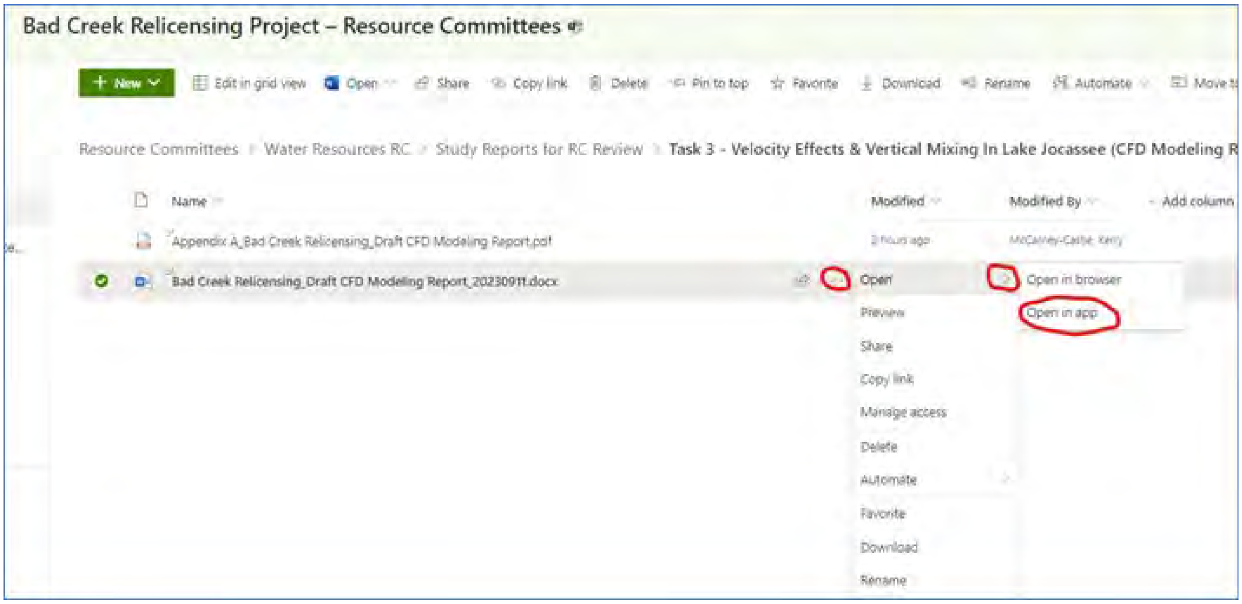
Bad Creek Relicensing Project – Resource Committees

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 - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)
Date: Wednesday, December 20, 2023 1:46:14 PM
Attachments: image001.png
image002.png

From: Elizabeth Miller <MillerE@dnr.sc.gov>
Sent: Tuesday, December 12, 2023 4:37 PM
To: Crutchfield Jr., John U <John.Crutchfield@duke-energy.com>; Stuart, Alan Witten <Alan.Stuart@duke-energy.com>; Abney, Michael A <Michael.Abney@duke-energy.com>
Cc: 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>
Subject: [EXTERNAL] RE: Bad Creek Relicensing - Impacts to Surface Waters and Associated Aquatic Fauna Draft Report (READY FOR RESOURCE COMMITTEE REVIEW)

Hi John,

Staff with the SCDNR have reviewed the Impacts to Surface Waters and Associated Aquatic Fauna draft report and have concerns regarding the report. We would like to request a meeting to discuss the draft report before submitting comments. Can Duke Energy and HDR staff be available for a meeting from 3-4pm on Thursday or Friday of this week? If not, please propose some dates that could work next week.

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

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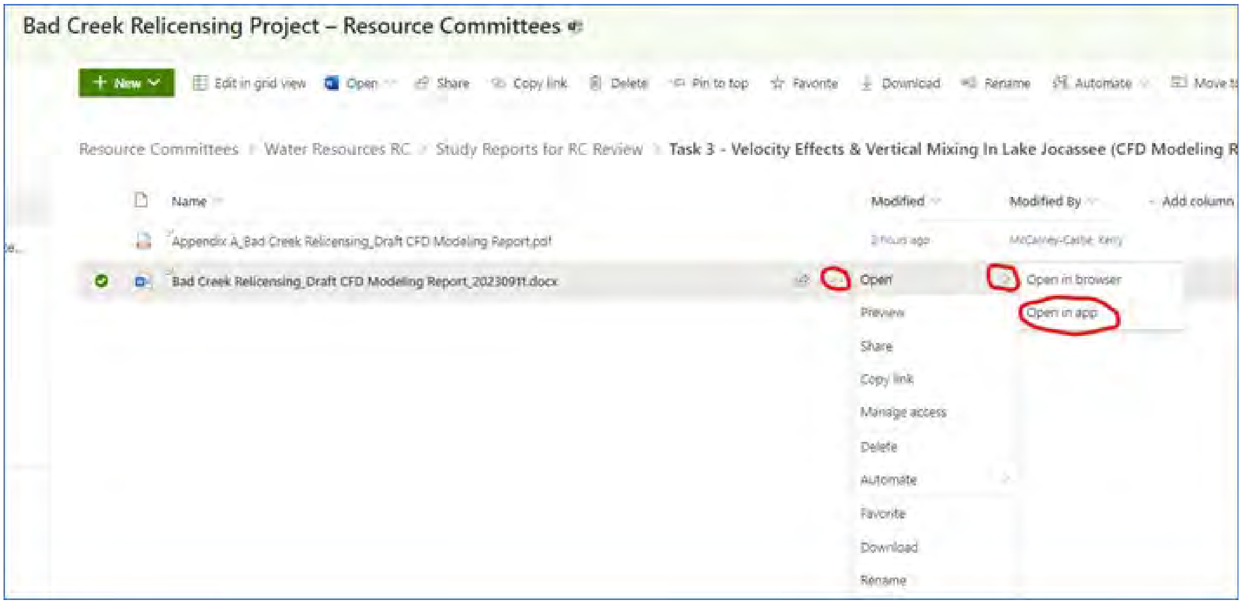

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Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

Discuss SCDNR Comments on Impacts to Surface Waters and Associated Aquatic Fauna Draft Report

Friday, December 29, 2023 11:01 AM

Meeting Date: 12/18/2023 3:00 PM
Location: Microsoft Teams Meeting
Link to Outlook Item: *click here*
Invitation Message

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

*****Rescheduling meeting to Monday, December 18.*****

Discuss SCDNR comments on Impacts to Surface Waters and Associated Aquatic Fauna Draft Report.

Microsoft Teams meeting

;

Join on your computer, mobile app or room device
Click here to join the meeting
Meeting ID: 269 880 505 057
Passcode: nRLFU4
Download Teams| Join on the web
Join with a video conferencing device
duke-energy@m.webex.com
Video Conference ID: 118 357 025 9
Alternate VTC instructions
Or call in (audio only)
+1 704-659-4701,,262780584# United States, Charlotte
Phone Conference ID: 262 780 584#
Find a local number| Reset PIN
Learn More| Help| Meeting options

Participants

- ☐ Crutchfield Jr., John U (Meeting Organizer)
- ☐ Stuart, Alan Witten
- ☐ Elizabeth Miller
- ☐ Lorianne Riggin
- ☐ Tom Daniel
- ☐ Dan Rankin
- ☐ William T. Wood
- ☐ Abney, Michael A
- ☐ Wahl, Nick
- ☐ Kulpa, Sarah (Accepted in Outlook)
- ☐ Settevendemio, Erin
- ☐ Mularski, Eric
- ☐ Huff, Jen
- ☐ Heise, Ryan Jeffrey

From:	Elizabeth Miller
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)
Date:	Thursday, December 21, 2023 1:33:42 PM
Attachments:	image001.png image002.png 20231221 Impacts to Surface Waters and Associated Aquatic Fauna Draft Report_SCDNR Comments.docx

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CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

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:

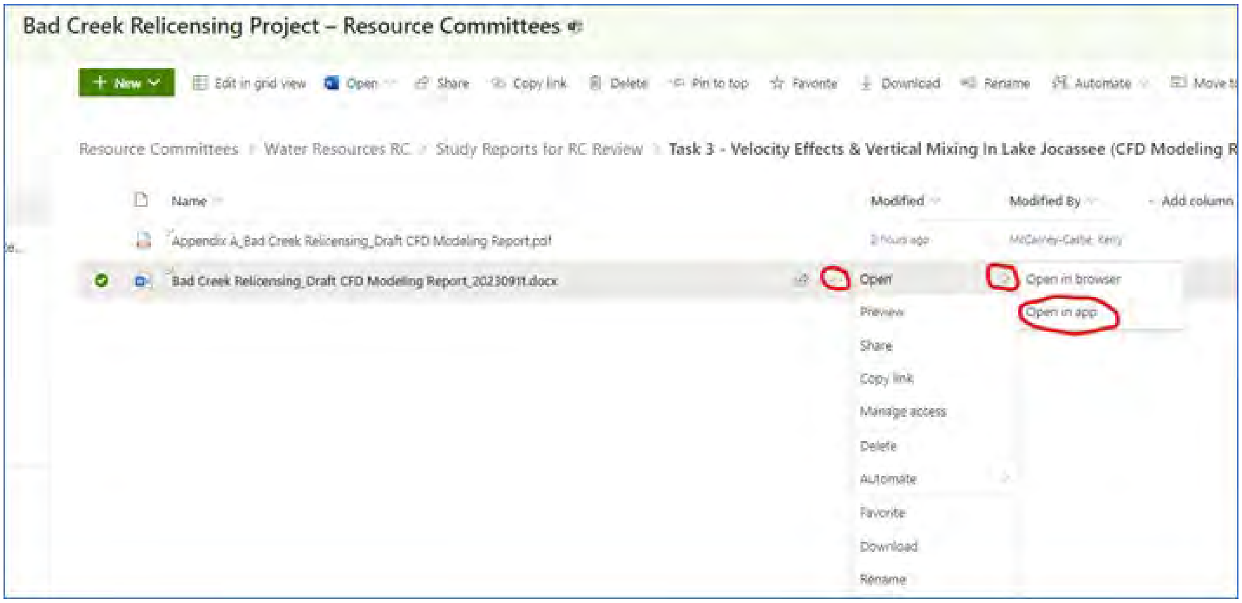
Duke Energy is pleased to distribute the Aquatic Resources Study Task 3 draft report *Impacts to Surface Waters and Associated Aquatic Fauna* for stakeholder review. The report (.doc) and associated attachments (.pdf) are available on the Bad Creek Relicensing SharePoint site at the following link: 🗀 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!*])



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

Impacts to Surface Waters and Associated Aquatic Fauna Draft Report
Bad Creek Pumped Storage Project – FERC Project No. 2740
November 17, 2023

SCDNR Comments – December 21, 2023

Table 6-3

1. 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.

Table 6-7

1. 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.
2. 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?

Attachment 2 – Potential Access Road Stream Crossings

1. All streams should be labeled on the maps and figures should be labeled.
2. 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.

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

1. 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.
2. 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)
3. 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)

Attachment F – SQT Rapid Assessment Method Forms

1. 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.

2. 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.
3. 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.
4. To avoid introducing rounding error into calculated parameters, please use full resolution (i.e., unrounded) measurements in all calculations.
5. The Flood Prone Width for Limber Pole Creek (Downstream) should be verified and/or revised as appropriate.
6. 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.
7. 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.
8. Stream 16 – notes that 20 times the bankfull width (10.5) is 20.5 – it should be 210.
9. Please check if the appropriate Rosgen stream type was chosen for Stream 15 Upstream and Stream 16 Downstream.
10. 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.
11. 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).
12. For Stream 16, please provide coordinates and a photo of the concentrated flow point.

Attachment J – SQT Catchment Assessment & Matrix Summary

1. 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 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.

2. 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.
3. 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?
4. 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?
5. 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.
6. SQT Limberpole Creek Upstream – LWD piece count entered as 39.4 but it is 49.2.
7. On all the SQT workbooks, under restoration potential, choose partial in the Site Information and Reference Curve Stratification section.
8. 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.

Additional Note

9. 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.

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:

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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: 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

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
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Columbia, SC 29202
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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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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

Elizabeth: Per request, use the SharePoint Wildlife and Botanical Resource Committee link below to access the kmz files.

Wildlife and Botanical RC

Regards,
John

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

From: Crutchfield Jr., John U
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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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

---

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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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>
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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
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EXTERNAL EMAIL: Do not click any links or open any attachments unless you trust the sender and know the content is safe.

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.

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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.

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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).

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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.

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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 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

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,

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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

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

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
Importance: High

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
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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*. 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 <u>not</u> 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? 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. 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

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.

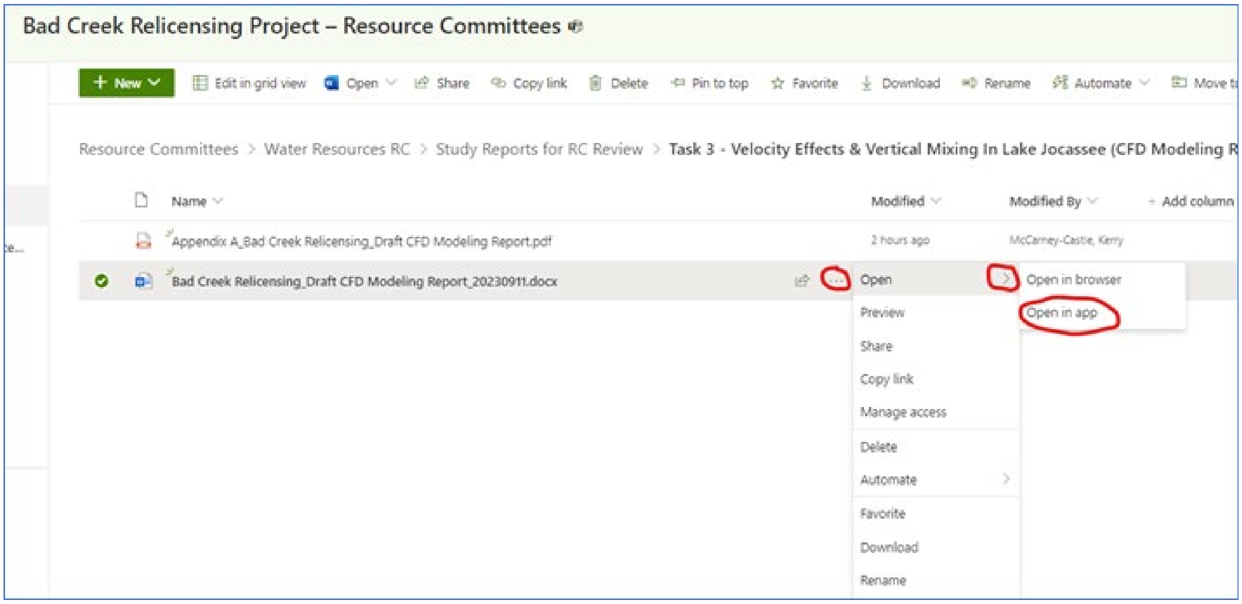
Duke Energy is requesting a 30-day review period, therefore, please submit all comments by **June 3rd**. A confirmation email is kindly requested upon review completion (email me at John.Crutchfield@duke-energy.com).

-

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!*])



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
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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

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

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

You don't often get email from melanie_olds@fws.gov. Learn why this is important

WARNING: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

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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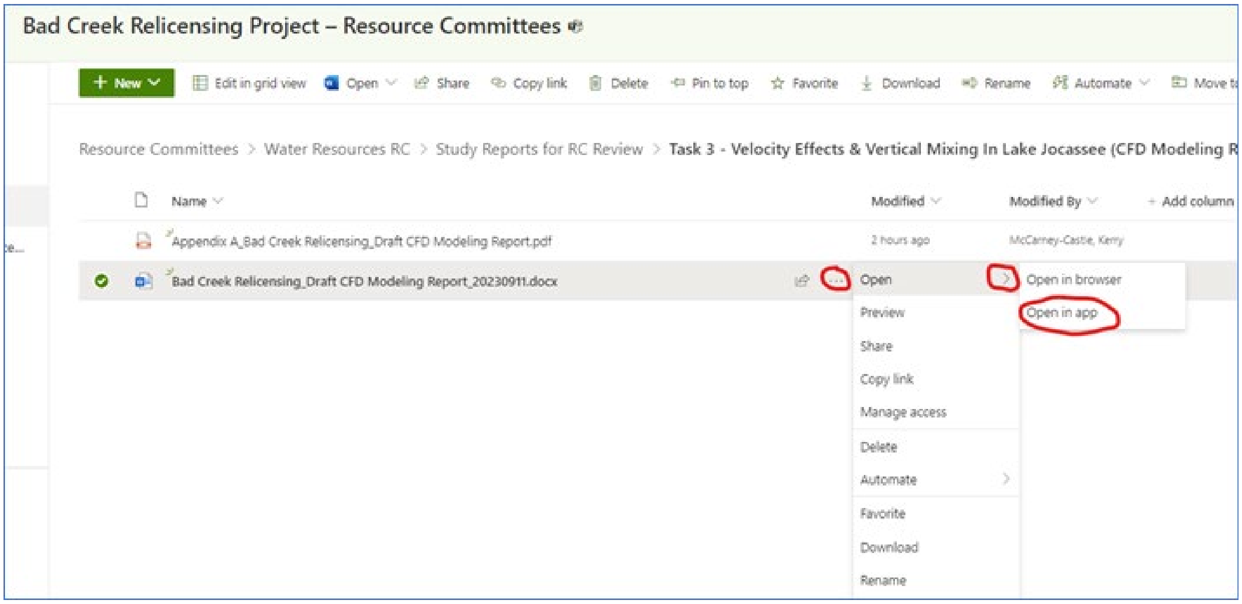
  (Note: If you are new to SharePoint, a very brief tutorial with screenshots is available on the home page of the Resource Committees tab called **"**Editing a Document in SharePoint". This is the same tutorial that was presented during the kick-off meeting. [*The tutorial provides an alternative way 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

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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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).

-

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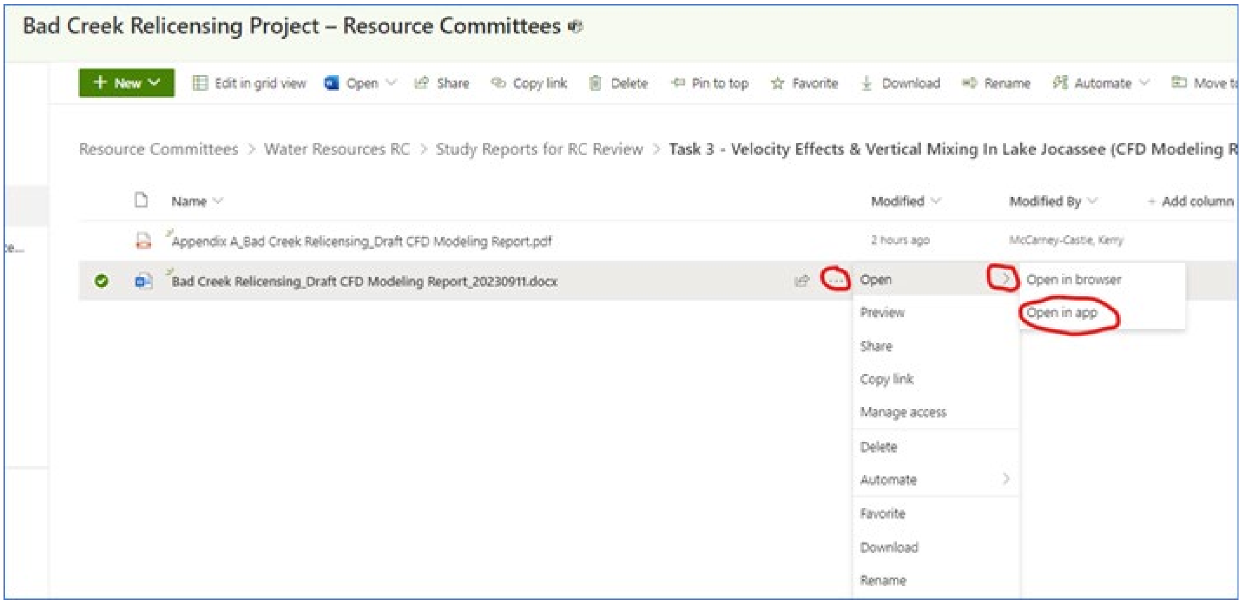

Bad Creek Relicensing Project – Resource Committees

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: 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

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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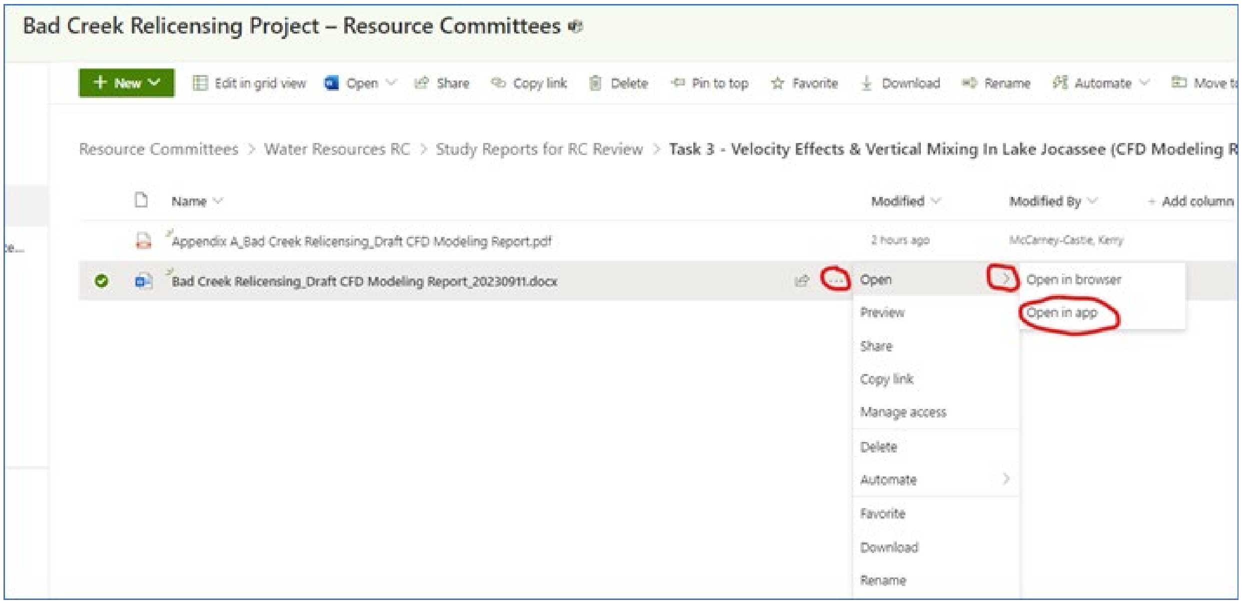

Resource Committees > Water Resources RC > Study Reports for RC Review > **Task 3 - Velocity Effects & Vertical Mixing In Lake Jocassee (CFD Modeling R**

Name	Modified	Modified By	+ 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.

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

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

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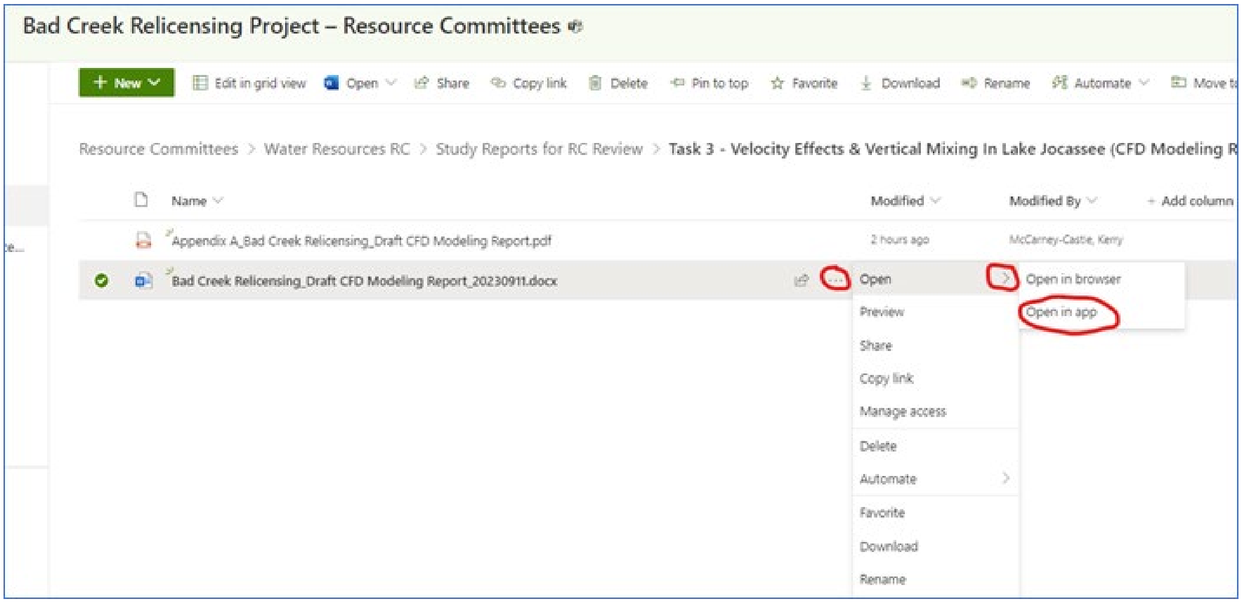

If you have any questions, please contact Alan Stuart or me.

Regards,

John Crutchfield
Project Manager II
Water Strategy, Hydro Licensing & Lake Services
Regulated & Renewable Energy
Duke Energy
525 South Tryon Street, DEP-35B | Charlotte, NC 28202
Office 980-373-2288| Cell 919-757-1095

From: Crutchfield Jr., John U
To: 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

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
Duke Energy
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Office 980-373-2288| Cell 919-757-1095