Aquatic Resources Study Report

Byllesby-Buck Hydroelectric Project (FERC No. 2514)

November 17, 2021

Prepared by:

HDR

Prepared for:

Appalachian Power Company

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Contents

Attachments

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1 Project Introduction and Background

Appalachian Power Company (Appalachian or Licensee), a unit of American Electric Power (AEP), is the Licensee, owner, and operator of the two-development Byllesby-Buck Hydroelectric Project (Project) (Project No. 2514), located on the upper New River in Carroll County, Virginia. The Byllesby development is located about 9 miles north of the city of Galax, and the Buck development is located approximately 3 river miles (RM) downstream of Byllesby and 43.5 RM upstream of Claytor Dam.

The Project is currently licensed by the Federal Energy Regulatory Commission (FERC or Commission). The Project underwent relicensing in the early 1990s, including conversion to run-of-river operations and incorporating additional protection, mitigation, and enhancement (PM&E) measures (FERC 1994). The current operating license for the Project expires on February 29, 2024. Accordingly, Appalachian is pursuing a subsequent license for the Project pursuant to the Commission's Integrated Licensing Process (ILP), as described at 18 Code of Federal Regulations (CFR) Part 5. In accordance with FERC's regulations at 18 CFR §16.9(b), the licensee must file its final application for a new license with FERC no later than February 28, 2022.

In accordance with 18 CFR §5.11 of the Commission's regulations, Appalachian developed a Revised Study Plan (RSP) for the Project that was filed with the Commission and made available to stakeholders on October 18, 2019. On November 18, 2019 FERC issued the Study Plan Determination (SPD). On December 12, 2019, Appalachian filed a clarification letter on the SPD with the Commission. On December 18, 2019, Appalachian filed a request for rehearing of the SPD. The SPD was subsequently modified by FERC by an Order on Rehearing dated February 20, 2020.

On July 27, 2020, Appalachian filed an updated ILP study schedule and a request for extension of time to file the Initial Study Report (ISR) to account for Project delays resulting from the COVID-19 pandemic. The request was approved by FERC on August 10, 2020, and the filing deadline for the ISR for the Project was extended from November 17, 2020 to January 18, 2021. Stakeholders provided written comments in response to Appalachian's filing of the ISR meeting summary, which are addressed in this Updated Study Report (USR) along with study methods and results.

In accordance with 18 CFR §5.15, Appalachian has conducted studies as provided in the RSP as subsequently approved and modified by the FERC. This report describes the methods and results of the Aquatics Resources Study conducted in support of preparing an application for new license for the Project.

2 Study Goals and Objectives

The goals and objectives of the Aquatic Resources Study are to:

- Collect a comprehensive baseline of existing aquatic resources in the vicinity of the Project.
- Compare current aquatic resources data to historical data to determine any significant changes to species composition or abundance.
- Confirm intake velocities for fish entrainment potential.

3 Study Components

The Aquatic Resources Study report comprises the following study reports:

1. 2020-2021 Fish Community Study Report – Attachment 1
2. Impingement and Entrainment Study Report – Attachment 2
3. 2020-2021 Macroinvertebrate and Crayfish Community Study Report – Attachment 3
4. Mussel Community Study Report – Attachment 4

For existing background information, study methods, study results, and analyses, please refer to the individual study reports in Attachments 1 through 4.

Germane correspondence is provided in Attachment 5 and includes the following:

- On April 3, 2020, HDR's sub-contractor (Edge Engineering and Science, LLC [EDGE]) sent the tentative walleye gill net methods and sampling sites to the Virginia Department of Wildlife Resources (VDWR) (formally known as the Virginia Department of Game and Inland Fisheries) as a response to VDWR's request on March 31, 2020.
- On September 29, 2020, HDR's sub-contractor (Stantec Consulting services, Inc. [Stantec]) sent an e-mail to the VDWR confirming completed mussel survey locations and requesting advice on completing the survey. On October 8, 2020, the VDWR confirmed that Stantec should re-deploy and complete the surveyed locations.
- On October 8, 2020, EDGE sent notification to the U.S. Fish and Wildlife Service and VWDR indicating that while conducting the benthic macroinvertebrate survey, multiple freshwater mussels including Virginia state listed Pistolgrip (*Tritogonia verrucosa*) were discovered in the surveyed substrates.
- On November 4, 2020, HDR e-mailed the VDWR to provide an update on the Fish Community Study and to confirm that performing the gillnet survey in November would be acceptable to the agency. On November 9, 2020, the VDWR concurred with HDR and EDGE's plan of action and confirmed that gill net surveying could be performed through early December.

Attachment 1

Attachment 1 – 2020 -2021 Fish Community Study Report

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Byllesby-Buck Hydroelectric Project
(FERC Project No. 2514)

2020-2021 Fish Community Survey Results, Virginia

October 12, 2021

Prepared for:

American Electric Power
BOUNDLESS ENERGY™

Byllesby-Buck → HDR2020-0001

Prepared by:

EDGE ENGINEERING & SCIENCE
further insight.

Edge Engineering and Science, LLC
Cincinnati, Ohio

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LIST OF ACRONYMS

AEP	American Electric Power – Client
Appalachian	Appalachian Power Company
CFS	Cubic feet per second
CPUE	Catch per unit effort
DO	Dissolved oxygen
EDGE	Edge Engineering and Science, LLC
EF	Electrofishing
FERC	Federal Energy Regulatory Commission
HDR	HDR, Inc. – Client
ISR	Initial Study Report
LDB	Left descending bank
NRSA	National Rivers and Streams Assessment
Project	Byllesby-Buck Hydroelectric Project
RDB	Right descending bank
RSP	Revised Study Plan
SAV	Submerged aquatic vegetation
TL	Total length
USFWS	U.S. Fish and Wildlife Service
USR	Updated Study Report
VAC	Virginia Administrative Code
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VDWR	Virginia Department of Wildlife Resources (formerly VDGIF)

1.0 INTRODUCTION

The Byllesby and Buck Dams form the 30.1-megawatt Byllesby-Buck Hydroelectric Project (Project) located on the New River in Carroll County, Virginia. Appalachian Power Company (a unit of American Electric Power; AEP) is pursuing a new license from the Federal Energy Regulatory Commission (FERC) for the Project as their existing license expires in 2024. Aquatic biological studies were completed to satisfy their existing FERC license and results of these studies are ultimately used as a record and reference for current relicensing efforts. The New River, along with the two contiguous impoundments resulting from the Project, harbors a diverse community of aquatic biota where aquatic biological studies are required to survey and document the contemporary community of organisms present within the Project area (Figure 1). The New River and lower reaches of tributary streams are included in the Project survey area. The information gained from the Fish Community Study will provide a comprehensive baseline of the current fish community (i.e., abundance, diversity, and distribution) near the Project. These resulting data will be compared to historical data to identify temporal trends in fish community abundance, diversity, or distribution near the Project.

Study scoping with state and federal agencies resulted in the development and approval of a project specific Revised Study Plan (RSP) that identified two objectives for Project studies (AEP 2019) pertaining to the fish community.

Goals and Objectives

1) Collect a comprehensive baseline of existing aquatic resources in the vicinity of the Project.
2) Compare current aquatic resources data to historical data to determine any significant changes to species composition or abundance.

In accordance with the RSP, field sampling efforts were necessary to satisfy each of the two objectives. Some of the objectives were not accomplished during the 2020 calendar year due to delays resulting from unforeseeable circumstances including heavy precipitation and high flows and the COVID-19 global pandemic; therefore, an Initial Study Report (ISR) was submitted on January 18, 2021. This report serves as the Update Study Report (USR) now that all field sampling efforts within the RSP have been completed.

2.0 METHODS

The RSP provided guidance on the sampling framework for the Project that included general fish community methodologies. Fish community sampling conducted in 2020 employed boat electrofishing and gillnetting to target representative fish habitats throughout the Project area. Backpack electrofishing surveys were not completed in 2020; therefore, these methods and results were not discussed in the ISR but are included herein. Fish community sampling conducted in 2021 employed boat and backpack electrofishing and gillnetting to target representative fish habitats throughout the Project area. The selected sampling methods include a combination of equipment, techniques, seasonality, and number and location of sample sites, to provide a contemporary representation of the Project area and correspond to previous sampling efforts (Appalachian and AEP 1991) for comparison.

2.1 Fish Community Sampling

The fish community study, detailed in the RSP, consists of two temporally independent efforts (one fall survey and one spring survey). Sampling methods were derived from the National Rivers and Streams Assessment (NRSA) Field Operations Manual (USEPA 2019), which guides standardized electrofishing methods in lotic waterbodies of variable sizes. Gillnet methods were established in coordination with the Virginia Department of Wildlife Resources (VDWR). Within the constraints of the Project's objectives and geographic limits, boat and backpack electrofishing and gillnetting techniques were employed to most-effectively target specific sites based on the habitat types present in the Project area. Boat electrofishing was used to target near-shore pool habitats (i.e., non-wadeable), backpack electrofishing was used to target riffle/run habitats (i.e., wadeable), and gillnetting was used to target mid-channel pool habitats. Seven boat electrofishing sites were in the Byllesby Pool and 10 were in the Buck Pool. Three backpack electrofishing sites were located upstream of Byllesby Dam, six were located between Byllesby Dam and Buck Dam, and four were located below Buck Dam. Six gillnetting sites were in the Byllesby Pool to specifically target Walleye (*Sander vitreus*), as recommended by VDWR.

Sampling techniques are described further in subsequent sections. Specific sampling dates are based on factors including (but not limited to) weather conditions, water temperatures, river flows and reservoir elevations, and safety of field staff and the public. Site naming conventions are as follows: Location-Seasonality-Method-Site Number. For example, BFB1 = Byllesby-Buck Fall Boat Site 1, BSBP1 = Byllesby-Buck Spring Backpack Site 1, and BFG1 = Byllesby-Buck Fall Gillnet Site 1. Site numbers increase in the downstream direction.

2.1.1 Boat Electrofishing

Boat electrofishing techniques were used to survey the fish community at 17 pool sites (i.e., BFB and BSB site names) along 100-meter transects. Upon arrival at boat electrofishing sites (Figures 1-8), transects were delineated in pool habitat and the start and endpoint coordinates were recorded. The effectiveness of boat electrofishing is reduced in deeper water (i.e., greater than three meters), especially during daylight hours; therefore, sampling was performed within 30 meters of shore. Site photos were taken in four directions (upstream, downstream, left descending bank [LDB], and right descending bank [RDB]; all 90 degrees to one another) and substrate, and field conditions were recorded (e.g., time, date, air temperature, precipitation, cloudy/overcast, etc.). At each sample site, habitat characteristics (e.g., substrate, estimated water velocity, depth, and instream cover) and water quality parameters (e.g., pH, water temperature, dissolved oxygen [DO], and conductivity) were measured and recorded. Additionally, a Secchi disk reading was taken at each sample site at the time of sampling. Multiple points for habitat and water quality measurements were taken if there was large variation within a single site. Prior to initiating sample collection, electrofishing equipment was calibrated based on the water conductivity at each sample site. Sampling effort (i.e., electrofishing time) was also recorded during each sampling event.

Starting at the downstream end of the transect and moving upstream, all available habitat types (i.e., shallow shoreline, deep shoreline, emergent vegetation, submerged wood, etc.) were candidates for sampling throughout the reach and particular care was taken to thoroughly sample complex habitat and instream structures. During sampling, a boat driver maneuvered the boat along each transect (nosing into and then away from the bank) while two field personnel or netters collected stunned fish in dip nets and one person guided the driver. For each 100-meter transect, a minimum of five minutes electrofishing was required, and more time may have been necessary depending on the complexity of the habitat. Fish were placed in live wells until sampling for that transect had concluded and then returned to the stream at the survey location. Each fish was identified to the lowest taxonomic level practicable, enumerated, and examined for signs of external parasites, disease, or physical abnormalities. In addition, the total length (TL) and weight was recorded for the first 30 individuals of a species per sample site. All captured individuals were enumerated. If more than 30 individuals of a single species were collected at a given sample site, the additional fish were counted, and length measurements were recorded for specimens that exceed the upper or lower maximum recorded lengths from the 30 individuals previously measured. Photos were taken in the field for a representative specimen of each fish taxon collected during the study and for those fish that could not be identified to species (e.g., minnows, juvenile Moxostoma sp.), representative specimens were preserved and identified in a laboratory setting based on sampling permit specifications.

2.1.2 Backpack Electrofishing

Backpack electrofishing surveys of the fish community occurred at 13 riffle/run sites (i.e., BSBP site names) along 100-meter transects (or two 50-meter transects if habitat was limited longitudinally). Upon arrival at wadeable sites (Figure 1 and Figures 9-13), transects were delineated in riffle/run habitat and the start and endpoint coordinates were recorded. Site photos, field conditions, habitat characteristics, and water quality parameters were recorded in the same manner as boat electrofishing sites (see Section 2.1.1). Multiple points for habitat and water quality measurements were taken if there was large variation within a single site. Prior to initiating sample collection, electrofishing equipment was calibrated based on the conductivity of the water at each sample site. Sampling effort (i.e., electrofishing time) was also recorded during each sampling event.

Starting at the downstream end of the transect and moving upstream, all riffle/run habitats were candidates for sampling throughout the reach. All major habitat types identified within the transect were sampled and particular care was taken to thoroughly sample complex habitat and instream structures, while a netter(s) actively captured stunned fish with a dip net. In areas of elevated stream velocities, a stationary seine (2.4-meters-wide by 1.8-meters-tall with 0.48-centimeter mesh) was positioned downstream of the sample location perpendicular to stream flow and the operator of the backpack electrofishing unit simultaneously performed kicks/sweeps in a downstream manner toward the seine. Stunned fishes were driven into the net with the aid of stream currents and the seine was then swept upward and fish retrieved for processing. For each 100-meter transect, a minimum of five minutes electrofishing time was expended, and more time may have been necessary depending on the complexity of the habitat. All collected fish were kept in aerated buckets and/or instream live wells during surveys and processed in the same manner as boat electrofishing methods (see Section 2.1.1) before being returned to the stream at the survey location.

2.1.3 Gillnetting

Gillnetting techniques were used to survey the fish community at six pool sites (i.e., BFG and BSG site names) with 36.5-meter-long by 2.4-meter-deep gillnets. Each gillnet was comprised of eight 4.6-meter-long panels with mesh sizes of 1.9, 2.5, 3.2, 3.8, 5.1, 6.4, 7.6, and 10.2 centimeters. Upon arrival at gillnet sites (Figure 1 and Figures 14-16), gillnets were anchored with a cinder block, so the top of the net was at least 0.5 meter below the surface. Starting on the shoreward side, and with the smallest mesh size, gillnets were pulled taught as the boat operator moved towards the channel and slightly downstream of and perpendicular to shore. The start and endpoint coordinates were recorded for each gillnet deployment. Site photos, field conditions, habitat characteristics, and water quality parameters were recorded in the same manner as boat electrofishing sites (see Section 2.1.1). Nets were set for 24 hours before they were retrieved with a grappling hook and checked for fish, which were placed in live wells for processing. Nets were reset in the same location and fish were processed in the same manner as boat electrofishing methods (see Section 2.1.1), except processed fish were released at least 100 meters from the site so they did not immediately become entangled when the gillnets were reset. Nets soaked for another 24 hours before being checked again and pulled from the location after a total of 48 hours of soak time per site.

2.2 Deviations from Revised Study Plan

2.2.1 COVID-19 Delays

The initial field plan included spring and fall 2020 sampling events (boat electrofishing, backpack electrofishing, and gillnetting); however, the COVID-19 pandemic, and subsequent restrictions on non-essential travel and safety considerations for field staff, prohibited spring 2020 field efforts. As a result, AEP requested, and was granted, an extension to accommodate the change in schedule as VDWR, Virginia Department of Environmental Quality (VDEQ), U.S. Fish and Wildlife Service (USFWS), and Virginia Department of Conservation and Recreation (VDCR) all concurred with adaptable schedule revisions. EDGE was contracted and given notice to proceed with fieldwork at the beginning of September 2020 and was able to complete the fall 2020 boat electrofishing and gillnet sampling efforts. Fall 2020 backpack electrofishing methods were postponed due to weather delays. Spring boat and backpack electrofishing and gillnetting methods occurred in 2021.

2.2.2 Weather Delays

Periodic delays associated with weather and stream conditions plagued the fall 2020 sampling season. Average rainfall for Galax, Virginia (collected at this station since 1981) is approximately 26 centimeters between September 1 and December 1 (US Climate Data 2020); yet during the same three-month period in 2020, Galax accumulated over 37 centimeters of rain (USGS 2020), a 42 percent increase. Therefore, the fall 2020 boat electrofishing and gillnet sampling efforts were completed the baseflows around 2,000-2,500 cubic feet per second (cfs), which at the time were the assumed baseflows for 2020. As a result of the 42 percent increase from average precipitation that occurred in 2020, the study area portion of the New River remained elevated well above the average annual baseflow conditions throughout the fall 2020 field study season. The relatively high discharge did not impact boat electrofishing and gillnet methods, but riffle/run habitat within the Project area remained too swift and deep to effectively and safely sample using backpack electrofishing methods. Thus, the backpack electrofishing surveys that were proposed for completion in 2020 (along with boat electrofishing and gillnetting) occurred in spring 2021. Spring 2021 flows more closely matched average flows during the sampling period.

2.2.3 Sampling Locations

At the time of sampling, multiple proposed locations did not correspond well with the targeted habitats identified during the desktop-based site selection process. As such, sampling methods for those locations were adjusted in the field to provide the best possible sample collection effort from the sampling locations identified in the RSP. Two sites upstream of a high-gradient riffle complex, located between Byllesby Dam and Buck Dam (originally identified as boat electrofishing sites) were switched to backpack electrofishing methods based on the presence of boulder habitat with swift currents. All backpack electrofishing sites (between Byllesby Dam and Buck Dam) were chosen based on available habitat and site accessibility. A range of habitats found in this area (e.g., variable depths, substrate size, instream cover, etc.) were sampled to get a comprehensive illustration of the fish community. Furthermore, one proposed backpack electrofishing site (at the mouth of Crooked Creek in the Byllesby Pool) was replaced with boat electrofishing methods as the site consisted of pool habitat and was not conducive to backpack electrofishing methods. All site adjustments carried over into spring 2021 sampling efforts.

3.0 RESULTS

The fish community results were divided and analyzed in three distinct sections to directly evaluate potential differences in the fish community throughout the Project Area – upstream of Byllesby Dam, between Byllesby Dam and Buck Dam, and downstream of Buck Dam. Backpack electrofishing results (from spring 2021) were compared between these three sections. Boat electrofishing results (from fall 2020 and spring 2021) were compared between the Byllesby Pool and Buck Pool. Gillnetting results in the Byllesby Pool were primarily used to investigate the presence and distribution of Walleye. Understanding how the fish community changes throughout the Project area provides insight into the impact, or lack thereof, that the Project has on the New River.

3.1 Fish Community Sampling

Boat electrofishing surveys were conducted between October 22 and 24-25, 2020, and April 25-26 and May 27, 2021. Backpack electrofishing surveys were conducted between April 20-23, 2021. Gillnet surveys were conducted between November 9-11 and 18-20, 2020, and April 20-24, 2021. All surveys followed methods outlined in the RSP and occurred during relatively low-flow and clear stream conditions. Sampling was performed by EDGE's state permitted fish biologist under Virginia Scientific Collecting Permit No. 070705 (Appendix A). There were differences in habitat type and substrates observed between sites (Appendix B); however, differences in sampling dates, time of day, and low number of intra- and inter-site samples do not facilitate statistical comparison of physiochemical properties between sites. Results of physiochemical data collected at sample sites met the state water quality standards established for the New River, indicating that water quality within the Project area is capable of supporting fish communities (this will be detailed further in the Project-specific USR water quality study report referencing Virginia Administrative Code [VAC] Chapter 260).

3.1.1 Boat Electrofishing

A total of 597 fish were collected, representing 32 species, using boat electrofishing methods at 17 sites throughout the Project area (sampled fall 2020 and spring 2021) and nine species were collected exclusively using this method. The raw field sampling data for both seasons and all sample sites are provided in Appendix C. A total of 410 fish were collected, representing 24 species, using backpack electrofishing methods at 13 sites throughout the Project area (sampled spring 2021) and seven species were collected exclusively using this method. A total of 112 fish were collected, representing 10 species, using gillnet methods at six sites in the Byllesby Pool (sampled fall 2020 and spring 2021) and Walleye was the only species collected exclusively using this method.

The substrate at boat electrofishing sites within the Byllesby Pool generally consisted of sand (70%), silt (20%), gravel (5%), and boulder (5%). Many of the sites along the LDB exhibited a low-gradient, vegetated floodplain whereas many of the sites along the RDB exhibited a high-gradient, rock face (Appendix B). Both sides of the impoundment displayed shoreline habitat that rapidly descended towards the center of the channel. The habitat structure at most sites within the Byllesby Pool generally consisted of sparse woody debris, submerged aquatic vegetation (SAV), and scattered boulders. Water quality parameters (temperature, pH, DO, velocity, and conductivity) remained relatively consistent throughout the Byllesby Pool except velocity was slightly higher in the two upstream most sites toward the head of the impoundment (Appendix C).

The substrate at boat electrofishing sites within the Buck Pool generally consisted of sand (60%), silt (20%), boulder (15%), and gravel (5%). Many of the sites along the LDB exhibited a low-gradient, vegetated floodplain whereas many of the sites along the RDB exhibited a high-gradient, rock face (Appendix B). The upstream portion of the Buck Pool was relatively shallow with a consistent depth across the width of the stream whereas the downstream portion of the pool had shallow banks that rapidly descended towards the center of the channel. There was very little habitat structure at most sites within the Buck Pool, but scattered woody debris, SAV, and boulders were present. Water quality parameters remained relatively consistent throughout the impoundment except DO and velocity were higher toward the upstream end of the impoundment, just below a section of high-gradient riffles.

A total of 244 fish were collected, representing 20 species, in the Byllesby Pool from seven boat electrofishing sites. A total of 353 fish were collected, representing 24 species, in the Buck Pool from 10 boat electrofishing sites. The most abundant species collected during boat electrofishing surveys in the Byllesby Pool were Telescope Shiner (*Notropis telescopus*) (29.5%), Bluegill (*Lepomis macrochirus*) (15.2%), and Redbreast Sunfish (*Lepomis auritus*) (9.8%); however, Telescope Shiner were only collected at one site. The most abundant species collected during boat electrofishing surveys in the Buck Pool were Redbreast Sunfish (28.9%), Smallmouth Bass (*Micropterus dolomieu*) (20.4%), and Whitetail Shiner (*Cyprinella galactura*) (11.6%), each of which being captured at a minimum of five sites. Distribution of individuals was relatively consistent throughout each pool and correlates with habitat preference and complexity. The Byllesby Pool was dominated by the invertivore-piscivore trophic guild and the water column habitat guild, whereas the Buck Pool was dominated by the invertivore trophic guild and the water column habitat guild (McCormick et al. 2001).

Overall, species diversity resulting from boat electrofishing surveys was negligibly higher in the Byllesby Pool (H’ = 2.32) than in the Buck Pool (H’ = 2.26). Similarly, catch per unit effort (CPUE) ranged from 0.3 to 14.2 individuals per minute in the Byllesby Pool (averaging 2.9) and CPUE ranged from 0.5 to 9.5 individuals per minute in the Buck Pool (averaging 2.8). CPUE was 54% higher in the spring than the fall in the Byllesby Pool and 214% higher in the spring than the fall in the Buck Pool. Representative site and fish photos are provided in Appendix B and raw data for fish collections are provided in Appendix C.

3.1.2 Backpack Electrofishing

The substrate at backpack electrofishing sites upstream of the Byllesby Dam generally consisted of bedrock (25%), boulder (25%), cobble (20%), gravel (15%), and sand (15%). Two sites were along the RDB, and one site was along the LDB, but all three sites were in the first riffle/run section above the Byllesby Pool (approximately 5.5 km upstream of the Byllesby Dam) (Figure 9). Habitat structure at these sites primarily consisted of well-developed, swift riffles varying from a few centimeters to a meter in depth. The substrate at backpack electrofishing sites between the Byllesby Dam and the Buck Dam was consistent to that in the first three sites, except higher percent bedrock at site BSBP4 (Bypass Reach), higher percent cobble at site BSBP5 (Figure 10), and higher percent gravel at site BSBP6 (Figure 11). All types of riffle/run habitat present between the dams was surveyed, from low-gradient riffles with relatively small substrate and no instream cover to high-gradient riffles with relatively large substrate and substantial instream cover. The substrate downstream of the Buck Dam generally consisted of bedrock (35%), boulder (25%), cobble (20%), gravel (15%), and sand (5%) in the two Bypass Reach sites (Figure 12) where the primary habitat is well-developed riffle. Bedrock (25%), boulder (25%), cobble (20%), gravel (15%), and sand (15%) were dominant substrates in the two sites downstream of the Bypass Reach (Figure 13) where the primary habitat structure is more run than riffle, with sporadic undercut banks and overhanging vegetation. Water quality parameters (temperature, pH, DO, velocity, and conductivity) remained relatively consistent throughout all backpack electrofishing sites except velocity (Appendix C), which often changes drastically within a single transect.

A total of 48 fish were collected, representing 11 species, upstream of the Byllesby Dam from three backpack electrofishing sites. A total of 156 fish were collected, representing 18 species, between the Byllesby Dam and Buck Dam from six backpack electrofishing sites. A total of 206 fish were collected, representing 17 species, downstream of the Buck Dam from four backpack electrofishing sites. The most abundant species collected during backpack electrofishing surveys upstream of the Byllesby Dam were Whitetail Shiner (39.6%) and Rosyface Shiner (*Notropis rubellus*) (16.7%), with Whitetail Shiner being the only species captured at all three sites. The most abundant species collected during backpack electrofishing surveys between the Byllesby Dam and Buck Dam were Telescope Shiner (43.6%) and Whitetail Shiner (14.7%) with the least productive site occurring in the Bypass Reach (BSBP4; only accounting for 2.5% of total abundance between the dams). The most abundant species collected during backpack electrofishing surveys downstream of the Buck Dam were Central Stoneroller (*Campostoma anomalum*) (28.6%) and Telescope Shiner (25.7%). In contrast to the two Bypass Reach sites below Byllesby Dam (accounting for 14 individuals), the Bypass Reach sites below Buck Dam accounted for 142 individuals.

Overall, species diversity resulting from backpack electrofishing surveys was comparable between the sites upstream of the Byllesby Dam, between the Byllesby Dam and Buck Dam, and downstream of the Buck Dam (H' = 1.92, 1.97, and 1.98, respectively). In contrast, the average CPUE for sites upstream of the Byllesby Dam was 1.7 individuals per minute, between the Byllesby Dam and Buck Dam was 3.5 individuals per minute, and downstream of the Buck Dam was 7.6 individuals per minute. The doubling of CPUE moving downstream through the Project area may have resulted from availability of preferred habitat or efficacy of sampling techniques in select habitats; however, it is understood that dams may limit upstream movement of fish and abundance generally increases in the downstream direction of most rivers. Representative site and fish photos are provided in Appendix B and raw data for fish collections are provided in Appendix C.

3.1.3 Gillnetting

The substrate at gillnetting sites within the Byllesby Pool generally consisted of sand (70%), silt (25%), and gravel (5%); however, the near-shore substrates ranged from vertical rock face and boulder to sand and silt flats. Many of the sites along the LDB exhibited a low-gradient, vegetated floodplain whereas many of the sites along the RDB exhibited a high-gradient, rock face (Appendix B). Both sides of the impoundment displayed shoreline habitat that rapidly descended towards the center of the channel (Figure 1 and Figures 14-16). Water quality parameters (temperature, pH, DO, velocity, and conductivity) remained relatively consistent throughout the Byllesby Pool except velocity was slightly higher in the two upstream most sites toward the head of the impoundment (Appendix C). No fish were captured at site BFG1/BSG1, which exhibited relatively swift current as it was located within the thalweg of the river on the outside bank of a meander and may not be suitable for consistent fish utilization.

A total of 112 fish were collected, representing 10 species, in the Byllesby Pool from six gillnet sites. The most abundant species collected during gillnet surveys in the Byllesby Pool were Common Carp (*Cyprinus carpio*) (51.8%), Channel Catfish (*Ictalurus punctatus*) (24.1%), White Sucker (*Catostomus commersonii*) (8.0%), and Walleye (8.0%) (Appendix C). Distribution of individuals was relatively consistent throughout the Byllesby Pool and likely correlates with habitat preference and complexity; however, a large majority of the Common Carp (most abundant species) were collected at one site (BFG3/BSG3).

Overall, species diversity (H' = 1.43) resulting from gillnetting surveys in the Byllesby Pool was relatively low, although there were no direct comparisons to be made as gillnetting did not occur anywhere else in the Project area. CPUE ranged from 0.5 to 22 individuals per net set (averaging 6.2), and like boat electrofishing methods, CPUE was 62% higher in spring than in fall. Representative site and fish photos are provided in Appendix B and raw data for fish collections are provided in Appendix C.

4.0 DISCUSSION

4.1 Fish Community

A total of 404 fish were collected, representing 26 species, upstream of Byllesby Dam from seven boat electrofishing sites (sampled fall 2020 and spring 2021), three backpack electrofishing sites (sampled spring 2021), and six gillnet sites (sampled fall 2020 and spring 2021). The raw field sampling data for both seasons and all sample sites are provided in Appendix C. Five species were collected exclusively upstream of Byllesby Dam. A total of 509 fish were collected, representing 33 species, between Byllesby Dam and Buck Dam from 10 boat electrofishing sites (sampled fall 2020 and spring 2021) and six backpack electrofishing sites (sampled spring 2021). Seven species were collected exclusively between Byllesby Dam and Buck Dam. A total of 206 fish were collected, representing 17 species, below Buck Dam from four backpack electrofishing sites (sampled spring 2021). Two species were collected exclusively below Buck Dam.

With regards to boat electrofishing, 20 species were collected in the Byllesby Pool from seven sites and 24 species were collected in the Buck Pool from 10 sites; however, species diversity was negligibly higher in the Byllesby Pool than in the Buck Pool and CPUE was nearly identical. The additional species may be attributable to a greater number of sites being surveyed or slight differences in habitat availability. Overall, the Byllesby Pool and Buck Pool exhibit similar fish community characteristics. Boat electrofishing yielded two game fish species in the Byllesby Pool that were not present in the Buck Pool (i.e., Muskellunge [*Esox masquinongy*] and Rainbow Trout [*Oncorhynchus mykiss*]). In contrast, boat electrofishing in the Buck Pool yielded nine species of darters, minnows, shiners, suckers, and sunfish that were not present in the Byllesby Pool (Appendix C).

With regards to backpack electrofishing, 11 species were collected upstream of the Byllesby Dam from three sites, 18 species were collected between the Byllesby Dam and Buck Dam from six sites, and 17 species were collected downstream of the Buck Dam from four sites. These differences in species richness may result from differences in effort between the Project areas; however, differences in species diversity were negligible between each Project area. The general abundance of fish in riffle/run habitats increased in the downstream direction, with CPUE doubling from upstream sites to middle sites and doubling again from middle sites to downstream sites. For example, the two sites in the Bypass Reach of the Byllesby Dam yielded less than 10-percent of the individuals compared to the two sites in the Bypass Reach of Buck Dam. No fish species were exclusively collected using backpack electrofishing methods upstream of Byllesby Dam; however, Kanawha Darter (*Etheostoma kanawhae*) and Saffron Shiner (*Notropis rubricroceus*) were only collected between Byllesby Dam and Buck Dam and Kanawha Sculpin (*Cottus kanawhae*) and White Shiner (*Luxilus albeolus*) were only collected downstream of the Buck Dam (Appendix C).

Gillnetting methods were only implemented in the Byllesby Pool, by request from VDWR, to target Walleye. Walleye was the only species of fish exclusively captured using gillnets as all other species captured using gillnets were also captured with either boat or backpack electrofishing methods. A total of nine Walleye were captured at three of six gillnet sites. The three sites where they were capture had primarily sand and silt substrates with lower-gradient bed slope compared to the three sites where they were not captured, which had larger substrates near the shore and higher-gradient bed slope towards the channel. Further, the three sites where Walleye were captured were in the upper, middle, and lower sections of the Byllesby Pool, indicating that they are using the entire length of the pool. Six Walleye were collected in fall 2020 and three were collected in spring 2021. Six of the nine Walleye were collected at the downstream most site in the Byllesby Pool, indicating that they may be occupying the deeper sections more often.

In a previous study in the Project area, Appalachian and AEP (1991) employed boat electrofishing, gillnetting, and hoop netting techniques. Although they did not use backpack electrofishing techniques, they used boat electrofishing techniques in both pool and riffle habitat. The total number and spatial distribution of sample sites is comparable between the current and historical studies. However, the historical study sampled each site six times, resulting in 216 total samples, compared to 59 samples in the current study. Additionally, for each pair of sites surveyed in Appalachian and AEP (1991), one was sampled during the day and the other at night. The current study does not include nighttime electrofishing due to safety concerns. These differences in methodology do not appear to have impacted the results of the study drastically and conclusions can still be drawn between the two.

The historical study (Appalachian and AEP 1991) collected a total of 2,679 individuals representing 34 species, compared to the current study which collected 1,119 individuals representing 40 species. Therefore, despite the lower effort in the present study, there was an increase in overall richness of fish species within the Project area. Both studies documented a low incidence of parasites and physical abnormalities. Four species were captured in the previous study that were not captured in the current study including Johnny Darter (*Etheostoma nigrum*), Silver Redhorse (*Moxostoma anisurum*), Bluehead Chub (*Nocomis leptocephalus*), and Silver Shiner (*Notropis photogenis*), which may simply be a result of fewer sampling types and sampling events, sampling seasonality, or absence of nighttime electrofishing; however, 11 species were captured in the current study that were not captured in the previous study (Appendix C). The overall diversity of the fish community was greater in the current study (H’=2.91) than in the previous study (H’=2.53). Smallmouth Bass and Redbreast Sunfish were two of the four most abundant species in both studies and many of the other mutual species were found in similar relative abundance. Walleye were not captured during the previous study, but multiple specimens were collected in the current study, which is a good sign for the popular fishery. No state or federally listed threatened or endangered species were collected in this study or the historical study. Overall, fish species distribution, richness, and abundance throughout the Project area during the current study closely matched that of Appalachian and AEP (1991). For example, the highest average CPUE and richness per sample for riffle/run habitat was recorded downstream of the Buck Dam in both studies.

For Appalachian and AEP (1991) fish community studies, fish abundance was not reported separately for electrofishing of pool and riffle habitats. Additionally, gill and hoop net results were not reported separately. For the purposes of this report, a comparison of species richness at boat electrofishing sites in 2020/2021 and Appalachian and AEP (1991) were used to help identify any trends in the fish community within the Project area. Species richness observed in the current study during boat electrofishing in pool habitats were 20 species and 24 species in the Byllesby Pool and Buck Pool, respectively. Species richness observed in the previous study during boat electrofishing in pool habitats were 9 species and 11 species in the Byllesby Pool and Buck Pool, respectively. Overall, fish community composition was quite similar between the two studies, but richness in the Project area seems to have increased indicating that the Project area is just as capable (if not more capable) of hosting an abundant and diverse fishery.

Water quality parameters and trends throughout the Project area did not change markedly from Appalachian and AEP (1991) (Appendix C). Information regarding effects of Project operations on the fish community (e.g., fish length frequency, effects on spawning habitat, etc.) can be referenced in Appalachian and AEP (1991) and in the USR.

5.0 LITERATURE CITED

American Electric Power Service Corporation. 2019. Byllesby-Buck Hydroelectric Project (FERC No. 2514-186) Filing of Revised Study Plan for Relicensing Studies. October 18, 2019.

Appalachian Power Company (Appalachian) and American Electric Power Service Corporation (AEP). 1991. The Status of Fish Populations in the Vicinity of Byllesby-Buck Hydroelectric Project. April 10, 1991.

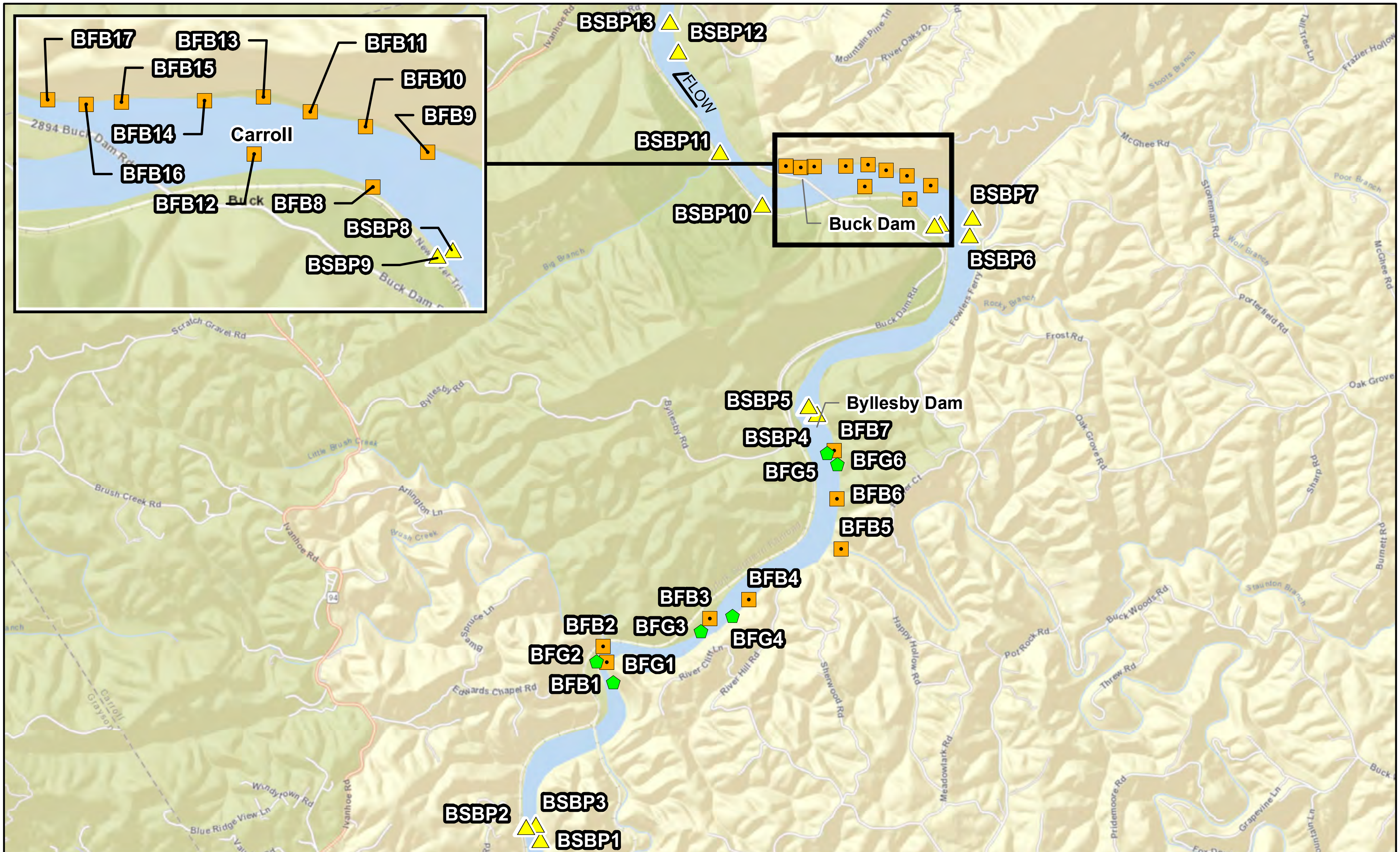
McCormick, F. H., R. M. Hughes, P. R. Kaufmann, D. V. Peck, J. L. Stoddard, and A. T. Herlihy. 2001. Development of an Index of Biotic Integrity for the Mid-Atlantic Highlands Region. Transactions of the American Fisheries Society, 130:5, 857-877.

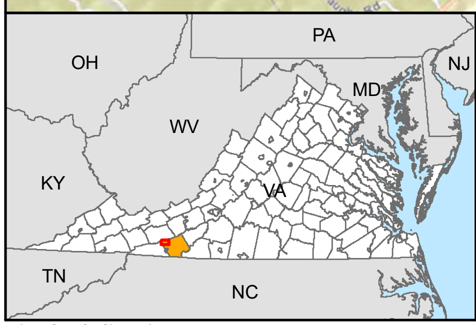
U.S. Climate Data. 2020. https://www.usclimatedata.com/climate/galax/virginia/united-states/usva0301. Accessed 24 December 2020.

U.S. Environmental Protection Agency (USEPA). 2019. National Rivers and Streams Assessment 2018/19 Field Operations Manual Non-Wadeable Version 1.2. EPA-841-B-17-003b.Washington, DC.

U.S. Geological Survey (USGS). 2020. National Water Information System (NWIS): Web Interface. https://waterdata.usgs.gov/nwis/uv?cb_00045=on&format=html&site_no=03164000&period=&begin_date=2020-09-01&end_date=2020-12-01. Accessed 24 December 2020.

Figures





Legend

Fish Sample Location

- Backpack electrofishing
- Boat Electrofishing - 100-meter survey extent
- Gillnet - 36.5-meter survey extent

N

0 0.6 1.2

Kilometers

Scale: 1:51,181

AMERICAN ELECTRIC POWER

EDGE ENGINEERING & SCIENCE

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 1
Overall Byllesby-Buck project area including backpack electrofishing (BSBP), boat electrofishing (BFB), and gillnet (BFG) survey sites on the New River in Carroll County, Virginia

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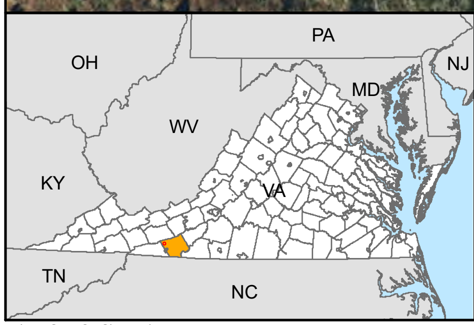

Legend

- Boat Electrofishing - 100-meter survey extent
- Boat Electrofishing - 100-meter survey extent

N

0 50 100

Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 2
Boat electrofishing 100-meter survey extent in pool habitat in Carroll County, Virginia.

Legend

- Boat Electrofishing - 100-meter survey extent (point)
- Boat Electrofishing - 100-meter survey extent (line)

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 3
Boat electrofishing 100-meter survey extent in pool habitat in Carroll County, Virginia.

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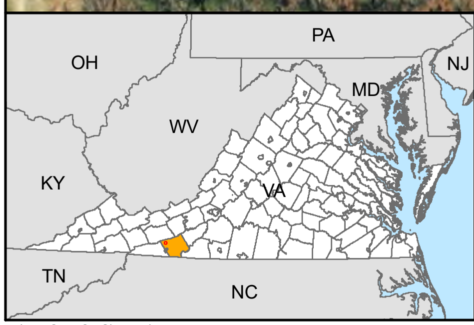


Legend

- Boat Electrofishing - 100-meter survey extent
- Boat Electrofishing - 100-meter survey extent

N

0 50 100
Meters

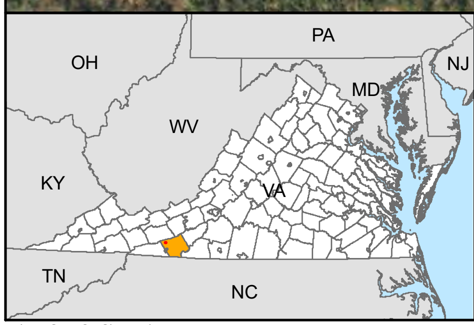
Scale: 1:3,937

AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY

EDGE
ENGINEERING & SCIENCE

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 4
Boat electrofishing 100-meter survey extent in pool habitat in Carroll County, Virginia.



Legend

Boat Electrofishing - 100-meter survey extent

Boat Electrofishing - 100-meter survey extent

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 5
Boat electrofishing 100-meter survey extent in pool habitat in Carroll County, Virginia.

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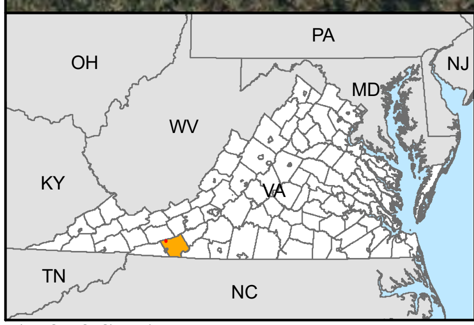


Legend

Boat Electrofishing - 100-meter survey extent

Boat Electrofishing - 100-meter survey extent

N

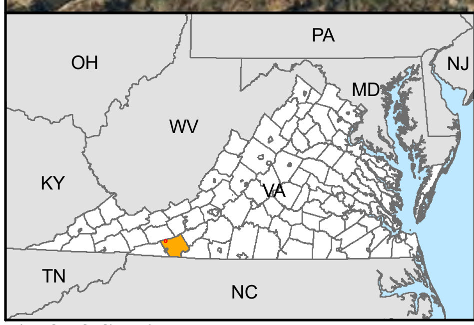
0 50 100

Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 6
Boat electrofishing 100-meter survey extent in pool habitat in Carroll County, Virginia.



Legend

- Boat Electrofishing - 100-meter survey extent
- Boat Electrofishing - 100-meter survey extent

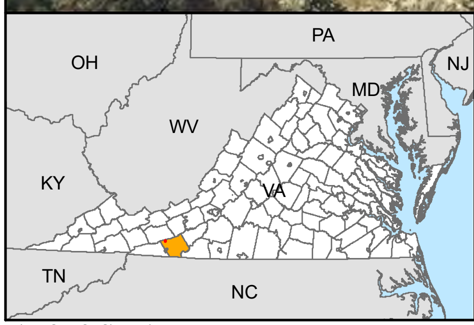
N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 7
Boat electrofishing 100-meter survey extent in pool habitat in Carroll County, Virginia.



Legend

Boat Electrofishing - 100-meter survey extent

Boat Electrofishing - 100-meter survey extent

N

0 50 100

Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 8
Boat electrofishing 100-meter survey extent in pool habitat in Carroll County, Virginia.

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Legend

△ Backpack electrofishing

— Backpack electrofishing

N

0 50 100

Meters

Scale: 1:3,937

AMERICAN ELECTRIC POWER

EDGE ENGINEERING & SCIENCE

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 9
Backpack electrofishing survey extent in riffle habitat in Carroll County, Virginia..

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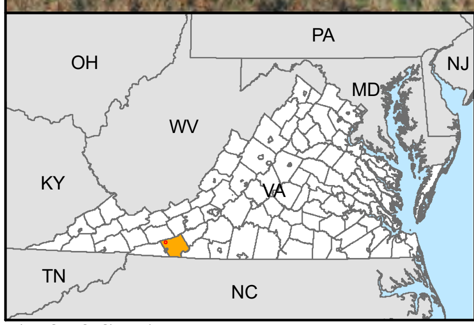

Legend

- ▲ Backpack electrofishing
- — Backpack electrofishing

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 10
Backpack electrofishing survey extent in riffle habitat in Carroll County, Virginia..

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Legend

- △ Backpack electrofishing
- ― Backpack electrofishing

N

0 50 100
Meters

Scale: 1:3,937

AMERICAN ELECTRIC POWER

EDGE ENGINEERING & SCIENCE

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 11
Backpack electrofishing survey extent in riffle habitat in Carroll County, Virginia..

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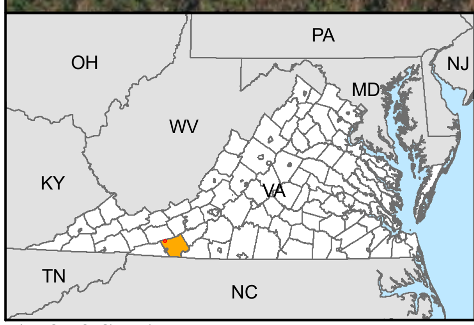

Legend

△ Backpack electrofishing

— Backpack electrofishing

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 12
Backpack electrofishing survey extent in riffle habitat in Carroll County, Virginia..

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Legend

△ Backpack electrofishing

— Backpack electrofishing

N

0 50 100

Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 13
Backpack electrofishing survey extent in riffle habitat in Carroll County, Virginia..

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Legend

- Gillnet - 36.5-meter survey extent (point)
- Gillnet - 36.5-meter survey extent (line)

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 14
Gillnet 36.5-meter survey extent in pool habitat in Carroll County, Virginia.

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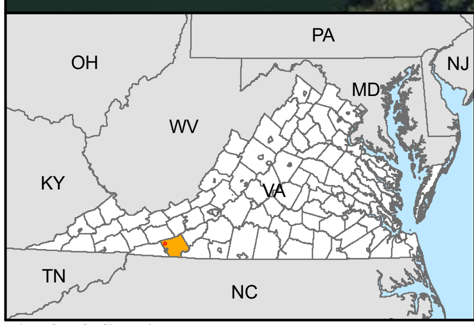


Legend

- Gillnet - 36.5-meter survey extent (point symbol)
- Gillnet - 36.5-meter survey extent (line symbol)

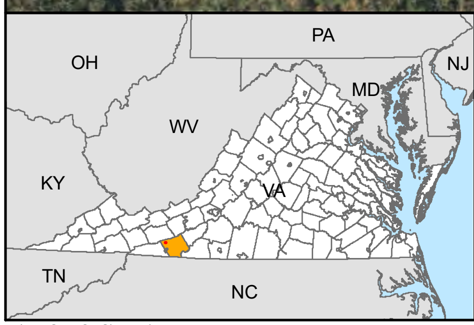
N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 15
Gillnet 36.5-meter survey extent in pool habitat in Carroll County, Virginia.



Legend

- Gillnet - 36.5-meter survey extent
- Gillnet - 36.5-meter survey extent

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Dam Fish Community Study

Figure 16
Gillnet 36.5-meter survey extent in pool habitat in Carroll County, Virginia.

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Appendix A

SCIENTIFIC COLLECTION PERMITS

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)
Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **New** Fee Paid: **$40.00** VADGIF Permit No. **070705**

Permittee: **Jonathan Studio**
Address: **36550 Chester Road, Apt. 4801**
Avon, OH 44011
Email: **jastudio@edge-es.com**

Home:
Office: **(440) 413-4609**
City/County:

Business: **Edge Engineering & Science, LLC**
4005 Ponder Drive
Cincinnati, OH 45245

Niagara Hydroelectric Project/Byllesby-Buck Hydroelectric Project

Authorized Collection Methods: By Hand/Dip Nets/Electrofishing/Gill Nets/Trawl Nets/Nets-Traps (Fyke/Hoop/D-Frame)/Seine Nets/Drift Nets
Authorized Waterbodies: Roanoke River/Tinker Creek/New River
Authorized Marking Techniques: N/A

SPECIAL CONDITIONS: No electrofishing in Roanoke Logperch TOYR unless requested and approved by both USFWS and DWR. Mussels may not be targeted and any inadvertently collected must be returned to the point-of-capture after the individual is identified (if ID is possible).

Permittee MUST notify DWR within the 7 day period prior to each sampling event. Notification must be made via email to: collectionpermits@dwr.virginia.gov

Report Due: 31 January 2022, 31 January 2023

ANNUAL REPORTS MUST BE SUBMITTED VIA: https://vafwis.dgif.virginia.gov/collection_permits/

STANDARD CONDITIONS ATTACHED APPLY TO THIS PERMIT.

Authorized Counties / Cities:
Carroll
Roanoke

Authorized Species:

Description	ID Number	Scientific Name
Aquatic Insects		
Crayfish		
Freshwater Fish		
Other Aquatic Invertebrates		

Annual Report Due End of Each Year

Authorized Sub-Permittees:
See Attached Sheet

Approved by: Randall T. Francis

Title: **Randall T. Francis - Permits Manager**

Date: **3/2/2021**

Applicants may appeal permit decisions within 30 days of issuance. The appeal must be in writing to the Director, Department of Game and Inland Fisheries.

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)
Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **New** Fee Paid: **$40.00** VADGIF Permit No. **070705**

20 Permit Effective **3/2/2021** through **12/31/2022** **22**

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778

(804) 367-1000 (V/TDD)

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **New**	FeePaid: **$40.00**	VADGIF Permit No. **070705**

Authorized Sub-Permittees:

Sarah Messer, Edge Engineering & Science, LLC
John Spaeth, Edge Engineering & Science, LLC
Aaron Prewitt, Edge Engineering & Science, LLC
Adam Benshoff, Edge Engineering & Science, LLC
David Foltz, Edge Engineering & Science, LLC
Mitchell Kriege, Edge Engineering & Science, LLC
Alyssa Jones, Edge Engineering & Science, LLC
David Ford, Edge Engineering & Science, LLC
Tim Brust, Edge Engineering & Science, LLC

Virginia Department of Wildlife Resources

P O Box 3337 Henrico, VA 23228-3337

(804) 367-6913

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

SCIENTIFIC COLLECTION PERMIT – STANDARD CONDITIONS

1. Permits are issued to permittees with the understanding that if the principal permittee leaves the project the permit will be null and void and anyone desiring to continue the activities must apply for a new permit.

2. This permit, or a copy, must be carried by the permittee(s) during collection activities.

3. Permittee MUST notify the Virginia Department of Wildlife Resources (VDWR) within the seven (7) day period prior to EACH sampling event. Notification must be made via email to: collectionpermits@DWR.virginia.gov.)

4. The permittee is required to submit to this Department a report of all specimens collected under this permit by the report due date. Report form may be found at https://vafwis.DWR.virginia.gov/collection_permits/. FAILURE TO RETURN THIS REPORT WILL RESULT IN NON-ISSUANCE OF FUTURE PERMITS. If no activity occurs under this permit, an email should be sent to collectionpermits@DWR.virginia.gov containing the following statement: No activity occurred under Permit #*insert permit ID* during insert year (i.e. 2017). Permit reports are due by January 31.

5. Permittees shall give any and all changes of name, address, and/or phone number to the VDWR Permits Section within no more than seven (7) days of those changes. All permittees (to include sub-permittees) shall provide DWR with a complete home address, contact telephone number (home or cellular), and a valid e-mail address.

6. This permit does not support any activities outside of those associated with the application and proposal submitted to and approved by DWR.

7. No species currently listed by the U.S. Fish and Wildlife Service or VDWR as threatened or endangered may be intentionally collected under this permit. If incidental d*eath or injury* of threatened or endangered species does occur, the permittee is required to notify VDWR at collectionpermits@DWR.virginia.gov within twenty-four (24) hours of occurrence. The following information must be reported: collector, date, species, location (county, quad, waterbody, and latitude and longitude to nearest second), and number collected.

8. If incidental *observation or collection and live release* of threatened or endangered species occurs, the permittee is required to notify VDWR at collectionpermits@DWR.virginia.gov within four (4) working days, providing the same information as the Condition No. 7.

9. If incidental *mortality or injury of specimens intended to be taken live* occurs, the permittee is required to notify VDWR at collectionpermits@DWR.virginia.gov within 48 hours, providing the same information as the above conditions. In addition, the permittee must provide the cause of mortality or injury and steps that are being taken to address the problem.

10. No species may be retained unless specifically authorized by this permit.

11. Game birds/game mammals/game fish protected by State and/or Federal laws must be taken during authorized hunting and trapping seasons and under applicable daily and seasonal bag/number limits by properly licensed persons unless otherwise specifically authorized. A valid Virginia fishing license is required for each person collecting samples by hook-and-line.

12. All traps must be marked with the name and address of the trapper or an identification number issued by VDWR (Code of Virginia §29.1-521.7). Steel foothold traps, Conibear-style body gripping traps, and snares must be marked with a nonferrous metal tag bearing this information (Virginia Administrative Code 4 VAC 15-40-170).

13. All traps must be checked at least once a day and all captured animals removed, except completely submerged body-gripping traps which must be checked at least once every 72 hours (Code of Virginia §29.1-521.9).

14. The permittee is required to report any incidences of wildlife deaths or diseases observed during the course of collection activities. Reports should be made to: collectionpermits@DWR.virginia.gov within four (4) working days.

15. This permit satisfies only VDWR's requirement for collection permits and is issued with the understanding that no collections will be made on Federal, state, or private property without the prior approval and necessary permits from the landowners involved. The permittee is responsible for obtaining any additional permits required for collection.

16. Sampling gear, boats, or trailers which have been used in states harboring zebra mussels must be cleaned and prepared following accepted guidelines for removal of zebra mussels, prior to being used in Virginia.

17. For safety reasons, it is recommended that all permittees display at least 100 square inches of solid blaze orange material at shoulder level within body reach and visible from 360 degrees, especially during hunting season.

Appendix B

REPRESENTATIVE PHOTOGRAPHS

BFB1 - Downstream
Boat Electrofishing Sample Site

BFB2 - Downstream
Boat Electrofishing Sample Site

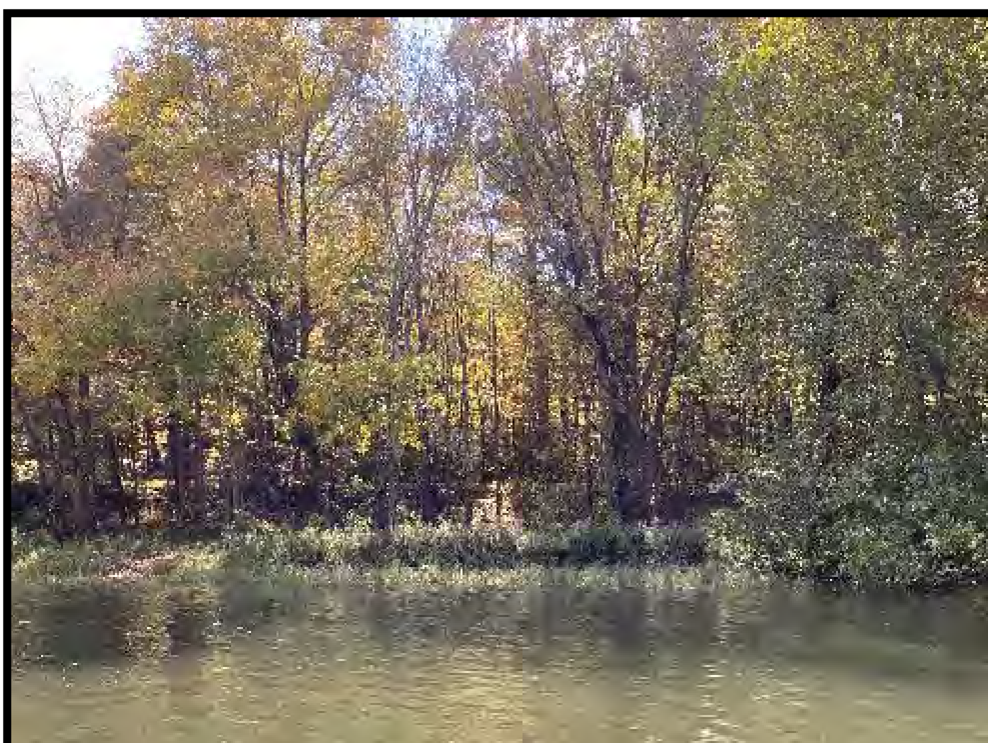
BFB3 - Upstream
Boat Electrofishing Sample Site

BFB4 - Right Descending Bank
Boat Electrofishing Sample Site

BFB5 - Upstream
Boat Electrofishing Sample Site

BFB6 - Right Descending Bank
Boat Electrofishing Sample Site

BFB7 - Downstream
Boat Electrofishing Sample Site

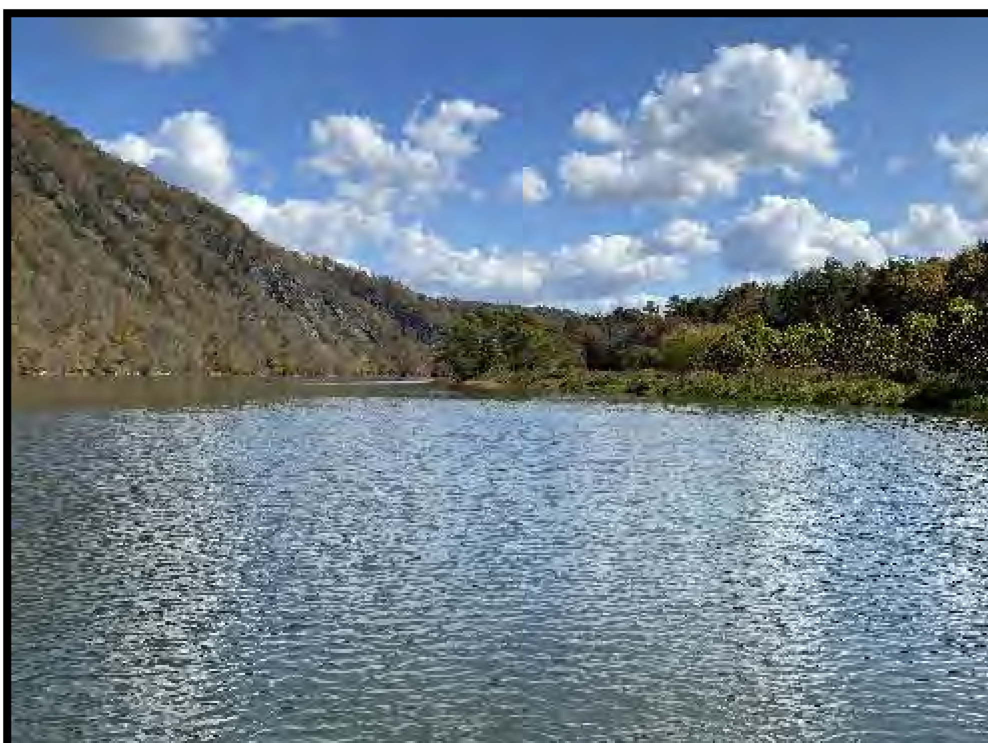


BFB8 - Left Descending Bank
Boat Electrofishing Sample Site

BFB9 - Upstream
Boat Electrofishing Sample Site

BFB10 - Upstream
Boat Electrofishing Sample Site

BFB11 - Upstream
Boat Electrofishing Sample Site



BFB12 - Upstream
Boat Electrofishing Sample Site

BFB13 - Downstream
Boat Electrofishing Sample Site

BFB14 - Right Descending Bank
Boat Electrofishing Sample Site

BFB15 - Downstream
Boat Electrofishing Sample Site

BFB16 - Right Descending Bank
Boat Electrofishing Sample Site

BFB17 - Downstream
Boat Electrofishing Sample Site

BFBP1 - Upstream
Backpack Electrofishing Sample Site

BFBP2 - Downstream
Backpack Electrofishing Sample Site

BFBP3 - Upstream
Backpack Electrofishing Sample Site

BFBP4 - Upstream
Backpack Electrofishing Sample Site

BFBP5 - Downstream
Backpack Electrofishing Sample Site

BFBP6 - Downstream
Backpack Electrofishing Sample Site

BFBP7 - Downstream
Backpack Electrofishing Sample Site

BFBP8 - Upstream
Backpack Electrofishing Sample Site

BFBP9 - Upstream
Backpack Electrofishing Sample Site

BFBP10 - Upstream
Backpack Electrofishing Sample Site

BFBP11 - Upstream
Backpack Electrofishing Sample Site

BFBP12 - Upstream
Backpack Electrofishing Sample Site

BFBP13 - Downstream
Backpack Electrofishing Sample Site

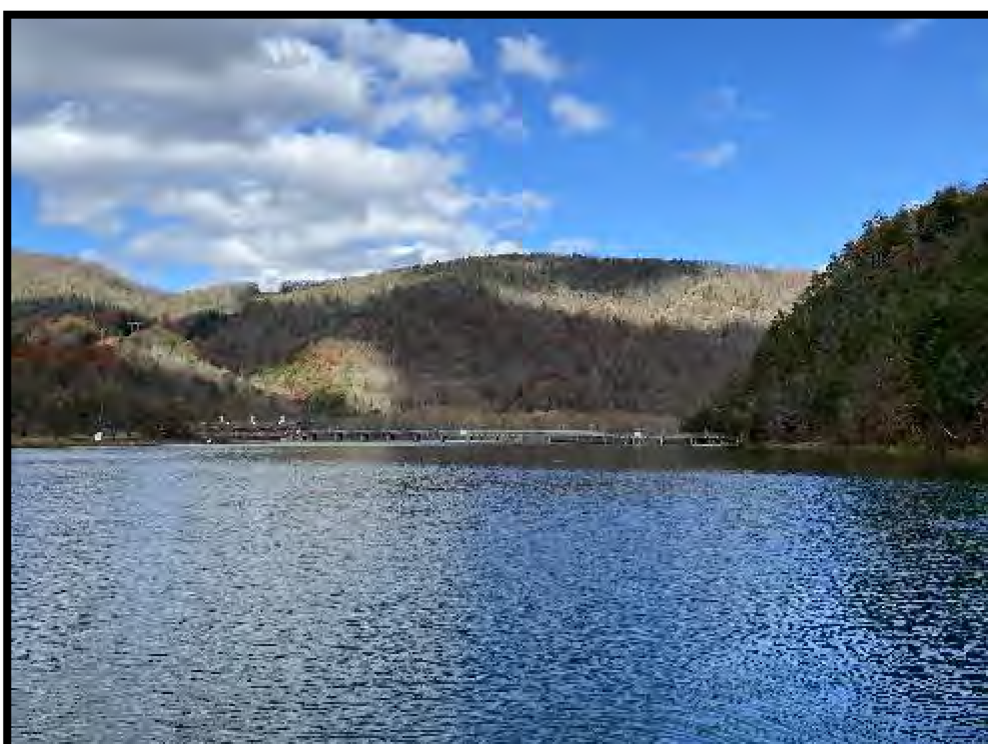
BFG1 – Upstream
Gillnetting Sample Site

BFG2 - Downstream
Gillnetting Sample Site

BFG3 - Left Descending Bank
Gillnetting Sample Site

BFG4 - Downstream
Gillnetting Sample Site

BFG5 - Right Descending Bank
Gillnetting Sample Site



BFG6 - Downstream
Gillnetting Sample Site

Rock Bass
(*Ambloplites rupestris*)

Central Stoneroller
(*Campostoma anomalum*)

White Sucker
(*Catostomus commersonii*)

Kanawha Sculpin
(*Cottus kanawhae*)

Whitetail Shiner
(*Cyprinella galactura*)

Spotfin Shiner
(*Cyprinella spiloptera*)

Common Carp
(*Cyprinus carpio)*

Muskellunge
(*Esox masquinongy*)

Greenside Darter
(*Etheostoma blennioides*)

Fantail Darter
(*Etheostoma flabellare*)

Kanawha Darter
(*Etheostoma kanawhae*)

Northern Hog Sucker
(*Hypentelium nigricans*)

Channel Catfish
(*Ictalurus punctatus*)

Redbreast Sunfish
(*Lepomis auritus*)

Green Sunfish
(*Lepomis cyanellus*)

Pumpkinseed
(*Lepomis gibbosus*)

Bluegill
(*Lepomis macrochirus*)

White Shiner
(*Luxilus albeolus*)

Rosefin Shiner
(*Lythrurus ardens*)

Smallmouth Bass
(*Micropterus dolomieu*)

Spotted Bass
(*Micropterus punctulatus*)

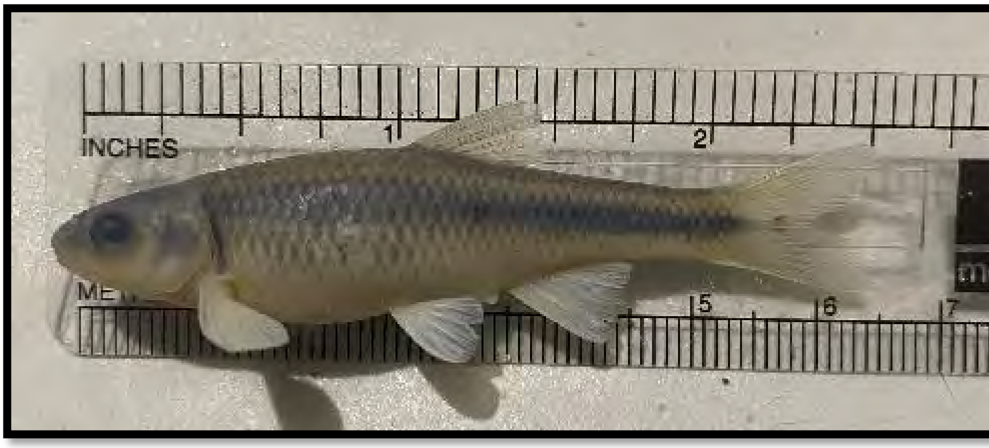
Largemouth Bass
(*Micropterus salmoides*)

Bigmouth Chub
(*Nocomis platyrhynchus*)

Spottail Shiner
(*Notropis hudsonius*)

Swallowtail Shiner
(*Notropis procne*)

Rosyface Shiner
(*Notropis rubellus*)



Saffron Shiner
(*Notropis rubricroceus*)

New River Shiner
(*Notropis scabriceps*)

Telescope Shiner
(*Notropis telescopus*)

Mimic Shiner
(*Notropis volucellus*)

Margined Madtom
(*Noturus insignis*)

Rainbow Trout
(*Oncorhynchus mykiss*)

Logperch
(*Percina caprodes*)

Sharpnose Darter
(*Percina oxyrhynchus*)

Bluntnose Minnow
(*Pimephales notatus*)

Black Crappie
(*Pomoxis nigromaculatus*)

Flathead Catfish
(*Pylodictis olivaris*)

Walleye
(*Sander vitreus*)

Appendix C

RAW DATA

Fish species captured by method (EF = Electrofishing) and Project location (US = Upstream and DS = Downstream). Highlighted cells indicate species exclusively captured using that method or in that location.

Species	Method			Location		
	Boat EF	Backpack EF	Gillnet	US Byllesby	Between Dams	DS Buck
Ambloplites rupestris	X	X	X	X	X	
Campostoma anomalum		X		X	X	X
Catostomus commersonii	X		X	X		
Cottus kanawhae		X				X
Cyprinella galactura	X	X		X	X	X
Cyprinella spiloptera	X	X		X	X	X
Cyprinus carpio	X		X	X	X	
Esox masquinongy	X		X	X		
Etheostoma blennioides	X	X		X	X	X
Etheostoma flabellare	X	X			X	X
Etheostoma kanawhae		X			X	
Hypentelium nigricans	X	X			X	X
Ictalurus punctatus	X		X	X	X	
Lepomis auritus	X	X		X	X	X
Lepomis cyanellus	X			X	X	
Lepomis gibbosus	X				X	
Lepomis macrochirus	X		X	X	X	
Lepomis sp.	X	X		X	X	X
Luxilus albeolus		X				X
Lythrurus ardens	X				X	
Micropterus dolomieu	X	X	X	X	X	X
Micropterus punctulatus	X			X	X	
Micropterus salmoides	X			X	X	
Nocomis platyrhynchus	X	X		X	X	
Nocomis sp.	X	X		X	X	
Notropis hudsonius	X				X	
Notropis procne	X				X	
Notropis rubellus	X	X		X	X	X
Notropis rubricroceus		X			X	
Notropis scabriceps	X	X		X	X	X
Notropis telescopus	X	X		X	X	X
Notropis volucellus	X	X		X	X	
Noturus insignis		X			X	X
Oncorhynchus mykiss	X			X		
Percina caprodes	X	X			X	X
Percina oxyrhynchus		X			X	X
Pimephales notatus	X				X	
Pomoxis nigromaculatus	X		X	X		
Pylodictis olivaris	X	X	X	X	X	
Sander vitreus			X	X		
Total Number of Exclusive Species	9	7	1	5	7	2

Water quality parameters at boat electrofishing sites in fall 2020 (BFB site names) and spring 2021 (BSB site names). Sites above the dashed line are in Byllesby Pool and below dashed line are in Buck Pool.

Date	Site ID	Water Temp. (C)	pH	DO (%)	Velocity (m/s)	Conductivity (us/cm)
10/25/2020	BFB1	16.3	7.2	87.3	0.05	65.8
10/25/2020	BFB2	16.3	7.2	87.3	0.09	65.8
10/25/2020	BFB3	16.5	7.0	88.1	0.03	55.2
10/24/2020	BFB4	16.1	7.3	96.9	0.03	55.0
10/25/2020	BFB5	15.0	7.5	95.2	0.05	52.2
10/24/2020	BFB6	16.4	7.5	87.9	0.02	56.4
10/24/2020	BFB7	16.4	7.5	87.9	0.02	56.4
4/25/2021	BSB1	10.1	7.6	99.0	0.12	58.6
4/25/2021	BSB2	10.1	7.6	99.0	0.06	58.6
4/25/2021	BSB3	9.6	7.0	97.8	0.06	59.8
4/25/2021	BSB4	9.6	7.0	97.8	0.06	59.8
4/25/2021	BSB5	9.6	7.3	100.2	0.04	50.3
4/25/2021	BSB6	9.7	7.0	102.3	0.09	59.4
4/25/2021	BSB7	9.7	7.0	102.3	0.09	59.4
10/22/2020	BFB8	15.9	7.9	105.3	0.08	67.1
10/22/2020	BFB9	15.9	7.4	104.6	0.08	55.2
10/22/2020	BFB10	15.9	7.4	104.6	0.06	55.2
10/22/2020	BFB11	14.5	7.5	99.3	0.03	65.5
10/22/2020	BFB12	15.5	7.5	107.2	0.02	66.5
10/22/2020	BFB13	14.5	7.5	99.3	0.03	65.6
10/22/2020	BFB14	14.5	7.5	99.3	0.02	65.6
10/22/2020	BFB15	14.4	6.8	97.7	0.02	51.6
10/22/2020	BFB16	14.4	6.8	97.7	0.02	51.6
10/22/2020	BFB17	14.4	6.8	97.7	0.02	51.6
5/27/2021	BSB8	26.8	7.9	97.5	0.09	31.5
5/27/2021	BSB9	26.8	7.9	97.5	0.09	31.5
5/27/2021	BSB10	26.8	7.9	97.5	0.09	31.5
5/27/2021	BSB11	26.8	7.9	97.5	0.09	31.5
5/27/2021	BSB12	26.8	7.9	97.5	0.09	31.5
5/27/2021	BSB13	25.1	8.1	93.2	0.03	35.0
5/27/2021	BSB14	25.1	8.1	93.2	0.03	35.0
5/27/2021	BSB15	25.1	8.1	93.2	0.03	35.0
4/26/2021	BSB16	11.5	7.4	95.9	0.08	58.2
4/26/2021	BSB17	11.5	7.4	95.9	0.08	58.2

Boat electrofishing results (total number of fish) from Byllesby Pool in fall 2020 (BFB site names; left of solid line) and spring 2021 (BSB site names; right of solid line).

Common Name	**Species**	**BFB1**	**BFB2**	**BFB3**	**BFB4**	**BFB5**	**BFB6**	**BFB7**	**BSB1**	**BSB2**	**BSB3**	**BSB4**	**BSB5**	**BSB6**	**BSB7**	**Total**	**Rel. Abund.**
Rock Bass	*Ambloplites rupestris*	1	-	-	-	-	1	-	1	-	-	-	-	-	-	3	1.2%
White Sucker	*Catostomus commersonii*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	0.4%
Whitetail Shiner	*Cyprinella galactura*	1	1	-	-	-	-	4	-	-	-	-	-	-	4	10	4.1%
Spotfin Shiner	*Cyprinella spiloptera*	-	-	-	-	-	-	-	-	-	-	3	-	-	-	3	1.2%
Common Carp	*Cyprinus carpio*	-	1	-	-	6	-	-	-	-	-	-	-	-	1	8	3.3%
Muskellunge	*Esox masquinongy*	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	0.8%
Redbreast Sunfish	*Lepomis auritus*	3	2	-	3	-	5	6	1	-	-	2	-	-	2	24	9.8%
Green Sunfish	*Lepomis cyanellus*	2	-	-	-	-	-	-	8	1	-	1	-	-	-	12	4.9%
Bluegill	*Lepomis macrochirus*	9	15	-	2	-	-	1	3	4	-	-	-	1	2	37	15.2%
Sunfish	*Lepomis sp.*	4	-	-	1	-	-	3	7	4	1	1	-	-	-	21	8.6%
Smallmouth Bass	*Micropterus dolomieu*	6	1	-	1	-	3	2	4	-	-	1	-	1	-	19	7.8%
Spotted Bass	*Micropterus punctulatus*	-	1	-	-	-	-	1	-	-	-	-	-	-	-	2	0.8%
Largemouth Bass	*Micropterus salmoides*	-	1	-	-	-	1	1	-	1	-	-	1	1	3	9	3.7%
Rosyface Shiner	*Notropis rubellus*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	0.4%
New River Shiner	*Notropis scabriceps*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	0.4%
Telescope Shiner	*Notropis telescopus*	-	-	-	-	-	-	-	-	-	-	72	-	-	-	72	29.5%
Mimic Shiner	*Notropis volucellus*	-	-	-	-	-	-	-	-	-	9	5	-	-	-	14	5.7%
Rainbow Trout	*Oncorhynchus mykiss*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	0.4%
Black Crappie	*Pomoxis nigromaculatus*	-	-	-	-	1	-	-	1	-	-	-	-	-	-	2	0.8%
Flathead Catfish	*Pylodictis olivaris*	-	-	-	1	-	-	-	-	-	-	-	-	1	-	2	0.8%
	Total	26	22	0	8	7	10	18	25	10	12	88	2	4	12	**244**	
	Rel. Abund.	10.7%	9.0%	0.0%	3.3%	2.9%	4.1%	7.4%	10.2%	4.1%	4.9%	36.1%	0.8%	1.6%	4.9%		

Boat electrofishing results (total number of fish) from Buck Pool in fall 2020 (BFB site names; left of solid line) and spring 2021 (BSB site names; right of solid line).

Common Name	**Species**	**BFB8**	**BFB9**	**BFB10**	**BFB11**	**BFB12**	**BFB13**	**BFB14**	**BFB15**	**BFB16**	**BFB17**	**BSB8**	**BSB9**	**BSB10**	**BSB11**	**BSB12**	**BSB13**	**BSB14**	**BSB15**	**BSB16**	**BSB17**	**Total**	**Rel. Abund.**
Rock Bass	*Ambloplites rupestris*	-	1	1	-	-	-	1	-	-	-	3	1	2	2	-	2	3	5	-	-	21	5.9%
Whitetail Shiner	*Cyprinella galactura*	4	7	-	-	-	6	5	7	-	-	8	2	-	-	2	-	-	-	-	-	41	11.6%
Spotfin Shiner	*Cyprinella spiloptera*	1	3	-	-	-	-	-	-	-	-	3	-	-	-	1	-	-	-	-	-	8	2.3%
Common Carp	*Cyprinus carpio*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	3	0.8%
Greenside Darter	*Etheostoma blennioides*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	0.3%
Fantail Darter	*Etheostoma flabellare*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	0.3%
Northern Hog Sucker	*Hypentelium nigricans*	-	3	1	-	1	-	-	-	-	-	13	2	-	-	-	-	-	-	-	-	20	5.7%
Channel Catfish	*Ictalurus punctatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.3%
Redbreast Sunfish	*Lepomis auritus*	-	-	1	1	-	6	1	-	1	-	1	18	7	4	-	9	16	29	2	6	102	28.9%
Green Sunfish	*Lepomis cyanellus*	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	2	1	1	7	2.0%
Pumpkinseed	*Lepomis gibbosus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	0.3%
Bluegill	*Lepomis macrochirus*	-	1	1	-	-	1	-	-	-	-	1	2	-	-	2	1	3	-	17	2	31	8.8%
Rosefin Shiner	*Lythrurus ardens*	1	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1.1%
Smallmouth Bass	*Micropterus dolomieu*	-	1	-	5	-	3	2	-	1	-	11	11	6	2	1	9	11	7	2	-	72	20.4%
Spotted Bass	*Micropterus punctulatus*	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	2	-	3	-	8	2.3%
Largemouth Bass	*Micropterus salmoides*	-	-	1	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	2	2	8	2.3%
Bigmouth Chub	*Nocomis platyrhynchus*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.3%
Chub	*Nocomis sp.*	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.6%
Spottail Shiner	*Notropis hudsonius*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.3%
Swallowtail Shiner	*Notropis procne*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.3%
New River Shiner	*Notropis scabriceps*	1	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	11	3.1%
Logperch	*Percina caprodes*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	0.3%
Bluntnose Minnow	*Pimephales notatus*	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5	1.4%
Flathead Catfish	*Pylodictis olivaris*	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	2	0.6%
	Total	9	18	6	7	4	16	9	7	3	0	55	43	17	9	7	23	35	43	30	12	**353**	
	Rel. Abund.	2.5%	5.1%	1.7%	2.0%	1.1%	4.5%	2.5%	2.0%	0.8%	0.0%	15.6%	12.2%	4.8%	2.5%	2.0%	6.5%	9.9%	12.2%	8.5%	3.4%		

Diversity (H’ = Shannon diversity index) of the fish community by location within the Project area. Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam. CPUE is individuals per minute for electrofishing (EF) and individuals per net set for gillnetting.

Method	Location	Abundance	Richness	Diversity (H')	Evenness	Effort	CPUE
Boat EF	US Byllesby	244	20	2.32	0.77	91.4	2.7
Backpack EF	US Byllesby	48	11	1.92	0.80	27.8	1.7
Gillnet	US Byllesby	112	10	1.43	0.62	24.0	4.7
Boat EF	Between Dams	353	24	2.26	0.71	136.0	2.6
Backpack EF	Between Dams	156	18	1.97	0.68	45.9	3.5
Backpack EF	DS Buck	206	17	1.98	0.70	27.0	7.6

Water quality parameters at backpack electrofishing sites in spring 2021. Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam.

Date	Site ID	Water Temp. (C)	pH	DO (%)	Velocity (m/s)	Conductivity (us/cm)
4/20/2021	BSBP1	13.5	7.9	105.4	0.82	56.6
4/20/2021	BSBP2	12.6	7.7	100.4	0.33	58.8
4/20/2021	BSBP3	14.4	8.0	100.6	0.30	56.7
4/21/2021	BSBP4	13.7	7.6	95.6	0.17	57.7
4/21/2021	BSBP5	13.7	7.4	93.2	0.48	57.9
4/23/2021	BSBP6	6.9	7.6	102.8	0.40	58.8
4/23/2021	BSBP7	9.5	7.6	99.5	0.46	58.5
4/21/2021	BSBP8	13.8	7.5	101.6	0.71	57.8
4/21/2021	BSBP9	13.8	7.5	101.6	0.10	57.8
4/22/2021	BSBP10	13.0	7.9	99.3	0.08	57.6
4/22/2021	BSBP11	10.4	7.7	108.0	0.17	38.2
4/23/2021	BSBP12	11.0	7.8	105.7	0.19	64.4
4/23/2021	BSBP13	11.2	7.9	101.3	0.44	60.0

Backpack electrofishing results (total number of fish) from upstream of Byllesby Dam.

Common Name	Species	BSBP1	BSBP2	BSBP3	Total	Rel. Abund.
Rock Bass	*Ambloplites rupestris*	1	-	3	4	8.3%
Central Stoneroller	*Campostoma anomalum*	-	-	1	1	2.1%
Whitetail Shiner	*Cyprinella galactura*	1	1	17	19	39.6%
Greenside Darter	*Etheostoma blennioides*	3	-	-	3	6.3%
Redbreast Sunfish	*Lepomis auritus*	-	-	1	1	2.1%
Smallmouth Bass	*Micropterus dolomieu*	2	-	3	5	10.4%
Bigmouth Chub	*Nocomis platyrhynchus*	2	-	-	2	4.2%
Chub	*Nocomis sp.*	-	-	2	2	4.2%
Rosyface Shiner	*Notropis rubellus*	-	-	8	8	16.7%
Mimic Shiner	*Notropis volucellus*	-	-	2	2	4.2%
Flathead Catfish	*Pylodictis olivaris*	1	-	-	1	2.1%
	Total	10	1	37	**48**	
	Rel. Abund.	20.8%	2.1%	77.1%		

Backpack electrofishing results (total number of fish) from between Byllesby Dam and Buck Dam.

Common Name	Species	BSBP4	BSBP5	BSBP6	BSBP7	BSBP8	BSBP9	Total	Rel. Abund.
Rock Bass	*Ambloplites rupestris*	-	1	-	1	-	-	2	1.3%
Central Stoneroller	*Campostoma anomalum*	-	2	1	-	1	-	4	2.6%
Whitetail Shiner	*Cyprinella galactura*	-	-	20	-	3	-	23	14.7%
Greenside Darter	*Etheostoma blennioides*	-	1	-	-	-	-	1	0.6%
Fantail Darter	*Etheostoma flabellare*	-	1	6	11	1	-	19	12.2%
Kanawha Darter	*Etheostoma kanawhae*	1	-	-	-	-	-	1	0.6%
Northern Hog Sucker	*Hypentelium nigricans*	-	-	2	-	1	-	3	1.9%
Sunfish	*Lepomis sp.*	-	-	-	-	-	1	1	0.6%
Smallmouth Bass	*Micropterus dolomieu*	2	1	-	2	2	4	11	7.1%
Bigmouth Chub	*Nocomis platyrhynchus*	-	2	-	-	-	3	5	3.2%
Chub	*Nocomis sp.*	-	-	3	1	-	-	4	2.6%
Rosyface Shiner	*Notropis rubellus*	-	-	1	-	4	-	5	3.2%
Saffron Shiner	*Notropis rubricroceus*	-	-	-	1	-	-	1	0.6%
New River Shiner	*Notropis scabriceps*	-	-	1	-	-	-	1	0.6%
Telescope Shiner	*Notropis telescopus*	-	-	8	-	60	-	68	43.6%
Mimic Shiner	*Notropis volucellus*	-	-	2	-	-	-	2	1.3%
Margined Madtom	*Noturus insignis*	1	1	1	1	-	-	4	2.6%
Sharpnose Darter	*Percina oxyrhynchus*	-	1	-	-	-	-	1	0.6%
	Total	4	10	45	17	72	8	**156**	
	Rel. Abund.	2.6%	6.4%	28.8%	10.9%	46.2%	5.1%		

Backpack electrofishing results (total number of fish) from below Buck Dam.

Common Name	**Species**	**BSBP10**	**BSBP11**	**BSBP12**	**BSBP13**	**Total**	**Rel. Abund.**
Central Stoneroller	*Campostoma anomalum*	22	36	-	1	59	28.6%
Kanawha Sculpin	*Cottus kanawhae*	1	-	1	6	8	3.9%
Whitetail Shiner	*Cyprinella galactura*	11	8	4	-	23	11.2%
Spotfin Shiner	*Cyprinella spiloptera*	-	-	1	-	1	0.5%
Greenside Darter	*Etheostoma blennioides*	-	3	1	1	5	2.4%
Fantail Darter	*Etheostoma flabellare*	-	-	6	-	6	2.9%
Northern Hog Sucker	*Hypentelium nigricans*	-	-	2	1	3	1.5%
Redbreast Sunfish	*Lepomis auritus*	-	-	-	1	1	0.5%
Sunfish	*Lepomis sp.*	-	-	-	3	3	1.5%
White Shiner	*Luxilus albeolus*	1	-	1	-	2	1.0%
Smallmouth Bass	*Micropterus dolomieu*	-	1	2	1	4	1.9%
Rosyface Shiner	*Notropis rubellus*	-	-	1	-	1	0.5%
New River Shiner	*Notropis scabriceps*	-	1	-	-	1	0.5%
Telescope Shiner	*Notropis telescopus*	42	3	8	-	53	25.7%
Margined Madtom	*Noturus insignis*	2	8	13	10	33	16.0%
Logperch	*Percina caprodes*	1	-	-	-	1	0.5%
Sharpnose Darter	*Percina oxyrhynchus*	1	1	-	-	2	1.0%
	Total	81	61	40	24	**206**	
	Rel. Abund.	39.3%	29.6%	19.4%	11.7%		

Water quality parameters at gillnet sites in Byllesby Pool in fall 2020 (BFG site names; above solid line) and spring 2021 (BSG site names; below solid line).

Date	Site ID	Water Temp. (C)	pH	Velocity (m/s)	Conductivity (us/cm)
11/18/2020	BFG1	6.5	7.1	0.11	37.7
11/9/2020	BFG2	10.8	7.2	0.05	62.4
11/18/2020	BFG3	6.6	7.3	0.05	37.5
11/9/2020	BFG4	10.9	6.8	0.04	62.6
11/18/2020	BFG5	6.0	7.6	0.04	36.7
11/9/2020	BFG6	11.4	6.8	0.04	61.5
4/22/2021	BSG1	9.8	7.5	0.12	60.2
4/20/2021	BSG2	12.1	7.5	0.05	59.1
4/22/2021	BSG3	10.2	7.5	0.04	59.1
4/20/2021	BSG4	12.1	7.5	0.05	59.0
4/22/2021	BSG5	10.9	7.5	0.05	59.2
4/20/2021	BSG6	12.5	7.5	0.04	59.9

Gillnet results (total number of fish) from Byllesby Pool in fall 2020 (BFG site names; left of solid line) and spring 2021 (BSG site names; right of solid line).

Common Name	**Species**	**BFG1**	**BFG2**	**BFG3**	**BFG4**	**BFG5**	**BFG6**	**BSG1**	**BSG2**	**BSG3**	**BSG4**	**BSG5**	**BSG6**	**Total**	**Rel. Abund.**
Rock Bass	*Ambloplites rupestris*	-	-	-	-	-	-	-	-	3	-	-	-	3	2.7%
White Sucker	*Catostomus commersonii*	-	-	1	-	1	1	-	-	3	1	2	-	9	8.0%
Common Carp	*Cyprinus carpio*	-	2	9	-	3	-	-	-	34	5	5	-	58	51.8%
Muskellunge	*Esox masquinongy*	-	-	-	-	-	-	-	-	1	-	-	-	1	0.9%
Channel Catfish	*Ictalurus punctatus*	-	-	1	-	-	10	-	1	2	-	5	8	27	24.1%
Bluegill	*Lepomis macrochirus*	-	-	1	-	-	-	-	-	-	-	-	-	1	0.9%
Smallmouth Bass	*Micropterus dolomieu*	-	1	-	-	-	-	-	-	-	-	-	-	1	0.9%
Black Crappie	*Pomoxis nigromaculatus*	-	-	-	-	-	-	-	-	-	-	1	-	1	0.9%
Flathead Catfish	*Pylodictis olivaris*	-	-	-	-	-	1	-	-	-	-	1	-	2	1.8%
Walleye	*Sander vitreus*	-	1	1	-	4	-	-	-	1	-	2	-	9	8.0%
	Total	0	4	13	0	8	12	0	1	44	6	16	8	**112**	
	Rel. Abund.	0.0%	3.6%	11.6%	0.0%	7.1%	10.7%	0.0%	0.9%	39.3%	5.4%	14.3%	7.1%		

Comparison of methods used (EF = Electrofishing) and number of sites and samples in each Project area (US = Upstream and DS = Downstream) between the current relicensing study and the previous relicensing study.

Area	Method	Current Study			Appalachian and AEP 1991		
		Number of Sites	Samples per Site	Total	Number of Sites	Samples per Site	Total
US Byllesby	Pool EF	7	2	14	6	6	36
	Riffle EF	3	1	3	2	6	12
	Gillnet	6	2	12	6	6	36
	Hoop Net	-	-	-	6	6	36
Between Dams	Pool EF	10	2	20	6	6	36
	Riffle EF	6	1	6	2	6	12
	Hoop Net	-	-	-	6	6	36
DS Buck	Riffle EF	4	1	4	2	6	12
		36	Total Samples	59	36	Total Samples	216

Riffle EF only occurred during spring 2021 sampling due to high flows and safety concerns during fall 2020 sampling period.

Abundance, average length, and average weight of each species captured throughout the Project area in fall 2020 and spring 2021.

Common Name	Scientific Name	Count	Average Length (mm)	Average Weight (g)	Rel. Abund.
Rock Bass	*Ambloplites rupestris*	33	97.3	34.4	2.9%
Central Stoneroller	*Campostoma anomalum*	64	91.8	9.9	5.7%
White Sucker	*Catostomus commersonii*	10	404.5	825.0	0.9%
Kanawha Sculpin	*Cottus kanawhae*	8	86.9	9.1	0.7%
Whitetail Shiner	*Cyprinella galactura*	116	56.8	2.3	10.4%
Spotfin Shiner	*Cyprinella spiloptera*	12	58.0	2.2	1.1%
Common Carp	*Cyprinus carpio*	69	406.2	1158.0	6.2%
Muskellunge	*Esox masquinongy*	3	538.7	820.0	0.3%
Greenside Darter	*Etheostoma blennioides*	10	61.3	2.6	0.9%
Fantail Darter	*Etheostoma flabellare*	26	53.2	1.7	2.3%
Kanawha Darter	*Etheostoma kanawhae*	1	41.0	1.4	0.1%
Northern Hog Sucker	*Hypentelium nigricans*	26	111.4	17.3	2.3%
Channel Catfish	*Ictalurus punctatus*	28	374.9	580.1	2.5%
Redbreast Sunfish	*Lepomis auritus*	128	82.6	18.8	11.4%
Green Sunfish	*Lepomis cyanellus*	19	97.3	22.8	1.7%
Pumpkinseed	*Lepomis gibbosus*	1	112.0	21.1	0.1%
Bluegill	*Lepomis macrochirus*	69	60.4	8.7	6.2%
Sunfish	*Lepomis sp.*	25	58.1	5.6	2.2%
White Shiner	*Luxilus albeolus*	2	88.5	8.3	0.2%
Rosefin Shiner	*Lythrurus ardens*	4	36.3	0.4	0.4%
Smallmouth Bass	*Micropterus dolomieu*	112	111.8	34.1	10.0%
Spotted Bass	*Micropterus punctulatus*	10	80.7	6.8	0.9%
Largemouth Bass	*Micropterus salmoides*	17	185.9	255.2	1.5%
Bigmouth Chub	*Nocomis platyrhynchus*	8	105.5	24.2	0.7%
Chub	*Nocomis sp.*	8	61.4	2.7	0.7%
Spottail Shiner	*Notropis hudsonius*	1	83.0	4.3	0.1%
Swallowtail Shiner	*Notropis procne*	1	62.0	1.8	0.1%
Rosyface Shiner	*Notropis rubellus*	15	51.5	1.2	1.3%
Saffron Shiner	*Notropis rubricroceus*	1	66.0	2.7	0.1%
New River Shiner	*Notropis scabriceps*	14	44.9	0.9	1.3%
Telescope Shiner	*Notropis telescopus*	193	54.2	1.5	17.2%
Mimic Shiner	*Notropis volucellus*	18	47.8	1.1	1.6%
Margined Madtom	*Noturus insignis*	37	70.4	3.9	3.3%
Rainbow Trout	*Oncorhynchus mykiss*	1	490.0	1250.0	0.1%
Logperch	*Percina caprodes*	2	114.0	12.5	0.2%
Sharpnose Darter	*Percina oxyrhynchus*	3	90.7	5.8	0.3%
Bluntnose Minnow	*Pimephales notatus*	5	54.0	3.6	0.4%
Black Crappie	*Pomoxis nigromaculatus*	3	146.7	41.9	0.3%
Flathead Catfish	*Pylodictis olivaris*	7	283.1	754.4	0.6%
Walleye	*Sander vitreus*	9	342.4	356.7	0.8%

The raw data from the 2020-2021 Byllesby-Buck Fish Community Survey is included as a Microsoft Excel spreadsheet.

Filed separately: "**Byllesby-Buck_General Fish Community Raw Data.xlsx"**

Attachment 2

Attachment 2 – Fish Impingement and Entrainment Study Report

Fish Impingement and Entrainment Study Report

Byllesby-Buck Hydroelectric Project (FERC No. 2514)

November 17, 2021

Prepared by:

HDR

Prepared for:

Appalachian Power Company

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Acronyms and Abbreviations

ADCP	acoustic Doppler current profiler
AEP	American Electric Power
Appalachian or Licensee	Appalachian Power Company
AOI	Area of Influence
CFR	Code of Federal Regulations
cfs	cubic feet per second
EPRI	Electric Power Research Institute
FERC or Commission	Federal Energy Regulatory Commission
fps	feet per second
ft	feet/foot
hr	Hour
ILP	Integrated Licensing Process
ISR	Initial Study Report
m	meter
PM&E	protection, mitigation, and enhancement
Project	Byllesby-Buck Hydroelectric Project
RM	river mile
RSP	Revised Study Plan
SPD	Study Plan Determination
TBSA	Turbine Blade Strike Analysis
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USR	Updated Study Report
VDGIF	Virginia Department of Game and Inland Fisheries
VDWR	Virginia Department of Wildlife Resources

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1 Project Introduction and Background

1.1 Introduction

Appalachian Power Company (Appalachian or Licensee), a unit of American Electric Power (AEP), is the Licensee, owner, and operator of the two-development Byllesby-Buck Hydroelectric Project (Project) (Project No. 2514), located on the upper New River in Carroll County, Virginia. The Byllesby Development is located about 9 miles north of the city of Galax, and the Buck Development is located approximately 3 river miles (RM) downstream of Byllesby and 43.5 RM upstream of Claytor Dam.

The Project is currently licensed by the Federal Energy Regulatory Commission (FERC or Commission). The Project underwent relicensing in the early 1990s, including conversion to run-of-river operations and incorporating additional protection, mitigation, and enhancement (PM&E) measures. The current operating license for the Project expires on February 29, 2024. Accordingly, Appalachian is pursuing a subsequent license for the Project pursuant to the Commission's Integrated Licensing Process (ILP), as described at 18 Code of Federal Regulations (CFR) Part 5. In accordance with FERC's regulations at 18 CFR §16.9(b), the licensee must file its final application for a new license with FERC no later than February 28, 2022.

In accordance with 18 CFR §5.11, Appalachian developed a Revised Study Plan (RSP) for the Project that was filed with the Commission and made available to stakeholders on October 18, 2019. On November 18, 2019 FERC issued the Study Plan Determination (SPD). On December 18, 2019, Appalachian filed a request for rehearing of the SPD. The SPD was subsequently modified by FERC by an Order on Rehearing dated February 20, 2020.

On July 27, 2020, Appalachian filed an updated ILP study schedule and a request for extension of time to file the Initial Study Report (ISR) to account for Project delays resulting from the COVID-19 pandemic. The request was approved by FERC on August 10, 2020, and the filing deadline for the ISR for the Project was extended from November 17, 2020 to January 18, 2021. Appalachian conducted a virtual ISR Meeting on January 28, 2021 and filed the ISR Meeting summary with the Commission on February 12, 2021. Stakeholders provided written comments in response to Appalachian's filing of the ISR meeting summary, which are addressed in this Updated Study Report (USR) along with study methods and results.

Appalachian has conducted studies in accordance with 18 CFR §5.15, as provided in the RSP and as subsequently modified by FERC. This USR describes the methods and results of the Fish Impingement and Entrainment Study conducted in support of preparing an application for new license for the Project.

1.2 Background

A desktop entrainment study was conducted for the Project during the previous relicensing (Appalachian 1991a). Electric Power Research Institute (EPRI) data, project characteristics, as well as the behavioral and life history characteristics and preferred habitat of the resident fish were used to assess entrainment potential. The fish species and life stages likely to be entrained are those most likely to occur in forebay areas within the area of influence of the intake structure.

Several of the species in the Centrarchidae family (black basses and sunfishes) and the Ictaluridae family (catfishes) prefer habitat types with structure and cover, such as rocks, logs, stumps, and aquatic vegetation. These species are also generally nest or cavity spawners, depositing adhesive or demersal eggs in beds created by males and often guarded until hatching. Unless these habitats are found within the forebay of the dams and near the intake structures, it is unlikely that these species, regardless of life stage, would occur in the vicinity of the Project intakes, thus minimizing their potential for entrainment. Exceptions to this may include White Crappie (*Pomoxis annularis*) or Black Crappie (*P. nigromaculatus*); which construct nests in the littoral zone, but developing larvae are pelagic until they mature into the juvenile stage and move inshore (Rohde et al. 2009). Habitat generalists, pelagic species, or benthic species may be more likely to occur within the forebay areas, such as clupeids (ex. Gizzard Shad [*Dorosoma cepedianum*]), cyprinids (shiners, minnows, chubs, or carp), catostomids (suckers), or moronids (temperate basses). Some of these species, such as clupeids and some cyprinids, are broadcast spawners. Broadcast spawners, unlike nesting centrarchids, scatter or release eggs in the water column where they can be carried into the intake, and thus are more susceptible to entrainment. However, even if fish larvae and eggs become entrained through the Project, it is unlikely that turbine passage would cause harm under optimal design conditions and if cavitation is not excessive (Appalachian 1991b).

Muskellunge (*Esox masquinongy*) is a popular game fish and a species of interest for the Virginia Department of Wildlife Resources (VDWR) in terms of stocking as well as scientific research (VDWR 2020). The susceptibility of Muskellunge to entrainment at the Project likely varies throughout the year due to variations in predatory behavior (Cook and Solomon 1987). Immediately following spawning in the spring and through midsummer, Muskellunge typically exhibit crepuscular prey-seeking behaviors at a variety of water depths and across a range of habitat types; as such, Muskellunge may enter the forebay area in pursuit of forage fish (i.e., pelagic species). In late summer, Muskellunge become sedentary ambush predators with a strong association with vegetated areas. Although Muskellunge may occur in the forebay area during certain times of year, the age and size (and subsequent swimming ability) at which they would be seeking forage fish (i.e., older/larger individuals), would likely allow them to avoid entrainment into the turbines (EPRI 2000).

Appalachian (1991b) determined that, for juvenile or larger fish potentially drawn into the facility turbines, the occurrence of pressure changes, turbulence, shear, and cavitation would be minimal and unlikely to cause substantial harm. Additionally, the study concluded that fish likely swim against the current as they enter through the stay vanes and wicket gates and, therefore, are unlikely to contact the vanes perpendicularly.

The Appalachian (1991b) study also evaluated the probability of contact with a runner blade based on the Byllesby and Buck turbine dimensions and concluded that the probability of collision with runner blades was less than five percent for most species, particularly for the smaller fish exhibiting the greatest likelihood of entrainment. Mortality would, therefore, be lower than five percent, assuming blade strikes can range from slight glancing blows to head-on collisions. Considering behavioral characteristics, habitat preferences (including spawning habitat), and life-history characteristics of resident fish species, the prior study concluded that the likelihood of substantial numbers of fish occurring in the forebays was minimal and the potential for entrainment effects was expected to be low (Appalachian 1991b). Further, angled-bar trash-racks with close spacing, such as those installed at the Project developments, are a common protection measure in place at hydroelectric projects to reduce entrainment. Based on the results of the previous entrainment study and accounting for the trash racks already installed at the Project intakes, Appalachian does not propose any additional measures to address impingement and entrainment. Appalachian expects to operate the Project in the existing run-of-river mode and with the existing minimum flows and ramping rate. Operating the Project in this manner provides a relatively stable reservoir elevation and protects shoreline stability and water quality for the benefit of fish and other resources.

1.3 Proposed Turbine Unit Upgrades

During the new license term, Appalachian proposes to modernize the Byllesby and Buck developments to include replacement of Byllesby Units 1, 2 and 4 and Buck Units 1 and 3. All but one (Buck Unit 2) of the seven turbine-generator units installed at the Project are the original major components of the Project as constructed in 1912. The existing vertical Francis units would be replaced by fixed blade Kaplan units. Unit upgrade activities would be confined to within the powerhouse, and there would be minimal changes to operating parameters for the Project. Following completion of the upgrades, the authorized installed capacities for the Byllesby and Buck developments will be 20.85 MW and 10.39 MW, respectively, with maximum hydraulic capacities of 5,511 cfs and 3,570 cfs, respectively. Due to efficiencies of the Kaplan units and modern components, the upgrades are expected to increase average annual generation at the Project by approximately 25,927 MWh.

Given the regulatory context, project background, and considering the planned upgrades from Francis to Kaplan turbines, this study report presents a desktop evaluation of entrainment potential for the two-development Project that involves reexamining and updating (as applicable) certain aspects of the prior evaluations of entrainment potential at the intake structures and evaluating blade strike probabilities under existing and proposed turbine design and operating conditions.

2 Study Goals and Objectives

In accordance with Appalachian's October 18, 2019 RSP and the Commission's November 18, 2019 SPD for the Project, the goal of this study is to verify or update certain aspects pertaining to the Project operations and to examine entrainment potential at the two-development Project. Additionally, planned unit upgrades are proposed for both Byllesby and Buck developments, which would influence the results of the turbine blade strike analysis. Therefore, the study objectives were updated to incorporate additional scenarios using the proposed design and operations of the developments with the new turbines installed.

The study objectives are to:

- Confirm flow velocities at the Byllesby and Buck dam intake structures located to facilitate a desktop assessment of entrainment and impingement potential at the Project.
- Perform an updated desktop review of entrainment potential at the Project during hydropower generation.
- Perform a blade strike evaluation of the existing and proposed turbine configurations at the two-development Project using the U.S. Fish and Wildlife Service (USFWS) Turbine Blade Strike Analysis Model (2020). This model is a probabilistic Excel-based Visual Basic for Applications implementation of the methods outlined by Franke et al. (1997) for evaluating fish mortalities due to turbine entrainment.

3 Study Area

The study area includes the lower reach of the Reservoir located just upstream of each of the two developments as shown in Figure 3-1 and Figure 3-2.

Figure 3-1. Fish Impingement and Entrainment Analysis Study Area for the Byllesby Development Intake at the Byllesby-Buck Hydroelectric Project

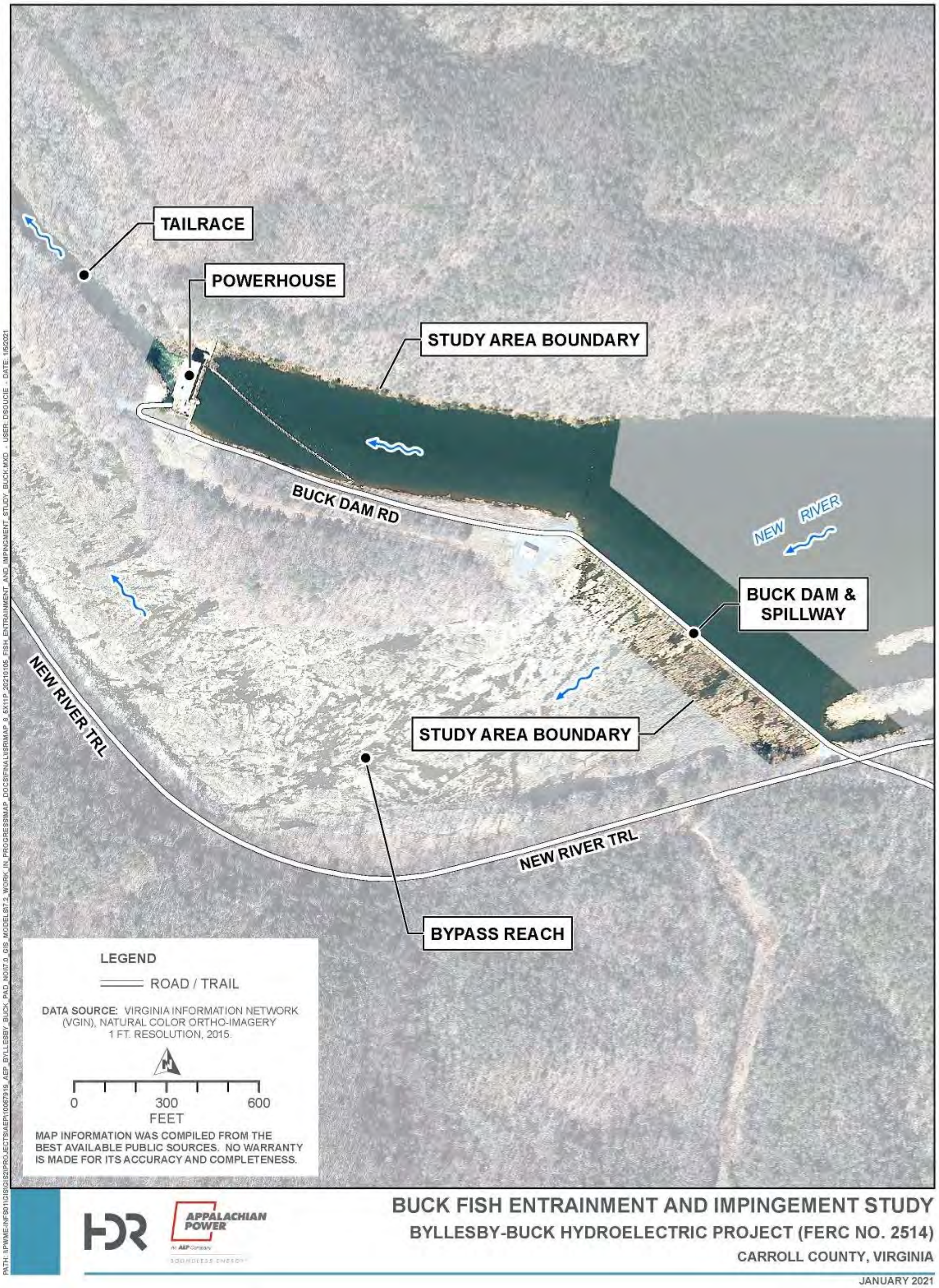


Figure 3-2. Fish Impingement and Entrainment Analysis Study Area for the Buck Development Intake at the Byllesby-Buck Hydroelectric Project

4 Methodology

4.1 Intake Structure, Velocities, and Turbine Characteristics

The physical specifications of the turbines and each intake structure at the Project developments were compiled and used to calculate velocities at the intake structures. Approach velocities (i.e., at a point approximately one foot upstream of the trashracks) were calculated using site-specific intake dimensions. Per the Project RSP and Commission's SPD, intake velocities would be measured using an acoustic Doppler current profiler (ADCP) along the upstream face of the angled trash racks to determine the approximate approach velocity immediately upstream of the intake structure. During the 2020 field season, a combination of high flow events and inoperable units prevented field data collection efforts. As a result, approach velocity was calculated using the intake structure and trash rack dimensions along with the design maximum flow capacity of the generating units.

4.2 Desktop Review of Impingement and Entrainment Potential

The potential for fish to become entrained or impinged at a hydroelectric facility is dependent on a variety of factors such as fish life history, size and swimming ability, water quality, operating regimes, inflow, and intake/turbine configurations (Cada et al. 1997). Impingement occurs when a fish is held against or entrapped on the exterior intake structure screen (i.e., trash racks) due to forces created by the intake velocities. Entrainment occurs when the fish passes through the trash racks and is withdrawn into the intake structure.

The potential for fish entrainment is variable throughout a given year depending on species periodicity, life stage and body size, and project-specific operations. Early life stage and smaller-sized fish may be more abundant during certain portions of the year, thus increasing their susceptibility to entrainment. In addition, diurnal and seasonal movements of both small and large fish may bring them in close proximity to intake structures. Physical and operational characteristics of a given project, including trash rack bar spacing, intake velocities, intake depth, waterbody stratification, and intake proximity to feeding and rearing habitats also affect the potential for a fish to become entrained. These factors were used to make general assessments of entrainment and impingement potential at the Project using a desktop study approach.

A targeted species list was developed based on recent (Appalachian 2021) and historical (Appalachian 1991b) fish community studies, as well as a species list developed by the former Virginia Department of Games and Inland Fisheries (VDGIF), recently renamed the Virginia Department of Wildlife Resources (VDWR), for the New River at the time of the historical fish community study (Appalachian 1991). The list includes consideration of fish community composition and abundance of the New River and any other species of interest to or under protection of state and/or federal agencies, or with angler significance. Selected species were evaluated for potential of entrainment and impingement based on swim speed, behavior, habitat preferences, life stages, and seasonal or temperature-dependent behavioral changes in relation to Project design and operations.

4.2.1 Intake Avoidance and Impingement Risk

Intake avoidance and impingement was considered at both intakes based on the calculated approach velocities and 2.28-inch clear bar spacing of trash racks at each of the Project developments. This process involved comparing fish swim speeds with calculated intake velocities, as well as estimating minimum fish lengths that would be excluded or impinged by the trash racks for each of the target fish species. A scaling factor relating fish length to body width was used for the impingement assessment to determine minimum sizes of the target fish species that would physically be excluded by the trash racks (Smith 1985).

4.2.2 Fish Entrainment Potential

4.2.2.1 Fish Entrainment Rate Calculation

A database developed by EPRI (1997) provides detailed results of fish entrainment studies from 43 hydroelectric projects. This database was designed specifically to facilitate the desktop analysis of available data to assess entrainment and impingement impacts at a hydroelectric facility.

Although some facilities included in the EPRI database may not match the exact specifications of the developments at the Project, using as many data points as possible from the EPRI database allows the analysis to account for the natural variability of aquatic ecosystems and fish populations, while providing a robust dataset for calculating average monthly entrainment rates for a wide range of species. This is a commonly applied approach in desktop entrainment evaluations and has been readily accepted by FERC in relicensing efforts for other Projects.

Site characteristics (i.e., reservoir size, usable storage, plant capacity, operating mode, average velocity at trash racks, trash rack spacing) and available data (i.e., entrainment data, collection efficiency) were reviewed for applicability to the Project using the EPRI (1997) database. Entrainment data from five facilities were eliminated for having trash rack clear bar spacing that was considerably wider (e.g., double the clear spacing) than specifications at the Project. Therefore, data from 33 facilities were retained for use in this analysis with the understanding that entrainment rates developed for the Project would be conservative (i.e., overestimated) since some fish species may be excluded by the trash racks at the Project, which have a narrower open bar spacing than many of the facilities in the EPRI database (Appendix A).

The EPRI (1997) entrainment database provides results from field studies conducted at hydroelectric facilities using full-flow tailrace netting by placing a conical net in the immediate tailrace to collect the entire discharge on a seasonal or monthly basis. This results in the calculation of entrainment rates (fish/volume of water if recorded, or fish/hour (hr)/cubic feet per second [cfs] of sampled unit capacity), including the number, species, and size of entrained fish.

The studies included in the EPRI (1997) database recorded number of hours sampled and hydraulic capacity of the sampled units. Using this information, data was standardized to the number of fish/hr of unit capacity, and then used to calculate fish entrainment rates (fish/hr) at maximum turbine discharge at the Projects based on existing development-specific turbine design capacity (5,868 cfs for the Byllesby Development and 3,540 cfs for the Buck Development). Entrainment rates were calculated and summarized by month, season (winter = December, January, and February; spring = March, April, and May; summer = June, July, and August; and fall = September, October, and November) and annually.

4.2.2.2 Qualitative Turbine Entrainment Risk

While the use of the EPRI (1997) database provides a means to quantitatively estimate entrainment risk at the Project at multiple time scales (i.e., month, season, year) based on empirical data collected at comparable hydroelectric projects; it is important to note that the resultant entrainment rate estimates do not consider the other site-specific factors likely to influence species-specific entrainment risk at the Project. Various comprehensive reviews of entrainment and mortality data (FERC 1995) as well as fish behavior relative to turbine passage (Coutant and Whitney 2000) suggest that one or more factors may influence the risk of turbine entrainment or mortality.

Therefore, an additional traits-based qualitative assessment modified from Cada and Schweizer (2012) of entrainment risk at the Project was performed that ranks entrainment risk as low, moderate, or high based upon break points in relative entrainment risk. The overall risk categories are defined as:

- Low: species-life stage is generally not present in the forebay; utilizes shallow, shoreline habitats away from the intake structures; and/or not susceptible to approach intake velocities
- Moderate: species-life stage may routinely or seasonally occupy the forebay or utilize habitats near the intake structures; and some life stages/ages may be susceptible to intake velocities
- High: pelagic species that reside or spawn in or near the forebay and intake structures and are susceptible to intake velocities, species with life stages that are expected to reside in the forebay or encounter intake structures during seasonal activities, and species-life stages that broadcast spawn buoyant eggs in open waters in lake or reservoir habitats

These qualitative risk categories were utilized to describe entrainment potential of the target fish species on a monthly basis. A matrix of monthly Project entrainment risk for the target species was constructed using the empirical seasonal entrainment rates estimated from the EPRI (1997) database using maximum turbine discharge frequency (full generation), swim burst speed comparison to intake velocities, size exclusion by trash racks, species periodicity, abundance, habitat utilization, migratory behavior, and expected distributions.

4.2.2.3 Turbine Blade Strike and Spillway Survival Assessment

The turbine blade strike evaluation used the most recent version of the Turbine Blade Strike Analysis (TBSA) Model created by the USFWS (2020), which is a probabilistic Excel-based Visual Basic for Applications implementation of the methods outlined by Franke et al. (1997) for evaluating fish mortalities due to turbine entrainment, as well as through non-turbine routes. The TBSA tool allows for the estimation of turbine passage and survival based on mortality from blade strikes based on site-specific information (i.e., turbine type, number of units, bar rack spacing, etc.) and length distributions for target species. Using the model, fish can be subjected up to 20 hazards, or routes, including 3 turbine types and bypasses, incorporating the Franke et al. (1997) equations into a Monte Carlo simulation that produces estimates of blade strike (mortalities) and passage (survival) probabilities for turbine and non-turbine pathways.

The TBSA tool was used to model the downstream passage survival under two operational scenarios for each of the Project developments: 1) fish that are subject to dam passage through the powerhouse and turbines, and required bypass flow only, or 2) fish that are subject to dam passage through the powerhouse and turbines or the spillway leading into the bypass channel. The probability of a fish passing through a turbine or via spill was assumed to be in direct proportion to the volume of flow passing through each route. A spillway and bypass passage survival rate of 97 percent was assumed based on the average of 136 survival tests conducted with juvenile salmonids on the Columbia river (Amaral et al. 2013).

Flow exceedance percentile data were reviewed to determine the volume of spillage at the range of percentiles where river discharge exceeded turbine capacity. Downstream passage survival was estimated by the model for each spillage scenario.

Two scenarios were evaluated for existing conditions at each Project development and rerun for proposed conditions (proposed turbine upgrades) at each Project development:

1. Typical/normal conditions (i.e., no spill beyond required bypass minimum flow)
    a. Byllesby existing condition:
        i. Routes: Turbine Units 1 through 4, each with 25 percent of flow (1,467 cfs/unit).
        ii. Fish size classes: 2, 4, 6, 8, 10, 15, 20, 25, and 30 inches.
    b. Byllesby proposed condition:
        i. Routes: Three Kaplan (Proposed Kaplan) turbine Units with 24.7 percent of flow each (1,348 cfs/unit and a single existing Francis (Existing Francis) turbine unit with 26.0 percent flow (1,467 cfs).
        ii. Fish size classes: 2, 4, 6, 8, 10, 15, 20, 25, and 30 inches.
    c. Buck existing condition:
        i. Routes: Turbine Units 1 through 3, each with 33 percent of flow (1,180 cfs/unit).
        ii. Fish size classes: 2, 4, 6, 8, 10, 15, 20, 25, and 30 inches.
    d. Buck proposed condition
        i. Routes: Two Proposed Kaplan turbine units (1,195 cfs/unit) and one Existing Francis turbine unit (1,180 cfs); each with 33 percent of flow.
        ii. Fish size classes: 2, 4, 6, 8, 10, 15, 20, 25, and 30 inches.
2. Spilling conditions - Flow exceedance percentile data were reviewed to determine the volume of spillage at the range of percentiles where river discharge exceeded turbine capacity. A downstream passage survival estimate was calculated for each spillage scenario and based on the average length of Walleye collected in the 2020 – 2021 Fish Community Survey (Appalachian 2021) conducted in the Project area.
    a. Byllesby existing condition:
        i. Routes: Turbine Units 1 through 4, each with equal amounts of flow (1,467 cfs/unit) and spillage at 4, 3, 2, and 1 percent exceedance.
        ii. The fish length inputs (mean=13.5 inches and standard deviation=1.5 inches) were taken from the Walleye collected in the 2020 – 2021 Fish Community Survey (Appalachian 2021) conducted in the Project area.
    b. Byllesby proposed condition:

   i. Routes: Three Kaplan (Proposed Kaplan) turbine Units with 24.7 percent of flow each (1,348 cfs/unit and a single existing Francis (Existing Francis) turbine unit with 26.0 percent flow (1,467 cfs) and spillage at 4, 3, 2, and 1 percent exceedance.
   ii. The fish length inputs (mean=13.5” and standard deviation=1.5”) were taken from the Walleye collected in the 2020 – 2021 Fish Community Survey (Appalachian 2021) conducted in the Project area.

c. Buck existing condition:
   i. Route: Turbine Units 1 through 3, each at 1,180 cfs/unit and spillage at 12, 10, 8, 6, 4, 2, and1 percent exceedance.
   ii. The fish length inputs (mean=13.5 inch and standard deviation=1.5 inch) were taken from the Walleye collected in the 2020 – 2021 Fish Community Survey (Appalachian 2021) conducted in the Project area.

d. Buck proposed condition:
   i. Route: Two Proposed Kaplan turbine units (1,195 cfs/unit) and one Existing Francis turbine unit (1,180 cfs) and spillage at 12, 10, 8, 6, 4, 2, and1 percent exceedance.
   ii. The fish length inputs (mean=13.5 inch and standard deviation=1.5 inch) were taken from the Walleye collected in the 2020 – 2021 Fish Community Survey (Appalachian 2021) conducted in the Project area.

5 Study Results

5.1 Intake Structure, Velocities, and Turbine Characteristics

Pursuant to the SPD, Appalachian compiled information on the key physical characteristics, identified from Project drawings, along with operational information (intake flows and pathways) associated with the Project. These data are summarized in the following sections and were used to calculate intake velocities for the Byllesby and Buck developments.

5.1.1 Byllesby Development

5.1.1.1 Intake Specifications and Flows

The Byllesby intake, located immediately upstream of the powerhouse, consists of four inlet bays. Each bay has a 14-ft-high by 23-ft-wide headgate, which is used during maintenance periods. A 3-ft-wide, reinforced-concrete pier is set vertically in the middle of each inlet bay to support the headgate. Each headgate is closed and opened by a gear and screw lift shaft assembly powered by an electric motor. Each bay admits water to a concrete volute casing, which channels flow to a vertical-shaft Francis hydraulic turbine direct-connected to a generator on the upper level of the powerhouse. Flow through the four turbines passes to concrete draft tubes and into the New River on the downstream side of the powerhouse.

The intake structure at the Byllesby development is approximately 143 ft wide and is equipped with 3/8-inch by 3.5-inch rectangular steel bars. The bars are 47.5 ft long and are inclined toward the powerhouse at approximately 15 degrees. The bars are spaced 2.66 inches center-to-center and have a clear space of 2.28 inches.

The design maximum flow capacity of the four existing generating units at Byllesby development is 1,420 cfs each, for a total existing plant capacity of 5,868 cfs. An evaluation of U.S. Geological Survey (USGS) gage data (USGS 03165500 New River at Ivanhoe) from February 1996 to August 2020 showed that average monthly river flows rarely exceed total plant capacity (Figure 5-1); however, spillage to the bypass (reflecting opportunity for maximum operations) may occur up to eight percent of the time during winter and spring months (January to April) for average flow years, and up to 59 percent of the time during wet years (see Appendix A of the Updated Study Report [Bypass Reach Flow and Aquatic Habitat Study Report] for additional spillage information).

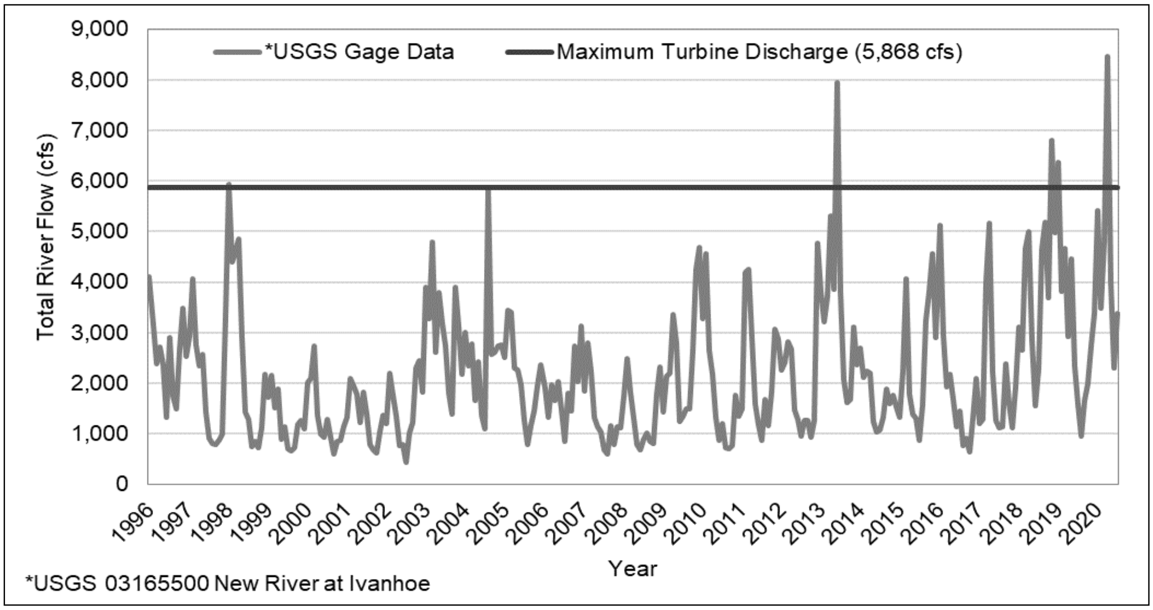


Figure 5-1.USGS 03165500 Gage Data versus Maximum Turbine Discharge (5,868 cfs) at Byllesby Development

5.1.1.2 Turbine Specifications

A summary of the turbine design and operational specifications for the existing conditions and proposed conditions (after replacement of 3 Francis units with 3 Kaplan units) for the Byllesby Development is provided in Table 5-1.

Table 5-1. Turbine Design and Operational Specifications for the Byllesby Development

Term	Units	Description	Byllesby (Existing)	Byllesby (Proposed)	
Turbines	(#)	Number of Turbines	4	3	1
Blades	(#)	Number of blades on the turbine runner	16	5	16
Type	(-)	Francis, Kaplan, propeller, or bypass	Vertical shaft Francis	Kaplan	Vertical shaft Francis
Net Head	(ft)	Net head on the turbine; headwater to tailwater, less head loss through system	56	54	56
Runner Dia. at Discharge	(ft)	Diameter at the outlet of the runner (typically before the draft tube; see Figure 4.3.2-3 in Franke et al., 1997)	9.8	--	9.8
Runner Dia. at Inlet	(ft)	Diameter at the intake of the runner (typically beyond the guide vanes)	8.8	--	8.8
Runner Diameter	(ft)	Nominal diameter of runner; maximum radius is assumed to be half of diameter	7.52	8.70	7.52
Runner Height	(ft)	Runner height at inlet	3.06	--	3.06

Term	Units	Description	Byllesby (Existing)	Byllesby (Proposed)	
Speed	(rpm)	Runner revolutions per minute	116	189.5	116
Turbine Discharge (Q)	(cfs)	Hydraulic capacity or discharge for each turbine	1,467	1,348	1,467
Turbine Efficiency	(-)	Ratio of output shaft power to input fluid power; typ. from vendor curves or index testing	0.89	0.917	0.89
Turbine $Discharge_{OPT}$	(cfs)	Turbine discharge at optimal efficiency	1,120	1,248	1,120
Percent Discharge at Opt. Efficiency	%	Ratio of turbine discharge at best efficiency to hydraulic capacity	79.0%	92%	79.0%
Swirl Coefficient	(-)	Ratio between Q or turbine discharge (cfs) with no exit swirl and Q_{OPT} (recommended x=1.1 for Francis turbines)	1.1	--	1.1
Model Routes		Unit 1, Unit 2, Unit 3, Unit 4, spillway At the Byllesby Project replacement of three existing Francis units with Kaplan units is proposed, one of the original Francis units will be retained for a total of 4 units.			
Bypass spill mortality		A spillway and bypass passage survival rate of 97 percent (3 percent mortality) was assumed based on the average of 136 survival tests conducted with juvenile salmonids on the Columbia river (Amaral et al. 2013).			

5.1.1.3 Intake Velocities

The approach velocity was calculated by determining the area of influence (AOI) directly in front of the headgate opening and dividing that area into the maximum turbine discharge capacity. For existing turbine conditions at Byllesby, it was assumed that the height of the AOI is approximately 150 percent of the headgate opening height (i.e., 14-ft x 1.5) and the width was based on the width of the intake structure (i.e., 143 ft). As a result, the calculated approach velocity in front of the intake structure is approximately 2.0 ft per second (fps) (i.e., 5,868 cfs / (143 ft x 14 ft x 1.5)). This approach velocity is within the range estimated for the previous relicensing effort (Appalachian 1991). This velocity is also comparable to the range of river velocities measured at riffle/run complexes above and below the project (Appalachian 1991). Because no substantial changes have occurred in this area of the New River since the last relicensing, flow conditions in these areas are expected to be the similar to historical conditions. Therefore, it is likely that fish in the vicinity of the intake can navigate intake flows similar to normal river conditions.

Under the proposed turbine upgrade conditions, a reduction in turbine capacity from 5,868 to 5,511 cfs would reduce the intake approach velocity to 1.84 fps (i.e., 5,511 cfs / (143 ft x 14 ft x 1.5)). The anticipated reduction to intake velocity would provide a further reduction in the susceptibility of fish to entrainment or impingement at the Byllesby intake.

5.1.2 Buck Development

5.1.2.1 Intake Specifications and Flows

The Buck intake section, which is immediately upstream of the powerhouse, is of concrete construction and consists of three inlet bays. Each bay has a 14-ft-high by 23-ft-wide headgate which is used during maintenance periods. A 3-ft-wide, reinforced-concrete pier is set vertically in the middle of each inlet bay to support the headgate. Each gate is operated by a gear and threaded lift shaft assembly powered by an electric motor. The bays admit water to a concrete volute casing, which channels flow to a vertical-shaft Francis hydraulic turbine, direct-connected to a generator on the upper level of the powerhouse. Flow through the three turbines passes to concrete draft tubes and into the New River downstream of the powerhouse.

The Buck intake structure is approximately 104 ft wide and is equipped with 3/8-inch by 3.5-inch rectangular steel bars. The screen is 39.2 ft high and is inclined toward the powerhouse at approximately 15 degrees to the vertical. The bars are spaced 2.66 inches center-to-center and have a clear space of 2.28 inches.

The design maximum flow capacity of the three existing generating units at the Buck Development is 1,180 cfs each, for a total existing plant capacity of 3,540 cfs. An evaluation of USGS gage data (USGS 03165500 New River at Ivanhoe) from February 1996 to August 2020 showed that average monthly river flows regularly exceed plant capacity, indicating opportunity for maximum operation at Buck. An evaluation of spillage to the bypass reach suggests that maximum operations could occur up to 25 percent of the time in an average year during the wetter months (January to May), and up to 98 percent of the time during wet years (see Appendix A of the USR [Bypass Reach Flow and Aquatic Habitat Study Report] for additional spillage information).

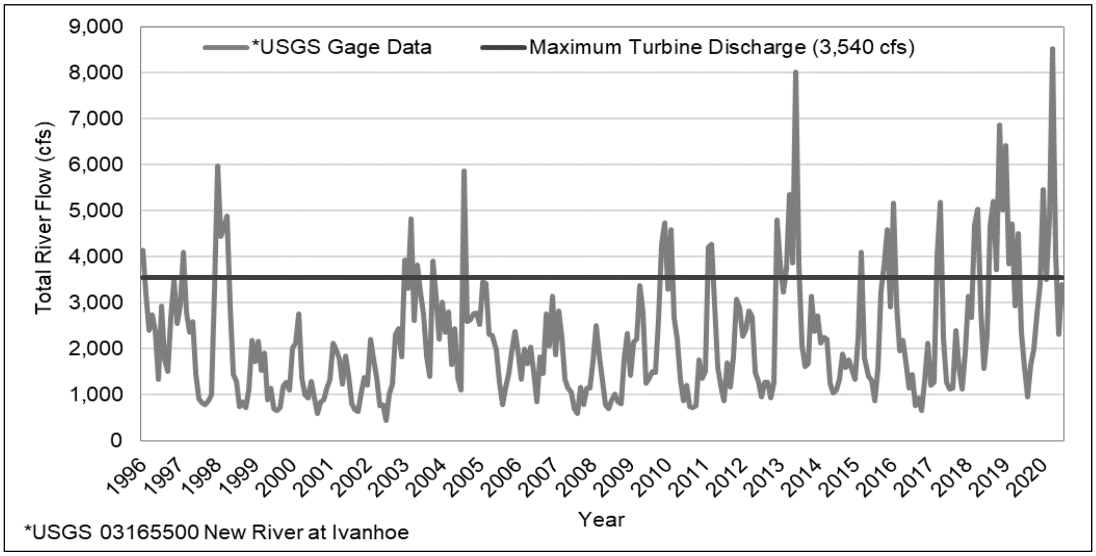


Figure 5-2. USGS 03165500 Gage Data versus Maximum Turbine Discharge (3,540 cfs) at Buck Development Hydroelectric Project

5.1.2.2 Turbine Specifications

A summary of the turbine design and operational specifications for the existing conditions and proposed conditions (after replacement of 2 Francis units with 2 Kaplan units) for the Buck Development is provided in Table 5-2.

Table 5-2. Turbine Design and Operational Specifications for the Buck Development

Term	Units	Description	Buck (Existing)	Buck (Proposed)	
Turbines	*(#)*	Number of Turbines	3	2	1
Blades	*(#)*	Number of blades on the turbine runner	16	5	16
Type	*(-)*	Francis, Kaplan, propeller, or bypass	Vertical shaft Francis	Kaplan	Vertical shaft Francis
Net Head	(ft)	Net head on the turbine; headwater to tailwater, less head loss through system	40	42.4	40
Runner Dia. at Discharge	*(ft)*	Diameter at the outlet of the runner (typically before the draft tube; see Figure 4.3.2-3 in Franke et al., 1997)	9.8	--	9.8
Runner Dia. at Inlet	*(ft)*	Diameter at the intake of the runner (typically beyond the guide vanes; see Figure 4.3.2-3 in Franke et al., 1997)	8.8	--	8.8
Runner Diameter	*(ft)*	Nominal diameter of runner; maximum radius is assumed to be 1/2 of diameter	7.52	8.7	7.52
Runner Height	*(ft)*	Runner height at inlet (see Figure 4.3.2-3 in Franke et al., 1997 for clarification)	3.06	--	3.06

Term	Units	Description	Buck (Existing)	Buck (Proposed)	
Speed	*(rpm)*	Runner revolutions per minute (model automatically converts to radians per second)	97	156.5	97
Turbine Discharge (Q)	*(cfs)*	Hydraulic capacity or turbine discharge	1,180	1,195	1,180
Turbine Efficiency	*(-)*	Ratio of output shaft power to input fluid power; typically, from vendor curves or index testing	0.85	0.92	0.85
Turbine $Discharge_{OPT}$	*(cfs)*	Turbine discharge at optimal efficiency	956	930	956
Percent Discharge at Opt. Efficiency	%	Ratio of turbine discharge at best efficiency to hydraulic capacity	90%	77.8	90.0%
Swirl Coefficient	*(-)*	Ratio between Q or turbine discharge (cfs) with no exit swirl and Q_{OPT} (recommended x=1.1 for Francis turbines)	1.1	--	1.1
Model Routes		Unit 1, Unit 2, Unit 3, spillway At the Buck Project replacement of two Francis units with Kaplan units is proposed, one of the existing Francis units will be retained for a total of 3 units.			
Bypass/Spillway Mortality		A spillway and bypass passage survival rate of 97 percent (3 percent mortality) was assumed based on the average of 136 survival tests conducted with juvenile salmonids on the Columbia river (Amaral et al. 2013).			

5.1.2.3 Intake Velocities

The approach velocity was calculated by determining the AOI directly in front of the headgate opening and dividing that area into the maximum turbine discharge capacity. For Buck, it was assumed that the height of the AOI is approximately 150 percent of the headgate opening height (i.e., 14-ft x 1.5) and the width was based on the width of the intake structure (i.e., 104 ft). As a result, the calculated approach velocity in front of the intake structure is approximately 1.6 fps (i.e., 3,540 cfs / (104 ft x 14 ft x 1.5)). This approach velocity is within the range calculated in the historical report (Appalachian 1991). This velocity is also within range of river velocities measured at various locations during the prior fish community study (Appalachian 1991). Because no substantial changes have occurred in this area of the New River since the last relicensing and conditions are not anticipated to have changed, it is likely that fish in the vicinity of the intake can navigate intake flows similarly as expected normal river conditions.

Under the proposed turbine upgrade conditions, a change in turbine capacity from 3,540 cfs to 3,570 cfs would result in a fractional increase in the intake approach velocity from 1.6 to 1.63 fps (i.e., 3,570 cfs / (143 ft x 14 ft x 1.5)). The anticipated small increase in the intake approach velocity is not expected to result in a measurable change to the susceptibility of fish to entrainment or impingement at the Buck intake; as such, most fish in the vicinity of the intake are still expected to avoid intake approach velocities.

5.2 Desktop Review of Impingement and Entrainment Potential

5.2.1 Fish Community and Target Species

A Fish Community Study was performed by Edge Engineering and Science, LLC (EDGE) at the Project between October 2020 and May 2021 to characterize the New River fishery in the vicinity of the Project, details of the methods and results of the study are presented in the Byllesby Buck 2020-2021 Fish Community Survey Report (Appalachian 2021), see Attachment 1 to Appendix C. Boat electrofishing surveys were conducted between October 22 and 24-25, 2020, and April 25-26 and May 27, 2021. Backpack electrofishing surveys were conducted between April 20-23, 2021 and gillnet surveys were performed between November 9-11 and 18-20, 2020 and April 20-24, 2021. All surveys followed methods outlined in the RSP and occurred during relatively low-flow and clear stream conditions. Sampling was performed by EDGE's fish biologists under Virginia Scientific Collecting Permit No. 070705. Results of physiochemical data collected at sample sites met the state water quality standards established for the New River, indicating that water quality within the Project area is capable of supporting fish communities.

The Project is in a rural area within a relatively large watershed, which may contribute to potential issues pertaining to water quality and habitat degradation in this portion of the New River that are independent of the Project. Byllesby and Buck dams influence habitat availability in the Project area, which determines species diversity and distribution by impounding the existing riffle and run habitats and creating the pool habitats now present in the Project reservoirs. However, study data demonstrate that the habitats available within the Project area support a relatively healthy and diverse fish community.

Between fall 2020 and spring 2021, a total of 404 fish from 26 species were collected upstream of Byllesby Dam from seven boat electrofishing sites (244 fish from 20 species), six gillnet sites (112 fish from 10 species), and three backpack electrofishing sites (sampled spring 2021, 48 fish from 11 species). Five species were collected exclusively upstream of Byllesby Dam.

Between fall 2020 and spring 2021, a total of 509 fish representing 33 species were collected between Byllesby Dam and Buck Dam from 10 boat electrofishing sites (353 fish from 24 species) and six backpack electrofishing sites sampled during spring 2021 (156 fish from 18 species). Seven species were collected exclusively between Byllesby Dam and Buck Dam.

A total of 206 fish, representing 17 species, were collected below Buck Dam from four backpack electrofishing sites (sampled spring 2021). Two species were collected exclusively below Buck Dam. A summary of the fish species collected by each method and location is provided in Table 5-3.

Table 5-3. Fish Species Captured by Sampling Method and Location during the 2020-2021 Fish Community Study at the Byllesby-Buck Project

Species		Method			Location		
Common Name	Scientific Name	Boat EF[1]	Backpack EF[1]	Gillnet	US Byllesby[2]	Between Dams[3]	DS Buck[4]
Rock Bass	*Ambloplites rupestris*	X	X	X	X	X	
Central Stoneroller	*Campostoma anomalum*		X		X	X	X
White Sucker	*Catostomus commersonii*	X		X	X		
Kanawha Sculpin	*Cottus kanawhae*		X				X
Whitetail Shiner	*Cyprinella galactura*	X	X		X	X	X
Spotfin Shiner	*Cyprinella spiloptera*	X	X		X	X	X
Common Carp	*Cyprinus carpio*	X		X	X	X	
Muskellunge	*Esox masquinongy*	X		X	X		
Greenside Darter	*Etheostoma blennioides*	X	X		X	X	X
Fantail Darter	*Etheostoma flabellare*	X	X			X	X
Kanawha Darter	*Etheostoma kanawhae*		X			X	
Northern Hogsucker	*Hypentelium nigricans*	X	X			X	X
Channel Catfish	*Ictalurus punctatus*	X		X	X	X	
Redbreast Sunfish	*Lepomis auritus*	X	X		X	X	X
Green Sunfish	*Lepomis cyanellus*	X			X	X	
Pumpkinseed	*Lepomis gibbosus*	X				X	
Bluegill	*Lepomis macrochirus*	X		X	X	X	
Unknown Sunfish Species	*Lepomis* spp.	X	X		X	X	X
White Shiner	*Luxilus albeolus*		X				X
Rosefin Shiner	*Lythrurus ardens*	X				X	
Smallmouth Bass	*Micropterus dolomieu*	X	X	X	X	X	X
Spotted Bass	*Micropterus punctulatus*	X			X	X	
Largemouth Bass	*Micropterus salmoides*	X			X	X	
Bigmouth Chub	*Nocomis platyrhynchus*	X	X		X	X	
Unknown Chub Species	*Nocomis* spp.	X	X		X	X	

Species		Method			Location		
Common Name	Scientific Name	Boat EF[1]	Backpack EF[1]	Gillnet	US Byllesby[2]	Between Dams[3]	DS Buck[4]
Spottail Shiner	*Notropis hudsonius*	X				X	
Swallowtail Shiner	*Notropis procne*	X				X	
Rosyface Shiner	*Notropis rubellus*	X	X		X	X	X
Saffron Shiner	*Notropis rubricroceus*		X			X	
New River Shiner	*Notropis scabriceps*	X	X		X	X	X
Telescope Shiner	*Notropis telescopus*	X	X		X	X	X
Mimic Shiner	*Notropis volucellus*	X	X		X	X	X
Margined Madtom	*Noturus insignis*		X			X	X
Rainbow Trout	*Oncorhynchus mykiss*	X			X		
Logperch	*Percina caprodes*	X	X			X	X
Sharpnose Darter	*Percina oxyrhynchus*		X			X	X
Bluntnose Minnow	*Pimephales notatus*	X				X	
Black Crappie	*Pomoxis nigromaculatus*	X		X	X		
Flathead Catfish	*Pylodictis olivaris*	X	X	X	X	X	
Walleye	*Sander vitreus*			X	X		
Total Number of Exclusive Taxa		**9**	**7**	**1**	**5**	**7**	**2**

1) Electrofishing (EF) methods (boat or backpack).
2) Upstream (US) of Byllesby Dam (the Byllesby Pool).
3) Between dams includes the Byllesby bypass and tailwaters, transition zone, and Buck Pool.
4) Downstream (DS) of Buck Dam (Buck bypass and tailwater).

These data were used to determine the target species for inclusion in this Desktop study and included those species of management (i.e., state/federal protection), economic, and ecological importance (Table 5-4). Where appropriate, representative or surrogate species were used when evaluating other factors, such as swim burst speed and impingement potential.

Table 5-4. Target Fish Species and Species Groups Included in the Impingement and Entrainment Study for Byllesby-Buck Hydroelectric Project

Common Name	Scientific Name
Black Crappie	*Pomoxis nigromaculatus*
Bullheads and Madtoms	*Ameiurus* spp. and *Noturus* spp.
Catfishes	*Ictalurus* spp.

Common Name	Scientific Name
Common Carp	*Cyprinus carpio*
Darters and Logperch	*Etheostoma* and *Percina* spp.
Largemouth Bass	*Micropterus salmoides*
Lepomis Sunfishes	*Lepomis* spp.
Muskellunge	*Esox masquinongy*
Rock Bass	*Ambloplites rupestris*
Shiners, Chubs, and Minnows	Leuciscinae
Smallmouth Bass	*Micropterus dolomieu*
Spotted Bass	*Micropterus punctulatus*
Suckers and Redhorse	Catostomidae and *Moxostoma* spp.
Walleye	*Sander vitreus*
White Bass	*Morone chrysops*

5.2.2 Intake Avoidance and Impingement Risk

5.2.2.1 Intake Avoidance

Burst swim speeds for target or representative species were compared to the estimated intake velocity to evaluate whether fish may be susceptible to intake flows at the Project. Burst swim speed is the swim speed used to escape predation, maneuver through high flows, or in this case, escape intake velocities and avoid entrainment. Burst swim speed data were compiled from the literature, however if data for a specific species or group was not available, it was calculated as 2x critical swim speed based on Bell (1991).

As described in Section 5.1 of this study report, the assessment of impingement and entrainment susceptibility at the Project developments assumed velocities calculated under maximum discharge based on the design capacity of the existing turbines (5,868 cfs at Byllesby and 3,540 cfs at Buck), corresponding to maximum approach velocities of 2.0 fps and 1.6 fps at Byllesby and Buck developments, respectively. Burst swim speeds found in literature suggest that most fish species and life stages that may be in the vicinity of the intake would be able to avoid entrainment based on approach velocities at the Project (Table 5-5). The life stages most likely to be entrained are larvae, however the larvae of most species in the Project area are unlikely to occur near the intake based on their life history characteristics (i.e., appropriate spawning habitat requirements of adults such as low velocity, riffles, cover, substrate, vegetation, etc.). Additional analyses were performed to assess potential intake avoidance under the proposed turbine upgrades, which would result in a slight increase in approach velocity at Buck and 0.4 fps reduction at Byllesby. Given the overall swimming performance of the target species in the Project vicinity, that the small changes anticipated with the turbine unit upgrades would not result in a measurable change in fish susceptibility to impingement or entrainment at the Project intake structures.

Table 5-5. Summary of Fish Burst Swim Speeds by Species

Target Species/Group	Surrogate Species	Age	Length[1]	Burst Swim Speed (fps)[2]	Reference
Black Crappie	White Crappie	Juvenile	3.03	**1.04**	Smiley and Parsons 1997
	White Crappie	Juvenile/ Adult	6.7	**1.19**	Katopodis and Gervais 2016
Catfishes	Channel Catfish x Blue Catfish	Juvenile	6.30-9.06	7.88	Beecham et al. 2009
	Blue Catfish	Juvenile	2.05	**1.97**	Katopodis and Gervais 2016
Common Carp	Common Carp	Juvenile	6.02	2.76-4.59	Tsukamoto et al. 1975
Darters & Logperch	Darters (*Etheostoma* spp.)	Adult	1.42	2.62	Katopodis and Gervais 2016
	Greenside Darter	Adult	1.57-2.68	**1.02**-2.64	Layher 1993
Largemouth Bass	Largemouth Bass	Juvenile	3.5-4.72 (FL)	2.32-3.28	Farlinger and Beamish 1977
		Juvenile	5.04	2.46	Katopodis and Gervais 2016
Lepomis Sunfishes	Sunfish Species	Adult	3.19	4.35	Katopodis and Gervais 2016
	Bluegill	Adult	3.94-5.91	2.44	Gardner et al. 2006
		Juvenile	1.97	2.66	Katopodis and Gervais 2016
	Longear Sunfish	Juvenile/ Adult	2.20-5.35	**1.24**-2.56	Layher 1993
	Pumpkinseed	Adult	5.000	2.44	Brett and Sutherland 1965
	Redbreast Sunfish	Juvenile	1.890	2.32	Katopodis and Gervais 2016
Shiners, Chubs, and Minnows	Emerald Shiner	Adult	2.5	4	Bell 1991
	Golden Shiner	Adult	1.54-4.33	2.02-2.64	Layher 1993
	Blacknose Dace	Adult	1.60-1.74 (SL)	2.54	Nelson et al. 2003
		Juvenile	1.69	2.02-3.02	Katopodis and Gervais 2016
	Central Stoneroller	Juvenile	1.81	4.13	Katopodis and Gervais 2016

Target Species/Group	Surrogate Species	Age	Length[1]	Burst Swim Speed (fps)[2]	Reference
Smallmouth Bass, Spotted Bass	Smallmouth Bass	Larvae	0.55-0.98	**1.2**-1.74	Larimore and Deuver 1968
		Juvenile	3.58-3.66	2.6-3.6	Webb 1998
		Adult	10.3-14.9	3.2-7.8	Bunt et al. 1999
		Adult	11.81	5.77	Katopodis and Gervais 2016
Suckers and Redhorse	Longnose Sucker	Juvenile/ Adult	3.9-16.0	4.0-8.0	Bell 1991
	White Sucker	Adult	6.69-14.57 (FL)	4.96	Hunter and Mayor 1986
	Robust Redhorse	Larvae	0.51-0.8	**0.46-0.76**	Reutz and Jennings 2000
	Suckers	Adult	7.05	8.33	Katopodis and Gervais 2016
Walleye	Walleye	Juvenile	6.3 (FL)	6.02 (S)	Peake et al. 2000
		Adult	13.78 (FL)	7.2 (S)	Peake et al. 2000
		Adult	22.44 (FL)	8.57 (S)	Peake et al. 2000
White Bass	Striped Bass	Larvae	0.51	**0.36-0.60**	Bell 1991
		Larvae	0.98	**0.52-1.00**	Bell 1991
		Juvenile	2.01	**1.10-2.00**	Bell 1991
		Juvenile	5.0	2.10-5.00	Bell 1991

[1] Lengths are Total Length (TL) unless otherwise noted (SL: standard length; FL: fork length)
[2] Burst swim speeds were calculated as 2x critical speed (Bell 1991), unless burst speed was provided in the literature. (S): startle speed.
Bold text indicates speeds at or below approach velocity at Byllesby (1.0 fps) or Buck (1.6 fps) developments.

5.2.2.2 Impingement Risk

Proportional estimates of body width to length (scaling factor) were compiled by Smith (1985) for all the target and representative species in this study. The scaling factor multiplied by the maximum recorded length for the species (Jenkins and Burkhead 1993), or maximum recorded length from field data collected during the 2020-2021 Fish Community Study (Appalachian 2021), resulted in a corresponding width which was then compared to the trash rack spacing at the Project (2.28 inches) (Table 5-6).

Most of the smaller-sized species, such as shiners, darters, minnows, and sunfishes would be able to pass through the trash racks and become entrained at the Project. However, some larger-bodied fishes, including recreationally important species, may be excluded once they reach the minimum size depending on species-specific length-to-width ratios (Table 5-6). Channel Catfish (*Ictalurus punctatus*), Common Carp, Largemouth Bass (*Micropterus salmoides*), Walleye (*Sander vitreus*), and

White Sucker (*Catostomus commersonii*) may all be excluded once they reach minimum size, which ranges from 14.5 inches up to 18.5 inches.

Table 5-6. Estimated Minimum Lengths (inches) of Target and Representative Species Excluded by Trash Racks at Byllesby-Buck Hydroelectric Project

Common Name	Scaling Factor for Body Width[1]	Maximum Reported Length (inches)[2]	Corresponding Body Width (inches)	Minimum Size (inches) Excluded by Trash Rack at the Project (2.28 inches)
River Chub	0.127	8.9	1.1	Not Excluded
Black Crappie	0.099	15.6	1.5	Not Excluded
Blacknose Dace	0.132	2.8	0.4	Not Excluded
Bluegill*	0.132	6.7	0.9	Not Excluded
Bluegill	0.132	8.7	1.1	Not Excluded
Bluntnose Minnow	0.119	4.2	0.5	Not Excluded
Central Stoneroller	0.126	5.9	0.7	Not Excluded
Channel Catfish	0.156	27.6	4.3	14.5
Channel Catfish*	0.156	18.1	2.8	14.5
Common Carp	0.162	27.0	4.4	14.5
Common Carp*	0.162	30.5	4.9	14.5
Common Logperch	0.104	4.7	0.5	Not Excluded
Golden Redhorse	0.127	14.8	1.9	Not Excluded
Golden Shiner	0.105	7.9	0.8	Not Excluded
Green Sunfish*	0.154	5.3	0.8	Not Excluded
Green Sunfish	0.154	7.1	1.1	Not Excluded
Greenside Darter	0.122	3.5	0.4	Not Excluded
Johnny Darter	0.118	1.6	0.2	Not Excluded
Largemouth Bass*	0.134	17.5	2.3	17.0
Largemouth Bass	0.134	25.6	3.4	17.0
Longear Sunfish	0.153	5.9	0.9	Not Excluded
Longnose Dace	0.139	3.3	0.5	Not Excluded
Mimic Shiner	0.101	2.2	0.2	Not Excluded
Northern Hog Sucker*	0.146	4.4	0.6	Not Excluded
Northern Hog Sucker	0.146	11.8	1.7	Not Excluded

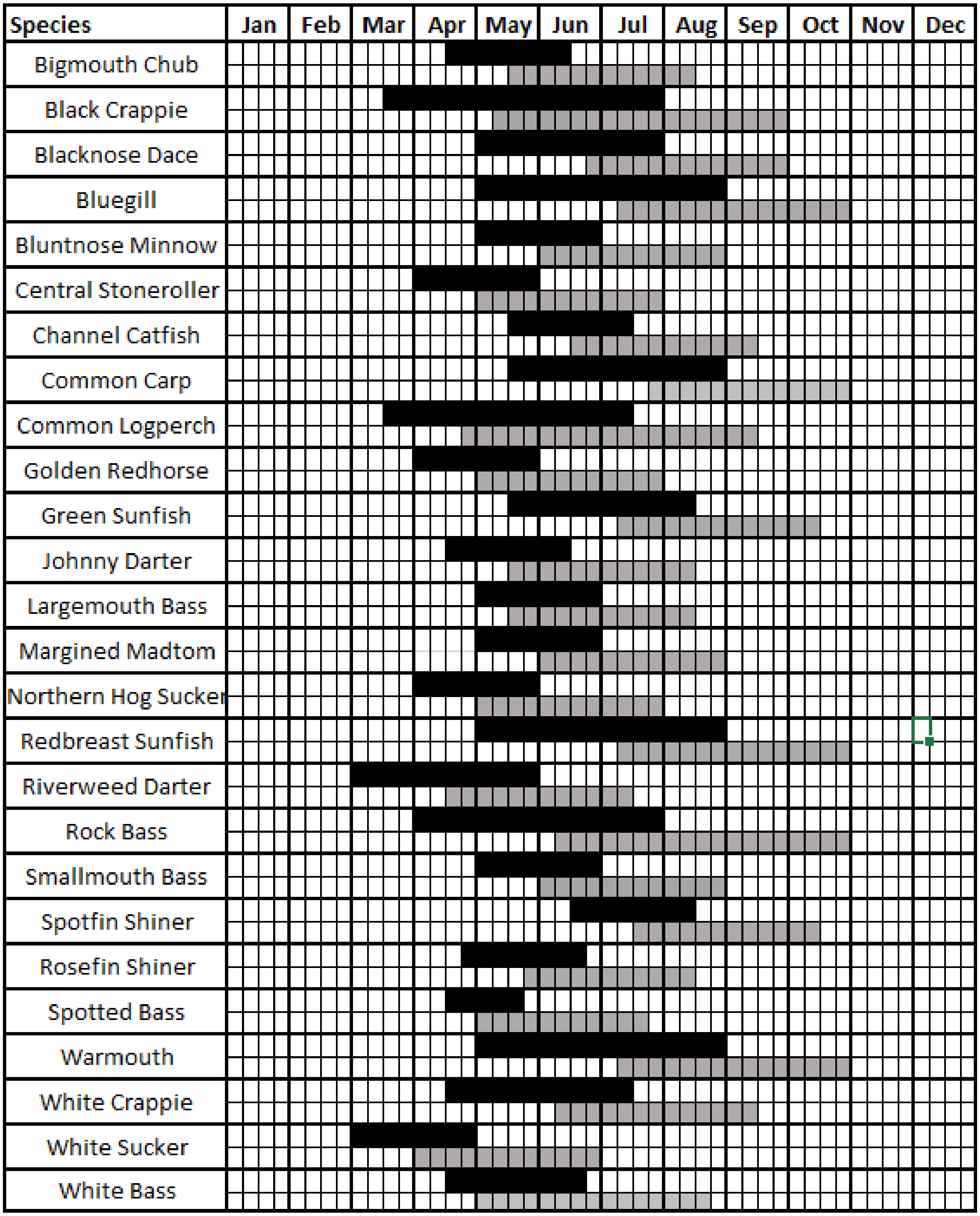
Common Name	Scaling Factor for Body Width[1]	Maximum Reported Length (inches)[2]	Corresponding Body Width (inches)	Minimum Size (inches) Excluded by Trash Rack at the Project (2.28 inches)
Pumpkinseed	0.124	6.3	0.8	Not Excluded
Rainbow Darter	0.134	2.0	0.3	Not Excluded
Redbreast Sunfish*	0.150	7.4	1.1	Not Excluded
Redbreast Sunfish	0.150	7.3	1.1	Not Excluded
Rock Bass*	0.155	4.4	0.7	Not Excluded
Rock Bass	0.155	7.9	1.2	Not Excluded
Smallmouth Bass*	0.128	13.0	1.7	Not Excluded
Smallmouth Bass	0.128	16.9	2.2	Not Excluded
Spotfin Shiner*	0.110	2.7	0.3	Not Excluded
Spotfin Shiner	0.110	2.8	0.3	Not Excluded
Spottail Shiner*	0.140	3.3	0.5	Not Excluded
Spottail Shiner	0.140	3.5	0.5	Not Excluded
Spotted Bass*	0.128	2.7	0.3	Not Excluded
Spotted Bass	0.128	15.0	1.9	Not Excluded
Walleye	0.125	21.8	2.7	18.5
Walleye	0.125	15.4	1.9	Not Excluded
Warmouth	0.140	7.9	1.1	Not Excluded
White Crappie*	0.085	4.5	0.4	Not Excluded
White Crappie	0.085	15.7	1.3	Not Excluded
White Sucker	0.146	15.7	2.3	16.0
Yellow Bullhead	0.172	11.8	2.0	Not Excluded

[1] Scaling factor (Smith 1985) expresses body width as a function of length based on proportional measurements.
[2] Maximum length reported by Jenkins and Burkhead (1993).
*Species and length collected in the 2020-2021 Fish Community Survey (Appalachian 2021).

5.2.3 Fish Entrainment Potential

The early life stages of fish (eggs and larvae) are unable to move independently (eggs) or have limited swimming ability (larvae), and therefore are at the mercy of the current and susceptible to entrainment at the Project. An assessment of target and representative species shows that the majority of species have spawning periods from late April through June, with subsequent egg and larvae development from late May through August (Table 5-7).

Table 5-7. Spawning and Early Life Stage Periodicities for Target and Representative Fish Species in the Vicinity of Byllesby-Buck Hydroelectric Project



Spawning Period (Stauffer et al. 1995; Jenkins and Burkhead 1993)

Eggs and larvae (estimated to begin two-thirds of the way through the spawning period and lasting 60 days post spawn)

Some species or groups, such as *Lepomis* sunfish, have long spawning periods with corresponding prolonged windows of egg and larvae development, increasing their risk of entrainment. However, this group, like others in the Centrarchidae family, guard nests constructed in shallow areas with cover (i.e., vegetation, woody debris, etc.) and newly hatch larvae use the cover for protection from predation, which also helps reduce the risk of entrainment to early life stages. Additionally, most freshwater fish species have demersal and/or adhesive eggs and larvae that remain close to areas with protective cover, which also lowers risk of entrainment (Cada 1991). A summary of life history information for target and representative species is included in Appendix B.

Although some early life stage organisms may be swept from nesting areas during high flow events or from reservoir level fluctuations (which does not exceed more than one foot at each development), it is expected that ichthyoplankton mortality resulting from turbine passage is low, at two to five percent (Cada 1991). Other sources of injury or mortality to early life stages, such as pressure changes, cavitation, turbulence, and shear stress are limited at the facility based on the prior entrainment study (Appalachian 1991). As no significant changes have occurred at the facility since the last relicensing, impacts from these factors are also considered minimal. Further, the proposed unit upgrades from Francis to Kaplan turbines will further reduce the risk of impacts to fish entrained through the turbines.

5.2.3.1 Fish Entrainment Estimates

Findings from FERC (1995) and Winchell et al. (2000) suggest that the majority of fish size classes entrained at hydroelectric projects is substantially smaller than the minimum length of fish physically excluded by a certain clear spacing, and that length frequencies of entrainment compositions are similar among sites with differing trash rack spacing. This indicates that the lack of larger fish may be related to their increased swimming performance and ability to avoid intake velocities as they approach the intake.

According to the EPRI (1997) database selections used for this study, fish less than eight inches in length exhibited the highest entrainment rates throughout the year (**Error! Reference source not found.**), of those, most (88 percent) consisted of fish measuring six inches in length or smaller (Figure 5-3) overall, and. Of the fish less than eight inches in length, entrainment rates in summer and fall were greatest, suggesting these are the species likely spawned the prior spring and recently recruited to sizes large enough to be captured in the sampling nets.

Table 5-8. Annual and Seasonal Entrainment Rates of Target Species and Species Groups by Fish Size Class

Fish Size (total length)	Average Monthly Entrainment Rate by Season (fish/hr)				
	Winter	Spring	Summer	Fall	Annual
Entrainment Rate (fish/hr) at Byllesby Development (5,868 cfs)					
<4 inch	0.35	0.85	0.98	0.58	**0.69**
4-8 inch	0.47	0.28	0.50	1.48	**0.68**
8-15 inch	0.07	0.06	0.06	0.08	**0.07**
>15 inch	0.00	0.00	0.00	0.00	**0.00**

Fish Size (total length)	Average Monthly Entrainment Rate by Season (fish/hr)				
	Winter	Spring	Summer	Fall	Annual
Total	**0.88**	**1.21**	**1.54**	**2.14**	**1.44**
Entrainment Rate (fish/hr) at Buck Development (3,540 cfs)					
<4 inch	0.21	0.51	0.59	0.35	**0.42**
4-8 inch	0.28	0.17	0.30	0.89	**0.41**
8-15 inch	0.04	0.04	0.04	0.05	**0.04**
>15 inch	0.00	0.00	0.00	0.00	**0.00**
Total	**0.53**	**0.73**	**0.93**	**1.29**	**0.87**
Note: Values represent average fish/hr entrainment from 33 sites selected from the EPRI database and adjusted for maximum turbine discharge (cfs) at each Project development.					

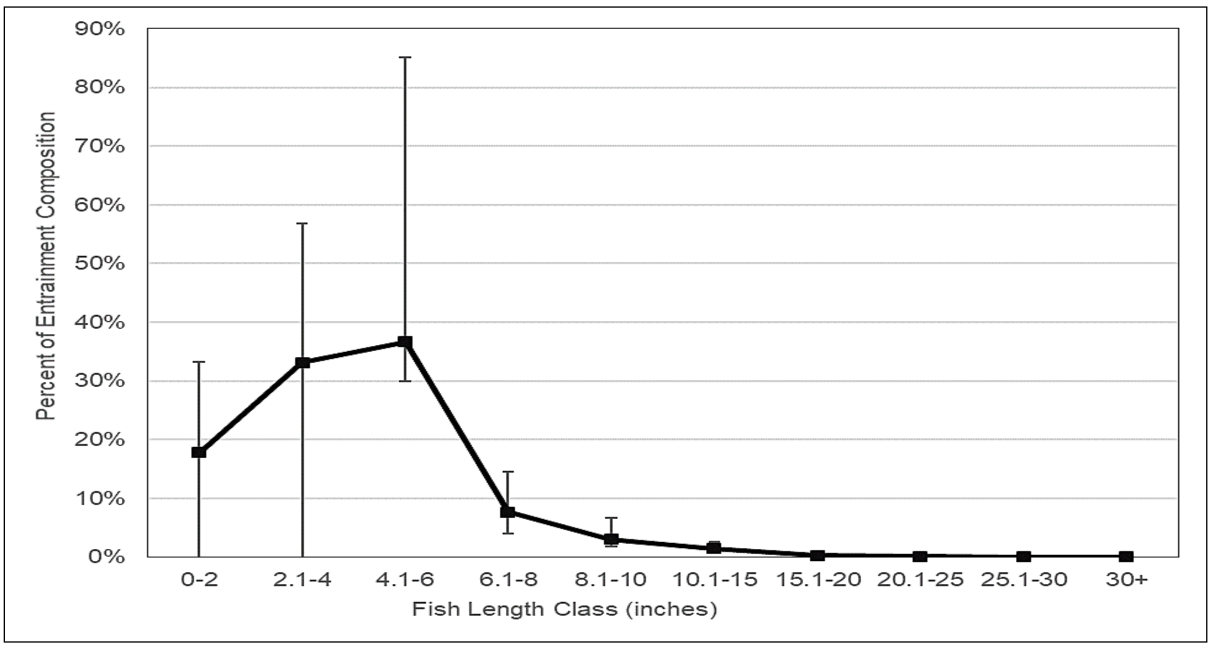


Figure 5-3. Mean Percent (standard deviation) of Entrainment Composition by Fish Size Class According to Target Species from 33 Hydroelectric Developments (EPRI 1997)

Seasonal entrainment rates from the EPRI (1997) database by target species and species group is presented in Table 5-9 for Byllesby Development and Table 5-10 for Buck Development. These include average entrainment rates by fish species and size class, combined by month and averaged by season. Mean monthly seasonal entrainment rates by target species/group and size is provided in Appendix C for Byllesby Development and Appendix D for Buck Development.

Table 5-9. Seasonal and Annual Entrainment Rates for Target Species and Species Groups at Byllesby Development (5,868 cfs)

Target Species/Group	Average Monthly Entrainment Rate (fish/hr) by Season				
	Winter	Spring	Summer	Fall	Annual
Rock Bass	4.69	6.09	4.49	12.70	6.99
Catfishes	0.59	10.07	15.72	1.05	6.86
Suckers and Redhorse	3.93	2.06	2.52	8.78	4.32
Lepomis Sunfishes	0.40	4.24	3.90	7.55	4.02
Black Crappie	1.03	1.06	6.73	4.35	3.29
Largemouth Bass	0.32	0.37	4.27	1.71	1.67
Darters and Logperch	0.29	4.53	1.03	0.24	1.52
Shiners, Chubs, and Minnows	1.02	1.35	1.38	1.50	1.31
Walleye	0.71	0.37	3.03	0.63	1.19
Bullheads and Madtoms	0.15	1.01	1.98	0.44	0.89
Smallmouth Bass	0.12	0.15	1.47	1.13	0.72
White Bass	0.09	1.20	0.09	0.13	0.38
Muskellunge	0.11	0.55	0.53	0.22	0.35
Common Carp	0.03	0.04	0.10	0.04	0.05
Total	**13.48**	**33.09**	**47.24**	**40.47**	**33.56**

[dashed box] Top 90 percent of species by relative abundance on annual basis.

Table 5-10. Seasonal and Annual Entrainment Rates for Target Species and Species Groups at Buck Development (3,540 cfs)

Target Species/Group	Average Monthly Entrainment Rate (fish/hr) by Season				
	Winter	Spring	Summer	Fall	Annual
Rock Bass	2.83	3.67	2.71	7.66	4.22
Catfishes	0.36	6.08	9.48	0.64	4.14
Suckers and Redhorse	2.37	1.24	1.52	5.30	2.61
Lepomis Sunfishes	0.24	2.56	2.35	4.56	2.43
Black Crappie	0.62	0.64	4.06	2.63	1.99
Largemouth Bass	0.19	0.22	2.57	1.03	1.01
Darters and Logperch	0.17	2.73	0.62	0.15	0.92
Shiners, Chubs, and Minnows	0.62	0.81	0.84	0.91	0.79
Walleye	0.43	0.23	1.83	0.38	0.72
Bullheads and Madtoms	0.09	0.61	1.19	0.27	0.54
Smallmouth Bass	0.07	0.09	0.88	0.68	0.43
White Bass	0.06	0.72	0.05	0.08	0.23
Muskellunge	0.07	0.33	0.32	0.13	0.21
Common Carp	0.02	0.02	0.06	0.03	0.03
Total	**8.14**	**19.95**	**28.48**	**24.45**	**20.27**

Top 90 percent of species by relative abundance on annual basis.

Rock Bass (*Ambloplites rupestris*), catfishes, suckers and redhorses, *Lepomis* sunfishes, and Black Crappie, Largemouth Bass, darters and logperch, and shiners, chubs, and minnows represent the top 90 percent of target species and species groups entrained at the Byllesby and Buck developments based on the EPRI (1997) database (Table 5-9 and Table 5-10). Peaking months of entrainment for these species and species groups varied: Rock Bass, suckers and redhorse, and *Lepomis* sunfishes showed highest entrainment rates in fall; catfishes, Black Crappie, and Largemouth Bass entrainment rates were greatest during the summer season; darters and logperch peaked during spring months, and shiners, chubs, and minnows had relatively even entrainment rates throughout the year.

Entrainment rates were highest from April to October, with peaks in April, July, and October (Figure 5-4). Peaking months may correspond to spawning movements (April), recruitment to catchable size (July or October), or large storm/flow events.

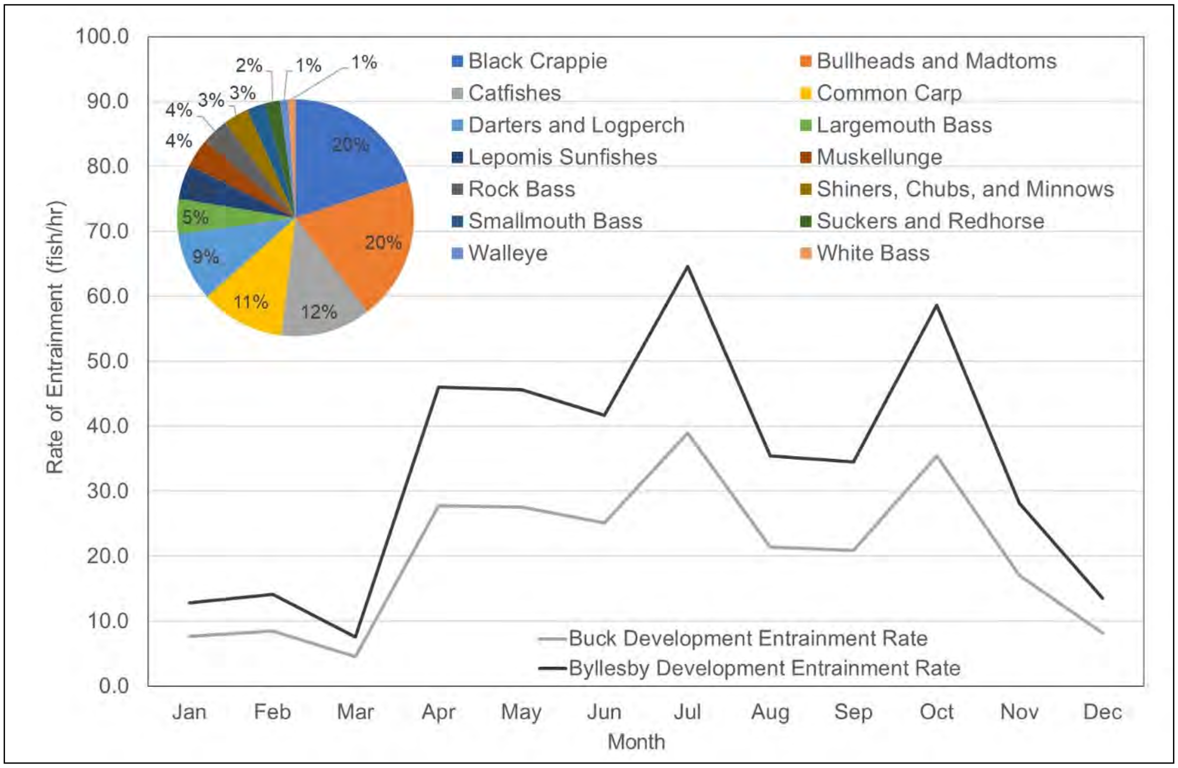


Figure 5-4. Average Monthly Entrainment Rate and Species Composition based on EPRI (1997) Entrainment Database Selections for the Byllesby-Buck Hydroelectric Project

5.2.3.2 Qualitative Turbine Entrainment Risk

Several factors were considered for qualitative entrainment risk ratings for target species at each of the Project developments, including:

- Entrainment rates for each species and species group based on the EPRI (1997) database and site-specific information (see Section 5.2.3.2);
- Maximum turbine discharge frequency (see Section 5.1);
- Comparison of burst swim speed versus intake velocity for likelihood of intake avoidance (see Section 5.2.2.1;
- Size exclusion (see Section 5.2.2.2); and
- Life history characteristics, such as migratory behavior, habitat preferences, spawning behavior/requirements, and early life stage periodicity (see Section 5.2.3).

Although few fish species in the vicinity of the Project developments would be excluded by the trash racks, almost all juvenile and adult fish species could avoid the intake entirely based on approach velocity and associated swim burst speeds. Therefore, most target species with elevated qualitative rankings were driven by increased entrainment rates based on the EPRI (1997) database, which has limited velocity data for comparison.

Some species have higher entrainment rates in the spring period, which may reflect increased activity associated with spawning (e.g., dispersal for nest site selection, increased feeding); none of the species evaluated for this study exhibit fall spawning behavior (see Section 5.2.3 and Appendix B). Although spring spawning is common for many species, some species migrate upstream and away from the intake (e.g., suckers and redhorse), create nests in protected areas (e.g., central stoneroller, crevice-spawning shiners), and/or require habitat not found in the vicinity of the intake (see Appendix B); therefore most species were given a low (L) ranking unless elevated entrainment rates were noted (Table 5-11 and Table 5-12).

Increased entrainment for certain species during the fall months (such as Rock Bass or suckers and redhorse group) may indicate increased activity in response to cooling summer water temperatures, triggering the need for increased foraging in preparation for the winter season, or possibly increased activity following late-summer egg hatch and swim up stage. Since most species are not expected to spawn in the vicinity of the intake or where eggs and larvae would be susceptible to intake flows, rankings for potential entrainment of early life stages were not elevated.

Since the same selection of data from the EPRI (1997) database was applied to both facilities, trends across species are similar, and therefore the considerations given below apply to both Byllesby and Buck developments (Table 5-11 and Table 5-12). However, slight differences in qualitative ratings may also be due to differences in total plant capacity.

The majority (59 percent) of catfishes entrained from May to July, based on the EPRI (1997) database, were of the 2-4-inch size class. Since swim burst speed data suggests that catfish of this size are able to swim faster than the intake velocity (1.97 fps [Katopodis and Gervais 2016] versus 1.0 fps; see Table 5-5), the qualitative rating for this species group was designated as moderate (M) for these months despite the relatively high entrainment rate in the EPRI (1997) database.

Similarly, the analysis indicated that Rock Bass have increased entrainment rates during the months of April, October, and November. Most fish estimated to be entrained in April were of the 2 to 4-inch size class, therefore this month was given an elevated entrainment potential rating. However, the majority of Rock Bass estimated to be entrained in October and November were larger in size (4-6 inches). Based on similar body size and shape as *Lepomis* species, swim burst speeds are likely similar and sufficient to also exclude them from susceptibility to entrainment at the Project. Therefore, the entrainment potential rating for Rock Bass was determined to be low-moderate (L-M).

Black Crappie exhibited higher entrainment rates in July and August based on the EPRI (1997) database; these fish were mostly 0-2 inches (60 percent) or 2-4 inches (39 percent) total length, and therefore likely juvenile fish. Black Crappie of this size (using White Crappie as a surrogate) do not have a swim burst speed substantially greater than the intake velocity, therefore the entrainment potential rating for Black Crappie was elevated to moderate-high (M-H).

Table 5-11. Range of Monthly Turbine Entrainment Potential for the Target Species at the Byllesby Development

Target Species/Group	Qualitative Rating of Monthly Entrainment Potential*											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black Crappie	L	L	L	L	L	L	M-H	M	L-M	L-M	L-M	L
Bullheads and Madtoms	L	L	L	L	L	L	L-M	L	L	L	L	L
Catfishes	L	L	L	L	M	M	M	M	L	L	L	L
Common Carp	L	L	L	L	L	L	L	L	L	L	L	L
Darters and Logperch	L	L	L	L-M	L-M	L	L	L	L	L	L	L
Largemouth Bass	L	L	L	L	L	L-M	M	L-M	L-M	L	L	L
Lepomis Sunfishes	L	L	L	M-H	L-M	L	L-M	L-M	L-M	L-M	L	L
Muskellunge	L	L	L	L	L	L	L	L	L	L	L	L
Rock Bass	L	L-M	L	M	L	L-M	L-M	L-M	L-M	L-M	L-M	L-M
Shiners, Chubs, and Minnows	L	L	L	L	L	L	L	L	L	L	L	L
Smallmouth Bass	L	L	L	L	L	L	L	L	L	L	L	L
Suckers and Redhorse	L-M	L-M	L	L	L	L	L-M	L	L	M	M	L-M
Walleye	L	L	L	L	L	L-M	L-M	L	L	L	L	L
White Bass	L	L	L	L	L	L	L	L	L	L	L	L

*L (low), L-M (low-moderate), M (moderate), M-H (moderate-high), H (high)

Table 5-12. Range of Monthly Turbine Entrainment Potential for the Target Species at the Buck Development

Target Species/Group	Qualitative Rating of Monthly Entrainment Potential*											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Black Crappie	L	L	L	L	L	L	M-H	L-M	L	L	L	L
Bullheads and Madtoms	L	L	L	L	L	L	L	L	L	L	L	L
Catfishes	L	L	L	L	M	M	M	L-M	L	L	L	L
Common Carp	L	L	L	L	L	L	L	L	L	L	L	L
Darters and Logperch	L	L	L	L	L	L	L	L	L	L	L	L
Largemouth Bass	L	L	L	L	L	L	L-M	L	L	L	L	L
Lepomis Sunfishes	L	L	L	M	L	L	L	L-M	M	L-M	L	L
Muskellunge	L	L	L	L	L	L	L	L	L	L	L	L
Rock Bass	L	L-M	L	L-M	L	L	L	L-M	L-M	L-M	L-M	L-M
Shiners, Chubs, and Minnows	L	L	L	L	L	L	L	L	L	L	L	L
Smallmouth Bass	L	L	L	L	L	L	L	L	L	L	L	L
Suckers and Redhorse	L	L	L	L	L	L	L	L	L	M	L-M	L
Walleye	L	L	L	L	L	L	L	L	L	L	L	L
White Bass	L	L	L	L	L	L	L	L	L	L	L	L

*L (low), L-M (low-moderate), M (moderate), M-H (moderate-high), H (high)

Lepomis sunfish had higher entrainment rates for the months of April and September. In April, most of the fish were of the 2-4 and 4-6-inch size classes (45 and 52 percent, respectively). In October, 91 percent of *Lepomis* sunfish entrained were within the 4-6-inch size class. Since almost half of the sunfish collected in April were relatively small, and with consideration of swim burst speeds for juvenile fishes, the rating for April was elevated. However, since the sunfishes estimated for October are larger and likely able to navigate intake flows adequately to avoid entrainment, the entrainment potential rating was determined to be low-moderate.

While entrainment rates of darters and logperch were low throughout the year, rates were slightly elevated in April and May. However, based on the required habitat of most species in the *Etheostoma* and *Percina* genera, these taxa are not expected to be found in the vicinity of the intake and at risk of entrainment. Therefore, ratings for these months were determined to be low-medium or low.

Suckers and redhorse were another group with elevated entrainment rates, which peaked in October and November. The November data shows elevated entrainment rates reported from several facilities, however entrainment in October was primarily driven by fish within the 4 to 6-inch size class from one facility. This single report accounted for 98 percent of the estimated entrainment of 4 to 6-inch fish for that month. With this consideration and the high burst swim speeds exhibited by suckers and redhorse (Section 5.2.2), the qualitative entrainment potential rating was determined to be moderate (M).

5.2.3.3 Turbine Blade Strike Analysis

As stated previously, the historical entrainment study completed for the prior license (Appalachian 1991a) concluded that impacts due to turbine passage on the fish population in the vicinity of the Project was negligible. A new turbine blade strike analysis was performed for the Project in 2021 based on the final results of the 2020-2021 Fish Community Survey. The evaluation was performed using the most recent version available of the Turbine Blade Strike model, mean and standard deviation of fish lengths based on fish data collected during the 2020-2021 Fish Community Study, and site-specific inputs for required model parameters, as summarized in Table 5-1and Table 5-2. All outputs for turbine blade strike analyses are provided in Appendix E through H.

Turbine blade strike probabilities for entrained fish of varying sizes were estimated for each Project under the existing and proposed conditions presented in Table 5-1and Table 5-2. For the size classes evaluated, blade strike probabilities at the Buck Project ranged from 4.5 - 65.9 percent under existing conditions and 2.9 - 42.2 percent under the proposed conditions (Table 5-13). For the size classes evaluated, blade strike probabilities at the Byllesby Dam ranged from 4.5 - 66.6 percent under existing conditions and 2.8 - 41.0 percent under the proposed conditions (Table 5-13). The probability of blade strike increased with increasing fish length. The existing Francis units have estimated blade strike probability that are more than double those of the proposed Kaplan units. During the 2020-2021 Fish Community Survey, a total of 1,119 fish were collected in the Project area. The average length was 4.65 inches and 72.5 percent of fish collected were smaller than 6 inches. While larger fish theoretically have a greater potential for blade strike, they are more likely to be excluded by the trash racks. Table 5-6 summarizes fish body length to width ratios and determines the minimum length at which fish species would be excluded by the trash racks. For the larger bodied fish species such as Largemouth Bass, Walleye, White Sucker, Channel Catfish, and Common Carp that attain sizes that could be excluded by the trash racks, the minimum size of exclusion ranged from 14.5 to 18 inches.

Table 5-13. Turbine Blade Strike Probability by Project Configuration and Fish Length

Project Dam	Turbine Type	Fish Length Class (inches)								
		2	4	6	8	10	15	20	25	30
Byllesby	Existing Francis	4.8%	9.2%	14.0%	18.7%	23.2%	35.0%	46.7%	46.7%	69.9%
Buck	Existing Francis	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%
Byllesby Proposed Condition	New Kaplan (Units 1, 2 & 3)	2.2%	4.3%	6.5%	8.7%	10.8%	16.3%	21.7%	27.1%	32.5%
	Existing Francis	4.5%	8.8%	13.3%	17.8%	22.1%	33.3%	44.5%	55.4%	66.6%
	Average Strike Probability	2.8%	5.4%	8.2%	11.0%	13.6%	20.5%	27.4%	34.2%	41.0%
Buck Proposed Condition	New Kaplan (Units 1 & 2)	2.1%	4.0%	6.1%	8.1%	10.1%	15.2%	20.3%	25.3%	30.4%
	Existing Francis	4.5%	8.7%	13.2%	17.7%	21.9%	32.9%	44.0%	54.8%	65.9%
	Average Strike Probability*	2.9%	5.6%	8.4%	11.3%	14.0%	21.1%	28.2%	35.1%	42.2%

*Reflects blended average strike probability for the 1 remaining Francis turbine and the 2(Buck), 3(Byllesby) proposed Kaplan turbines.

The TBSA was also used to estimate the downstream passage survival of Walleye under a variety of spill conditions. This approach allows for the inclusion of alternate routes such as the spillway and individual turbines to be combined into an overall passage survival estimate. The percentage of Walleye that would experience blade strike, spillway mortality, or pass downstream successfully was estimated for the range of flow conditions summarized in Table 5-14 below. The TBSA tool run outputs were exported and are available for review in Appendices E through H. It is important to note, that the results of this analysis only reflect the potential outcomes for fish that pass downstream of the project and does not include fish that remain in the Project impoundments. Due to the assumed survival rate of 97 percent for spillway passage, the overall downstream passage survival rate increased with the increasing volume of spill for the range of flow percentiles evaluated. For the Byllesby project spillage first occurred at annual 4 percent exceedance and Buck at a 12 percent exceedance flow.

For Walleye the percentage of fish that would survive downstream passage ranged from 67.7 to 82.7 percent under existing conditions at the Byllesby project and 82.8 to 88.8 percent under proposed conditions For the Buck Project the percentage of walleye that would survive downstream passage ranged from 71.1 to 88.8 percent under existing conditions and 82.7 to 91.4 percent under proposed conditions.

Table 5-14. Walleye Downstream Passage Survival Estimates for Existing and Proposed Project Configurations at Varying Amounts of Spill.

Project	Turbine Configuration	Flow Exceedance %	Volume Spill (CFS)	Spill Route Selection Probability	Turbine Strike Mortalities	Spillway Mortalities	Cumulative Downstream Passage Survival
Byllesby	Existing	4	230	0.0389	32.1%	0.2%	67.7%
Byllesby	Existing	3	1128	0.1657	24.9%	0.4%	74.7%
Byllesby	Existing	2	2355	0.2931	20.8%	0.6%	78.6%
Byllesby	Existing	1	5094	0.4728	15.9%	1.4%	82.7%
Byllesby	Proposed	4	425.6	0.0720	17.0%	0.2%	82.8%
Byllesby	Proposed	3	1324.3	0.1945	14.8%	0.4%	84.8%
Byllesby	Proposed	2	2551.2	0.3175	11.4%	0.8%	87.8%
Byllesby	Proposed	1	5290.3	0.491	9.4%	1.9%	88.8%
Buck	Existing	12	123	0.0336	28.3%	0.1%	71.1%
Buck	Existing	10	421	0.1063	27.2%	0.3%	72.5%
Buck	Existing	8	816	0.1874	24.3%	0.4%	75.2%
Buck	Existing	6	1427	0.2872	22.7%	0.8%	76.5%
Buck	Existing	4	2370	0.4010	16.1%	1.3%	82.6%
Buck	Existing	2	4495	0.5594	14.1%	1.8%	84.1%
Buck	Existing	1	7234	0.6714	9.1%	2.1%	88.8%
Buck	Proposed	12	92	0.0253	17.2%	0.1%	82.7%
Buck	Proposed	10	391	0.0987	17.5%	0.5%	82.0%
Buck	Proposed	8	786	0.1805	15.4%	0.5%	84.1%
Buck	Proposed	6	1397	0.2812	14.0%	1.1%	84.9%
Buck	Proposed	4	2340	0.3959	12.4%	0.93%	86.7%
Buck	Proposed	2	4465	0.5557	7.6%	1.8%	90.6%
Buck	Proposed	1	7204	0.6687	6.5%	2.1%	91.4%

6 Summary

In summary, the primary findings of the Desktop Fish Impingement and Entrainment Study include:

The Project is in a rural area within a relatively large watershed that which has the potential to influence habitat and water quality in this portion of the New River in ways that are independent of the Project. Byllesby and Buck dams influence habitat availability in the Project area, which determines species diversity and distribution, by impounding the existing riffle and run habitats and creating the pool habitats now present in the Project reservoirs. However, results of 2020-2021 Fish Community Survey were comparable to results of historical fish community assessments performed at the Project. Further, the data demonstrate that the habitats available in the New River within the Project boundary support a relatively healthy and diverse fish community.

Based on species-specific size distributions documented in the 2020-2021 Fish Community Survey, most fish in the New River would not be impinged on the intake trash racks. However, a comparison of calculated intake approach velocities to known fish swim speeds from existing literature indicates that most juvenile and adult fish are able to avoid impingement or entrainment at the Project intakes. Intake drawings are provided in Appendix I.

Entrainment of early life stage fishes (eggs and larvae) is likely minimal given the life history characteristics of species in the vicinity of the Project and the lack of suitable habitats near the Project intakes. Susceptibility to entrainment is expected to vary depending on species and time of year; however, most target species and species groups have low entrainment potential for most of the year.

A turbine blade strike and spillway survival assessment were performed to estimate the potential survival of those few life stages of fish that would be at risk of entrainment at the Project intakes. The assessment determined that:

- Blade strike mortality is expected to increase with increasing fish size; however, most larger fish are able to avoid the intake structures and are less likely to become entrained.
- The turbine upgrades planned for completion during the next license period will result in a substantial reduction in blade strike risk (up to 15 percent at Byllesby and 10 percent at Buck) to fish that are entrained at the Project intake structures.
- The low head Project dams and design of the Project spillways result in high spillway survival; as such, increasing spill events reduces turbine entrainment strike mortalities. However, spill events occur infrequently at the Project developments.
- Depending on the percent flow exceedance, the cumulative downstream passage survival (turbine and spillway passage) under the proposed conditions is expected to increase by as much as 15 percent at the Byllesby Development and 10 percent at the Buck Development.
- The cumulative downstream fish passage survival estimated to occur at the Byllesby Development after the turbine upgrades is between 82.8 and 88.8 percent of all fish, and between 82.7 and 92.4 percent of all fish at the Buck Development.
- Therefore, the findings of this study concur with the historical entrainment study completed for the prior relicensing in that impingement or entrainment effects to the fish community in the Project vicinity are expected to be minimal.

7 Variances from FERC-approved Study Plan

The Fish Impingement and Entrainment Study was conducted in full accordance with the methods described in the RSP. As detailed in Section 4.1, per the RSP and Commission's SPD, intake velocities were to be measured using an ADCP along the upstream face of the angled trash racks to determine the approximate approach velocity immediately upstream of the intake structure. During the 2020 field season, a combination of high flow events and inoperable units prevented field data collection efforts. As a result, approach velocity was calculated using the intake structure and trash rack dimensions along with the design maximum flow capacity of the two generating units.

8 References

Amaral, S., C. Fay, and G. Hecker. 2013. Estimating Total Passage Survival for Fish Migrating Downstream at Hydropower Projects. Alden Research Laboratory Technical Paper.

Appalachian Power Company (Appalachian). 2021. 2020-2021 Fish Community Survey Results, Byllesby Buck Hydroelectric Project, Virginia. Developed by Edge Engineering, Inc. for Appalachian Power Company, October 12, 2021.

Appalachian Power Company (Appalachian). 1991a. Application for License for Major Project Existing Dam. Byllesby/Buck Hydroelectric Project No. 2514. American Electric Power Service Corporation, Roanoke, Virginia.

______. 1991b. The Status of Fish Populations in the Vicinity of Byllesby/Buck Hydroelectric Project. American Electric Power Service Corporation, Roanoke, Virginia. April 10, 1991.

______. 2021. 2020-2021 Fish Community Survey Results, Byllesby Buck Hydroelectric Project, Virginia. Developed by Edge Engineering, Inc. for Appalachian Power Company, October 12, 2021.

Becker, G. C. 1983. Fishes of Wisconsin. University of Wisconsin Press, Madison. 1,052 pp.

Beecham, R.V., P.R. Pearson, S.B. Labarre, and C.D. Minchew. 2009. Swimming Performance and Metabolism of Golden Shiners. North American Journal of Aquaculture. 71:59-63.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. Prepared for U.S. Army Corps of Engineers, North Pacific Division, Fish Passage Development and Evaluation Program, Portland, OR. Third Edition.

Brett, J.R. and D.B. Sutherland. 1965. Respiratory metabolism of pumpkinseed (Lepomis gibbosus) in relation to swimming speed. Journal of the Fisheries Research Board Canada 22: 405-409.

Bunt, C.M., C. Katopodis, and R.S. McKinley. 1999. Attraction and passage efficiency of white suckers and smallmouth bass by two Denil fishways. North American Journal of Fisheries Management 19:793-803.

Cada, G.F. 1991. Effects of hydroelectric turbine passage on fish early life stages. CONF-910778-2. Prepared for the U.S. Department of Energy, Federal Energy Regulatory Commission. Washington, DC.

Cada, G. F., C. C. Coutant, and R. R. Whitney. 1997. Development of biological criteria for the design of advanced hydropower turbines. DOE/ID-10578. Prepared for the U.S. Department of Energy, Idaho Operations Office, Idaho Falls, Idaho.

Cada, G.F. and P.E. Schweizer. 2012. The application of traits-based assessment approaches to estimate the effects of hydroelectric turbine passage on fish populations. ORNL/TM-2012/110, UT-Battelle, LLC.

Cook, M.F., and R.C. Solomon. 1987. Habitat Suitability Index Models: Muskellunge. U.S. Fish and Wildlife Service Biological Report 82(10.148). 33 pp.

Electric Power Research Institute (EPRI). 1997. Turbine Entrainment and Survival Database – Field Tests. Prepared by Alden Research Laboratory, Inc., Holden, Massachusetts. EPRI Report No. TR-108630. October 1997. Department of Energy, Energy Efficiency and Renewable Energy. PNNL-15370. Richland, VA.

______. 2000. Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact under Clean Water Act Section 316(b). Final Report 1000731. Palo Alto, CA.

Farlinger, S. and F.W.H. Beamish. 1977. Effects of time and velocity increments on the critical swimming speed of largemouth bass (Micropterus salmoides). Transactions of the American Fisheries Society 106(5):436-439.

Federal Energy Regulatory Commission (FERC) 1995. Preliminary Assessment of Fish Entrainment at Hydropower Projects, A Report on Studies and Protective Measures, Volumes 1 and 2 (appendices). FERC Office of Hydropower Licensing, Washington, D.C. Paper No. DPR-10. June 1995 (Volume 1) and December 1994 (Volume 2).

Franke, G. F., D. R. Webb, R. K. Fisher, Jr., D. Mathur, P. N. Hopping, P. A. March, M. R. Headrick, I. T. Laczo, Y. Ventikos, and F. Sotiropoulos. 1997. Development of Environmentally Advanced Hydropower Turbine System Design Concepts. Prepared for U.S. Department of Energy, Idaho Operations Office, Contract DE-AC07-94ID13223.

Gardner, A.N., G.D. Jennings, W.F. Hunt, and J.F. Gilliam. 2006. Non-anadromous fish passage through road culverts. Paper No. 067034, Annual Meeting, American Society of Agricultural and Biological Engineers, St. Joseph, MI.

Hunter, L.A., and L. Mayor. 1986. Analysis of Fish Swimming Performance Data. Unpublished Report. Vol. I.

Jenkins, R.E. and N.M. Burkhead. 1993. Freshwater Fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Katopodis, C. and R. Gervais. 2016. Fish Swimming Performance Database and Analyses. Canadian Science Advisory Secretariat. Research Document 2016/002. Winnipeg, MB.

Larimore, R.W. and M. J. Duever. 1968. Effects of temperature acclimation on the swimming ability of small-mouth bass fry. Trans Am Fish Soc 97:175–184.

Layher, W.G. 1993. Determining swimming speeds for darters of the genera Etheostoma and two cyprinid fishes. Final Report. Challenge cost-share grant between the Ouchita National Forest U.S.D.A. Forest Service and the University of Arkansas at Pine Bluff.

Nelson, J. A., P. S. Gotwalt, and J. W. Snodgrass. 2003. Swimming performance of Blacknose dace (Rhinichthys atratulus) mirrors home-stream current velocity. Canadian Journal of Fisheries and Aquatic Sciences 60: 301-308.

Peake, S., R. S. McKinley, and D. A. Scruton. 2000. Swimming performance of Walleye (Stizostedion vitreum). Canadian Journal of Zoology 78:1686-1690.

Reutz III, C.R., and C. A. Jennings. 2000. Swimming performance of larval robust redhorse (Moxostoma robustum) and low-velocity habitat modeling in the Oconee River, Georgia. Transactions of the American Fisheries Society 129:398-407.

Smiley, P. and G.R. Parsons. 1997. Effects of photoperiod and temperature on the swimming performance of white crappie. Transactions of the American Fisheries Society, 126:495-499.

Smith, C.L. 1985. The Inland Fishes of New York State. The New York State Department of Environmental Conservation, Albany, New York.

Stauffer, J. R., J. M. Boltz, and L. R. White. 1995. The fishes of West Virginia. Academy of Natural Sciences, Philadelphia, Pennsylvania.

Tsukamoto, K., Kajihara, T. and Nishiwaki, M. 1975. Swimming ability of fish. Bulletin of the Japanese Society of the Science of Fisheries 41: 167–74.

U.S. Fish and Wildlife Service (USFWS). 2020. TBSA Model: A Desktop Tool for Estimating Mortality of Fish Entrained in Hydroelectric Turbines. Excel file dated December 9, 2020.

Virginia Department of Wildlife Resources (VDWR). 2017a. Fish and Wildlife Information Service. Online [URL]: http://vafwis.org/fwis/?Menu=Home.Geographic+Search (Accessed September 27, 2017).

______. 2017b. Virginia Fishes. Online [URL]: https://www.dgif.virginia.gov/wildlife/fish/ (Accessed September 20, 2017).

______. 2020. Muskellunge. Online [URL]: https://dwr.virginia.gov/wildlife/fish/muskellunge/ (Accessed December 21, 2020).

Winchell, F., S. Amaral, and D. Dixon. 2000. Hydroelectric Turbine Entrainment and Survival Database: An Alternative to Field Studies. HydroVision Conference, August 8-11, 2000, Charlotte, North Carolina.

Webb, P.W. 1998. Swimming. In the Physiology of Fishes (D. H. Evans, ed.), pp.3 -24. Boca Raton: CRC Press.

Appendix A

Appendix A – Site Characteristics of Hydropower Facilities from the EPRI (1997) Database

Table 1. Electric Power Research Institute Entrainment Database[1] Sites Used for the Byllesby-Buck Hydroelectric Project Fish Impingement and Entrainment Study

No.	Site Name	State	River	Reservoir Area (ac)	Reservoir Volume (ac-ft)	Usable Storage (ac-ft)	Fluctuation Limits (ft)	Length (mi)	Width (ft)	Total Plant Capacity (cfs)	No. Units	Operating Mode[2]	Average Velocity at Trash Rack (ft/sec)	Trash Rack Spacing (inch)
1	Belding	MI	Flat	-	-	-	-	-	-	416	2	-	-	2
2	Bond Falls	MI	W.B. Ontonagon	-	-	-	-	-	-	900	2	PK	-	3
3	Brule	WI	Brule	545	8880	530	1	5.2	340	1,377	3	PK-partial	1	1.62
4	Caldron Falls	WI	Peshtigo	1,180	-	-	-	-	-	1,300	2	PK	-	2
5	Centralia	WI	Wisconsin	250	-	-	0	2	1400	3,640	6	ROR	2.3	3.5
6	Colton	NY	Raquette	195	620	103	0.5	-	-	1,503	3	PK	-	2
7	Crowley	WI	N.F. Flambeau	422	3,539	-	1	-	-	2,400	2	ROR	1.4	2.375
8	Feeder Dam	NY	Hudson	-	-	-	-	-	-	5,000	5	PK	-	2.75
9	Four Mile Dam	MI	Thunder Bay	1,112	2,500		0.5	-	-	1,500	3	ROR	-	2
10	Grand Rapids	MI/ WI	Menominee	250	-	-	0.5	-	-	3,870	5	ROR	-	1.75
11	Herrings	NY	Black	140	-	-	-	-	-	3,610	3	ROR	-	4.125
12	High Falls - Beaver River	NY	Beaver	145	1,058	290	-	-	-	900	3	-	0.7	1.81
13	Higley	NY	Raquette	742	4,446	-	1.5	-	-	2,045	3	PK	-	3.63
14	Hillman Dam	MI	Thunder Bay	988	1,600	-	-	-	-	270	1	ROR	-	3.25
15	Johnsonville	NY	Hoosic	450	6,430	540	6.5	-	-	1,288	2	PK	-	2
16	Kleber	MI	Black	270	3,000	-	0	0.9	-	400	2	ROR	1.41	3
17	Lake Algonquin	NY	Sacandaga	-	-	-	-	-	-	750	1	-	-	1
18	Luray	VA	S.F. Shenandoah	-	-	-	-	-	-	1,477	3	ROR	-	2.75

No.	Site Name	State	River	Reservoir Area (ac)	Reservoir Volume (ac-ft)	Usable Storage (ac-ft)	Fluctuation Limits (ft)	Length (mi)	Width (ft)	Total Plant Capacity (cfs)	No. Units	Operating Mode[2]	Average Velocity at Trash Rack (ft/sec)	Trash Rack Spacing (inch)
19	Minetto	NY	Oswego	350	4,730	290	1.8	-	-	7,500	5	PULSE	2.4	2.5
20	Moshier	NY	Beaver	365	7,339	680	3	-	-	660	2	PK	-	1.5
21	Ninth Street Dam	MI	Thunder Bay	9,884	2,600	-	0.5	-	-	1,650	3	ROR	-	1
22	Norway Point Dam	MI	Thunder Bay	10,502	3,800	-	0.5	-	-	1,775	2	ROR	-	1.69
23	Potato Rapids	WI	Peshtigo	288	-	-	-	-	-	1,380	3	ROR	-	1.75
24	Raymondville	NY	Raquette	50	264	-	1	-	-	1,640	1	PK	-	2.25
25	Sandstone Rapids	WI	Peshtigo	150	-	-	-	-	-	1,300	2	PK	-	1.75
26	Schaghticoke	NY	Hoosic	164	1,150	120	6.5	-	-	1,640	4	ROR	-	2.125
27	Sherman Island	NY	Hudson	305	6,960	1,060	3.7	-	-	6,600	4	PK	-	3.125
28	Thornapple	WI	Flambeau	295	1,000	295	1.5	4	600	1,400	2	ROR-mod	1.22	1.69
29	Tower	MI	Black	102	620	-	0	0.9	-	404	2	ROR	0.82	1
30	Twin Branch	IN	St. Joseph	1,065	-	-	-	8.75	-	3,200	-	ROR	-	3
31	Warrensburg	NY	Schroon	-	-	-	-	-	-	1,350	1	-	-	-
32	White Rapids	MI/ WI	Menominee	435	5,155	415	1	2.3	580	3,994	3	PK-partial	1.9	2.5
33	Wisconsin River Division	WI	Wisconsin	240	1,120	-	0	2.5	1,000	5,150	10	ROR	1.4	2.19

[1] Electric Power Research Institute. 1997. Turbine Entrainment and Survival Database. TR-108630. Palo Alto, CA.
[2]Operating Mode: peaking (PK), pulse, or run-of-river (ROR)
Notes: ac=acre; ac-ft=acre-feet; mi=mile; cfs=cubic feet per second; ft/sec=feet per second

Appendix B

Appendix B – Life History Information for Target Fish Species and Species Groups

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Black Crappie - *Pomoxis nigromaculatus*

Black Crappie is native throughout the Great Lakes-St. Lawrence and Mississippi basins, Gulf slope, and Atlantic slope, and widely transplanted to other regions (Jenkins and Burkhead 1993). They are found in swamps, ponds, lakes, reservoirs, and slack water of low-to-moderate gradient, usually associated with vegetation or other structure such as woody debris and stumps. Young Black Crappie feed on microcrustaceans, insects, and larval fish; adults feed on fish, crustaceans, and insects.

Spawning occurs early, with nest construction beginning in March and continuing through July; however, most spawning occurs in April in Virginia (Jenkins and Burkhead 1993). Nests are excavated in shallow to moderately deep water associated with vegetation and may be crowded.

Channel Catfish - *Ictalurus punctatus*

Channel Catfish are found in lakes and larger rivers with relatively clean sand, gravel, or stone substrate, over mud flats, and seldom in dense weedy areas (VDWR 2017b). They live in deep, slow pools of swift, clear-running streams. They are often found below dams in large reservoirs.

Spawning occurs from late May through July when water temperatures reach the mid-70s (VDGIF 2017b). Channel Catfish often deposit their eggs on rocky ledges, undercut banks, hollow logs, and other underwater structures. Males guard the nest and the eggs hatch in 7 to 10 days. The fry travel in schools, which are often herded and guarded by the male.

Common Carp – *Cyprinus carpio*

Common Carp are indigenous to Asia and was first introduced to Virginia in the 1870s (Jenkins and Burkhead 1993). It is an adaptable species found in a range of habitats except for high-gradient, small coldwater streams or habitats with extreme conditions, such as hot springs or very-low pH waters. It prefers sluggish pools with vegetation and soft bottoms. It is an omnivore and will feed on aquatic and terrestrial insects, small fish, plants, and organic matter.

Spawning occurs from late March to August, and possible into September (Jenkins and Burkhead). Common Carp spawn in backwaters and sloughs, and along shorelines of impoundments over vegetation or tree roots. Eggs are adhesive and demersal.

Common Logperch – *Percina caprodes*

Common Logperch are found throughout the Ohio basin and in several drainages of the southwestern Mississippi basin (Jenkins and Burkhead 1993). In Virginia, they are in the upper Tennessee drainage in the Valley and Ridge Province, but generally not found in the Blue Ridge. This species inhabits warm streams to large rivers with moderate gradient; it can also be found in lakes and reservoirs; however, it is associated with gravels and cobble in riffles, runs, and pools. Common Logperch feed on a variety of insects and invertebrates, often by turning over stones.

Spawning occurs on sand or gravel in swift current of streams or near shores of lakes, from mid-March to mid-July (Jenkins and Burkhead 1993). It is not a territorial spawner and often forms spawning groups. Eggs are buried by the spawning act or otherwise eaten by logperches and suckers.

Johnny Darter – *Etheostoma nigrum*

The Johnny Darter is found throughout Hudson Bay, Great Lakes, Mississippi, and Mobile basins (Jenkins and Burkhead 1993). It inhabits warm, moderate-gradient creeks, streams, and rivers, and rarely in lacustrine habitats. It prefers pools and slow runs with rubble, gravel, sand, silt, or detritus substrates.

Johnny Darter spawn from mid-March to mid-May in shallow parts of streams in slow to moderate current (Jenkins and Burkhead 1993). Nests have cover consisting of shelving stones, wood, tiles and cans, or other shelf-like materials and cover. Eggs are attached in a single layer to the underside of the nesting cover and the nest is territorially defended by the male.

Largemouth Bass – *Micropterus salmoides*

Largemouth Bass are native to the Great Lakes-St. Lawrence and Mississippi basins and the Gulf and south Atlantic slopes but has been widely introduced elsewhere in North America (Jenkins and Burkhead 1993). They are found in marshes, swamps, ponds, lakes, reservoirs, creeks, and large rivers. They feed on a wide array of aquatic animals.

Largemouth Bass spawn in May and June (Jenkins and Burkhead 1993). Males fan a nest area over a variety of substrates, and guards it against intruders. They may be found in open areas or associated with various cover, such as vegetation, ledges, or woody debris.

***Lepomis* Sunfishes - *Lepomis* spp.**

Lepomis are the largest genus of the Centrarchidae. All *Lepomis* in Virginia are found in pools and backwater areas of warm, clear creeks, streams, and rivers of low to moderate gradient, as well as lakes and ponds (Jenkins and Burkhead 1993). They feed on small prey such as aquatic insects, small fish and crustaceans, and incidentally, plant material.

Spawning begins in May with nests constructed in colonially in open, shallow areas on sand and small gravel (Jenkins and Burkhead 1993). Nests are constructed in water 2 meters deep or shallower and are defended by males.

Margined Madtom – *Noturus insignis.*

Margined Madtom are indigenous to the Atlantic slope drainages, and introduced to northern drainages in New York, New Hampshire, Maryland, and Pennsylvania (Jenkins and Burkhead 1993). It is found in low and moderate-gradient areas of large creeks to large rivers, over soft and hard bottoms of pools, runs, and riffles. It feeds on a variety of aquatic invertebrates, fish and terrestrial insects. Margined Madtom spawn in May and June. They create nests underneath flat rocks in gentle runs and slow water above and below riffles.

Muskellunge – *Esox masquinongy*

Muskellunge are native from the St. Lawrence to the Great Lakes, the upper Mississippi basin and Ohio basin (Jenkins and Burkhead 1993). It is unclear as to whether Muskellunge are native to Virginia. Muskellunge are found in lakes, reservoirs, and slow-moving parts of rivers. It prefers vegetative cover and structure such as brush piles, logs, bars, and rock outcrops. It is a voracious piscivore.

Spawning begins when water is between 49 and 60°F (Jenkins and Burkhead 1993). Muskellunge move to the shallows of streams and in lakes in northern areas, usually over detritus or living vegetation.

Northern Hogsucker – *Hypentelium nigricans*

Northern Hogsucker are widespread through the Great Lakes, upper Mississippi and Ohio basins, and present in certain drainages of the Gulf and south Atlantic slopes (Jenkins and Burkhead 1993). In Virginia, it is found in many of the major drainages. It is found in a range of habitats from large creeks to small rivers in upland and montane areas with cool or warm waters and gravelly or rocky bottoms. They feed on immature aquatic insects and microcrustaceans, small mollusks, and rarely, fish eggs. Spawning occurs in April and May, when they may or may not move into streams to reproduce. Northern Hogsucker prefers to spawn in gravelly tails of pools, riffles, or runs.

Rock Bass - *Ambloplites rupestris*

Rock Bass are native only to the Tennessee and Big Sandy drainages, but has been introduced to the New and all other major Atlantic slope drainages (Jenkins and Burkhead 1993). They are found in clear, cool and warm creeks, streams, and rivers with moderate gradient, as well as pools and backwater areas. They are strongly associated with shelter and avoid areas with heavy siltation and turbidity. Rock bass are generalist feeders and will eat a variety of microcrustaceans, insects, and other invertebrates when young, shifting to larger prey as adults such as fish and crayfish.

Spawning occurs from April to July (Jenkins and Burkhead 1993). Males fan out circular nests in shallow areas with coarse sand and large gravel substrates and defend them against other males.

Smallmouth Bass/Spotted Bass - *Micropterus dolomieu/M. punctulatus*

Smallmouth Bass are native to Virginia (VDWR 2017a) and they are now abundant in most large rivers and lakes throughout the State. Smallmouth Bass prefer slow-to-moderate current and select areas of rocky shorelines. They are most active in 19°C to 22°C water and are intolerant of silty, warm, polluted water.

Spawning usually occurs from late April to early June as temperatures exceed 16°C, in water depths of 2 to 4 feet. Males build a nest in sand, gravel, or rubble where they will guard the nest and fry (VDWR 2017b). Eggs hatch between 7 and 21 days after fertilization, depending on the water temperature (Smith 1985).

Walleye – *Sander vitreus*

Walleye are native from Canada to the Great Lakes and Mississippi basin, and widely introduced outside of its indigenous range (likely including those on the Atlantic slope south of the St. Lawrence) (Jenkins and Burkhead 1993). Walleye are found in a wide variety of habitats, including rivers with low to moderate gradient, lakes and impoundments greater than 400 acres in size. Bottom types include detritus, sand, gravel, rubble, and boulder. Walleye, like Muskellunge, are voracious predators, and are known to be cannibalistic.

Walleye spawning occurs within a three-week window from March to June, soon after ice-out (Jenkins and Burkhead 1993). They congregate and migrate short distances to spawning grounds. Spawning usually occurs at night over gravel or rock substrate in shallow areas of lakes and rivers.

They rarely spawn in vegetation or flooded areas. In rivers, spawning will take place in runs and reservoir tailwaters, but also in riffles. Eggs are broadcast over the bottom where they drop into crevices.

White Bass – *Morone saxatilis*

White Bass are native to the Atlantic Slope and was introduced across the U.S. (Jenkins and Burkhead 1993). It is an anadromous schooling fish that lives in large freshwater rivers, small and large estuaries, and the ocean. While many inland reservoirs support White Bass fisheries, these populations are generally stocked as they are not able to spawn naturally. They are predatory generalists and feed on open water species such as clupeids, and to a lesser extent littoral species such as black basses or crappies.

Whitetail Shiner – *Cyprinella galactura*

Whitetail Shiner was the most common shiner collected in the 2020 Fish Community Study. Whitetail Shiner is native to Tennessee and Cumberland drainages and part of the southern Ozarks (Jenkins and Burkhead 1993). It is considered native, though possibly introduced, to other drainages on the Atlantic slope. It feeds on a diverse array of allochthonous and benthic organisms such as worms, mites, insects, larval fish, and plant material.

Whitetail Shiners spawn from late May to August in Virginia (Jenkins and Burkhead 1993). Spawning occurs in shallow moderate-current runs and adjacent pools, where eggs are typically deposited above the bottom in crevices or underside of boulders, sticks, or trash. Males are territorial.

Yellow Bullhead – *Ameiurus natalis*

The Yellow Bullhead is commonly found in in shallow, soft-bottomed warm lakes, ponds, and reservoirs or slow-moving streams with emergent vegetation. This species lays eggs in saucer-shaped depressions beside or beneath banks, tree roots, logs, in burrows or along the bottom under debris (Becker 1983). Spawning occurs in spring and early summer, with eggs hatching out in 5-10 days. Nests and compact schools of young are guarded by parents until they reach approximately 50 mm in length. Sexual maturity for this species is believed to occur at age of 2-3 years.

Appendix C

Appendix C – Mean Monthly Entrainment Rates (Fish/Hour) for Target Species/Groups at Byllesby Development

Target Species/Group: Black Crappie

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.17	0.08	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.06	0.38	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.01	0.08	0.03	0.15	0.03	0.01	0.00	0.00	0.00	0.00
Apr	0.07	1.06	0.19	0.92	0.10	0.05	0.00	0.00	0.00	0.00
May	0.01	0.32	0.04	0.10	0.02	0.00	0.00	0.00	0.00	0.00
Jun	0.09	0.22	0.04	0.08	0.02	0.00	0.00	0.00	0.00	0.00
Jul	10.31	0.47	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Aug	1.50	7.13	0.04	0.10	0.06	0.01	0.00	0.00	0.00	0.00
Sep	0.47	4.27	0.11	0.06	0.03	0.01	0.00	0.00	0.00	0.00
Oct	0.47	3.79	0.15	0.03	0.02	0.01	0.00	0.00	0.00	0.00
Nov	0.13	3.31	0.17	0.03	0.01	0.00	0.00	0.00	0.00	0.00
Dec	0.03	2.24	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Grand Total	**13.32**	**23.33**	**0.88**	**1.57**	**0.30**	**0.10**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Bullheads and Madtoms

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.04	0.04	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Feb	0.04	0.10	0.00	0.02	0.06	0.00	0.00	0.00	0.00	0.00
Mar	0.03	0.08	0.04	0.05	0.05	0.00	0.00	0.00	0.00	0.00
Apr	0.09	0.39	0.13	1.25	0.35	0.11	0.00	0.00	0.00	0.00
May	0.03	0.25	0.08	0.05	0.04	0.03	0.00	0.00	0.00	0.00
Jun	0.01	0.21	0.14	0.39	0.36	0.11	0.00	0.00	0.00	0.00
Jul	0.67	0.10	0.28	1.91	0.21	0.06	0.00	0.00	0.00	0.00
Aug	0.07	0.20	0.47	0.66	0.07	0.02	0.00	0.00	0.00	0.00
Sep	0.04	0.16	0.20	0.24	0.09	0.01	0.00	0.00	0.00	0.00
Oct	0.01	0.18	0.03	0.06	0.06	0.01	0.00	0.00	0.00	0.00
Nov	0.02	0.10	0.04	0.04	0.03	0.00	0.00	0.00	0.00	0.00
Dec	0.02	0.09	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Grand Total	**1.04**	**1.89**	**1.46**	**4.66**	**1.33**	**0.35**	**0.01**	**0.00**	**0.00**	**0.00**

Target Species/Group: Catfishes

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.19	0.23	0.05	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Feb	0.57	0.41	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.20	0.26	0.04	0.23	0.01	0.00	0.00	0.00	0.00	0.00
Apr	0.05	0.57	0.31	0.07	0.04	0.02	0.00	0.00	0.00	0.00
May	0.06	23.50	1.19	0.72	2.40	0.57	0.00	0.00	0.00	0.00
Jun	0.18	10.23	1.16	2.66	4.35	0.39	0.01	0.01	0.00	0.00
Jul	12.77	6.63	0.34	0.66	0.48	0.05	0.00	0.00	0.01	0.01
Aug	4.56	1.35	0.52	0.26	0.33	0.25	0.00	0.00	0.00	0.00
Sep	0.68	0.66	0.14	0.16	0.30	0.08	0.00	0.00	0.00	0.00
Oct	0.23	0.25	0.03	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Nov	0.08	0.48	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.10	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**19.55**	**44.68**	**4.01**	**4.75**	**7.91**	**1.39**	**0.01**	**0.01**	**0.01**	**0.01**

Target Species/Group: Common Carp

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.00	0.02	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Jun	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Jul	0.05	0.07	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Aug	0.00	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.00	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Oct	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**0.12**	**0.23**	**0.11**	**0.02**	**0.01**	**0.01**	**0.03**	**0.10**	**0.00**	**0.00**

Target Species/Group: Darters and Logperch

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.18	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.09	0.24	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	1.02	6.45	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	4.61	1.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.49	0.69	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	1.32	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.08	0.09	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.03	0.13	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.02	0.20	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.01	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.07	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**7.92**	**9.96**	**0.40**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Largemouth Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.33	0.09	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Feb	0.00	0.18	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.02	0.09	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Apr	0.04	0.27	0.00	0.03	0.00	0.34	0.00	0.00	0.00	0.00
May	0.00	0.01	0.00	0.06	0.03	0.17	0.00	0.00	0.00	0.00
Jun	3.57	0.06	0.02	0.17	0.14	0.17	0.00	0.00	0.00	0.00
Jul	4.34	1.59	0.03	0.17	0.08	0.05	0.00	0.00	0.00	0.00
Aug	0.07	1.43	0.40	0.40	0.08	0.05	0.00	0.00	0.00	0.00
Sep	0.01	0.96	0.63	0.40	0.14	0.03	0.00	0.00	0.00	0.00
Oct	0.01	0.97	0.33	0.04	0.03	0.03	0.00	0.00	0.00	0.00
Nov	0.00	0.83	0.46	0.11	0.02	0.16	0.00	0.00	0.00	0.00
Dec	0.01	0.25	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**8.07**	**6.97**	**2.04**	**1.39**	**0.53**	**1.00**	**0.02**	**0.00**	**0.00**	**0.00**

Target Species/Group: *Lepomis* Sunfishes

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.31	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.12	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.06	0.05	0.44	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.23	4.06	4.65	0.06	0.00	0.00	0.00	0.00	0.00	0.00
May	0.11	2.21	0.70	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.54	0.75	1.26	0.24	0.01	0.00	0.00	0.00	0.00	0.00
Jul	0.99	0.32	1.88	0.14	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.22	0.28	4.83	0.22	0.01	0.00	0.00	0.00	0.00	0.00
Sep	0.51	0.39	11.74	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.76	1.00	6.23	0.01	0.00	0.04	0.00	0.00	0.00	0.00
Nov	0.83	0.71	0.23	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.03	0.46	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**4.71**	**10.37**	**32.07**	**1.05**	**0.03**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Muskellunge

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.11	0.13	0.15	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.02	0.03	0.11	0.37	0.23	0.36	0.00	0.00
May	0.00	0.02	0.01	0.02	0.04	0.02	0.00	0.00	0.00	0.00
Jun	0.03	0.14	0.07	0.01	0.07	0.01	0.01	0.00	0.00	0.00
Jul	0.01	0.13	0.45	0.28	0.03	0.03	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.11	0.16	0.03	0.01	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.01	0.01	0.00	0.06	0.15	0.00	0.00	0.00
Oct	0.00	0.00	0.01	0.01	0.01	0.06	0.15	0.00	0.00	0.00
Nov	0.00	0.00	0.01	0.03	0.00	0.13	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.07	0.00	0.00
Grand Total	**0.04**	**0.29**	**0.68**	**0.68**	**0.42**	**0.91**	**0.75**	**0.44**	**0.00**	**0.00**

Target Species/Group: Rock Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	1.93	0.65	0.25	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Feb	3.46	1.41	0.81	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.37	0.04	0.41	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.61	9.76	4.75	0.12	0.06	0.00	0.00	0.00	0.00	0.00
May	0.16	0.55	0.72	0.59	0.11	0.00	0.00	0.00	0.00	0.00
Jun	0.15	1.14	2.15	0.92	0.06	0.00	0.00	0.00	0.00	0.00
Jul	1.00	0.29	1.55	0.39	0.05	0.00	0.00	0.00	0.00	0.00
Aug	0.17	0.29	4.01	1.20	0.12	0.00	0.00	0.00	0.00	0.00
Sep	0.36	0.23	2.46	2.73	0.03	0.00	0.00	0.00	0.00	0.00
Oct	0.34	0.87	19.70	0.29	0.01	0.00	0.00	0.00	0.00	0.00
Nov	0.18	0.33	10.10	0.48	0.01	0.00	0.00	0.00	0.00	0.00
Dec	0.40	1.17	3.54	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**9.13**	**16.72**	**50.44**	**7.18**	**0.45**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Shiners, Chubs, and Minnows

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.02	0.61	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.05	1.37	0.36	0.08	0.07	0.00	0.00	0.00	0.00	0.00
Mar	0.04	0.83	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.56	1.09	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.00
May	0.34	0.79	0.08	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Jun	0.28	0.59	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	0.84	1.25	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.23	0.81	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.22	1.46	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.08	1.11	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.06	1.35	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.02	0.30	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**2.76**	**11.56**	**1.23**	**0.14**	**0.07**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Smallmouth Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.11	0.01	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.00	0.04	0.00	0.00	0.00	0.07	0.01	0.00	0.00	0.00
May	0.00	0.01	0.00	0.01	0.03	0.13	0.03	0.00	0.00	0.00
Jun	0.40	0.23	0.01	0.03	0.04	0.07	0.01	0.00	0.00	0.00
Jul	2.31	0.24	0.04	0.03	0.02	0.02	0.00	0.00	0.00	0.00
Aug	0.24	0.34	0.14	0.09	0.05	0.07	0.00	0.00	0.00	0.00
Sep	0.04	1.19	0.72	0.28	0.07	0.03	0.00	0.00	0.00	0.00
Oct	0.05	0.55	0.18	0.04	0.02	0.04	0.00	0.00	0.00	0.00
Nov	0.00	0.10	0.07	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Dec	0.04	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**3.20**	**2.90**	**1.24**	**0.57**	**0.22**	**0.44**	**0.04**	**0.00**	**0.00**	**0.00**

Target Species/Group: Suckers and Redhorse

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.04	0.87	1.55	1.18	0.74	0.52	0.00	0.00	0.00	0.00
Feb	0.05	0.55	1.39	0.98	0.11	0.00	0.02	0.00	0.00	0.00
Mar	0.05	0.21	0.75	0.64	0.06	0.06	0.00	0.00	0.00	0.00
Apr	0.19	1.02	0.45	0.31	0.40	1.22	0.36	0.00	0.00	0.00
May	0.02	0.15	0.04	0.03	0.06	0.14	0.02	0.00	0.00	0.00
Jun	2.37	0.35	0.05	0.02	0.01	0.05	0.01	0.00	0.00	0.00
Jul	3.69	0.43	0.07	0.02	0.01	0.04	0.01	0.00	0.00	0.00
Aug	0.28	0.09	0.02	0.01	0.02	0.01	0.01	0.00	0.00	0.00
Sep	0.03	0.16	0.05	0.06	0.03	0.08	0.00	0.00	0.00	0.00
Oct	0.02	0.30	16.45	0.82	1.06	0.25	0.08	0.00	0.00	0.00
Nov	0.01	0.23	0.43	3.71	2.37	0.22	0.00	0.00	0.00	0.00
Dec	0.05	0.09	0.48	2.47	0.67	0.01	0.00	0.00	0.00	0.00
Grand Total	**6.79**	**4.43**	**21.75**	**10.23**	**5.54**	**2.60**	**0.51**	**0.00**	**0.00**	**0.00**

Target Species/Group: Walleye

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.11	0.01	0.03	0.11	1.13	0.39	0.00	0.00	0.00	0.00
Feb	0.00	0.05	0.15	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.04	0.04	0.05	0.12	0.01	0.00	0.00	0.00
May	0.00	0.01	0.07	0.27	0.17	0.31	0.01	0.00	0.00	0.00
Jun	2.14	0.61	0.02	0.15	0.11	0.19	0.01	0.00	0.00	0.00
Jul	0.39	3.92	0.27	0.06	0.06	0.08	0.06	0.00	0.00	0.00
Aug	0.01	0.28	0.48	0.07	0.06	0.13	0.00	0.00	0.00	0.00
Sep	0.01	0.15	0.41	0.16	0.08	0.05	0.02	0.01	0.00	0.00
Oct	0.00	0.02	0.19	0.29	0.12	0.16	0.01	0.00	0.00	0.00
Nov	0.00	0.03	0.05	0.05	0.02	0.04	0.02	0.00	0.00	0.00
Dec	0.00	0.00	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**2.67**	**5.10**	**1.79**	**1.26**	**1.80**	**1.47**	**0.13**	**0.01**	**0.00**	**0.00**

Target Species/Group: White Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.01	0.81	0.08	0.15	0.03	0.01	0.00	0.00	0.00	0.00
Apr	0.01	0.22	0.02	0.07	0.02	0.00	0.00	0.00	0.00	0.00
May	0.00	1.55	0.09	0.25	0.23	0.05	0.00	0.00	0.00	0.00
Jun	0.00	0.01	0.01	0.13	0.05	0.01	0.00	0.00	0.00	0.00
Jul	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.04	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Sep	0.00	0.01	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.00	0.04	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**0.02**	**3.04**	**0.43**	**0.62**	**0.35**	**0.07**	**0.00**	**0.00**	**0.00**	**0.00**

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Appendix D

Appendix D – Mean Monthly Entrainment Rates (Fish/Hour) for Target Species/Groups at Buck Development

Target Species/Group: Black Crappie

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.10	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.04	0.23	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.01	0.05	0.02	0.09	0.02	0.01	0.00	0.00	0.00	0.00
Apr	0.04	0.64	0.11	0.55	0.06	0.03	0.00	0.00	0.00	0.00
May	0.01	0.19	0.02	0.06	0.01	0.00	0.00	0.00	0.00	0.00
Jun	0.06	0.13	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.00
Jul	6.22	0.29	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.91	4.30	0.02	0.06	0.04	0.00	0.00	0.00	0.00	0.00
Sep	0.28	2.57	0.07	0.04	0.02	0.01	0.00	0.00	0.00	0.00
Oct	0.28	2.29	0.09	0.02	0.01	0.00	0.00	0.00	0.00	0.00
Nov	0.08	2.00	0.10	0.02	0.01	0.00	0.00	0.00	0.00	0.00
Dec	0.02	1.35	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Grand Total	**8.04**	**14.08**	**0.53**	**0.95**	**0.18**	**0.06**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Bullheads and Madtoms

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.02	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Feb	0.02	0.06	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00
Mar	0.02	0.05	0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.00
Apr	0.06	0.24	0.08	0.75	0.21	0.07	0.00	0.00	0.00	0.00
May	0.02	0.15	0.05	0.03	0.02	0.02	0.00	0.00	0.00	0.00
Jun	0.01	0.13	0.08	0.23	0.22	0.07	0.00	0.00	0.00	0.00
Jul	0.40	0.06	0.17	1.15	0.13	0.04	0.00	0.00	0.00	0.00
Aug	0.04	0.12	0.29	0.40	0.04	0.01	0.00	0.00	0.00	0.00
Sep	0.03	0.10	0.12	0.14	0.05	0.00	0.00	0.00	0.00	0.00
Oct	0.01	0.11	0.02	0.04	0.04	0.01	0.00	0.00	0.00	0.00
Nov	0.01	0.06	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00
Dec	0.01	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Grand Total	**0.63**	**1.14**	**0.88**	**2.81**	**0.80**	**0.21**	**0.01**	**0.00**	**0.00**	**0.00**

Target Species/Group: Catfishes

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.11	0.14	0.03	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Feb	0.34	0.25	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.12	0.16	0.02	0.14	0.01	0.00	0.00	0.00	0.00	0.00
Apr	0.03	0.34	0.19	0.04	0.02	0.01	0.00	0.00	0.00	0.00
May	0.04	14.17	0.72	0.44	1.45	0.34	0.00	0.00	0.00	0.00
Jun	0.11	6.17	0.70	1.60	2.62	0.23	0.00	0.00	0.00	0.00
Jul	7.70	4.00	0.20	0.40	0.29	0.03	0.00	0.00	0.00	0.00
Aug	2.75	0.82	0.31	0.15	0.20	0.15	0.00	0.00	0.00	0.00
Sep	0.41	0.40	0.08	0.09	0.18	0.05	0.00	0.00	0.00	0.00
Oct	0.14	0.15	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Nov	0.05	0.29	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**11.79**	**26.95**	**2.42**	**2.87**	**4.77**	**0.84**	**0.01**	**0.00**	**0.00**	**0.00**

Target Species/Group: Common Carp

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Jun	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Jul	0.03	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Aug	0.00	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**0.07**	**0.14**	**0.07**	**0.01**	**0.01**	**0.01**	**0.02**	**0.06**	**0.00**	**0.00**

Target Species/Group: Darters and Logperch

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.11	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.05	0.14	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.62	3.89	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May	2.78	0.64	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.29	0.42	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	0.80	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.05	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.02	0.08	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.01	0.12	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**4.78**	**6.01**	**0.24**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Largemouth Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.20	0.05	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Feb	0.00	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.01	0.06	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.02	0.16	0.00	0.02	0.00	0.21	0.00	0.00	0.00	0.00
May	0.00	0.00	0.00	0.04	0.02	0.10	0.00	0.00	0.00	0.00
Jun	2.15	0.04	0.01	0.10	0.09	0.10	0.00	0.00	0.00	0.00
Jul	2.62	0.96	0.02	0.10	0.05	0.03	0.00	0.00	0.00	0.00
Aug	0.04	0.86	0.24	0.24	0.05	0.03	0.00	0.00	0.00	0.00
Sep	0.01	0.58	0.38	0.24	0.09	0.02	0.00	0.00	0.00	0.00
Oct	0.01	0.58	0.20	0.02	0.02	0.02	0.00	0.00	0.00	0.00
Nov	0.00	0.50	0.27	0.07	0.01	0.09	0.00	0.00	0.00	0.00
Dec	0.01	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**4.87**	**4.20**	**1.23**	**0.84**	**0.32**	**0.60**	**0.01**	**0.00**	**0.00**	**0.00**

Target Species/Group: *Lepomis* Sunfishes

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.19	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.07	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.04	0.03	0.27	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.14	2.45	2.81	0.04	0.00	0.00	0.00	0.00	0.00	0.00
May	0.07	1.33	0.42	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.33	0.45	0.76	0.15	0.01	0.00	0.00	0.00	0.00	0.00
Jul	0.60	0.20	1.13	0.09	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.14	0.17	2.92	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.31	0.23	7.09	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.46	0.60	3.76	0.01	0.00	0.02	0.00	0.00	0.00	0.00
Nov	0.50	0.43	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.02	0.28	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**2.84**	**6.25**	**19.34**	**0.63**	**0.02**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Logperch

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.00	4.45	0.08	0.00	0.00	0.01	0.00	0.00	0.00	0.00
May	0.09	0.61	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.05	0.70	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	1.42	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.04	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.01	0.12	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.00	0.11	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.01	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**1.79**	**7.63**	**0.40**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Muskellunge

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00
Mar	0.00	0.00	0.00	0.07	0.08	0.09	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.01	0.02	0.07	0.22	0.14	0.22	0.00	0.00
May	0.00	0.01	0.00	0.01	0.03	0.01	0.00	0.00	0.00	0.00
Jun	0.02	0.08	0.04	0.01	0.04	0.01	0.00	0.00	0.00	0.00
Jul	0.01	0.08	0.27	0.17	0.02	0.02	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.07	0.10	0.02	0.01	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.01	0.00	0.03	0.09	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.01	0.01	0.04	0.09	0.00	0.00	0.00
Nov	0.00	0.00	0.01	0.02	0.00	0.08	0.00	0.00	0.00	0.00
Dec	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04	0.00	0.00
Grand Total	**0.02**	**0.18**	**0.41**	**0.41**	**0.25**	**0.55**	**0.45**	**0.27**	**0.00**	**0.00**

Target Species/Group: Rock Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	1.17	0.39	0.15	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Feb	2.09	0.85	0.49	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.22	0.02	0.25	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.37	5.89	2.86	0.07	0.04	0.00	0.00	0.00	0.00	0.00
May	0.10	0.33	0.43	0.36	0.06	0.00	0.00	0.00	0.00	0.00
Jun	0.09	0.69	1.30	0.55	0.04	0.00	0.00	0.00	0.00	0.00
Jul	0.60	0.17	0.93	0.24	0.03	0.00	0.00	0.00	0.00	0.00
Aug	0.10	0.18	2.42	0.72	0.07	0.00	0.00	0.00	0.00	0.00
Sep	0.21	0.14	1.48	1.64	0.02	0.00	0.00	0.00	0.00	0.00
Oct	0.20	0.53	11.88	0.18	0.01	0.00	0.00	0.00	0.00	0.00
Nov	0.11	0.20	6.09	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.24	0.71	2.14	0.19	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**5.51**	**10.09**	**30.43**	**4.33**	**0.27**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Shiners, Chubs, and Minnows

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.01	0.37	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.03	0.83	0.21	0.05	0.04	0.00	0.00	0.00	0.00	0.00
Mar	0.03	0.50	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.34	0.65	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00
May	0.21	0.48	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jun	0.17	0.36	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	0.51	0.75	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.14	0.49	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.13	0.88	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.05	0.67	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.04	0.81	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.01	0.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**1.66**	**6.97**	**0.74**	**0.09**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Target Species/Group: Smallmouth Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.06	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.00	0.03	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
May	0.00	0.01	0.00	0.00	0.02	0.08	0.02	0.00	0.00	0.00
Jun	0.24	0.14	0.01	0.02	0.02	0.04	0.00	0.00	0.00	0.00
Jul	1.40	0.14	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00
Aug	0.15	0.21	0.08	0.05	0.03	0.04	0.00	0.00	0.00	0.00
Sep	0.02	0.72	0.43	0.17	0.04	0.02	0.00	0.00	0.00	0.00
Oct	0.03	0.33	0.11	0.03	0.01	0.02	0.00	0.00	0.00	0.00
Nov	0.00	0.06	0.04	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Dec	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**1.93**	**1.75**	**0.75**	**0.34**	**0.13**	**0.27**	**0.03**	**0.00**	**0.00**	**0.00**

Target Species/Group: Suckers and Redhorse

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.02	0.53	0.94	0.71	0.45	0.31	0.00	0.00	0.00	0.00
Feb	0.03	0.33	0.84	0.59	0.07	0.00	0.01	0.00	0.00	0.00
Mar	0.03	0.13	0.45	0.38	0.03	0.04	0.00	0.00	0.00	0.00
Apr	0.11	0.61	0.27	0.19	0.24	0.73	0.22	0.00	0.00	0.00
May	0.01	0.09	0.03	0.02	0.04	0.08	0.02	0.00	0.00	0.00
Jun	1.43	0.21	0.03	0.01	0.01	0.03	0.01	0.00	0.00	0.00
Jul	2.23	0.26	0.04	0.01	0.01	0.03	0.00	0.00	0.00	0.00
Aug	0.17	0.05	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Sep	0.02	0.09	0.03	0.03	0.02	0.05	0.00	0.00	0.00	0.00
Oct	0.01	0.18	9.92	0.50	0.64	0.15	0.05	0.00	0.00	0.00
Nov	0.01	0.14	0.26	2.24	1.43	0.13	0.00	0.00	0.00	0.00
Dec	0.03	0.05	0.29	1.49	0.40	0.01	0.00	0.00	0.00	0.00
Grand Total	**4.10**	**2.67**	**13.12**	**6.17**	**3.34**	**1.57**	**0.31**	**0.00**	**0.00**	**0.00**

Target Species/Group: Walleye

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.07	0.01	0.02	0.07	0.68	0.23	0.00	0.00	0.00	0.00
Feb	0.00	0.03	0.09	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr	0.00	0.00	0.02	0.03	0.03	0.07	0.01	0.00	0.00	0.00
May	0.00	0.01	0.04	0.16	0.10	0.19	0.00	0.00	0.00	0.00
Jun	1.29	0.37	0.01	0.09	0.07	0.12	0.01	0.00	0.00	0.00
Jul	0.23	2.37	0.16	0.03	0.03	0.05	0.04	0.00	0.00	0.00
Aug	0.01	0.17	0.29	0.04	0.04	0.08	0.00	0.00	0.00	0.00
Sep	0.01	0.09	0.25	0.10	0.05	0.03	0.01	0.01	0.00	0.00
Oct	0.00	0.01	0.12	0.18	0.08	0.09	0.00	0.00	0.00	0.00
Nov	0.00	0.02	0.03	0.03	0.01	0.02	0.01	0.00	0.00	0.00
Dec	0.00	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**1.61**	**3.08**	**1.08**	**0.76**	**1.09**	**0.89**	**0.08**	**0.01**	**0.00**	**0.00**

Target Species/Group: White Bass

Month	0-2 in	2-4 in	4-6 in	6-8 in	8-10 in	10-15 in	15-20 in	20-25 in	25-30 in	30+ in
Jan	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.00	0.49	0.05	0.09	0.02	0.00	0.00	0.00	0.00	0.00
Apr	0.01	0.14	0.01	0.04	0.01	0.00	0.00	0.00	0.00	0.00
May	0.00	0.93	0.05	0.15	0.14	0.03	0.00	0.00	0.00	0.00
Jun	0.00	0.00	0.01	0.08	0.03	0.01	0.00	0.00	0.00	0.00
Jul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.00	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**0.01**	**1.83**	**0.26**	**0.38**	**0.21**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**

Appendix E

Appendix E – USFWS Turbine Blade Strike Analysis Model Outputs for Byllesby Development – Existing Operations without Spill and with Varying Amounts of Spill for Walleye

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Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L2-S96 10/28/2021
Byllesby Development Existing , New River, Galax, Virginia KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	2.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	224 of 5000 fish	4.5%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4776 of 5000 fish	95.5%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L4-S92 10/28/2021
Byllesby Development Existing , New River, Galax, Virginia KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	4.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	401 of 5000 fish	8.0%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4599 of 5000 fish	92.0%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L6-S86 10/28/2021
Byllesby Development Existing , New River, Galax, Virginia KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	6.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	694 of 5000 fish	13.9%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4306 of 5000 fish	86.1%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L8-S83 10/28/2021

Byllesby Development Existing , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	8.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	853 of 5000 fish	17.1%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4147 of 5000 fish	82.9%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L10-S79 10/28/2021

Byllesby Development Existing , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	10.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1026 of 5000 fish	20.5%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3974 of 5000 fish	79.5%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L15-S67 10/28/2021

Byllesby Development Existing , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	15.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1634 of 5000 fish	32.7%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3366 of 5000 fish	67.3%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L20-S55 10/28/2021
Byllesby Development Existing , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	20.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	2229 of 5000 fish	44.6%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	2771 of 5000 fish	55.4%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L25-S44 10/28/2021
Byllesby Development Existing , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	25.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	2811 of 5000 fish	56.2%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	2189 of 5000 fish	43.8%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L30-S32 10/28/2021
Byllesby Development Existing , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.250	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.250	0.250	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.250	0.500	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.250	0.750	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	30.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	3389 of 5000 fish	67.8%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	1611 of 5000 fish	32.2%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S68 10/28/2021
Byllesby Existing: 4% Exceedance Flow (230 CFS spill). Walleye Length Data. KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.240	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.240	0.240	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.240	0.481	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.240	0.721	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.039	0.961	0	bypass													0.03

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	1603 of 5000 fish	32.1%
Bypass Failures:	10 of 5000 fish	0.2%
Passed:	3387 of 5000 fish	67.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S75 10/28/2021
Byllesby Existing: 3% Exceedance Flow (1128 CFS spill). Walleye KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.209	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.209	0.209	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.209	0.417	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.209	0.626	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.167	0.834	0	bypass													0.03

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	1246 of 5000 fish	24.9%
Bypass Failures:	20 of 5000 fish	0.4%
Passed:	3734 of 5000 fish	74.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S79 10/28/2021

Byllesby Existing: 2% Exceedance Flow (2355 CFS spill). Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.177	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.177	0.177	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.177	0.353	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.177	0.530	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.293	0.707	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1041 of 5000 fish	20.8%
Bypass Failures:	31 of 5000 fish	0.6%
Passed:	3928 of 5000 fish	78.6%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S83 10/28/2021

Byllesby Existing: 1% Exceedance Flow (5094 CFS spill). Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.132	0.000	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 2	0.132	0.132	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 3	0.132	0.264	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Unit 4	0.132	0.395	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.473	0.527	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	794 of 5000 fish	15.9%
Bypass Failures:	72 of 5000 fish	1.4%
Passed:	4134 of 5000 fish	82.7%

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Appendix F

Appendix F – USFWS Turbine Blade Strike Analysis Model Outputs for Byllesby Development – Proposed Operations without Spill and with Varying Amounts of Spill for Walleye

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L2-S97 10/28/2021

Byllesby Development Propsed , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	2.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	158 of 5000 fish	3.2%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4842 of 5000 fish	96.8%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L4-S94 10/28/2021

Byllesby Development Propsed , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	4.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	285 of 5000 fish	5.7%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4715 of 5000 fish	94.3%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L6-S92 10/28/2021

Byllesby Development Propsed , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	6.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	396 of 5000 fish	7.9%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4604 of 5000 fish	92.1%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L8-S89 10/28/2021
Byllesby Development Propsed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	8.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	565 of 5000 fish	11.3%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4435 of 5000 fish	88.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L10-S86 10/28/2021
Byllesby Development Propsed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	10.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	679 of 5000 fish	13.6%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4321 of 5000 fish	86.4%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L15-S79 10/28/2021
Byllesby Development Propsed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	15.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	1070 of 5000 fish	21.4%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3930 of 5000 fish	78.6%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L20-S73 10/28/2021
Byllesby Development Propsed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	20.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1354 of 5000 fish	27.1%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3646 of 5000 fish	72.9%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L25-S66 10/28/2021
Byllesby Development Propsed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	25.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1725 of 5000 fish	34.5%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3275 of 5000 fish	65.5%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L30-S58 10/28/2021
Byllesby Development Propsed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.247	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.247	0.247	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.247	0.493	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.260	0.740	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	30.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	2084 of 5000 fish	41.7%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	2916 of 5000 fish	58.3%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S83 10/28/2021
Byllesby Proposed, 4% Exceedance Flow (426 CFS) Walleye Length Data. KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.228	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.228	0.228	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.228	0.456	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.244	0.684	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.072	0.928	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	849 of 5000 fish	17.0%
Bypass Failures:	11 of 5000 fish	0.2%
Passed:	4140 of 5000 fish	82.8%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S85 10/28/2021
Byllesby Proposed, 3% Exceedance Flow (1324 CFS) Walleye Length Data. KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.198	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.198	0.198	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.198	0.396	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.212	0.594	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.195	0.805	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	741 of 5000 fish	14.8%
Bypass Failures:	21 of 5000 fish	0.4%
Passed:	4238 of 5000 fish	84.8%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S88 10/28/2021

Byllesby Proposed, 2% Exceedance Flow (2551 CFS) Walleye Length Data. KESTLER

Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.168	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.168	0.168	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.168	0.336	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.179	0.504	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.318	0.683	0	bypass													0.03

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	569 of 5000 fish	11.4%
Bypass Failures:	40 of 5000 fish	0.8%
Passed:	4391 of 5000 fish	87.8%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S89 10/29/2021

Byllesby Proposed, 1% Exceedance Flow (5290 CFS) Walleye KESTLER

Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.127	0.000	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 2	0.127	0.127	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 3	0.127	0.254	2	Kaplan	8.70	5		1,348	92.0%	54.0	189.5		0.20			0.92	
Unit 4	0.128	0.381	1	Francis	7.52	16	3.06	1,467	79.0%	56.0	116.0	1.10	0.20	8.8	9.8	0.89	
Spill	0.491	0.509	0	bypass													0.03

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	468 of 5000 fish	9.4%
Bypass Failures:	94 of 5000 fish	1.9%
Passed:	4438 of 5000 fish	88.8%

Appendix G

Appendix G – USFWS Turbine Blade Strike Analysis Model Outputs for Buck Development – Existing Operations without Spill and with Varying Amounts of Spill for Walleye

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 — ARCHIVED RUN .N5000-L2-S95 — 10/28/2021

Buck Development Existing , New River, Galax, Virginia — KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	2.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	229 of 5000 fish	4.6%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4771 of 5000 fish	95.4%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 — ARCHIVED RUN .N5000-L4-S91 — 10/28/2021

Buck Development Existing , New River, Galax, Virginia — KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	4.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	437 of 5000 fish	8.7%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4563 of 5000 fish	91.3%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 — ARCHIVED RUN .N5000-L6-S87 — 10/28/2021

Buck Development Existing , New River, Galax, Virginia — KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	6.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	667 of 5000 fish	13.3%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4333 of 5000 fish	86.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L8-S83 10/28/2021
Buck Development Existing , New River, Galax, Virginia KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	8.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	830 of 5000 fish	16.6%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4170 of 5000 fish	83.4%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L10-S79 10/28/2021
Buck Development Existing , New River, Galax, Virginia KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	10.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1064 of 5000 fish	21.3%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3936 of 5000 fish	78.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L15-S65 10/28/2021
Buck Development Existing , New River, Galax, Virginia KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	15.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1768 of 5000 fish	35.4%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3232 of 5000 fish	64.6%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L20-S56 10/28/2021

Buck Development Existing , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	20.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	2221 of 5000 fish	44.4%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	2779 of 5000 fish	55.6%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L25-S45 10/28/2021

Buck Development Existing , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	25.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	2753 of 5000 fish	55.1%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	2247 of 5000 fish	44.9%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L30-S35 10/28/2021

Buck Development Existing , New River, Galax, Virginia KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	30.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	3254 of 5000 fish	65.1%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	1746 of 5000 fish	34.9%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S72 10/29/2021

Buck Development, 12% Exceedance Flow (123 CFS Spill) Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.322	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.322	0.322	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.322	0.644	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Spill	0.033	0.967	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1413 of 5000 fish	28.3%
Bypass Failures:	4 of 5000 fish	0.1%
Passed:	3583 of 5000 fish	71.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S72(2) 10/29/2021

Buck Development, 10% Exceedance Flow (421 CFS Spill) Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.298	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.298	0.298	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.298	0.596	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Spill	0.106	0.894	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1361 of 5000 fish	27.2%
Bypass Failures:	14 of 5000 fish	0.3%
Passed:	3625 of 5000 fish	72.5%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S75 10/29/2021

Buck Development, 8% Exceedance Flow (816 CFS Spill) Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	D Runner Dia. (ft)	N Blades (#)	B Runner Height (ft)	Q Turbine Discharge (cfs)	Q_{OPT}/Q Discharge at Opt. Eff. (%)	H Net. Head (ft)	ω Speed (rpm)	ζ Swirl Coeff. (-)	λ Correlation Coeff. (-)	D_1 Runner Dia. at Inlet (ft)	D_2 Runner Dia. at Disch. (ft)	η Turbine Eff. (-)	P_B Estimated Mortality (-)
Unit 1	0.271	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.271	0.271	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.271	0.542	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Spill	0.187	0.813	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1216 of 5000 fish	24.3%
Bypass Failures:	22 of 5000 fish	0.4%
Passed:	3762 of 5000 fish	75.2%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S76 10/29/2021

Buck Development, 6% Exceedance Flow (1427 CFS Spill) Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.238	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.238	0.238	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.238	0.475	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Spill	0.287	0.713	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1136 of 5000 fish	22.7%
Bypass Failures:	39 of 5000 fish	0.8%
Passed:	3825 of 5000 fish	76.5%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S83 10/29/2021

Buck Development, 4% Exceedance Flow (2370 CFS Spill) Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.200	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.200	0.200	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.200	0.399	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Spill	0.401	0.599	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	803 of 5000 fish	16.1%
Bypass Failures:	67 of 5000 fish	1.3%
Passed:	4130 of 5000 fish	82.6%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S84 10/29/2021

Buck Development, 2% Exceedance Flow (4495 CFS Spill) Walleye KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.147	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.147	0.147	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.147	0.294	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Spill	0.559	0.441	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	707 of 5000 fish	14.1%
Bypass Failures:	90 of 5000 fish	1.8%
Passed:	4203 of 5000 fish	84.1%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S89 10/29/2021
Buck Development, 1% Exceedance Flow (7234 CFS Spill) Walleye KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.110	0.000	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 2	0.110	0.110	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.110	0.219	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Spill	0.671	0.329	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	457 of 5000 fish	9.1%
Bypass Failures:	104 of 5000 fish	2.1%
Passed:	4439 of 5000 fish	88.8%

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Appendix H

Appendix H – USFWS Turbine Blade Strike Analysis Model Outputs for Buck Development – Proposed Operations without Spill and with Varying Amounts of Spill for Walleye

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L2-S97 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	2.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	144 of 5000 fish	2.9%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4856 of 5000 fish	97.1%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L4-S94 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	4.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	310 of 5000 fish	6.2%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4690 of 5000 fish	93.8%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L6-S92 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	6.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	387 of 5000 fish	7.7%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4613 of 5000 fish	92.3%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L8-S89 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA														BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η		P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)		Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92		
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85		
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92		

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	8.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	552 of 5000 fish	11.0%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4448 of 5000 fish	89.0%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L10-S85 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA														BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η		P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)		Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92		
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85		
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92		

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	10.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	742 of 5000 fish	14.8%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	4258 of 5000 fish	85.2%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L15-S78 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA														BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η		P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)		Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92		
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85		
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92		

	MODEL SIMULATION INPUT PARAMETERS	
n_f	5,000	Number of fish
μ	15.0	Mean length (inches)
σ	0.0	SD in length (inches)

	BLADE STRIKE SIMULATION RESULTS	
Turbine Strikes:	1088 of 5000 fish	21.8%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3912 of 5000 fish	78.2%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L20-S73 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	20.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1330 of 5000 fish	26.6%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3670 of 5000 fish	73.4%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L25-S65 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	25.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	1771 of 5000 fish	35.4%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	3229 of 5000 fish	64.6%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L30-S57 10/28/2021
Buck Development Proposed , New River, Galax, Virginia KESTLER
Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.333	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.333	0.333	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.334	0.666	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	30.0	Mean length (inches)
σ	0.0	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	2126 of 5000 fish	42.5%
Bypass Failures:	0 of 5000 fish	0.0%
Passed:	2874 of 5000 fish	57.5%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S83 10/28/2021
Buck Proposed, 12% Exceedance Flow (92 CFS Spill) Walleye Length KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.326	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.322	0.326	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.326	0.649	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Spill	0.025	0.975	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	861 of 5000 fish	17.2%
Bypass Failures:	6 of 5000 fish	0.1%
Passed:	4133 of 5000 fish	82.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S82 10/28/2021
Buck Proposed, 10% Exceedance Flow (391 CFS Spill) Walleye Length KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.302	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.297	0.302	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.302	0.599	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Spill	0.099	0.900	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	876 of 5000 fish	17.5%
Bypass Failures:	23 of 5000 fish	0.5%
Passed:	4101 of 5000 fish	82.0%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S84 10/28/2021
Buck Proposed, 8% Exceedance Flow (786 CFS Spill) Walleye Length KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.274	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.271	0.274	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.274	0.545	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Spill	0.181	0.819	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	770 of 5000 fish	15.4%
Bypass Failures:	25 of 5000 fish	0.5%
Passed:	4205 of 5000 fish	84.1%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S85 10/28/2021

Buck Proposed, 6% Exceedance Flow (1397 CFS Spill) Walleye Length KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.241	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.238	0.241	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.241	0.478	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Spill	0.281	0.719	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	698 of 5000 fish	14.0%
Bypass Failures:	55 of 5000 fish	1.1%
Passed:	4247 of 5000 fish	84.9%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S87 10/28/2021

Buck Proposed, 4% Exceedance Flow (2340 CFS Spill) Walleye Length KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.202	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.200	0.202	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.202	0.402	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Spill	0.396	0.604	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	618 of 5000 fish	12.4%
Bypass Failures:	46 of 5000 fish	0.9%
Passed:	4336 of 5000 fish	86.7%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S91 10/28/2021

Buck Proposed, 2% Exceedance Flow (4465 CFS Spill) Walleye Length KESTLER

Release 201209

ROUTE SELECTION				TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.149	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.147	0.149	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.149	0.296	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Spill	0.556	0.444	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	378 of 5000 fish	7.6%
Bypass Failures:	92 of 5000 fish	1.8%
Passed:	4530 of 5000 fish	90.6%

Byllesby-Buck Hydroelectric Project, FERC Project No. 2514 ARCHIVED RUN .N5000-L14-S91(2) 10/28/2021
Buck Proposed, 1% Exceedance Flow (7204 CFS Spill) Walleye Length KESTLER
Release 201209

	ROUTE SELECTION			TURBINE DATA													BYPASS
					D	N	B	Q	Q_{OPT}/Q	H	ω	ζ	λ	D_1	D_2	η	P_B
Route Name	Route Selection Prob.	Prob. Lower Bound	Calc. Type	Route Type	Runner Dia. (ft)	Blades (#)	Runner Height (ft)	Turbine Discharge (cfs)	Discharge at Opt. Eff. (%)	Net. Head (ft)	Speed (rpm)	Swirl Coeff. (-)	Correlation Coeff. (-)	Runner Dia. at Inlet (ft)	Runner Dia. at Disch. (ft)	Turbine Eff. (-)	Estimated Mortality (-)
Unit 1	0.111	0.000	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Unit 2	0.110	0.111	1	Francis	7.52	16	3.06	1,180	90.0%	40.0	97.0	1.10	0.20	8.8	9.8	0.85	
Unit 3	0.111	0.220	2	Kaplan	8.70	5		1,195	77.8%	42.4	156.5		0.20			0.92	
Spill	0.669	0.331	0	bypass													0.03

MODEL SIMULATION INPUT PARAMETERS		
n_f	5,000	Number of fish
μ	13.5	Mean length (inches)
σ	1.5	SD in length (inches)

BLADE STRIKE SIMULATION RESULTS		
Turbine Strikes:	325 of 5000 fish	6.5%
Bypass Failures:	105 of 5000 fish	2.1%
Passed:	4570 of 5000 fish	91.4%

Appendix I

Appendix I – Additional Intake Drawings

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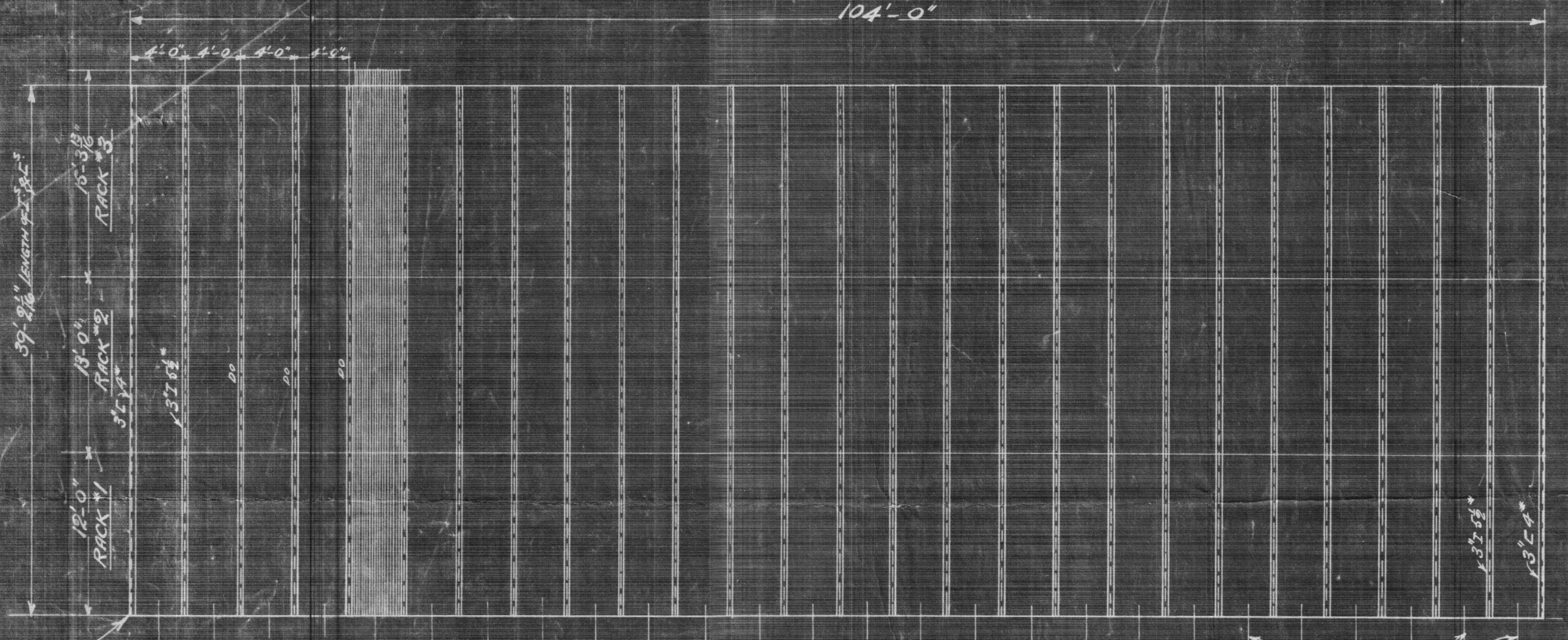
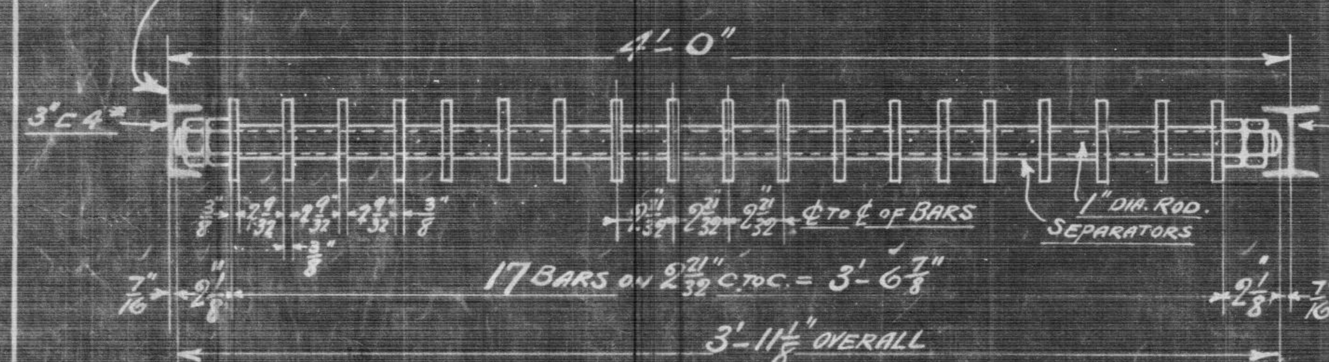
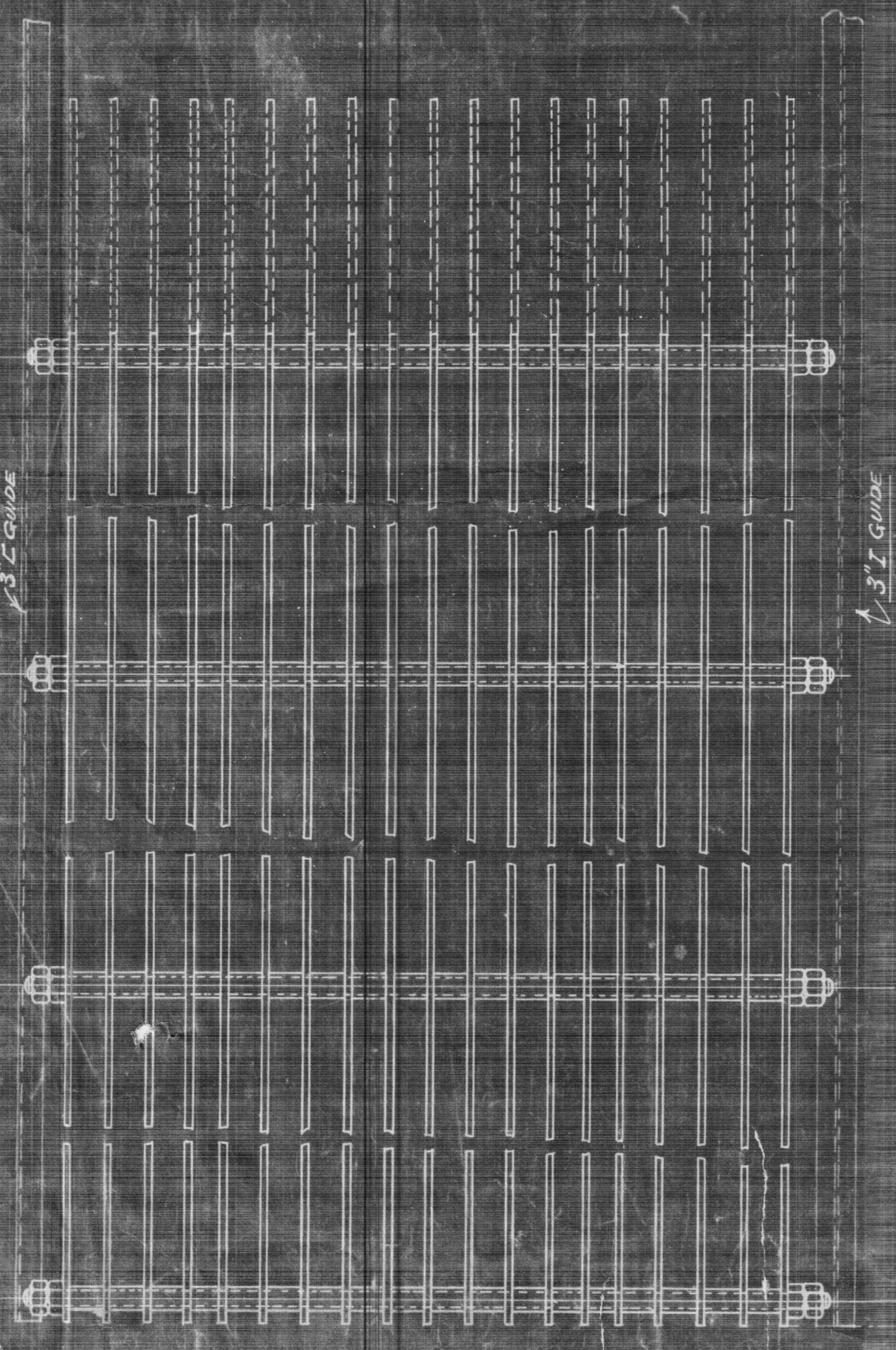
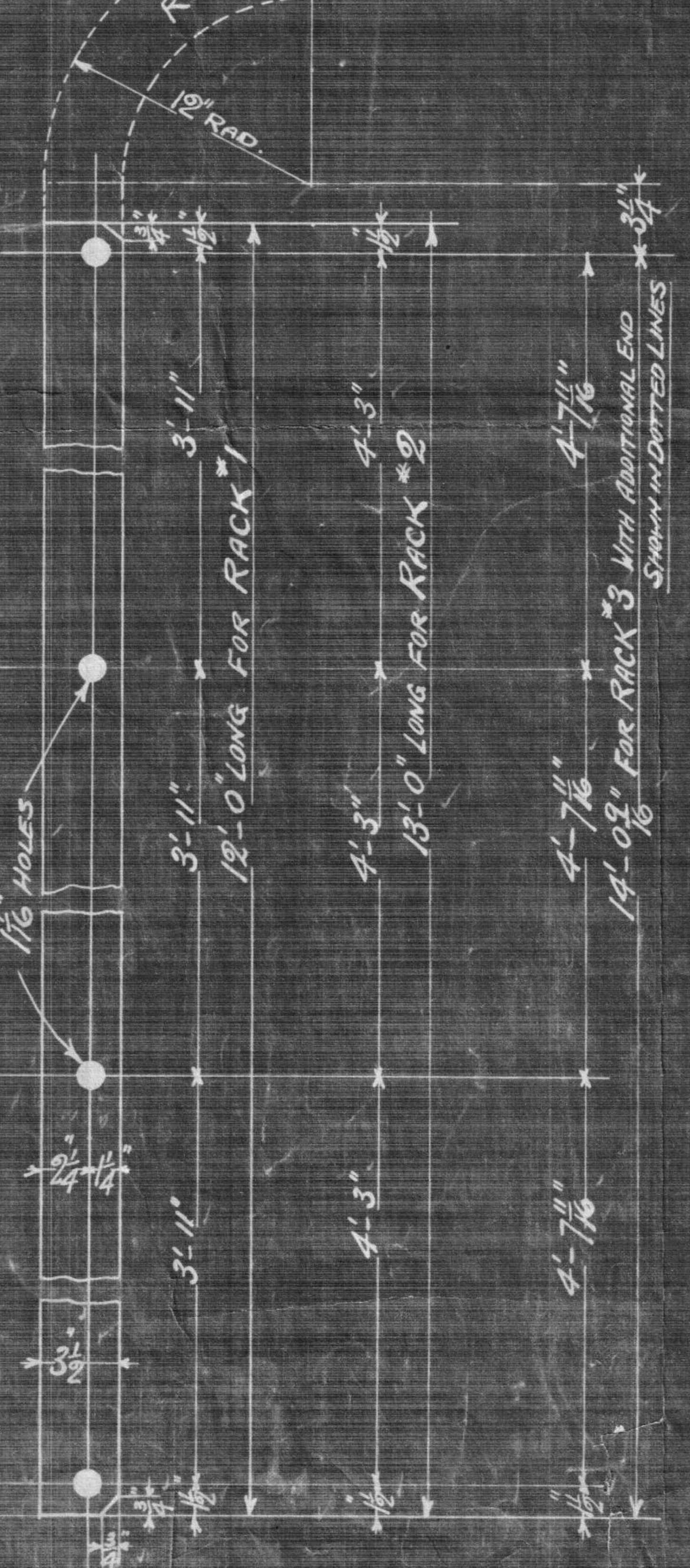


ASSEMBLY DIAGRAM OF RACKS & GUIDES
SCALE 1/8" = 1 FOOT

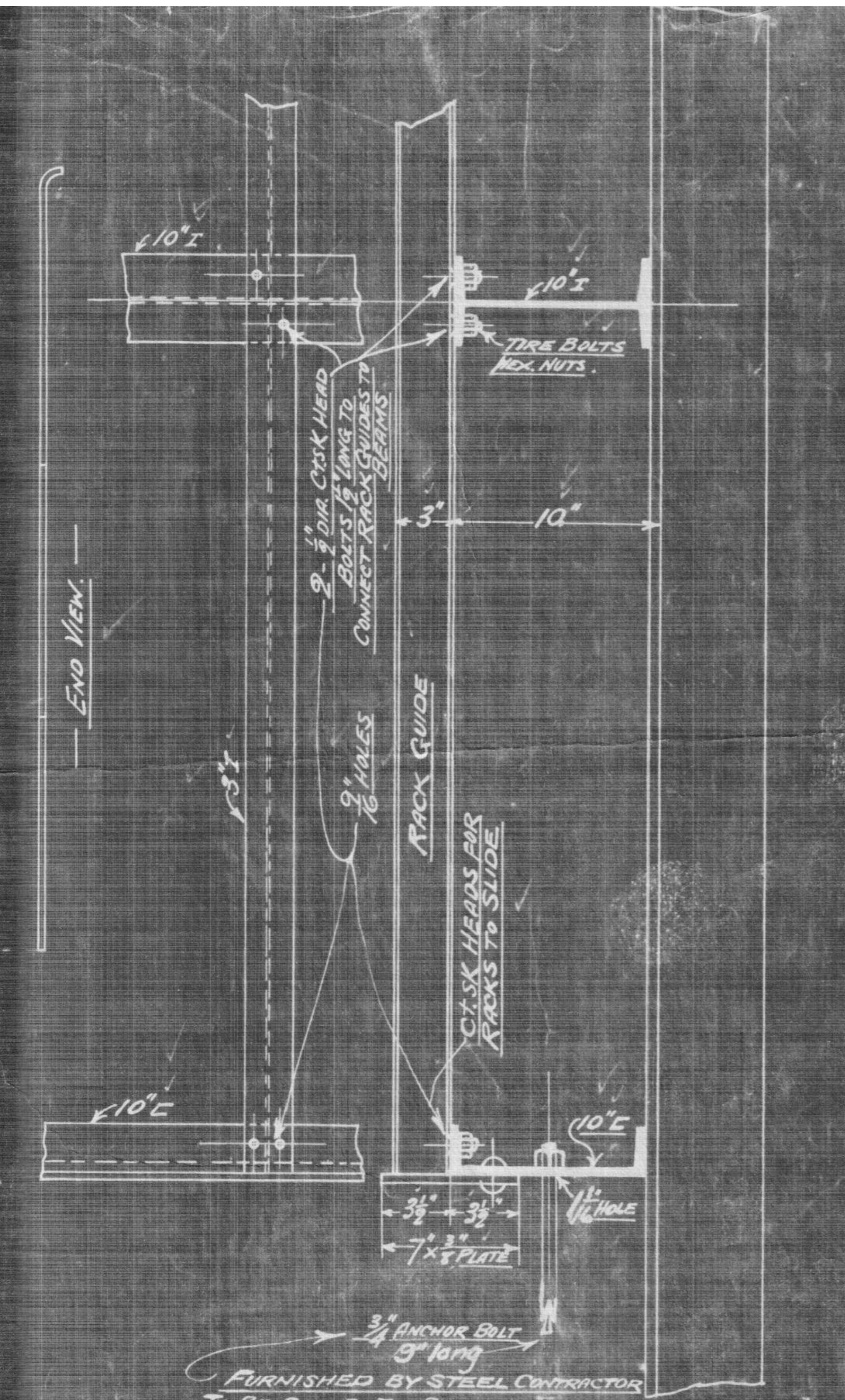




DETAIL OF RACK
SCALE 1 1/2" = 1 FOOT



END VIEW GIVING LENGTHS FOR RACK #1 RACK #2 & RACK #3



FURNISHED BY STEEL CONTRACTOR
TO BE SET BY THE POWER CO. AFTER STEEL IS ERECTED.
CONNECTIONS OF 3"I & 3"C RACK GUIDES TO 10" 9" & 7" I'S & C'S
SCALE 1 1/2" = 1 FOOT

BILL OF MATERIAL FOR RACK #1. 26 REQ.

DESCRIPTION	MARK	NO. REQ.	SIZE	LENGTH	REMARKS
BARS (STEEL)	R.1.	17	3 1/2" x 3/8"	12'-0"	SEE DETAIL
ROUND IRON RODS & 4 HEX. NUTS EACH	R.1	4	1" DIA.	3'-11 1/8"	EXACT LENGTH. NUTS TO SUIT 3"C SEE DETAIL
GAS PIPE SEPARATORS	R.1.	64	1 1/16" I. DIA.	2 9/32" (Exact)	STANDARD.

BILL OF MATERIAL FOR RACK #2 26 REQ.

DESCRIPTION	MARK	NO. REQ.	SIZE	LENGTH	REMARKS
BARS (STEEL)	R.2	17	3 1/2" x 3/8"	13'-0"	SEE DETAIL
ROUND IRON RODS & 4 HEX. NUTS EACH	R.2.	4	1" DIA.	3'-11 1/8"	EXACT LENGTH. NUTS TO SUIT 3"C SEE DETAIL.
GAS PIPE SEPARATORS	R.2.	64	1 1/16" I. DIA.	2 9/32" (Exact)	STANDARD.

BILL OF MATERIAL FOR RACK #3 26 REQ.

DESCRIPTION	MARK	NO. REQ	SIZE	LENGTH	REMARKS
BARS (STEEL)	R.3	17	3 1/2" x 3/8"	- "	DEVELOPED LENGTH SEE DETAIL
ROUND IRON RODS & 4 HEX. NUTS EACH.	R.3	4	1" DIA.	3'-11 1/8"	EXACT LENGTH. NUTS TO SUIT 3"C SEE DETAIL.
GAS PIPE SEPARATORS	R.3.	64	1 1/16" I. DIA.	2 9/32" (Exact)	STANDARD

GENERAL BILL OF MATERIAL

DESCRIPTION	MARK	NO. REQ	SIZE	LENGTH	REMARKS
TIRE BOLTS WITH HEX. NUTS		570	1/2" DIA.	1 1/2"	CT. SK. HEADS SEE DETAIL
ANCHOR BOLT WITH NUT		26	3/4" DIA.	0'-9"	FURNISHED BY STEEL CONTRACTOR
3"I 5 1/2#		25	3"I 5 1/2#	39'-2 1/16"	
3"C 4#		2	3"C 4#	39'-2 1/16"	

GENERAL NOTES:-

RACKS MUST BE STRAIGHT & TRUE SO THAT THEY CAN BE READILY PLACED IN POSITION. BUILD TO EXACT DIMENSIONS SHOWN SO THAT THEY WILL NOT SLIP OUT OF POSITION. NUTS ON RODS MUST BE OF DIMENSIONS SO AS TO ALLOW RACKS TO SLIDE IN THE 3" I'S & C'S.

MATERIAL, STEEL UNLESS NOTED. SHOP & FIELD CONN'S BOLTED. SHOP PAINT #30 MARINE DETROIT GRAPHITE. FIELD COAT #106.

A-3836

Buck

APPALACHIAN POWER CO.
DEVELOPMENT #4
DETAIL OF STEELWORK FOR INTAKE
RACKS & GUIDES
SCALE 1/8" & 1 1/2" - 1 FOOT
1911

VIELE, BLACKWELL & BUCK
CONSULTING ENGINEERS
49 WALL ST. NEW YORK

B 3836

CORRECT ... Brown ... APPROVED

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General Notes:-

All material Medium O. H. Steel.
Rivets 3/4" dia, holes 13/16" dia unless otherwise noted
Shop connections riveted.- Field connections riveted unless otherwise noted.
Workmanship first class according to Carnegie Handbook, Edition-1903.
Shop Paint #30 Marine Detroit Graphite. Field coat #106
Supply all material necessary to form complete Intake when erected:-
Racks, Girders, Beams, Angles, Anchors, Rivets and Bolts for Field, (5% excess.)
For detail of Racks and Guides see Sheet- B3836.
For Plan of Intake see Sheet- B3851.

No	DATE	REVISIONS
I	15/12/11	ADDED SKEW-BACK ANGLES ON 9" C
II	15/12/11	CUT 2' OFF ANGLE A-1 AT TOP

APPALACHIAN POWER CO.
DEVELOPMENT #4.
DETAILS OF STEELWORK FOR INTAKE

SCALE 1/2" & 1 1/2" = 1 FOOT. NOV. 1, 1911

VIELE, BLACKWELL & BUCK
CONSULTING ENGINEERS
49 WALL ST. NEW YORK.

A3852.

CORRECT ______ APPROVED ______

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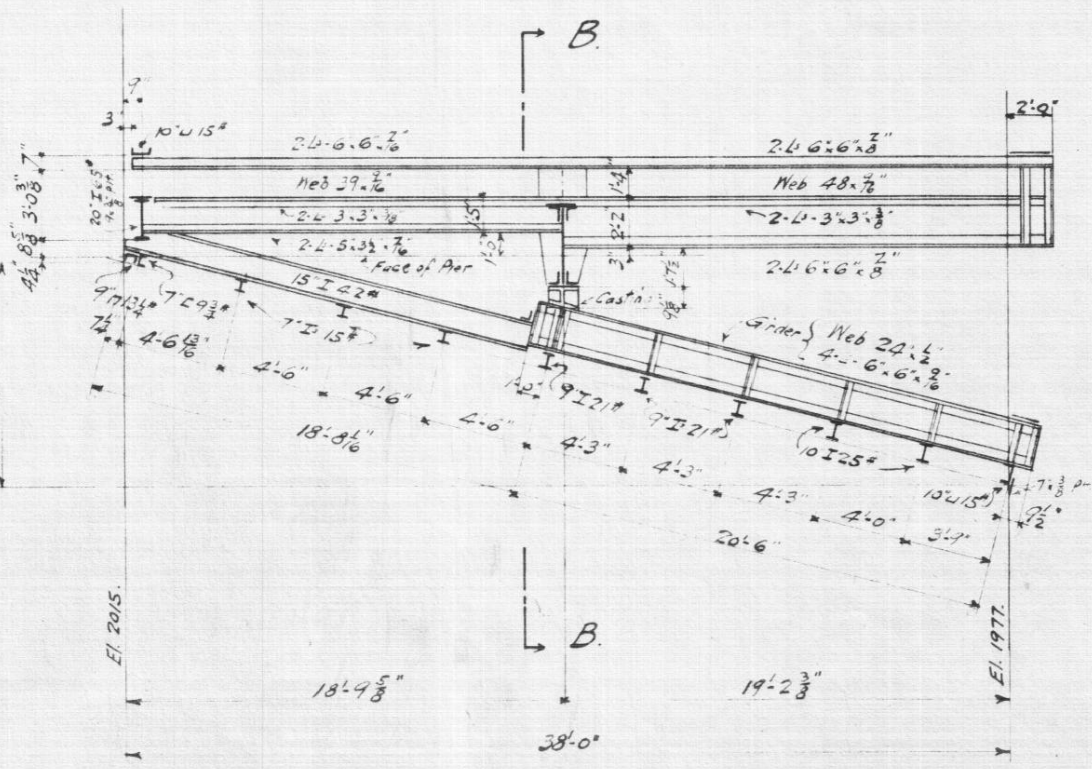
Plan



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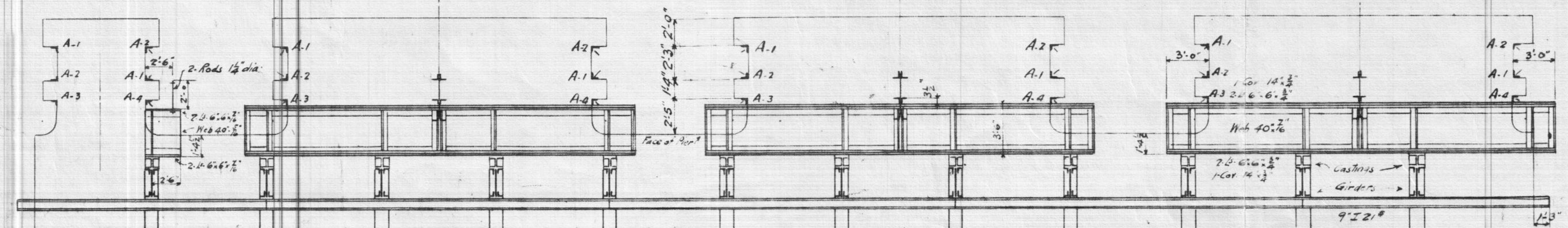

Section-B-B.

General Notes:-

For details of Racks and Guides see Sheet-B3836.
For details of Steelwork for Intake see Sheet-A3852
Notes on sheets B3836 and A3852 to apply for this sheet also.

APPALACHIAN POWER CO.
DEVELOPMENT #4
PLAN OF STEEL WORK FOR INTAKE

SCALE 1/8" = 1-FOOT. | NOV. 1st 1911

VIELE, BLACKWELL & BUCK
CONSULTING ENGINEERS
49 WALL ST. NEW YORK.

B3851.

CORRECT E. L. [illegible] M.V.K. APPROVED [illegible]

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Attachment 3

Attachment 3 – 2020 – 2021 Macroinvertebrate and Crayfish Community Study Report

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Byllesby-Buck Hydroelectric Project
(FERC Project No. 2514)

2020-2021 Macroinvertebrate and Crayfish Community Survey Results, Virginia

Prepared for:

AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY

Byllesby-Buck → HDR2020-0001

September 24, 2021

Prepared by:

EDGE ENGINEERING & SCIENCE
further insight.

Edge Engineering and Science, LLC
Cincinnati, Ohio

Table of Contents

LIST OF FIGURES

APPENDICES

LIST OF ACRONYMS

AEP	American Electric Power – Client
Appalachian	Appalachian Power Company
CFS	Cubic feet per second
CPUE	Catch per unit effort
DO	Dissolved oxygen
EDGE	Edge Engineering and Science, LLC
FERC	Federal Energy Regulatory Commission
HDR	HDR, Inc. – Client
ISR	Initial Study Report
LDB	Left descending bank
NRSA	National Rivers and Streams Assessment
Project	Byllesby-Buck Hydroelectric Project
RDB	Right descending bank
RSP	Revised Study Plan
SAV	Submerged aquatic vegetation
USFWS	U.S. Fish and Wildlife Service
USR	Updated Study Report
VAC	Virginia Administrative Code
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VDWR	Virginia Department of Wildlife Resources (formerly VDGIF)
VISAC	Virginia Invasive Species Advisory Committee

1.0 INTRODUCTION

The Byllesby and Buck Dams form the 30.1-megawatt Byllesby-Buck Hydroelectric Project (Project) located on the New River in Carroll County, Virginia. Appalachian Power Company (a unit of American Electric Power; AEP) is pursuing a new license for the Project as their existing license (FERC Project No. 2514) expires in 2024. Aquatic biological studies were completed to support existing FERC license and results of these studies are ultimately used as a record and reference for current relicensing efforts. The New River, along with the two contiguous impoundments resulting from the Byllesby Dam and the Buck Dam, harbors a diverse community of aquatic biota where aquatic biological studies are required to survey and document the contemporary community of organisms present within the Project area (Figure 1). The New River and lower reaches of tributary streams are included in the Project area. The information gained from these studies will document the current conditions of macroinvertebrate and crayfish abundance, diversity, and distribution in the vicinity of the Project.

Pre-licensing consultation with state and federal agencies resulted in the development and approval of a Project-specific Revised Study Plan (RSP) that identified two objectives for Project studies (AEP 2019) pertaining to the macroinvertebrate and crayfish community.

Goals and Objectives

1) Collect a baseline of existing macroinvertebrate and crayfish communities in the vicinity of the Project
2) Compare current aquatic resources data to historical data to determine any significant changes to species composition or abundance

In accordance with the RSP, field sampling efforts were necessary to satisfy each of the two objectives. Some of the objectives were not accomplished during the 2020 calendar year due to delays resulting from unforeseeable circumstances including the COVID-19 global pandemic; therefore, an Initial Study Report (ISR) was submitted on January 18, 2021. This report serves as the Update Study Report (USR) now that all field sampling efforts within the RSP have been completed.

2.0 METHODS

The RSP provided guidance on the biological sampling framework for the Project. Macroinvertebrate and crayfish sampling employ a variety of methods to target representative habitat at 16 sites throughout the Project area. The methods, number and location of sample sites, and seasonality were developed to document a comprehensive representation of the Project area and to correlate with previous sampling efforts for comparison. Replication of fall 2020 methods and sites occurred in spring 2021, both during the sample index period defined by Virginia Department of Environmental Quality (VDEQ) Biological Monitoring Program Quality Assurance Project Plan (VDEQ 2008).

2.1 Macroinvertebrate and Crayfish Community

The macroinvertebrate and crayfish study, detailed in the RSP, consists of two temporally independent efforts (one survey in fall and one survey in spring). Specific sampling dates within these timeframes are determined based on factors including (but not limited to) weather conditions, water temperatures, river flows and reservoir elevations, and safety of field staff and the public. Sampling methods were derived from National Rivers and Streams Assessment (NRSA) Field Operations Manual (USEPA 2019) and VDEQ (2008) and include quantitative and qualitative sampling methods that target different habitats. Within the constraints of the Project's objectives and geographic limits, quantitative sampling targets riffle/run habitats and qualitative sampling targets available microhabitats in pools. A variety of sampling techniques were used to sample macroinvertebrates using quantitative and qualitative methods as described in subsequent sections. Six sample sites were located upstream of the Byllesby Dam (two quantitative and four qualitative), eight sites were between Byllesby Dam and Buck Dam (four quantitative and four qualitative), and two sites were downstream of Buck Dam (both quantitative). Site naming conventions are as follows: Location-Seasonality-Method-Site Number. For example, BFQT1 = Byllesby-Buck Fall Quantitative Site 1, BFQL3 = Byllesby-Buck Fall Qualitative Site 3, and BSQL3 = Byllesby-Buck Spring Qualitative Site 3.

The sampling methods used to quantify macroinvertebrates only allows for the determination of presence of crayfish. To assess the crayfish community in the Project area, additional kick samples and seining efforts were performed following benthic macroinvertebrate sampling to ensure all crayfish habitat had been covered and that a broad representation of crayfish species available at each site was documented. The exact abundance of crayfish was not recorded because methods used are not crayfish specific and simply provide presence data.

2.1.1 Quantitative Sampling

Sampling for benthic macroinvertebrates and crayfish occurred at eight riffle/run sites (i.e., quantitative; BFQT and BSQT site names) along 100-meter transects following guidelines defined by USEPA (2019) and VDEQ (2008). Upon arrival at riffle/run sites (Figures 1-6), transects were delineated in riffle/run habitat and the start and endpoint coordinates were recorded. Site photos were taken in four directions (upstream, downstream, left descending bank [LDB], and right descending bank [RDB]; all 90 degrees to one another) and substrate, and field conditions were recorded (e.g., time, date, temperature, precipitation, cloudy/overcast, etc.). At each sample site, habitat characteristics (e.g., substrate, estimated water velocity, depth, and instream cover) and water quality parameters (e.g., pH, water temperature, dissolved oxygen [DO], and conductivity) were measured and recorded. Multiple points for habitat and water quality measurements were taken if there was large variation within a single site. Sampling effort (e.g., time, number of samples) was also recorded during each sampling event.

Starting at the downstream end of a transect and moving upstream, all riffle/run habitats were candidates for sampling throughout the reach. Sampling was conducted holding the D-frame net on the bottom of the stream perpendicular to flow and kicking substrate to agitate and dislodge organisms, allowing them to flow into the net. A single kick consists of disturbing the substrate upstream of the net by kicking with the feet and/or by using the hands to dislodge the cobble/boulder for 30-90 seconds. For example, a single sample was a composite of six kick sets, each disturbing approximately 0.33 m^2 above the dip net for a duration of 30-90 seconds and totaled an area comprising 2 m^2. The composited sample was washed by running clean stream water through the net 2-3 times and then transferred to a sieve (500 µm) if needed. For QA/QC measures, replicate sampling was conducted at one quantitative site within close proximity (not in the same locations as the first set of samples) of the initial sampling area. This replicate sample was completed between Byllesby Dam and Buck Dam (one from fall 2020 and one from spring 2021) and was included in data analysis.

2.1.2 Qualitative Sampling

Benthic macroinvertebrates and crayfish were also sampled at eight qualitative sites (i.e., multi-habitat; BFQL and BSQL site names) along 100-meter transects following guidelines defined by USEPA (2019) and VDEQ (2008). At pool sites (Figure 1 and Figures 7-13), transects were delineated in near-shore pool habitats and the start and endpoint coordinates were recorded. Site photos, field conditions, habitat characteristics, and water quality parameters were recorded in the same manner as quantitative sites (see Section 2.1.1). In addition, a Secchi disk reading was taken at each sample site at the time of sampling to assess water transparency. Multiple points for habitat and water quality measurements were taken if there was large variation within a single site.

A canoe was necessary to collect qualitative samples along each of the transects starting at the downstream end and moving upstream. Sampling was conducted by performing 20 jabs with a D-frame net into suitable, stable habitats (snags, vegetation, banks, and substrate). A single jab consists of forcefully thrusting the net into a microhabitat for a linear distance of 1.0 meter, followed by 2-3 sweeps of the same area to collect dislodged organisms for 20-90 seconds per jab, sweep, or kick. Multiple types of habitat were sampled in rough proportion to their frequency within the reach. Unique habitat types (i.e., those consisting of less than 5 percent of stable habitat within the sampling reach) were not sampled. Sampling effort was proportionally allocated (20 jabs/sweeps/kicks) to shore-zone and bottom-zone, 20-90 seconds per jab, sweep, or kick. Samples were cleaned and transferred to the sieve bucket at least every five jabs; or more often as necessary. At one qualitative site, replicate sampling was conducted within the initial sampling area in close proximity (not in the same locations as the first set of samples). This replicate sample was completed upstream of Byllesby Dam (one from fall 2020 and one from spring 2021) and was included in data analysis. All samples were preserved and processed in the same manner as quantitative methods (see Section 2.1.1).

2.1.3 Laboratory Processing

All field samples were preserved in 95% ethanol, placed in labeled jars, and sent to Civil & Environmental Consultants, Inc. (CEC) for processing and identification to the lowest practicable taxonomic level. Laboratory processing was performed in accordance with the VDEQ standard operating procedures “Methods for Laboratory Sorting and Subsampling of Benthic Macroinvertebrate Samples” (VDEQ 2008). Photo vouchers were taken of all unique or rare species collected. At the completion of the study, a summary of species and numbers collected will be provided to VDWR in compliance with the scientific collection permit specifications.

2.1.4 Data Analysis

The Virginia Stream Condition Index (VSCI) (Burton and Gerristen 2003) was employed to investigate the impairment of the New River within the Project area using eight metrics of the macroinvertebrate community. These metrics include (1) Total Taxa, (2) EPT Taxa (*Ephemeroptera* [mayflies], *Plecoptera* [stoneflies], and *Trichoptera* [caddisflies]), (3) Percent Ephemeroptera, (4) Percent Plecoptera plus Trichoptera less Hydropsychidae, (5) Percent Scrapers, (6) Percent Chironomidae, (7) Percent Top Two Dominant taxa, and (8) the Hilsenhoff Biotic Index (HBI). For the purposes of this study, and in agreement with VDEQ methods, all VSCI scores were calculated at family-level taxonomy. “Reference” conditions are a collection of aspects shared by streams deemed unimpaired within the region. The results of the VSCI scores determine the level of impairment at a specific site with scores over 80 indicating “reference” conditions, scores between 60 and 79 indicating “similar to reference” conditions, and scores below 60 indicating “impaired” conditions. VSCI scores were calculated by site and by season

(Appendix C). The site VSCI scores were also used to make qualitative comparisons of overall reach conditions between different Project areas (i.e., upstream of Byllesby Dam, between Byllesby and Buck Dam, and downstream of Buck Dam).

2.2 Deviations from Revised Study Plan

2.2.1 COVID-19 Delays

The initial field sampling plan called for spring and fall 2020 events; however, the COVID-19 pandemic, and subsequent restrictions on non-essential travel and safety considerations for field staff, prohibited spring 2020 field efforts. As a result, AEP requested and was granted an extension to accommodate the change in schedule as the VDEQ, U.S. Fish and Wildlife Service (USFWS), Virginia Department of Wildlife Resources (VDWR), and Virginia Department of Conservation and Recreation (VDCR) all concurred with adaptable schedule revisions. EDGE was contracted and given notice to proceed with fieldwork at the beginning of September 2020 and was able to complete the fall 2020 sampling event. Thus, spring macroinvertebrate and crayfish sampling was completed during spring 2021.

2.2.2 Weather Delays

Periodic delays associated with weather and stream conditions plagued the fall 2020 field study season. Average rainfall for Galax, Virginia (collected at this station since 1981) is approximately 26 centimeters between September 1 and December 1 (US Climate Data 2020); yet during the same three-month period in 2020, Galax accumulated over 37 centimeters of rain, a 42 percent increase (USGS 2020). Therefore, the fall 2020 sampling efforts were completed at the baseflows around 1,700 to 2,000 cubic feet per second (cfs), which at the time were the assumed baseflows for 2020. As a result of the 42 percent increase from average precipitation that occurred in 2020, the study area portion of the New River remained elevated well above the average annual baseflow conditions throughout the fall 2020 field study season. Spring 2021 flows more closely matched average flows during the sampling period.

3.0 RESULTS

Study samples were collected as closely as possible to the locations proposed in the RSP. Upon arrival at each proposed sample location, field biologists delineated the sample transect in the nearest location exhibiting the target habitat type (i.e., riffles, pools, etc.) using habitat-specific sampling methodologies. No notable or significant changes were made to proposed sampling locations for macroinvertebrate and crayfish survey efforts.

3.1 Macroinvertebrate and Crayfish Community

Macroinvertebrate samples were collected from 16 sites between October 6 and 8, 2020, during the fall sample index period (September 1 – November 30) and between April 20 and 23, 2021, during the spring sample index period (March 1 – May 31), as defined by VDEQ (2008). Sampling was performed by EDGE's state and federally permitted astacologist under Virginia Scientific Collecting Permit No. 070705 (see Appendix A). Visible differences in habitat and substrate types between sites were documented (Appendix B); however, differences in sampling dates, time of day, and low number of intra- and inter-site samples prevented a statistical comparison of physiochemical properties between sites. The resulting physiochemical data from each of the sample sites met the state water quality standards established for the New River (Virginia Administrative Code [VAC] Chapter 260), indicating that water quality conditions within the Project area are capable of supporting macroinvertebrate communities. Additional water quality data are provided in the Water Quality Study Report provided in the Project USR.

3.1.1 Upstream of Byllesby Dam

The substrate at quantitative macroinvertebrate sites upstream of Byllesby Dam consisted primarily of bedrock (25%), boulder (25%), cobble (20%), gravel (15%), and sand (15%) (Figure 1). Although instream habitat at these sites was relatively complex and conducive to macroinvertebrate and crayfish colonization, no crayfish were collected from these sites during the fall 2020 or spring 2021 sampling events. The substrate at qualitative macroinvertebrate sites upstream of Byllesby Dam generally consisted of sand (70%), silt (20%), gravel (5%), and boulder (5%). The impoundment upstream of Byllesby Dam exhibits predominantly steep sloped shorelines that converge toward the center of the channel. Along the LDB, many of the sample sites were located in lower gradient sections adjacent to vegetated floodplains; while sites located along the RDB were located in higher gradient habitats adjacent to rocky outcrops or steep rock face (Appendix B). The habitat structure at most sample sites within the Byllesby Pool generally consisted of sparse woody debris, submerged aquatic vegetation (SAV), and scattered boulders. Water quality parameters (temperature, pH, DO, and conductivity) remained relatively consistent throughout the Byllesby Pool, with the exception of velocity, which was slightly higher in the two upstream most sites near the head of the impoundment (Appendix C).

A total of 49 macroinvertebrate taxa were collected upstream of Byllesby Dam from two quantitative sites and four qualitative sites, along with the Spiny Stream Crayfish (*Faxonius cristavarius*), which was collected from a qualitative site near the dam. The average VSCI score for riffle/run sites and pool sites sampled upstream of Byllesby Dam in fall 2020 were 57.3 and 35.8, respectively, and only a single site (BFQT1) resulted in a “similar to reference” score above 60 (62.7) (Appendix C). The average VSCI score for riffle/run sites and pool sites sampled upstream of Byllesby Dam in spring 2021 were 65.9 and 26.9, respectively, and the same site (BSQT1) was the only site resulting in a “similar to reference” score above 60 (75.1). However, four sites in this Project area had HBI values indicating “Good” to “Excellent” water quality during the fall and spring sampling events based on the tolerance of the macroinvertebrate community. Two of these four sites were in riffle/run habitat and two were in pool habitat.

3.1.2 Between Byllesby Dam and Buck Dam

The substrate at quantitative macroinvertebrate sites between the Byllesby Dam and Buck Dam was comparable to that in the first two sites above Byllesby Dam, except higher percent bedrock at site BFQT7 (Bypass Reach), higher percent cobble at site BFQT8 (Figure 3), and higher percent gravel at site BFQT11 (Figure 4). All types of riffle/run habitat present between the dams was surveyed, from low-gradient riffles with relatively small substrate and no instream cover to high-gradient riffles with relatively large substrate and substantial instream cover. Conhoway Crayfish (*Cambarus appalachiensis*) and Spiny Stream Crayfish were both collected at quantitative sites within this Project area, with both species occurring at site BFQT7, the former also occurring at site BFQT10, and the latter also occurring at site BFQT11. Water quality parameters (temperature, pH, DO, velocity, and conductivity) remained relatively consistent throughout all quantitative sites except velocity (Appendix C), which often changed drastically within a single transect.

The substrate at qualitative macroinvertebrate sites between the Byllesby Dam and Buck Dam generally consisted of sand (60%), silt (20%), boulder (15%), and gravel (5%). Many of the sites along the LDB exhibited a low-gradient and were adjacent to a vegetated floodplain, whereas many of the sites along the RDB were located in a high-gradient area, adjacent to a rock face (Appendix B). The upstream portion of the Buck Pool was relatively shallow with a consistent depth across the width of the stream, whereas the downstream portion of the pool had shallow banks that rapidly descended towards the center of the channel. The habitat structure at most sites within the Buck Pool generally consisted of sparse woody debris, submerged aquatic vegetation (SAV), and scattered boulders. Spiny Stream Crayfish were collected at two qualitative sites within this Project area. Water quality parameters (temperature, pH, and conductivity) remained relatively consistent throughout the Buck Pool, except DO and velocity, which were higher toward the upstream end of the impoundment, just below a section of high-gradient riffles (Appendix C).

A total of 53 macroinvertebrate taxa were collected between the Byllesby Dam and Buck Dam from four quantitative sites and four qualitative sites. The average VSCI score for riffle/run sites and pool sites sampled between Byllesby Dam and Buck Dam in fall 2020 were 62.9 and 39.5, respectively, and four sites (three riffle/run and one pool) resulted in a "similar to reference" score above 60 (Appendix C). The average VSCI score for riffle/run sites and pool sites sampled between Byllesby Dam and Buck Dam in spring 2021 were 54.9 and 36.0, respectively, but only three sites (all riffle/run) resulted in a "similar to reference" score above 60. Four sites in this Project area had HBI values indicating "Good" to "Very Good" water quality during the fall sampling events and seven sites indicating "Good" to "Excellent" water quality during the spring based on the tolerance of the macroinvertebrate community.

3.1.3 Downstream of Buck Dam

The substrate at quantitative macroinvertebrate sites downstream of the Buck Dam generally consisted of bedrock (35%), boulder (25%), cobble (20%), gravel (15%), and sand (5%) in the Bypass Reach site (Figure 5) where the primary habitat is well-developed riffle. Bedrock (25%), boulder (25%), cobble (20%), gravel (15%), and sand (15%) were dominant substrates in the site downstream of the Bypass Reach (Figure 6) where the primary habitat structure is more typical of run habitats than riffles, with sporadic undercut banks and overhanging vegetation. Conhoway Crayfish and Spiny Stream Crayfish were collected at both quantitative sites within this Project area. Water quality parameters (temperature, pH, DO, and conductivity) remained relatively consistent throughout all quantitative sites except velocity (Appendix C), which often changed drastically within a single transect.

A total of 30 macroinvertebrate taxa were collected from two quantitative sites located downstream of the Buck Dam. The average VSCI score for riffle/run sites sampled below Buck Dam in fall 2020 and spring 2021 were 58.8 and 59.0, respectively, and one of two sites (BF/BSQT15) resulted in a "similar to reference" score above 60 during both sampling events (Appendix C). One of two sites in the fall and both sites in the spring had HBI values indicating "Good" to "Very Good" water quality based on the tolerance of the macroinvertebrate community.

4.0 DISCUSSION

4.1 Macroinvertebrate and Crayfish Community

Benthic macroinvertebrate and crayfish community metrics can be used as indicators of water quality, as these organisms often exhibit sensitivity to changing water quality conditions, and because they serve as a food resource for fish and other fauna in the riverine community. A healthy stream generally includes habitat diversity and limited pollution, often indicated by a high VSCI and HBI score (standard biological metrics). The Mustached Clubtail (*Gomphus adelphus*) and the Pygmy Snaketail (*Ophiogomphus howei*) were identified as species with potential to occur in the Project vicinity by VDCR in a letter dated September 23, 2017. The presence of these “species of greatest conservation need” would indicate relatively high water quality. The Pygmy Snaketail was collected from the New River near the Fries Project (Carey et al. 2017), which is located approximately 13 river kilometers upstream of the Byllesby-Buck Project. Prior to the present study, no macroinvertebrate data were available for the Project and the presence of the Mustached Clubtail and Pygmy Snaketail were unknown for the Project reach of the New River. Although *Gomphus* sp. were collected during both the fall and spring sampling events, none were identified as the Mustached Clubtail.

VSCI scores recorded at each site were relatively similar between the fall and spring, but substantially greater at riffle/run sites (quantitative) than pool sites (qualitative). VSCI scores at riffle/run sites were the lowest of the three Project areas in fall 2020 but the highest in spring 2021, although they were relatively consistent throughout the entire Project area. VSCI scores show at least one site upstream of the Byllesby Dam, between Byllesby Dam and Buck Dam, and downstream of Buck Dam was characterized as “similar to reference” conditions in fall 2020 and spring 2021. HBI scores at two riffle/run sites above the Byllesby Dam and two riffle/run sites below Buck Dam indicate better water quality at the upstream extent of the Project area as opposed to the downstream extent.

Crayfish surveys were also completed as part of the Fries Project, where Spiny Stream Crayfish were the only species collected (Carey et al. 2017); however, prior to the current study, no site-specific information on crayfish populations in the Project reach of the New River were available. Approximately 33 species of crayfish, including non-indigenous and/or invasive species such as Virile Crayfish (*Orconectes virilis*), have been documented in waterbodies throughout Virginia (VDGIF 2018; VISAC 2018). The Virile Crayfish was collected at the Claytor Project (DTA 2008) located 70 river kilometers downstream of the Byllesby-Buck Project.

One of two species of crayfish was collected upstream of Byllesby Dam, but both species were collected between Byllesby and Buck dam, and downstream of Buck Dam. There were zero crayfish captured at the two quantitative sites upstream of Byllesby Dam and both species of crayfish were captured at both quantitative sites below Buck Dam. These sites had similar substrate and habitat composition and relatively similar physiochemical parameters. Conhoway Crayfish were observed under large boulders both near the bank and further channelward, while the Spiny Stream Crayfish were concentrated in cobble and near shore cover. Overall, the presence of two relatively abundant native crayfish species and zero invasive crayfish species in the Project vicinity may indicate a healthy community.

5.0 LITERATURE CITED

American Electric Power Service Corporation (AEP). 2019. Byllesby-Buck Hydroelectric Project (FERC No. 2514-186) Filing of Revised Study Plan for Relicensing Studies. October 18, 2019.

Burton, J. and Gerristen, J. 2003. A stream condition index for Virginia non-coastal streams. Tetra Tech, Inc. Owing Mills, MD. Report prepared for USEPA Office of Science and Technology, Office of Water, Washington, DC; USEPA Region 3 Environmental Services Division, Wheeling, WV; Virginia Department of Environmental Quality, Richmond, VA.

Carey, C., D. Orth, and V. Emrick. 2017. Biological surveys for the Fries Hydroelectric Dam Project in the upper New River, Virginia. Final (Draft) Report to TRC Solutions, Reston, Virginia. Conservation Management Institute, Department of Fish and Wildlife Conservation, College of Natural Resources and Environment, Virginia Polytechnic Institute and State University, Blacksburg. VTCMI-Technical Report-03-2017.

Devine Tarbell & Associates (DTA). 2008. Claytor Hydroelectric Project (FERC No. 739) Aquatic Resources Assessment. Final Report. Prepared for Appalachian Power Company. December 2008.

U.S. Climate Data. 2020. https://www.usclimatedata.com/climate/galax/virginia/united-states/usva0301. Accessed 24 December 2020.

U.S. Environmental Protection Agency (USEPA). 2019. National Rivers and Streams Assessment 2018/19 Field Operations Manual Non-Wadeable Version 1.2. EPA-841-B-17-003b. Washington, DC.

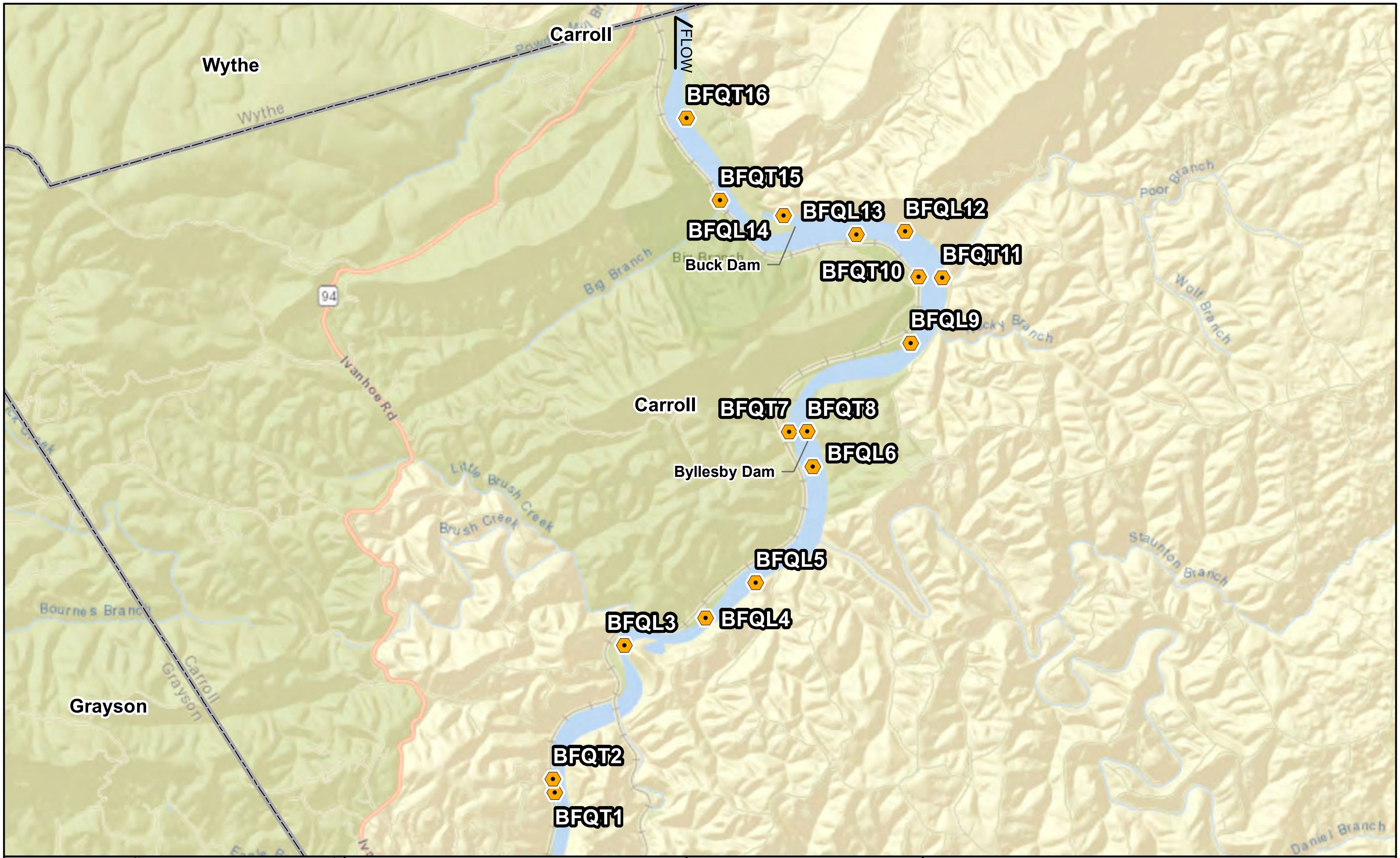
U.S. Geological Survey (USGS). 2020. National Water Information System (NWIS): Web Interface. https://waterdata.usgs.gov/nwis/uv?cb_00045=on&format=html&site_no=03164000&period=&begin_date=2020-09-01&end_date=2020-12-01. Accessed 24 December 2020.

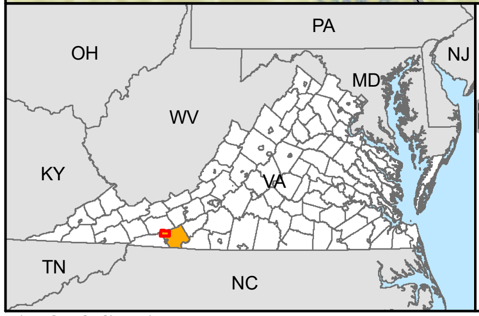
Virginia Department of Environmental Quality (VDEQ). 2008. Biological Monitoring Program Quality Assurance Project Plan for Wadeable Streams and Rivers. Division of Water Quality, Richmond, VA.

Virginia Department of Game and Inland Fisheries. 2018. List of Native and Naturalized Fauna of Virginia April, 2018. Accessed 10/27/2019. [URL]: https://www.dgif.virginia.gov/wp-content/uploads/virginia-native-naturalizedspecies.pdf.

Virginia Invasive Species Advisory Committee (VISAC). 2018. Virginia Invasive Species Management Plan. Virginia Department of Conservation and Recreation. Natural Heritage Technical Document 18-09. Richmond, VA. 33 pp.

Figures





Legend

- Macroinvertebrate Sample Location
- County Boundary

N

0 0.75 1.5
Kilometers

Scale: 1:59,055

American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 1
Overall Byllesby-Buck project area including quantitative (BFQT) and qualitative (BFQL) macroinvertebrate survey sites on the New River in Carroll County, Virginia.

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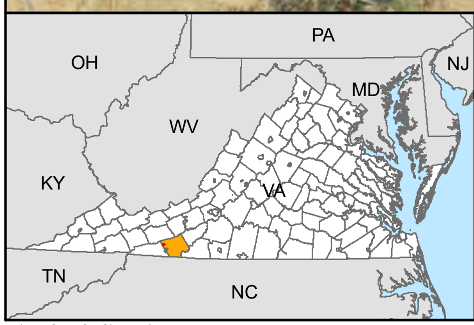

Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 2
Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Carroll County, Virginia.

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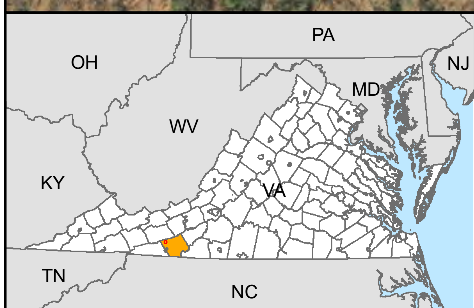

Legend

Macroinvertebrate Sample Location

Macroinvertabrate Sampling Transect

N

0 50 100

Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 3
Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Carroll County, Virginia.

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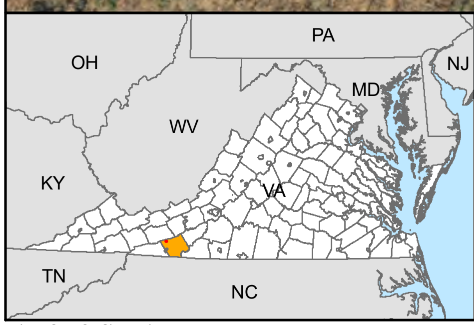


Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100
Meters

Scale: 1:3,937

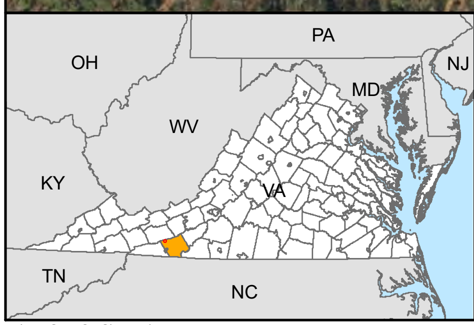
AMERICAN ELECTRIC POWER

EDGE ENGINEERING & SCIENCE

American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 4
Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd



Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100
Meters

Scale: 1:3,937

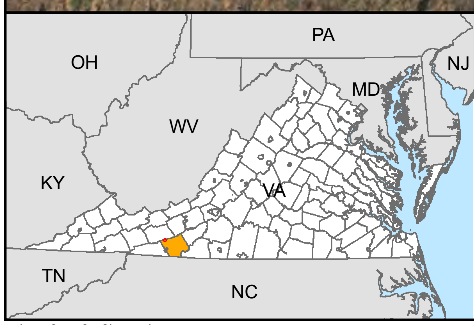
AMERICAN ELECTRIC POWER

EDGE
ENGINEERING & SCIENCE

American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 5
Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd



Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100

Meters

Scale: 1:3,937

AMERICAN ELECTRIC POWER

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Byllesby-Buck Benthic Aquatic Resource

Figure 6
Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd

Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 7
Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd

Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100
Meters

Scale: 1:3,937

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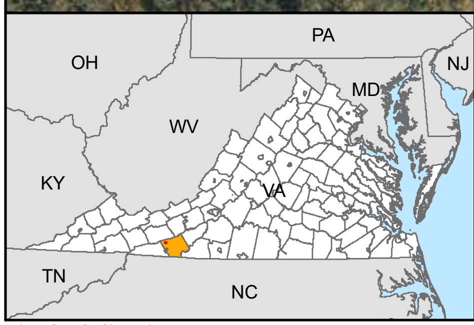
Byllesby-Buck Benthic Aquatic Resource

Figure 8
Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd



Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100
Meters

Scale: 1:3,937

AMERICAN ELECTRIC POWER

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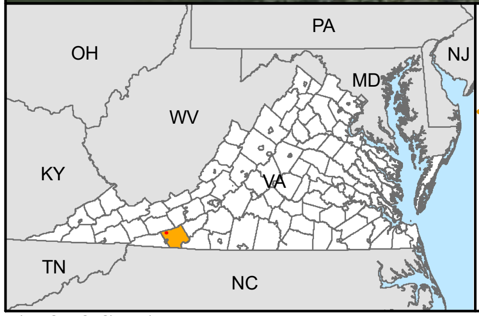
Byllesby-Buck Benthic Aquatic Resource

Figure 9
Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd



Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

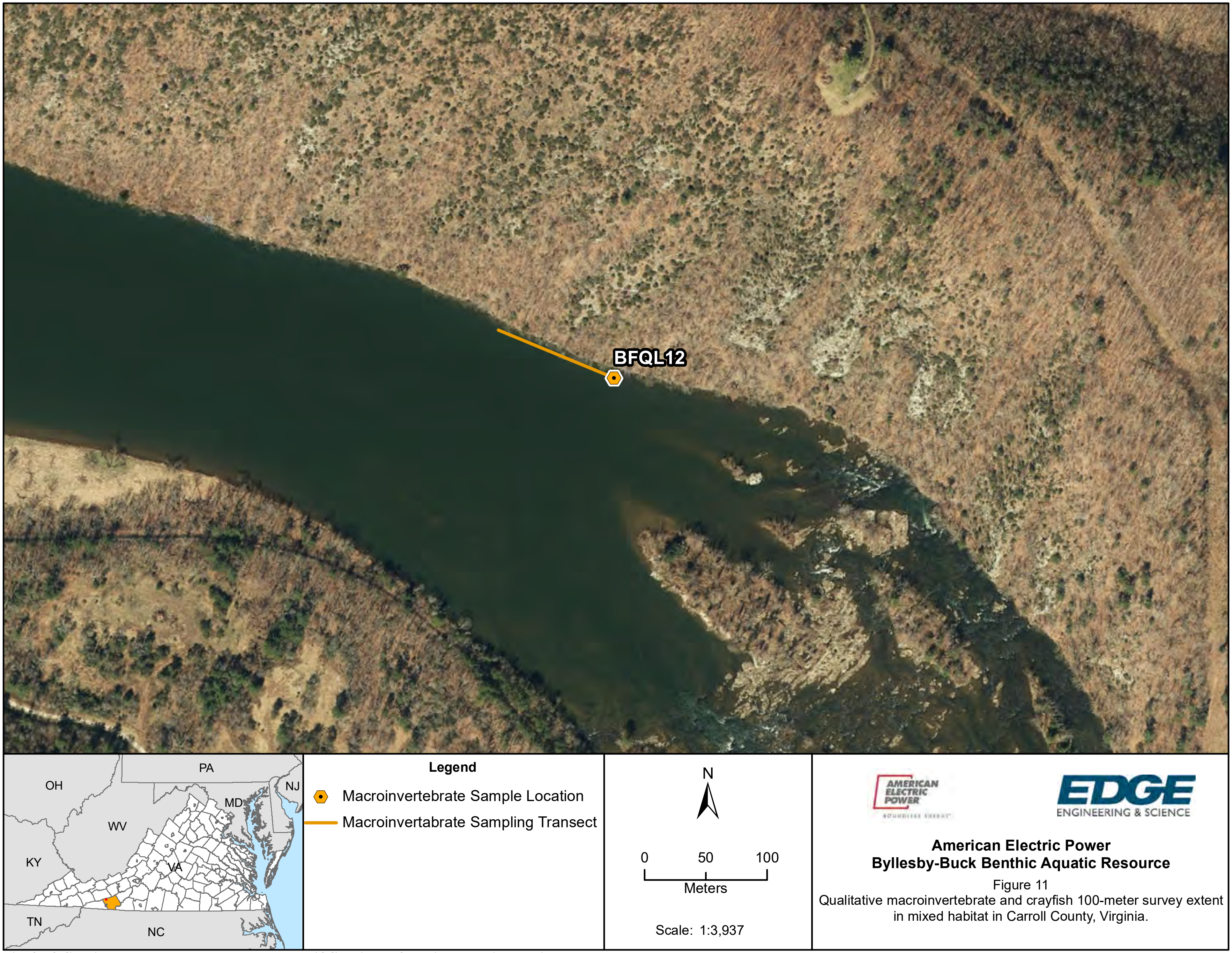
0 50 100
Meters

Scale: 1:3,937

American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 10
Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd



American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 11
Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd

Legend

- Macroinvertebrate Sample Location
- Macroinvertabrate Sampling Transect

N

0 50 100
Meters

Scale: 1:3,937

AMERICAN ELECTRIC POWER

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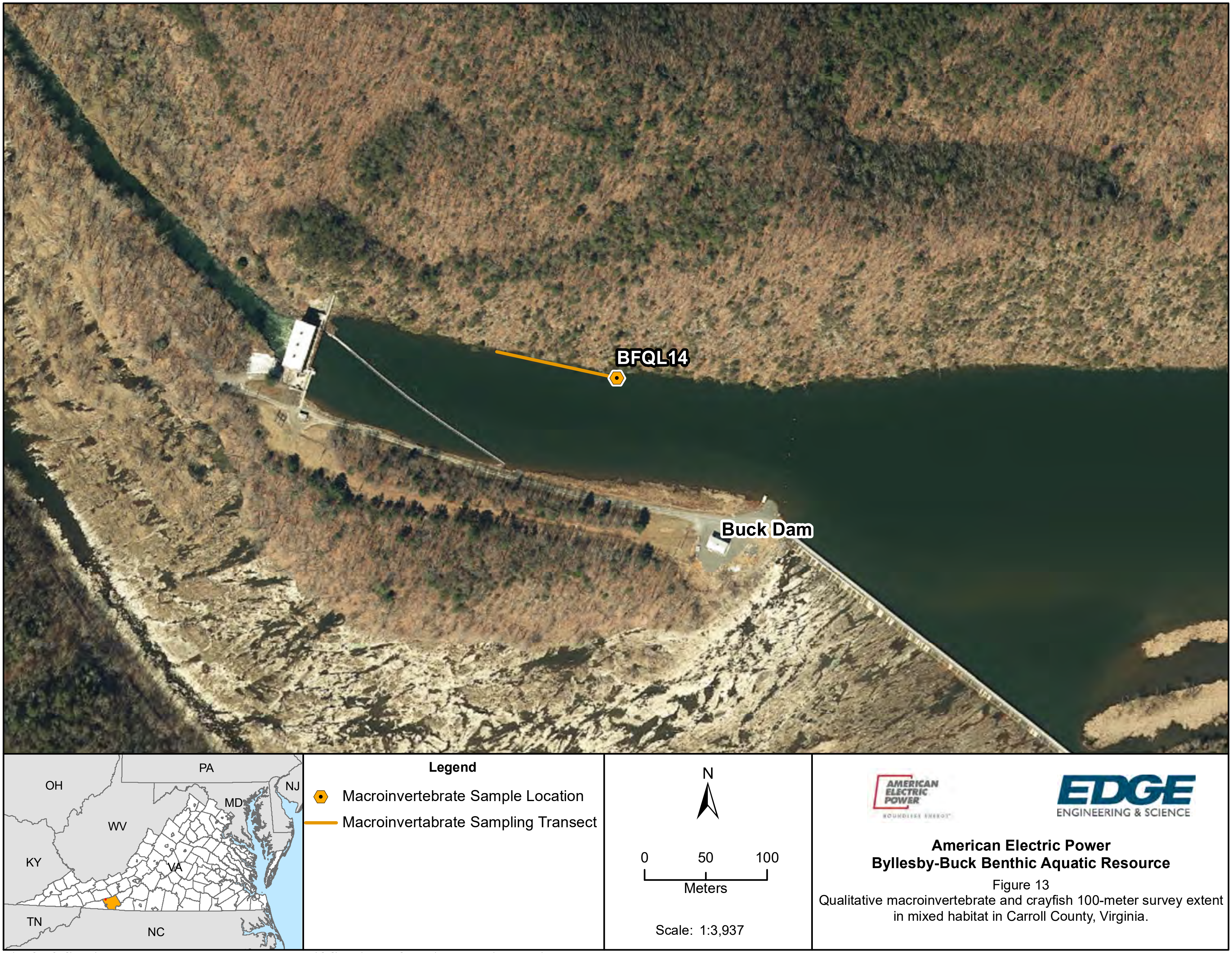
Byllesby-Buck Benthic Aquatic Resource

Figure 12
Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd



American Electric Power
Byllesby-Buck Benthic Aquatic Resource

Figure 13
Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Carroll County, Virginia.

D:\PROJECTS\HDR\HDR2020-0001 Byllesby-Buck Dam Relicensing\GIS\MXD\Macro_Surveys\Report_Figs\20201215\HDR2020-0001_Macro_Fig2_13_20201215.mxd

Appendix A

SCIENTIFIC COLLECTION PERMITS

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)
Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **New** Fee Paid: **$40.00** VADGIF Permit No. **070705**

Permittee: **Jonathan Studio**
Address: **36550 Chester Road, Apt. 4801**
Avon, OH 44011
Email: **jastudio@edge-es.com**

Home:
Office: **(440) 413-4609**
City/County:

Business: **Edge Engineering & Science, LLC**
4005 Ponder Drive
Cincinnati, OH 45245

Niagara Hydroelectric Project/Byllesby-Buck Hydroelectric Project

Authorized Collection Methods: By Hand/Dip Nets/Electrofishing/Gill Nets/Trawl Nets/Nets-Traps (Fyke/Hoop/D-Frame)/Seine Nets/Drift Nets
Authorized Waterbodies: Roanoke River/Tinker Creek/New River
Authorized Marking Techniques: N/A

SPECIAL CONDITIONS: No electrofishing in Roanoke Logperch TOYR unless requested and approved by both USFWS and DWR. Mussels may not be targeted and any inadvertently collected must be returned to the point-of-capture after the individual is identified (if ID is possible).

Permittee MUST notify DWR within the 7 day period prior to each sampling event. Notification must be made via email to: collectionpermits@dwr.virginia.gov

Report Due: 31 January 2022, 31 January 2023

ANNUAL REPORTS MUST BE SUBMITTED VIA: https://vafwis.dgif.virginia.gov/collection_permits/

STANDARD CONDITIONS ATTACHED APPLY TO THIS PERMIT.

Authorized Counties / Cities:
Carroll
Roanoke

Authorized Species:

Description	ID Number	Scientific Name
Aquatic Insects		
Crayfish		
Freshwater Fish		
Other Aquatic Invertebrates		

Annual Report Due End of Each Year

Authorized Sub-Permittees:
See Attached Sheet

Approved by: [signature]

Title: **Randall T. Francis - Permits Manager**

Applicants may appeal permit decisions within 30 days of issuance. The appeal must be in writing to the Director, Department of Game and Inland Fisheries.

Date: **3/2/2021**

Virginia Department of Game and Inland Fisheries
7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)
Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **New** Fee Paid: **$40.00** VADGIF Permit No. **070705**

20 Permit Effective **3/2/2021** through **12/31/2022** **22**

Virginia Department of Game and Inland Fisheries
7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **New**	FeePaid: **$40.00**	VADGIF Permit No. **070705**

Authorized Sub-Permittees:

Sarah Messer, Edge Engineering & Science, LLC
John Spaeth, Edge Engineering & Science, LLC
Aaron Prewitt, Edge Engineering & Science, LLC
Adam Benshoff, Edge Engineering & Science, LLC
David Foltz, Edge Engineering & Science, LLC
Mitchell Kriege, Edge Engineering & Science, LLC
Alyssa Jones, Edge Engineering & Science, LLC
David Ford, Edge Engineering & Science, LLC
Tim Brust, Edge Engineering & Science, LLC

Virginia Department of Wildlife Resources

P O Box 3337 Henrico, VA 23228-3337
(804) 367-6913

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

SCIENTIFIC COLLECTION PERMIT – STANDARD CONDITIONS

1. Permits are issued to permittees with the understanding that if the principal permittee leaves the project the permit will be null and void and anyone desiring to continue the activities must apply for a new permit.

2. This permit, or a copy, must be carried by the permittee(s) during collection activities.

3. Permittee MUST notify the Virginia Department of Wildlife Resources (VDWR) within the seven (7) day period prior to EACH sampling event. Notification must be made via email to: collectionpermits@DWR.virginia.gov.)

4. The permittee is required to submit to this Department a report of all specimens collected under this permit by the report due date. Report form may be found at https://vafwis.DWR.virginia.gov/collection_permits/. FAILURE TO RETURN THIS REPORT WILL RESULT IN NON-ISSUANCE OF FUTURE PERMITS. If no activity occurs under this permit, an email should be sent to collectionpermits@DWR.virginia.gov containing the following statement: No activity occurred under Permit #*insert permit ID* during insert year (i.e. 2017). Permit reports are due by January 31.

5. Permittees shall give any and all changes of name, address, and/or phone number to the VDWR Permits Section within no more than seven (7) days of those changes. All permittees (to include sub-permittees) shall provide DWR with a complete home address, contact telephone number (home or cellular), and a valid e-mail address.

6. This permit does not support any activities outside of those associated with the application and proposal submitted to and approved by DWR.

7. No species currently listed by the U.S. Fish and Wildlife Service or VDWR as threatened or endangered may be intentionally collected under this permit. If incidental d*eath or injury* of threatened or endangered species does occur, the permittee is required to notify VDWR at collectionpermits@DWR.virginia.gov within twenty-four (24) hours of occurrence. The following information must be reported: collector, date, species, location (county, quad, waterbody, and latitude and longitude to nearest second), and number collected.

8. If incidental *observation or collection and live release* of threatened or endangered species occurs, the permittee is required to notify VDWR at collectionpermits@DWR.virginia.gov within four (4) working days, providing the same information as the Condition No. 7.

9. If incidental *mortality or injury of specimens intended to be taken live* occurs, the permittee is required to notify VDWR at collectionpermits@DWR.virginia.gov within 48 hours, providing the same information as the above conditions. In addition, the permittee must provide the cause of mortality or injury and steps that are being taken to address the problem.

10. No species may be retained unless specifically authorized by this permit.

11. Game birds/game mammals/game fish protected by State and/or Federal laws must be taken during authorized hunting and trapping seasons and under applicable daily and seasonal bag/number limits by properly licensed persons unless otherwise specifically authorized. A valid Virginia fishing license is required for each person collecting samples by hook-and-line.

12. All traps must be marked with the name and address of the trapper or an identification number issued by VDWR (Code of Virginia §29.1-521.7). Steel foothold traps, Conibear-style body gripping traps, and snares must be marked with a nonferrous metal tag bearing this information (Virginia Administrative Code 4 VAC 15-40-170).

13. All traps must be checked at least once a day and all captured animals removed, except completely submerged body-gripping traps which must be checked at least once every 72 hours (Code of Virginia §29.1-521.9).

14. The permittee is required to report any incidences of wildlife deaths or diseases observed during the course of collection activities. Reports should be made to: collectionpermits@DWR.virginia.gov within four (4) working days.

15. This permit satisfies only VDWR's requirement for collection permits and is issued with the understanding that no collections will be made on Federal, state, or private property without the prior approval and necessary permits from the landowners involved. The permittee is responsible for obtaining any additional permits required for collection.

16. Sampling gear, boats, or trailers which have been used in states harboring zebra mussels must be cleaned and prepared following accepted guidelines for removal of zebra mussels, prior to being used in Virginia.

17. For safety reasons, it is recommended that all permittees display at least 100 square inches of solid blaze orange material at shoulder level within body reach and visible from 360 degrees, especially during hunting season.

Appendix B

REPRESENTATIVE PHOTOGRAPHS

Appendix B: Representative Photographs

BFQT1 - Upstream
Quantitative Macroinvertebrate Sample Site

BFQT2 - Upstream
Quantitative Macroinvertebrate Sample Site

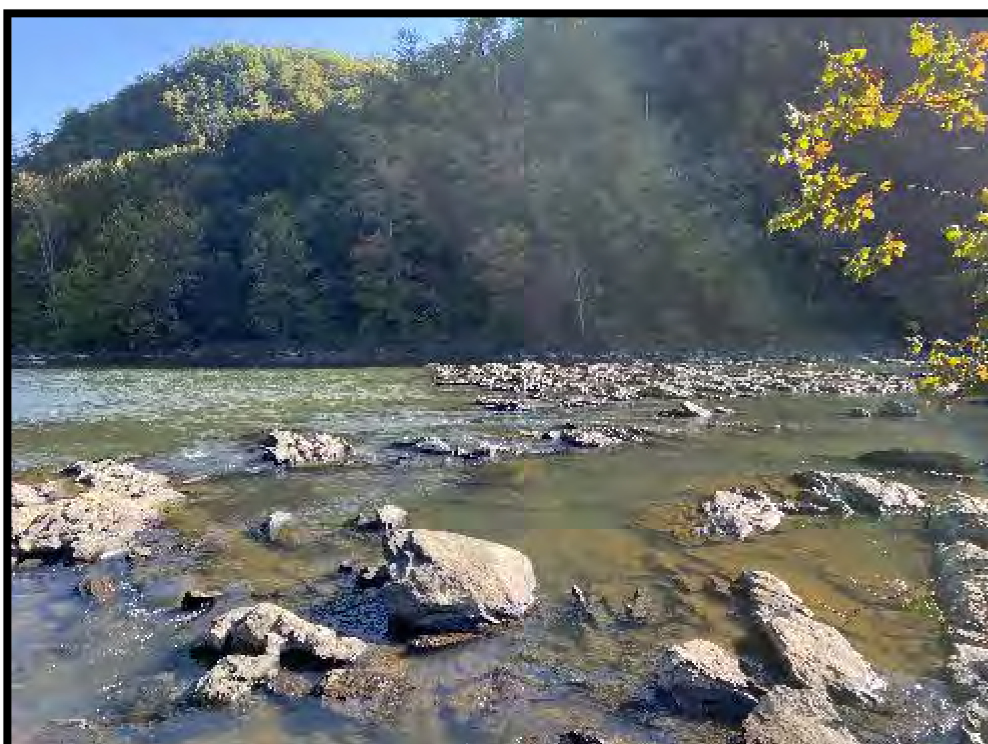
BFQL3 - Upstream
Qualitative Macroinvertebrate Sample Site

BFQL4 - Upstream
Qualitative Macroinvertebrate Sample Site

BFQL5 - Downstream
Qualitative Macroinvertebrate Sample Site

BFQL6 - Upstream
Qualitative Macroinvertebrate Sample Site

BFQT7 - Downstream
Quantitative Macroinvertebrate Sample Site



BFQT8 - Downstream
Quantitative Macroinvertebrate Sample Site

BFQL9 - Upstream
Qualitative Macroinvertebrate Sample Site

BFQT10 - Downstream
Quantitative Macroinvertebrate Sample Site

BFQT11 - Upstream
Quantitative Macroinvertebrate Sample Site

BFQL12 - Downstream
Qualitative Macroinvertebrate Sample Site

BFQL13 - Upstream
Qualitative Macroinvertebrate Sample Site

BFQL14 - Downstream
Qualitative Macroinvertebrate Sample Site

BFQT15 - Downstream
Quantitative Macroinvertebrate Sample Site

BFQT16 - Downstream
Quantitative Macroinvertebrate Sample Site

Conhaway Crayfish
(*Cambarus appalachiensis*)

Spiny Stream Crayfish
(*Faxonius cristavarius*)

Appendix C

RAW DATA

TAXON	Number of Organisms per Taxon per Subsample																	
	New River Samples and Collection Date																	
	BFQL1	BFQL2 ORIGINAL	BFQL2 REPLICATE	BFQT3	BFQT4	BFQL5	BFQL6	BFQT7 ORIGINAL	BFQT7 REPLICATE	BFQT8	BFQL9	BFQL10	BFQL11	BFQT12	BFQL13	BFQT14	BFQT15	BFQT16
	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/8/2020	10/8/2020	10/8/2020
PLATYHELMINTHES (flatworms)																		
TURBELLARIA																		
Planariidae	16	5	3			3	9			1						1		
ANNELIDA (segmented worms)																		
OLIGOCHAETA (aquatic worms)	11	55	17	2		17	30	1	8	1	10	14	6		8	1		4
ARTHROPODA (arthropods)																		
HYDRACARINA (water mites)										1								1
CRUSTACEA (crayfish, scuds, aquatic sow bugs)																		
AMPHIPODA (scuds, sideswimmers)																		
Talitridae																		
Hyalella sp.	2						23											
DECAPODA (crayfish)																		
Cambaridae																		
Faxonius sp.								1	1									
INSECTA (insects)																		
EPHEMEROPTERA (mayflies)																		
Baetidae (small minnow mayflies)			2		2		1											
Acentrella sp.				3						7				9		5		7
Acerpenna sp.		1	1		3			1		1	1	1			8			
Baetis flavistriga				1	1				2	3				3		4		3
Baetis intercalaris				51	58	1		35	19	18				13		15	3	10
Baetis spp.				17	4			4	8	1							1	3
Labiobaetis sp.			5								38	3	5					
Neocloeon sp.	2	1	3			6					10	4	4		2			
Plauditus sp.					17									1		1	3	1
Procloeon sp.									1			1						
Baetiscidae (armored mayflies)																		
Baetisca sp.															1			
Ephemerellidae (spiny crawler mayflies)																		
Eurylophella sp.									1									
Teloganopsis deficiens[1]								3		1							1	
Heptageniidae (flatheaded mayflies)																		
Heptagenia marginata				1	4			1	2					1		3		2
Maccaffertium spp.				6	1			8	5	14			1	3		7	7	9
Stenacron sp.				1	2			1		1	3		2			1		
Isonychiidae (brushlegged mayflies)																		
Isonychia sp.				2				5	2	6				1		1	10	15
Leptohyphidae (little stout crawlers)[2]																		
Tricorythodes sp.															1	1		
PLECOPTERA (stoneflies)																		
Chloroperlidae (green stoneflies)																		
Sweltsa sp.								1										
Perlidae (common stoneflies)																		
Acroneuria sp.				1				1		1						1		
Agnetina sp.									1									
Attaneuria ruralis														1				

TAXON	Number of Organisms per Taxon per Subsample New River Samples and Collection Date																	
	BFQL1	BFQL2 ORIGINAL	BFQL2 REPLICATE	BFQT3	BFQT4	BFQL5	BFQL6	BFQT7 ORIGINAL	BFQT7 REPLICATE	BFQT8	BFQL9	BFQL10	BFQL11	BFQT12	BFQL13	BFQT14	BFQT15	BFQT16
	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/8/2020	10/8/2020	10/8/2020
TRICHOPTERA (caddisflies)																		
Helicopsychidae (snail casemakers)																		
Helicopsyche borealis					1			1	1									
Hydropsychidae (common net-spinners)																		
Ceratopsyche morosa								1						1			1	3
Cheumatopsyche spp.								7	7	6				9		15	13	6
Hydropsyche spp.				2				1	1	4				5		4	28	6
Hydroptilidae (micro-caddisflies)											1							
Hydroptila sp.	1		1															
Lepidostomatidae (Lepidostomid caddisflies)																		
Lepidostoma sp.					1													
Leptoceridae (long-horned caddisflies)	1																	
Oecetis sp.									1									
Triaenodes spp.		1					2								9	1	1	
Molannidae (hood casemakers)																		
Molanna sp.						1												
Philopotamidae (fingernet caddisflies)																		
Chimarra sp.				4					2	2				1				1
Phryganeidae (giant casemakers)																		
Oligostomis sp.	1																	
Polycentropodidae (trumpetnet and tubemakers)																		
Neureclipsis sp.				1				6	1	1								
Nyctiophylax sp.									1									
Polycentropus sp.									1				1		26			
Psychomyiidae (tube-making caddisflies)																		
Psychomyia flavida									1									
COLEOPTERA (aquatic beetles)																		
Dryopidae (long-toed water beetle)																		
Helichus sp.															1			
Dytiscidae (predacious diving beetles)																		
Agabus sp.							1											
Elmidae (riffle beetles)																		
Ancyronyx sp.															1			
Dubiraphia sp.			1			1							1	1	1			
Gonielmis sp.	3				1							1					3	
Macronychus sp.			1	1						1					2			
Optioservus sp.				1										9		5	6	7
Oulimnius sp.														1				
Stenelmis sp.				1						3				13		5	4	18
Gyrinidae (whirligig beetles)																		
Dineutus sp.				2	7				1						7			

TAXON	Number of Organisms per Taxon per Subsample																	
	New River Samples and Collection Date																	
	BFQL1	BFQL2 ORIGINAL	BFQL2 REPLICATE	BFQT3	BFQT4	BFQL5	BFQL6	BFQT7 ORIGINAL	BFQT7 REPLICATE	BFQT8	BFQL9	BFQL10	BFQL11	BFQT12	BFQL13	BFQT14	BFQT15	BFQT16
	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/8/2020	10/8/2020	10/8/2020
Hydrophilidae (water scavenger beetles)																		
Berosus sp.	1		2															
Psephenidae (water penny beetles)																		
Psephenus herricki														2		1		
MEGALOPTERA (alderflies, fishflies, dobsonflies)																		
Corydalidae (fishflies, dobsonflies)																		
Corydalus sp.								1	1	1						1		3
Nigronia sp.																1		
ODONATA (dragonflies, damselflies)																		
ANISOPTERA (dragonflies)																		
Aeshnidae (darners)																		
Basiaeschna sp.	1	1	3															
Cordulegastridae (biddies)																		
Cordulegaster sp.													1					
Corduliidae/ Libellulidae (skimmers)			1										1					
Libellulidae (skimmers)																		
Plathemis sp.							1											
Gomphidae (clubtails)																		
Gomphurus sp.								1										
Hylogomphus sp.[4]								1										
Stylurus spiniceps													1					
Macromiidae (cruisers)																		
Macromia sp.		1													1			
ZYGOPTERA (damselflies)																		
Coenagrionidae (narrow-winged damselflies)																		
Argia sp.				1	1			1	3	10			5	2	7	1	1	4
Enallagma sp.	38	15	33			1	13				1							
Ishnura sp.	2																	
DIPTERA (true flies)																		
Ceratopogonidae (biting midges)																		
Culicoides sp.							4											
Probezzia sp.							1											
Chironomidae (A)[3] - (midges)	34	22	33	3	2	87	22	16	26	21	24	93	74	5	15	15	9	11
Simuliidae (blackflies)																		
Simulium sp.				1					1	3				6		2	7	1
Tabanidae (deer and horse flies)																		
Chrysops sp.							1											
Tipulidae (crane flies)				1														
LEPIDOPTERA (aquatic moths)																		
Pyralidae (pyralid moths)																		
Petrophila sp.									1	1								

TAXON	Number of Organisms per Taxon per Subsample																	
	New River Samples and Collection Date																	
	BFQL1	BFQL2 ORIGINAL	BFQL2 REPLICATE	BFQT3	BFQT4	BFQL5	BFQL6	BFQT7 ORIGINAL	BFQT7 REPLICATE	BFQT8	BFQL9	BFQL10	BFQL11	BFQT12	BFQL13	BFQT14	BFQT15	BFQT16
	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/6/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/7/2020	10/8/2020	10/8/2020	10/8/2020
HEMIPTERA (water bugs)																		
Belostomatidae (giant water bugs)							1											
Corixidae (water boatmen)						3												
Nepidae (water scorpions)																		
Ranatra sp.															1			
MOLLUSCA																		
GASTROPODA (snails, limpets)																		
Ancylidae (limpets)					3			6	7	4				3		3	1	
Lymnaeidae (pond snails)							1				1							
Planorbidae (ram's horn snails)		1					1											
Pleuroceridae (pleurocerid snails)				4												3	3	
Physidae (bladder snails)	1	2	4				8				17	2	1		1			1
BIVALVIA (clams or bivalves)																		
Corbiculidae (Asian clam)				3	2		1	12	4	3			2	30	7	14	10	1
Sphaeriidae (fingernail clams)		1	1												1		1	
TOTAL NUMBER OF TAXA	**17**	**15**	**19**	**26**	**20**	**12**	**20**	**27**	**31**	**29**	**13**	**11**	**17**	**25**	**22**	**29**	**23**	**25**
TOTAL NUMBER OF ORGANISMS	**132444**	**132436**	**132441**	**132440**	**132440**	**132450**	**132450**	**132449**	**132443**	**132449**	**132439**	**132452**	**132438**	**132453**	**132433**	**132448**	**132449**	**132453**

[1] - *Teloganopsis deficiens* previously identified as *Serratella deficiens*

[2] - Family Leptohyphidae previously named Family Tricorythidae

[3] - Chironomidae Group (A) includes all chironomid taxa except those that are highly tolerant of organic pollution, which are placed in Group (B). All identified Chironomidae specimens in all subsamples were assigned to Group A.

[4] - Based on taxonomic characteristics, this specimen does not appear to be *Hylogomphus adelphus* (Mustached Clubtail), identified in Virginia as a "species of greatest conservation need

TAXON	Number of Organisms per Taxon per Subsample																	
	New River Samples and Collection Date																	
	BSQT1	BSQT2	BSQL3	BSQL4 ORIGINAL	BSQL4 REPLICATE[3]	BSQL5	BSQL6	BSQT7 ORIGINAL	BSQT7 REPLICATE	BSQT8	BSQL9	BSQT10	BSQT11	BSQL12	BSQL13	BSQL14	BSQT15	BSQT16
	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/23/2021	4/21/2021	4/22/2021	4/22/2021	4/22/2021	4/23/2021
PLATYHELMINTHES (flatworms)																		
TURBELLARIA																		
Planariidae					1	7	2			2		1		2				1
ANNELIDA (segmented worms)																		
OLIGOCHAETA (aquatic worms)	7	27	8	39	14	10	39	12	29	46	23	17	12	8	10	81	6	8
ARTHROPODA (arthropods)																		
HYDRACARINA (water mites)				1		1												
CRUSTACEA (crayfish, scuds, aquatic sow bugs)																		
AMPHIPODA (scuds, sideswimmers)																		
Talitridae																		
Hyalella sp.						2												
ISOPODA (aquatic sow bugs)																		
Asellidae																		
Caecidotea sp.																5		
DECAPODA (crayfish)																		
Cambaridae																		
Cambarus sp.												1						
Faxonius sp.						1												
INSECTA (insects)																		
EPHEMEROPTERA (mayflies)																		
Baetidae (small minnow mayflies)																		
Acentrella sp.	4							2		14		5	6				33	12
Acerpenna sp.		2										1						
Baetis flavistriga		1								1		1	4				6	1
Baetis spp.	3	2						1	1	4		3	2				3	2
Heterocloeon spp.												1					2	
Plauditus spp.	23	17		1	1			6	6	6		17	1				3	4
Ephemerellidae (spiny crawler mayflies)																		
Dannella sp.		1										1						1
Ephemerella sp.													1					
Teloganopsis deficiens[1]	2												2				2	1
Ephemeridae (burrowing mayflies)																		
Ephemera sp.									1					2				
Heptageniidae (flatheaded mayflies)																		
Heptagenia marginalis	1	7																
Leucrocuta sp.	1	1								1		1						
Maccaffertium spp.	13	17						4	2	8	2	11	13	1			5	2
Stenacron sp.									1					1				
Isonychiidae (brushlegged mayflies)																		
Isonychia sp.	1									1			4					1
Siphlonuridae (primitive minnow mayflies)																		
Siphlonurus sp.				1	5				2		1			1	7			

TAXON	Number of Organisms per Taxon per Subsample																	
	New River Samples and Collection Date																	
	BSQT1	BSQT2	BSQL3	BSQL4 ORIGINAL	BSQL4 REPLICATE[3]	BSQL5	BSQL6	BSQT7 ORIGINAL	BSQT7 REPLICATE	BSQT8	BSQL9	BSQT10	BSQT11	BSQL12	BSQL13	BSQL14	BSQT15	BSQT16
	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/23/2021	4/21/2021	4/22/2021	4/22/2021	4/22/2021	4/23/2021
PLECOPTERA (stoneflies)																		
Chloroperlidae (green stoneflies)																		
Haploperla sp.									1				2	4				
Leuctridae (rolled-wing stoneflies)																		
Leuctra sp.																		1
Nemouridae (spring stoneflies)																		
Amphinemura sp.																		2
Perlidae (common stoneflies)																		
Acroneuria sp.	3	1										1	1				1	
Agnetina sp.																	1	
Perlesta sp.	6							1		5		2	8				4	
Perlodidae (stripetails, springflies)																		
Cultus sp.												1						
Helopicus sp.	1																	
Isoperla sp.													1	4			1	
Taeniopterygidae (broadbacks, winter stoneflies)																		
Taeniopteryx sp.										1								
TRICHOPTERA (caddisflies)																		
Brachycentridae (humpless casemakers)																		
Brachycentrus sp.	1									1			1				1	20
Glossosomatidae (saddle- casemakers)													1					
Hydropsychidae (common net-spinners)																		
Cheumatopsyche spp.	3											3	5				3	
Diplectrona sp.														1				
Hydropsyche spp.													4				1	
Hydroptilidae (micro-caddisflies)																		
Hydroptila sp.	2	2		1				3	2	1	3	6	5	2	4		1	1
Lepidostomatidae (Lepidostomid caddisflies)																		
Lepidostoma sp.	3											4			1			1
Leptoceridae (long-horned caddisflies)																		
Ceraclea sp.																		1
Oecetis sp.												1						
Triaenodes sp.											1							
Limnephilidae (northern casemakers)																		
Pycnopsyche sp.															1			
Polycentropodidae (trumpetnet and tubemakers)																		
Neureclipsis sp.			1							1		1						
Polycentropus sp.											1							
COLEOPTERA (aquatic beetles)																		
Elmidae (riffle beetles)																		
Dubiraphia sp.					1													
Gonielmis sp.				9	3	11	4		1	1	3			22	4	3	1	
Macronychus sp.	5																	
Optioservus sp.			1	4	1	3		1				1		4		1	1	
Oulimnius sp.													1					
Stenelmis sp.	6									2		3		1			10	2

TAXON	Number of Organisms per Taxon per Subsample																	
	New River Samples and Collection Date																	
	BSQT1	BSQT2	BSQL3	BSQL4 ORIGINAL	BSQL4 REPLICATE[3]	BSQL5	BSQL6	BSQT7 ORIGINAL	BSQT7 REPLICATE	BSQT8	BSQL9	BSQT10	BSQT11	BSQL12	BSQL13	BSQL14	BSQT15	BSQT16
	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/23/2021	4/21/2021	4/22/2021	4/22/2021	4/22/2021	4/23/2021
Gyrinidae (whirligig beetles)																		
Dineutus sp.		10			2	1		4	3		3							
Gyrinus sp.				3	4													
Haliplidae (crawling water beetles)																		
Peltodytes sp.					1	3												
Psephenidae (water penny beetles)																		
Psephenus herricki										2							2	
MEGALOPTERA (alderflies, fishflies, dobsonflies)																		
Corydalidae (fishflies, dobsonflies)																		
Corydalus sp.	4									1			1					
ODONATA (dragonflies, damselflies)																		
ANISOPTERA (dragonflies)																		
Gomphidae (clubtails)																		
Hylogomphus sp.[4]		1									1							
Macromiidae (cruisers)																		
Macromia sp.											2							
ZYGOPTERA (damselflies)																		
Calopterygidae (broad-winged damselflies)																		
Calopteryx sp.											1							
Coenagrionidae (narrow-winged damselflies)																		
Argia sp.										1	2	2						
Enallagma sp.						3												
DIPTERA (true flies)																		
Ceratopogonidae (biting midges)																		
Culicoides sp.							1											
Probezzia sp.							1							1				
Serromyia sp.						1												
Chironomidae (A)[2] - (midges)	17	29	105	52	54	65	54	81	56	16	65	16	32	52	72	21	21	36
Chironomidae (B)[2] - (midges)							11								3	1		
Empididae (dance flies)																		
Hemerodromia sp.													2					
Simuliidae (blackflies)																		
Simulium sp.	10				1			1	1	2		1					2	14
Tipulidae (crane flies)																		
Antocha sp.	1											5	1				1	1
Limonia sp.									1									
LEPIDOPTERA (aquatic moths)																		
Pyralidae (pyralid moths)																		
Petrophila sp.										1		1						

TAXON	Number of Organisms per Taxon per Subsample																	
	New River Samples and Collection Date																	
	BSQT1	BSQT2	BSQL3	BSQL4 ORIGINAL	BSQL4 REPLICATE[3]	BSQL5	BSQL6	BSQT7 ORIGINAL	BSQT7 REPLICATE	BSQT8	BSQL9	BSQT10	BSQT11	BSQL12	BSQL13	BSQL14	BSQT15	BSQT16
	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/20/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/21/2021	4/23/2021	4/21/2021	4/22/2021	4/22/2021	4/22/2021	4/23/2021
HEMIPTERA (water bugs)																		
Corixidae (water boatmen)							1											
Sigara sp.						3												
MOLLUSCA																		
GASTROPODA (snails, limpets)																		
Ancylidae (limpets)												2						
Planorbidae (ram's horn snails)					2	1	2											
Pleuroceridae (pleurocerid snails)	1											1						
Physidae (bladder snails)	1						2								1	3		
BIVALVIA (clams or bivalves)																		
Corbiculidae	1				1						1	3	8					2
Sphaeriidae (fingernail clams)					3		1					1						
TOTAL NUMBER OF TAXA	**28**	**17**	**7**	**12**	**18**	**17**	**13**	**14**	**17**	**25**	**17**	**34**	**27**	**18**	**11**	**9**	**26**	**24**
TOTAL NUMBER OF ORGANISMS	**133038**	**133036**	**133033**	**133029**	**133012**	**133030**	**133036**	**133037**	**133028**	**133039**	**133030**	**133036**	**133045**	**133027**	**133027**	**133039**	**133035**	**133041**

[1] - *Teloganopsis deficiens* previously identified as *Serratella deficiens*

[2] - Chironomidae Group (A) includes all chironomid taxa except those that are highly tolerant of organic pollution, which are placed in Group (B). The family Chironomidae is counted as one taxon, despite the Group A and Group B designations.

[3] - Sample BSQL4-(Site 8)-Replicate was completely sorted (50 of 50 primary grids) and produced a total of 94 organisms, five less than the minimum subsample target number of 99 organisms.

[4] - Based on taxonomic characteristics, these specimens do not appear to be *Hylogomphus adelphus* (Mustached Clubtail), identified in Virginia as a "species of greatest conservation need"

Water quality parameters at quantitative and qualitative sites in fall 2020 (BFQT and BFQL site names, respectively) and spring 2021 (BSQT and BSQL site names). Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam.

Date	Site ID	Water Temp. (C)	pH	DO (%)	Conductivity (us/cm)	Habitat
10/6/2020	BFQT1	15.6	8.10	113.9	66.2	Riffle
10/6/2020	BFQT2	15.7	8.00	109.9	64.5	Riffle/Run
10/6/2020	BFQL3	15.3	8.40	101.6	64.4	Pool
10/6/2020	BFQL4	15.1	8.30	91.4	65.5	Pool
10/6/2020	BFQL5	14.8	8.40	92.1	64.4	Pool
10/6/2020	BFQL6	27.3	7.20	84.3	44.9	Pool
4/20/2021	BSQT1	12.6	7.73	100.4	58.8	Riffle
4/20/2021	BSQT2	13.4	7.90	99.7	55.6	Riffle/Run
4/20/2021	BSQL3	14.7	7.60	92.6	58.5	Pool
4/20/2021	BSQL4	13.9	7.47	97.4	58.4	Pool
4/20/2021	BSQL5	13.5	7.60	100.3	58.1	Pool
4/20/2021	BSQL6	15.1	7.12	88.7	58.2	Pool
10/7/2020	BFQT7	15.3	7.20	115.7	63.9	Riffle/Run
10/7/2020	BFQT8	15.7	7.20	114.9	64.0	Riffle
10/7/2020	BFQL9	17.3	7.30	101.8	63.8	Pool
10/7/2020	BFQT10	17.1	7.40	104.8	63.8	Riffle
10/8/2020	BFQT11	15.1	7.00	110.7	66.6	Riffle
10/7/2020	BFQL12	17.4	7.30	101.3	65.7	Pool
10/7/2020	BFQL13	16.7	7.50	92.7	65.1	Pool
10/7/2020	BFQL14	16.7	7.50	92.7	65.1	Pool
4/21/2021	BSQT7	13.4	7.40	88.2	57.3	Riffle/Run
4/21/2021	BSQT8	13.7	7.60	95.6	57.7	Riffle
4/21/2021	BSQL9	13.6	7.40	93.6	57.7	Pool
4/21/2021	BSQT10	13.7	7.60	97.0	57.8	Riffle
4/23/2021	BSQT11	6.9	7.62	102.8	58.8	Riffle
4/22/2021	BSQL12	11.2	7.60	100.2	58.4	Pool
4/22/2021	BSQL13	11.3	7.50	96.1	58.7	Pool
4/22/2021	BSQL14	11.6	7.50	92.2	58.7	Pool
10/8/2020	BFQT15	17.2	7.70	108.1	57.7	Riffle
10/8/2020	BFQT16	16.4	7.00	107.3	69.9	Riffle
4/22/2021	BSQT15	10.4	7.70	108.0	38.2	Riffle
4/23/2021	BSQT16	11.0	7.80	105.7	64.4	Riffle

Raw data used to calculate VSCI scores for fall 2020 macroinvertebrate data (family). Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI
BFQT1	110	16	7	74.55	5.45	13.64	72.73	2.73	**4.08**
BFQT2	111	10	4	83.78	1.80	10.81	83.78	1.80	**4.23**
BFQL3	120	8	2	5.83	0.83	1.67	86.67	72.50	**5.07**
BFQL4 ORIGINAL	106	11	2	1.89	0.94	2.83	72.64	20.75	**3.36**
BFQL4 REPLICATE	111	12	2	9.91	0.90	6.31	59.46	29.73	**5.77**
BFQL5	114	13	4	1.75	2.63	4.39	64.91	29.82	**6.51**
BFQL6	120	16	2	0.83	1.67	8.33	44.17	18.33	**3.93**
BFQT7 ORIGINAL	117	17	9	50.43	7.69	13.68	48.72	13.68	**4.79**
BFQT7 REPLICATE	111	21	11	36.94	8.11	12.61	51.35	23.42	**4.68**
BFQT8	117	18	8	45.30	3.42	19.66	44.44	17.95	**4.98**
BFQL9	100	16	5	12.00	35.00	5.00	41.00	15.00	**5.31**
BFQT10	120	13	6	25.83	1.67	27.50	46.67	4.17	**5.50**
BFQT11	113	18	7	33.63	1.77	24.78	39.82	13.27	**5.20**
BFQL12	105	12	3	11.43	0.95	4.76	79.05	70.48	**5.52**
BFQL13	119	5	1	7.56	0.00	2.52	89.92	78.15	**5.16**
BFQL14	106	8	3	49.06	0.94	20.75	68.87	22.64	**4.81**
BFQT15	117	14	5	42.74	0.85	31.62	41.88	9.40	**4.08**
BFQT16	115	14	6	22.61	0.87	20.87	48.70	7.83	**5.12**

Site results of VSCI scores for fall 2020 macroinvertebrate data (family). Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI	VSCI Score
BFQT1	110	72.73	63.64	100.00	15.31	26.43	39.41	97.27	87.03	**62.73**
BFQT2	111	45.45	36.36	100.00	5.06	20.95	23.43	98.20	84.79	**51.78**
BFQL3	120	36.36	18.18	9.51	2.33	3.24	19.27	27.50	72.55	**23.62**
BFQL4 ORIGINAL	106	50.00	18.18	3.08	2.64	5.48	39.54	79.25	97.67	**36.98**
BFQL4 REPLICATE	111	54.55	18.18	16.17	2.53	12.23	58.58	70.27	62.14	**36.83**
BFQL5	114	59.09	36.36	2.85	7.39	8.51	50.70	70.18	51.34	**35.80**
BFQL6	120	72.73	18.18	1.35	4.69	16.14	80.68	81.67	89.22	**45.58**
BFQT7 ORIGINAL	117	77.27	81.82	82.27	21.60	26.51	74.11	86.32	76.67	**65.82**
BFQT7 REPLICATE	111	95.45	100.00	60.26	22.78	24.44	70.30	76.58	78.30	**66.01**
BFQT8	117	81.82	72.73	73.90	9.61	38.10	80.28	82.05	73.78	**64.03**
BFQL9	100	72.73	45.45	19.58	98.31	9.69	85.26	85.00	68.97	**60.62**
BFQT10	120	59.09	54.55	42.14	4.69	53.29	77.07	95.83	66.18	**56.61**
BFQT11	113	81.82	63.64	54.86	4.97	48.02	86.96	86.73	70.54	**62.19**
BFQL12	105	54.55	27.27	18.65	2.67	9.22	30.28	29.52	65.83	**29.75**
BFQL13	119	22.73	9.09	12.33	0.00	4.88	14.57	21.85	71.18	**19.58**
BFQL14	106	36.36	27.27	80.03	2.64	40.21	44.99	77.36	76.30	**48.15**
BFQT15	117	63.64	45.45	69.72	2.39	61.28	83.99	90.60	87.10	**63.02**
BFQT16	115	63.64	54.55	36.88	2.44	40.45	74.14	92.17	71.74	**54.50**

EPT = Ephemeroptera, Trichoptera, and Plecoptera; HBI = Hilsenhoff Biotic Index; VSCI = Virginia stream condition index

Raw data used to calculate VSCI scores for spring 2021 macroinvertebrate data (family). Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI
BFQT1	84	19	10	25.00	19.05	35.71	38.10	20.24	**3.81**
BFQT2	109	9	5	44.04	2.75	24.77	51.38	26.61	**3.53**
BFQL3	115	4	1	0.00	0.87	4.00	98.26	60.00	**5.57**
BFQL4 ORIGINAL	111	8	3	1.80	0.90	0.87	81.98	91.30	**3.61**
BFQL4 REPLICATE	94	12	2	6.38	0.00	7.45	72.34	57.45	**5.11**
BFQL5	103	13	0	0.00	0.00	14.56	76.70	63.11	**5.76**
BFQL6	118	10	0	0.00	0.00	6.78	49.47	55.08	**4.32**
BFQT7 ORIGINAL	116	9	4	11.21	3.45	6.90	80.17	69.83	**5.06**
BFQT7 REPLICATE	107	12	6	12.15	2.80	5.61	79.44	52.34	**4.07**
BFQT8	118	17	8	29.66	7.63	12.71	60.17	13.56	**2.70**
BFQL9	109	14	5	2.75	4.59	7.34	80.73	59.63	**4.57**
BFQT10	115	23	10	35.65	13.91	21.74	39.13	13.91	**3.95**
BFQT11	118	17	10	27.97	16.10	16.10	38.14	27.12	**4.19**
BFQL12	106	12	7	4.72	9.43	29.25	74.53	49.06	**4.67**
BFQL13	94	9	4	7.45	6.38	9.57	84.04	79.79	**5.97**
BFQL14	115	6	0	0.00	0.00	6.09	88.70	19.13	**1.52**
BFQT15	111	14	8	48.65	8.11	18.02	61.26	18.92	**4.07**
BFQT16	96	17	10	25.00	8.33	5.21	57.29	37.50	**4.63**

Site results of VSCI scores for spring 2021 macroinvertebrate data (family). Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI	VSCI Score
BFQT1	84	86.36	90.91	40.78	53.50	69.21	89.46	79.76	91.04	**75.13**
BFQT2	109	40.91	45.45	71.84	7.73	48.01	70.27	73.39	95.12	**56.59**
BFQL3	115	18.18	9.09	0.00	2.44	7.75	2.51	40.00	65.22	**18.15**
BFQL4 ORIGINAL	111	36.36	27.27	2.94	2.53	1.69	26.04	8.70	93.93	**24.93**
BFQL4 REPLICATE	94	54.55	18.18	10.41	0.00	14.43	39.97	42.55	71.96	**31.51**
BFQL5	103	59.09	0.00	0.00	0.00	28.22	33.67	36.89	62.39	**27.53**
BFQL6	118	45.45	0.00	0.00	0.00	13.14	73.02	44.92	83.50	**32.50**
BFQT7 ORIGINAL	116	40.91	36.36	18.28	9.69	13.37	28.65	30.17	72.64	**31.26**
BFQT7 REPLICATE	107	54.55	54.55	19.82	7.88	10.87	29.71	47.66	87.27	**39.04**
BFQT8	118	77.27	72.73	48.39	21.42	24.64	57.56	86.44	107.30	**61.97**
BFQL9	109	63.64	45.45	4.49	12.89	14.22	27.84	40.37	79.87	**36.10**
BFQT10	115	104.55	90.91	58.16	39.08	42.13	87.96	86.09	89.00	**74.73**
BFQT11	118	77.27	90.91	45.62	45.23	31.20	89.40	72.88	85.37	**67.24**
BFQL12	106	54.55	63.64	7.69	26.50	56.68	36.81	50.94	78.39	**46.90**
BFQL13	94	40.91	36.36	12.15	17.93	18.56	23.06	20.21	59.29	**28.56**
BFQL14	115	27.27	0.00	0.00	0.00	11.80	16.34	80.87	124.68	**32.62**
BFQT15	111	63.64	72.73	79.36	22.78	34.92	55.98	81.08	87.18	**62.21**
BFQT16	96	77.27	90.91	40.78	23.41	10.09	61.72	62.50	79.04	**55.72**

EPT = Ephemeroptera, Trichoptera, and Plecoptera; HBI = Hilsenhoff Biotic Index; VSCI = Virginia stream condition index

Crayfish observations. Sites above the first dashed line are upstream of Byllesby Dam, sites below the first dashed line are between Byllesby and Buck Dam, and sites below the second dashed line are downstream of Buck Dam. Both species are native.

Date	Site	Conhoway Crayfish	Spiny Stream Crayfish
10/6/2020	BFQT1		
10/6/2020	BFQT2		
10/6/2020	BFQL3		
10/6/2020	BFQL4		
10/6/2020	BFQL5		present
10/6/2020	BFQL6		
10/7/2020	BFQT7	present	present
10/7/2020	BFQT8		
10/7/2020	BFQL9		present
10/7/2020	BFQT10	present	
10/8/2020	BFQT11		present
10/7/2020	BFQL12		present
10/7/2020	BFQL13		
10/7/2020	BFQL14		
10/8/2020	BFQT15	present	present
10/8/2020	BFQT16	present	present

Attachment 4

Attachment 4 – Mussel Community Study Report

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Stantec

Prepared for Appalachian Power Company

Byllesby-Buck Hydroelectric Project Freshwater Mussel Survey (FERC No. 2514)

January 4, 2021

Prepared by:
Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, OH 45241

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Prepared by ________________________
Elizabeth Dilbone

____
Jane DeClerck

Reviewed by ________________________
Steve Bedross

Approved by ________________________
Cody Fleece

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Executive Summary

As part of the ongoing Aquatic Resources Study being conducted for relicensing of the Byllesby-Buck Hydroelectric Project (Project), current and historical mussel surveys within the Project area were assessed to evaluate the status of the mussel community effected by Project operations. This report is intended to present data from surveys conducted in 2020 as well as review and summarize existing information regarding mussel assemblages in the Project area.

During September and October 2020, mussel surveys were conducted to assess mussel assemblages in the reservoir reach of the New River between the Byllesby and Buck Dams, as well as the tailrace of Buck Dam. Prior to mussel surveys, a desktop assessment of hydraulic habitat types within the study area was conducted to identify ten potential habitat units for survey. Theses ten habitats were then examined via boat to identify specific areas to target during in-water surveys. Nine *Cyclonaias tuberculata* were found during survey of the ten habitat units. Live mussels were only found in two of the ten surveyed areas and overall mussel densities were lower than other sites within the Project area (e.g. downstream of Buck Dam). Quality habitat within the survey area was limited, with bedrock and overlying silt deposits being the most prominent substrate types. A reconnaissance level habitat assessment of the Buck Dam tailrace was also conducted. No evidence of spent valves or viable mussel habitat were observed within the Buck Dam tailrace, where high velocities resulting from a narrow, confined channel most likely preclude mussel occupancy.

Existing relevant and reasonably available studies of mussels within the Project area were reviewed and compared to results of summer 2020 field surveys. In total, data from six other mussel surveys conducted within the Project area between 1997 and 2018 were compiled to form a more comprehensive understanding of the mussel community in the vicinity of Project operations. Six species were observed within the Project area: *Cyclonaias tuberculata*, *Eurynia dilatata, Tritogonia verrucosa, Lampsilis fasciola, Lasmigona subviridis,* and *Lampsilis ovata.* Survey sites downstream of Buck Dam (downstream of the confluence of the tailrace and bypass channel) supported the highest density mussel habitats. *Cyclonaias tuberculata* and *Tritogonia verrucosa* were the most abundant species and mussel size data suggests that recent recruitment has occurred for these species. Results of 2020 field surveys are consistent with findings of historical surveys. High quality mussel habitat within the Project area is limited and does not support a diverse or abundant mussel community.

Abbreviations

AEP	American Electric Power
°C	Celsius
µS	Microsiemens
CFS	Cubic feet per second
CPUE	Catch per unit effort
DO	Dissolved Oxygen
EA	Environmental Assessment
FERC	Federal Energy Regulatory Commission
Ft	Feet
hr	Hour
ILP	Integrated Licensing Process
M	Meter
m^2	Square meter
mi^2	Square mile
mg/L	Milligrams per liter
mm	Millimeters
NOI	Notice of Intent
NTU	Nephelometric Turbidity Units
PAD	Pre-Application Document
PSP	Proposed Study Plan
RSP	Revised Study Plan
SCUBA	Self-Contained Underwater Breathing Apparatus
USFWS	U.S. Fish and Wildlife Service
VDWR	Virginia Department of Wildlife Resources

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

The existing Federal Energy Regulatory Commission (FERC or Commission) license for the Byllesby-Buck Hydroelectric Project (FERC No. 2514) (Project) located on the New River in Carroll County, Virginia expires on February 29, 2024. Accordingly, Appalachian Power Company (Appalachian), the Licensee, owner and operator of the Project, is pursuing a subsequent license for the Project pursuant to the Commission's Integrated Licensing Process (ILP). The Appalachian Power Company submitted a Pre-Application Document (PAD) and Notice of Intent (NOI) for the Project to initiate the ILP on January 7, 2019. At this time, the Commission stated its intent to prepare an Environmental Assessment (EA) that evaluates the potential effects of issuing a subsequent license.

In accordance with 18 CFR §5.11, Appalachian developed a Proposed Study Plan (PSP) for the Project that recommended studies and approaches to addressing agency and stakeholder requests. A Revised Study Plan (RSP) was submitted in response to the comments on the PSP from the Commission, U.S. Fish and Wildlife Service (USFWS), and Virginia Department of Wildlife Resources (VDWR) on October 18, 2019. This RSP included provisions for an Aquatic Resources Study to examine multiple taxa within the New River, including a Mussel Community Sub-study. Due to the lack of mussel abundance found in existing data summarized in the PAD, the proposed mussel community study involved a two-stage approach that included 1) field surveys of the Buck Dam Tailrace channel and the reach of the New River between Byllesby Dam and Buck Reservoir Islands and 2) A desktop literature review of available data on the mussel communities in the Project vicinity. The goals of this study are to:

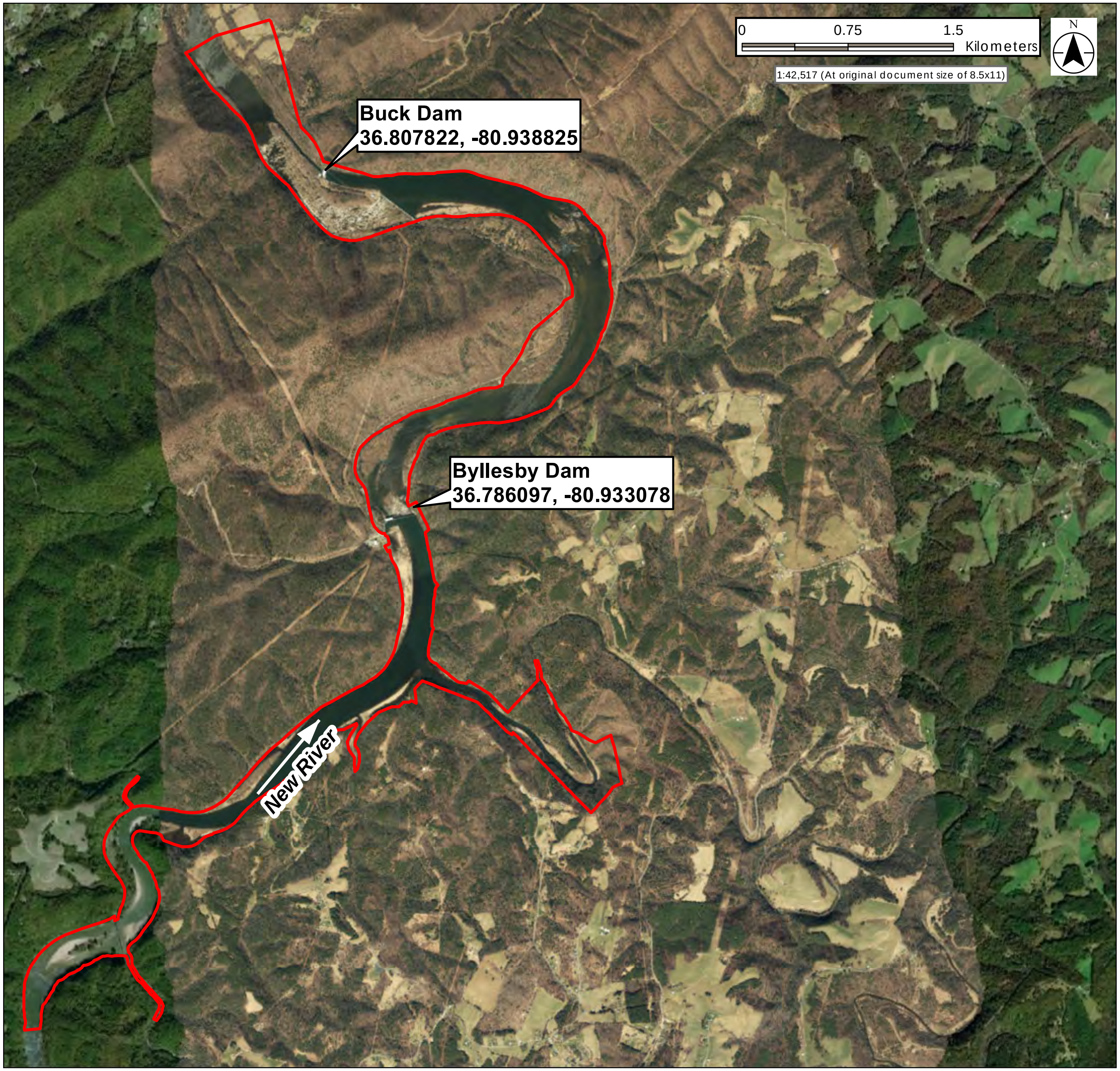
- Collect a more comprehensive baseline understanding of the mussel community within the Project area;
- Compare current mussel survey data to historical data to determine any significant changes in species composition or abundance; and
- Assess spatial distribution of mussel species within the Project area.

1.2 PROJECT AREA

The Project is located on the upper New River in Carroll County, Virginia. The Byllesby development is located about 9 mi north of the city of Galax, and the Buck development is located approximately 3 river miles (RM) downstream of Byllesby and 43.5 RM upstream of Claytor Dam (Figure 1). Each development consists of a reservoir, concrete gravity dam and spillway, and powerhouse. The Project area extends approximately 0.5 mi downstream of the Buck development. Figure 1 depicts the FERC project boundary and Project location.

1.3 STUDY OBJECTIVES

The Unionid fauna of the New River in the vicinity of the Project area has been studied at intervals beginning with Pinder et al. (2002) and most recently by Stantec (2020). Section 2.0 of this report presents the results of surveys completed in the un-impounded reach of the New River between Byllesby Dam and Buck Pool. Section 3.0 of the report presents a compilation and review of readily available studies of unionid mussels in the Project Area.

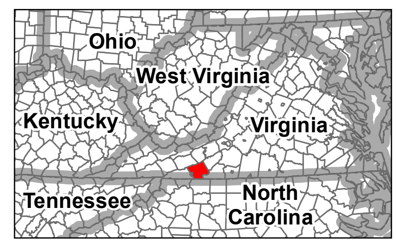


Stantec

Legend

Study Area Boundary

Notes
1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Base Imagery: ESRI Map Services.



Project Location
Carroll County, Virginia
New River

Prepared by EKD on 2020-11-24

Client/Project
Byllesby & Buck Hydroelectric Project
(FERC No. 2514)

Figure No.
1

Title
Byllesby - Buck Project Study Area

U:\1734\173430067_Buck_Byllesby_Mussel\03_Data\GIS\PDF\Byllesby_buck_ProjectArea.mxd Revised: 2020-11-30 By: edilbone

2.0 2020 MUSSEL SURVEY

2.1 METHODS

Methods consisted of visually identifying potential mussel habitats within the approximately 3,000 meter (m) long reach between Byllesby Dam and the Buck Reservoir Islands as well as the tailrace of Buck Dam. These areas were chosen for searching due to historic information already existing for the majority of the surrounding habitats (Pinder et al. 2002, Alderman 2008, Stantec 2018a, Stantec 2018b), as seen in Figure 2. These studies will be detailed in section 3.0. This study did not examine the Buck or Byllesby impoundment pools due to the recent studies done during drawdown activities (Stantec 2018a & 2018b).

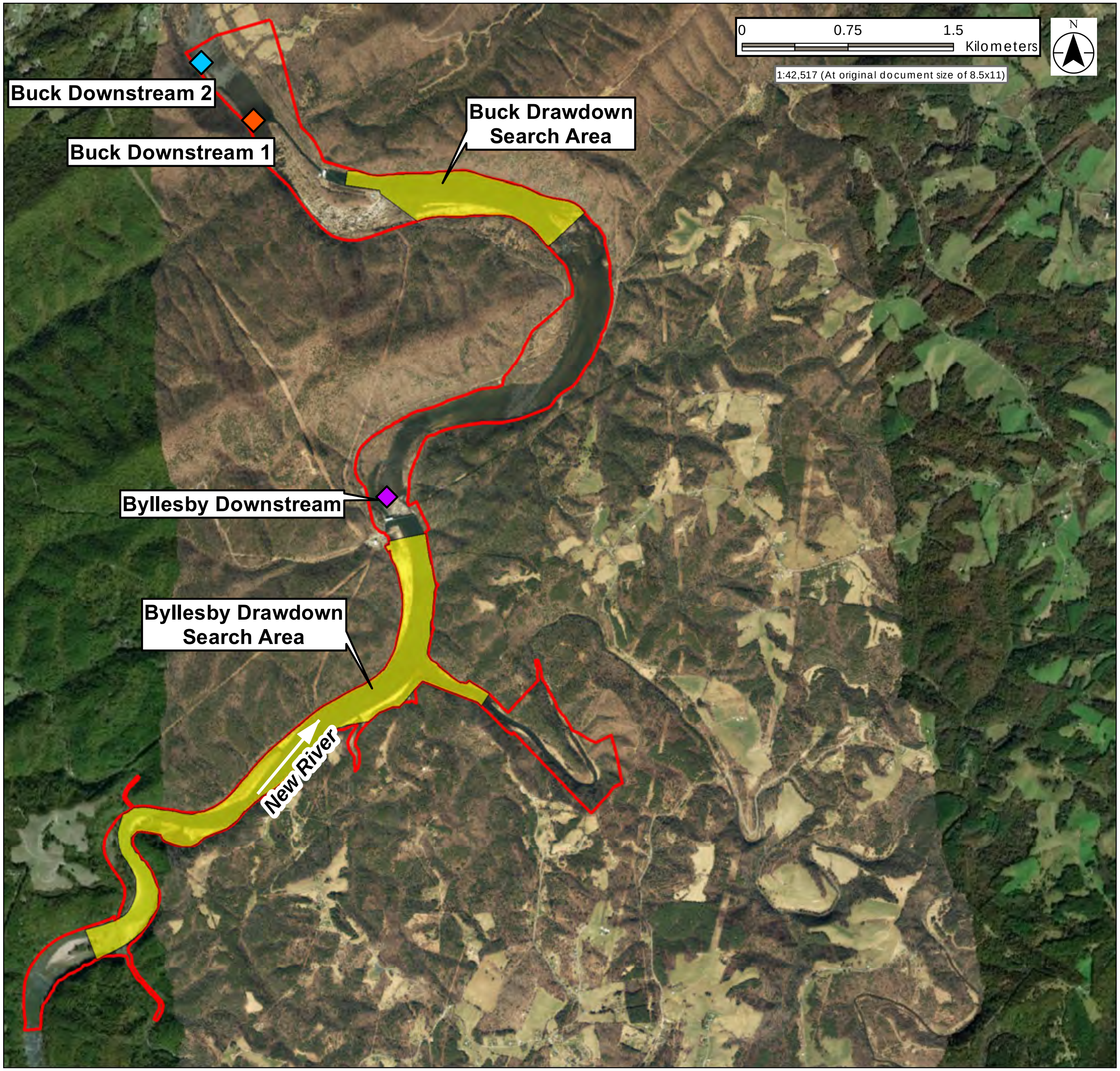
2.1.1 Agency Correspondence

A study plan outlining the proposed survey methodologies was submitted to Virginia Department of Wildlife Resources (VDWR) on September 8, 2020, with approval received from Mr. Brian Watson on September 21, 2020. Documentation of this approval can be found in Appendix A. Field surveys were led by Dan Symonds under Stantec's Scientific Collecting Permit (#605183) and Threatened and Endangered Species Permit (#067427) (Appendix B).

2.1.2 Unimpounded Reach Between Byllesby Dam and Buck Pool

Prior to field work, a desktop evaluation of hydraulic habitat types identified ten distinct habitats within the Project area. A boat-based habitat survey was performed to visually identify specific survey areas within the ten potential mussel habitats of varying hydraulic habitat types. The areas chosen for the wandering timed searches consisted of two shallow shoals, three deep shoals, three pools, and two side channels (Figure 3).

Qualitative surveys were conducted in the chosen survey areas when conditions were appropriate for detecting mussels as well as safe for divers to complete their work. Surveyors used SCUBA, surface supplied air diving, and snorkeling to conduct 200-minute wandering searches of the substrates in each area. Searching tactics included moving cobble and woody debris, hand sweeping away silt, sand, and/or small detritus, and disturbing/probing the upper five centimeters (two inches) of substrate where possible. Mussels were collected in mesh bags and brought to shore for identification and data collection. After data processing, mussels were hand placed on top of the substrate in the general area where they were found. Total search time was 33.3 hours. Turbidities rose higher than 21.6 NTU on the third day of surveying, inhibiting the visual searching techniques for the divers. Completion of the survey was postponed until October 21, 2020 when river conditions had improved. Photographs were taken of representative species (Appendix C).



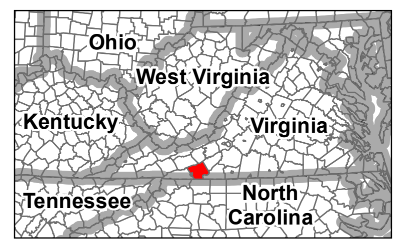
Legend

Study Area Boundary

Historical Survey Locations

- Stantec 2016, 2017, Alderman 2008, Pinder et al. 2002
- Stantec 2016, Alderman 2008
- Pinder et al. 2002
- Stantec 2018a, 2018b

Notes
1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Base Imagery: ESRI Map Services.



Project Location
Carroll County, Virginia
New River

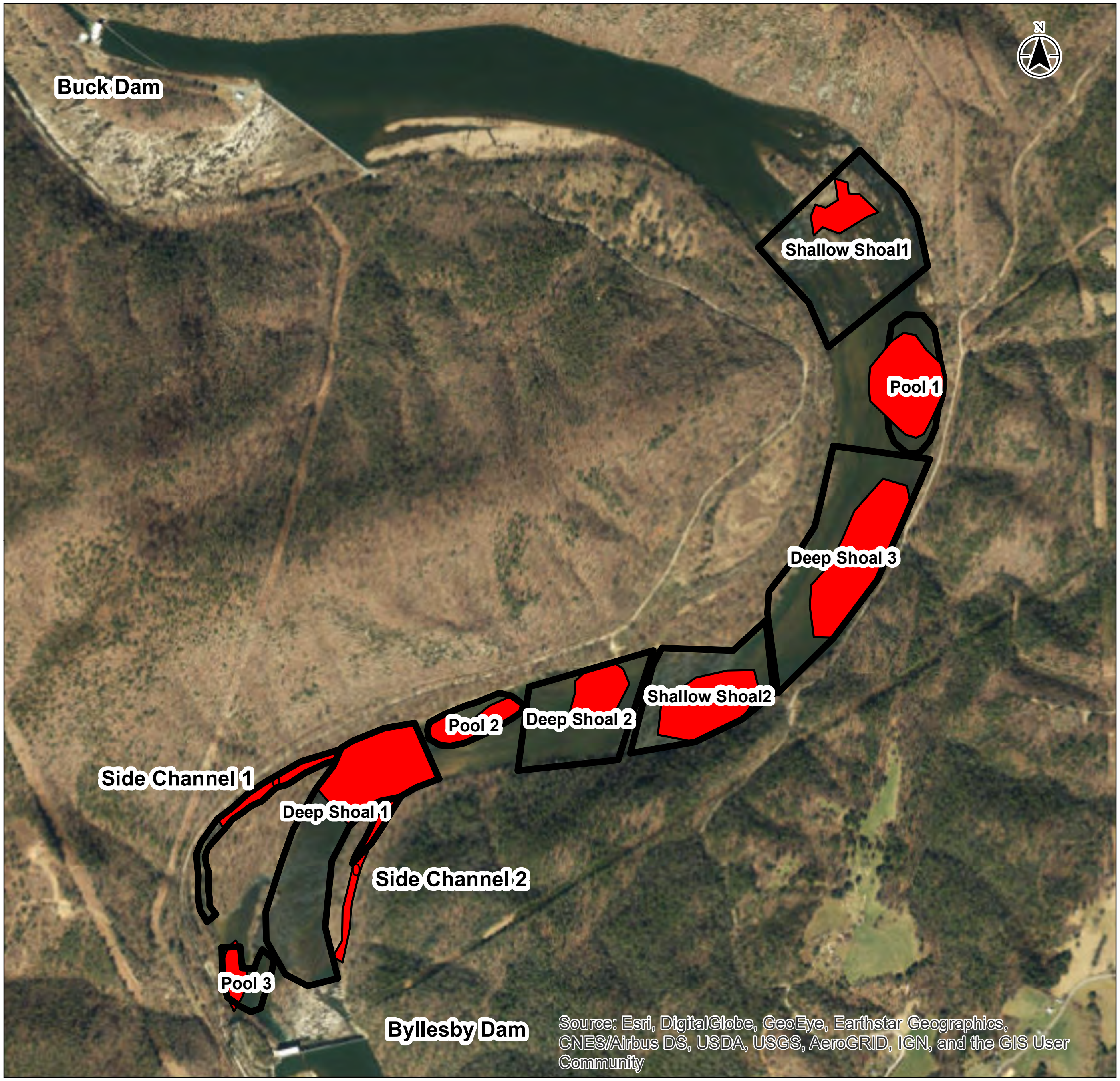
Prepared by EKD on 2020-11-24

Client/Project
Byllesby & Buck Hydroelectric Project
(FERC No. 2514)

Figure No.
2

Title
Historical Survey Locations

U:\1734\173430067_Buck_Byllesby_Mussel\03_Data\GIS\PDF\Byllesby_buck_Fig2.mxd Revised: 2020-12-01 By: edilbone



Stantec

Legend

- Survey Areas
- Hydraulic Habitat Units

0 720 1,440 Feet

1:14,557 (At original document size of 8.5x11)

Notes
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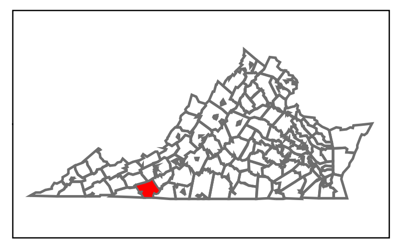
2. Base features: layer sources
3. Base Imagery: ESRI Map Services.



Project Location
Carroll County, Virginia

Prepared by DES on 2020-11-12

Client/Project
American Electric Power

Figure No.
1

Title
Buck/Byllesby Dam Mussel Survey Areas

C:\Users\dsymonds\Documents\2020 Surveys\Byllesby-Buck_HDR_Mussels\GIS\Survey_Areas.mxd Revised: 2020-11-12 By: dsymonds

2.1.3 Buck Dam Tailrace

A reconnaissance level habitat assessment of the Buck Dam tailrace was conducted. Surveyors walked approximately 500m along the stream bank adjacent to the tailrace channel to the point where it converges with the bypass channel (Figure 4). Visual searches were conducted of the exposed riverbanks to discern any spent valves or evidence of suitable mussel habitat. The high velocities and unknown depths in the narrow channel were not conducive for safe in-water surveys such as wading, SCUBA, or snorkeling.

2.2 RESULTS

2.2.1 Site Conditions

Surveys were conducted September 24-26, 2020 and October 21, 2020. Water quality data in the New River was recorded daily at the survey site (Table 1). Visibility was approximately 3-5 ft prior to higher turbidity observed on September 26. A midchannel turbidity reading on the 26th read 50 NTU's and surveys were discontinued. Water quality metrics were generally indicative of a site suitable for mussel occupancy. Discharge was higher than that of the seasonal daily median and varied between 1200 CFS and 1400 CFS (Figure 5).

Table 1. Water Quality

Date	Temperature (C°)	Turbidity (NTU)	pH	Conductivity (µS)	DO (% Sat)	DO (mg/L)
24-Sep	16.8	7.62	8.25	62	97.5	9.70
25-Sep	16.2	8.67	8.31	62	98.7	9.64
26-Sep	15.4	21.60	8.24	61	97.5	9.80
21-Oct	12.9	4.91	8.70	62	105.0	11.03

Stantec

Legend

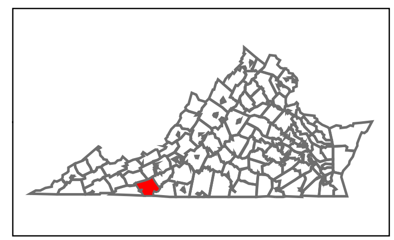
Tailrace

0 320 640 Feet

1:6,489 (At original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Base features: layer sources

3. Base Imagery: ESRI Map Services.



Project Location
Carroll County, Virginia

Prepared by DES on 2020-11-12

Client/Project
American Electric Power

Figure No.
2

Title
Buck Tailrace Survey Area

C:\Users\dsymonds\Documents\2020 Surveys\Byllesby-Buck_HDR_Mussels\GIS\Tailrace.mxd Revised: 2020-11-19 By: dsymonds

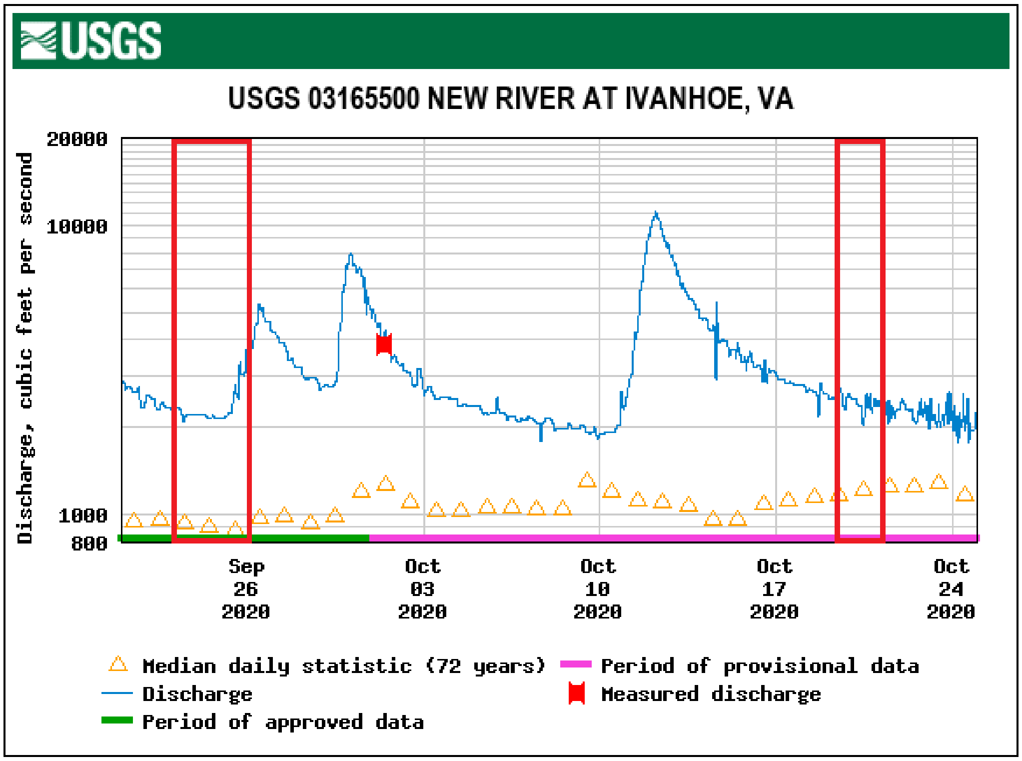


Figure 5. Discharge during time of site survey

Substrates in shallow shoals and deep shoals were predominantly bedrock and bedrock with silt on top. Bedrock and cobble were the dominant substrates in Pool 1, while Pool 2 and 3 were comprised primarily of sand. Substrates in the side channels were most suitable for mussel occupation with dominant substrates being gravel and cobble. Depths varied depending on the hydraulic habitat type with shallow shoals between 1 and 5 ft, deep shoals between 2 and 5 ft, and pools between 3 and 7ft with Pool 3 reaching a maximum depth of 24 ft (Table 2).

Table 2. Individual Site Characteristics

Survey Area	Effort (minutes)	Average Depth (feet)	Max Depth (feet)	Dominant Substrate
Shallow Shoal 1	200	1	3	Bedrock
Shallow Shoal 2	200	3	5	Bedrock
Pool 1	200	3	7	Bedrock/Cobble
Pool 2	200	5	7	Sand
Pool 3	200	10	24	Sand
Deep Shoal 1	200	2	4	Bedrock
Deep Shoal 2	200	3	4	Silt
Deep Shoal 3	200	3	5	Bedrock
Side Channel 1	200	1	2	Gravel
Side Channel 2	200	1	2	Cobble

2.2.2 Mussel Distribution and Abundance in Unimpounded Reach

Nine total live mussels were found all identified as *Cyclonaias tuberculata* (Purple Wartyback). The smallest of these was 48 mm and the largest was 95 mm in length. The mean length of live *Cyclonaias tuberculata* was 80 mm. One spent *Eurynia dilatata* (Spike) valve was found in weathered condition (Table 3).

Table 3. Mussels Found in Survey Area

Area	Species	Length (mm)	Condition
Shallow Shoal 1	*C. tuberculata*	48	Live
Shallow Shoal 1	*C. tuberculata*	87	Live
Shallow Shoal 1	*C. tuberculata*	-	Weathered
Deep Shoal 2	*C. tuberculata*	85	Live
Deep Shoal 2	*C. tuberculata*	84	Live
Deep Shoal 2	*C. tuberculata*	95	Live
Deep Shoal 2	*C. tuberculata*	85	Live
Deep Shoal 2	*C. tuberculata*	78	Live
Deep Shoal 2	*C. tuberculata*	91	Live
Deep Shoal 2	*C. tuberculata*	64	Live
Pool 1	*E. dilatata*	-	Weathered

2.2.3 Tailrace Findings

No evidence of freshwater mussels was found in the tailrace of Buck Dam. The exposed areas of the riverbanks were devoid of any spent valves. The velocity was high throughout the channel and visually estimated to be above 3.0 feet per second. Surveyors could not see or safely probe the bottom of the channel to gain information about substrate.

2.3 DISCUSSION

Overall mussel abundance and richness were low in the Project area. While the New River is not known as a productive mussel river, some reaches do support higher densities than observed in this study (See Section 3.0). 0.27 mussels per search hour is low relative to other freshwater mussel survey results, even within the New River Basin (See 3.2.6).

Most of the substrate was bedrock or a thin layer of sediment on top of bedrock. Impermeable bedrock can be inhabitable for burrowing invertebrates like freshwater mussels (Haag 2012). The West side channel contained the best substrate (Gravel/Cobble/Sand mixture). Combined with steady flow through a riffle/run complex, this was thought to be the best potential area for mussels. However, benthic macrofauna, unionid and non-unionid alike, were not encountered. While lack of quality habitat through the other survey areas is most likely dictating the lack of mussels, the absence in the side channel remains unexplained.

Similar findings were encountered during earlier studies by Stantec. In 2018 Stantec performed a mussel rescue during the Byllesby Dam drawdown necessary for scheduled repairs. This survey only collected 4 live mussels (3 *Cyclonaias tuberculata*, and 1 *Lasmigona subviridis* [Green floater]), and 20 spent valves (14 *Cyclonaias tuberculata*, 1 *Eurynia dilatata*, and 5 *Lasmigona subviridis*). That same year Stantec performed a mussel rescue during the Buck Dam drawdown necessary for scheduled repairs. This survey collected 2 live mussels (*Lampsilis fasciola* [Wavyrayed Lampmussel]) and 3 spent valves (2 *Lampsilis fasciola* and 1 *Cyclonaias tuberculata*).

The catch per unit of effort (CPUE) of the two 2018 studies and the current study were of similar low magnitude. The Byllesby Dam drawdown had 0.13 CPUE, the Buck Dam draw down had 0.15 CPUE, and this survey had 0.27 CPUE.

2.4 CONCLUSIONS

A total of nine live mussels were found during 33.3 diver-hours of surveying, representing one live species and one additional species solely by shell specimen. The total CPUE for this project was 0.27 mussels/hour. The mussels found did not represent any state or federal listed species. Overall, the Project area contains low numbers of mussels and shell specimens, which may be due to the overall lack of quality habitat through the riverine reach. The current results are consistent with results from recent survey efforts within the project area.

3.0 LITERATURE REVIEW

A literature review of available information regarding the freshwater mussel community in the Project area was performed to compile a baseline understanding of mussel resources within the Project area. All relevant and readily available studies regarding the mussel community in the Project vicinity were reviewed. This was combined with surveys conducted in 2020 to provide a complete picture of the status of freshwater mussel resources and their trends through time and across the Project area.

3.1 METHODS

For each study, survey methods, species composition, mussel abundance and density, and specimen length data (if available) was noted. CPUE was calculated as the number of mussels found per person-hour of searching using transect and timed search data. Mussel density was calculated for quantitative surveys as the number of mussels per m^2 of search area.

Survey methods, durations, and reported metrics differed substantially between studies (Table 4). However, qualitative comparison of reported data between survey sites and years allowed for assessment of potential spatial and temporal trends in species composition and abundance. Mussel locations relative to field-identified habitat types were also reviewed to help characterize the quality of mussel habitat within the Project area.

Table 4. Summary of Survey Methods

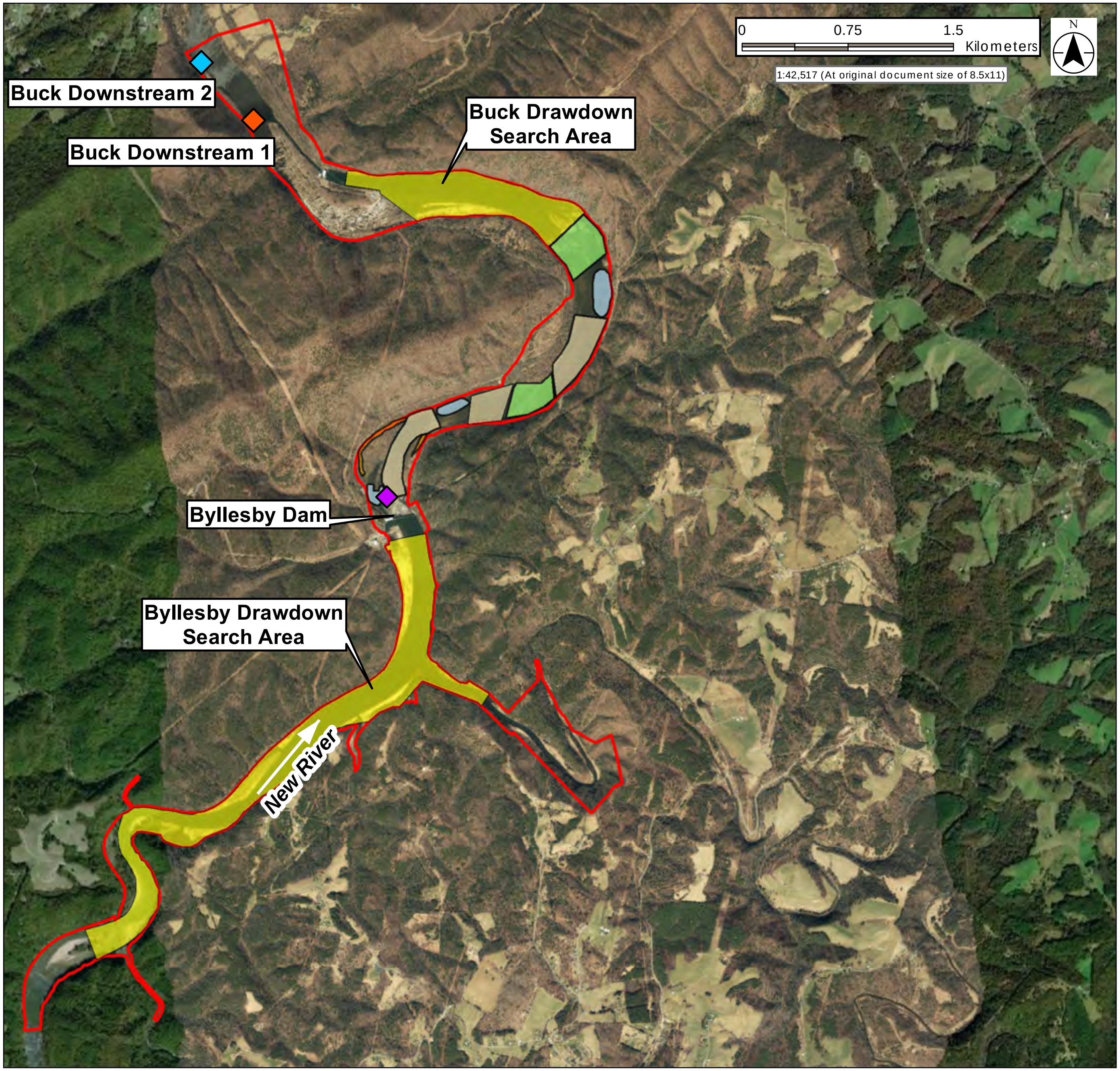
Study	Location	Methods	Site Search Time (Hours)	Total Search Time (hours)
Pinder et al. 2002	Buck 2 Bellow Byllesby	Wandering search - snorkel and/or viewscopes	1 - 4	5
Alderman 2008	Buck 2 Buck 1	Wandering search – snorkel, SCUBA and/or viewscopes	3.25 - 6	9.25
Stantec 2016	Buck 2 Buck 1	Transects – snorkel SCUBA Quadrat excavation	6.7	13.4
Stantec 2017	Buck 2	Transects – snorkel SCUBA Quadrat excavation	6.7	6.7
Stantec 2018a	Byllesby Drawdown Area	Wandering search – walking dewatered substrates	-	27.2
Stantec 2018b	Buck Drawdown Area	Wandering search – walking dewatered substrates	-	15.5
Stantec 2020	Un-impounded Reach	Wandering search – snorkel SCUBA	3.3	33.3

3.2 RESULTS

The following sections provide a summary of findings from freshwater mussel surveys identified by the RSP and Byllesby-Buck PAD as being located within the Project study area and relevant to Project operations (HDR 2019, Appalachian Power Company 2019). The GPS coordinates of each survey site assessed in this report are listed in Table 5. Survey site locations and their associated study are presented in Figure 6.

Table 5. Location of Historical Mussel Survey Sites

Site Name	Location
Buck Downstream 1	36.811950, -80.944339
Buck Downstream 2	36.815411, -80.948300
Buck Drawdown Area	0 - 2,700 m upstream of Buck Dam
Below Byllesby Dam	36.7875316, -80.934210
Byllesby Drawdown Area	0 - 5,000 m upstream of Byllesby Dam



Stantec

Legend

Study Area Boundary

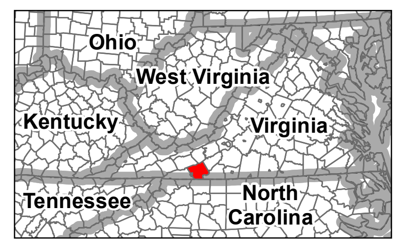
Historical Survey Locations

- Stantec 2016, 2017, Alderman 2008, Pinder et al. 2002
- Stantec 2016, Alderman 2008
- Pinder et al. 2002
- Stantec 2018a, 2018b

2020 Survey Locations

- Shallow Shoal
- Deep Shoal
- Pool
- Side Channel

Notes
1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Base Imagery: ESRI Map Services.



Project Location
Carroll County, Virginia
New River

Prepared by EKD on 2020-11-24

Client/Project
Byllesby & Buck Hydroelectric Project
(FERC No. 2514)

Figure No.
2

Title
Historical Survey Sites

3.2.1 Historical Studies

3.2.1.1 Pinder et al. 2002

Pinder et al. (2002) conducted a drainage wide survey of the New River to assess the status and distribution of freshwater mussels within the basin. Mussel surveys were conducted between 1997 and 1998 at 134 sites (Note the report was written in 2002 and is cited accordingly within), including mainstem and tributaries within the basin. Surveys were conducted using timed searches and snorkel or viewscope methods. Two of the 134 sites were located within the Project area; Site 20 corresponds with Buck Downstream 2 and Site 25 is directly below Byllesby Dam (Figure 6). Search effort was four person-hours at Buck Downstream 2 and one person-hour below Byllesby Dam. Table 6 presents a count of live mussels by species found for each survey site within the Project area. A total of 26 live mussels from four species were found between both sites. The two most widely distributed species both within the New River basin and Project area were *Cyclonaias tuberculata* and *Eurynia dilatata* (Table 6). Pinder et al. (2002) did not report mussel lengths.

Table 6. Live Mussels by Species Found by Pinder et al. (2002) Within the Project area

Species	Buck Downstream 2	Below Byllesby
Cyclonaias tuberculata	15	1
Eurynia dilatata	6	-
Lampsilis ovata	2	-
Tritogonia verrucosa	2	-
Total	25	1

3.2.1.2 Alderman 2008

Alderman (2008) conducted mussel surveys within the New River between 2007 and 2008 in support of the FERC relicensing of the Claytor Hydroelectric Project (FERC No. 739). Sites 20080724.1 and 20080724.2 were located within the Project area directly downstream of Buck Dam (corresponding to Buck Downstream 1 and Buck Downstream 2 in Figure 6). Surveys at these sites were conducted on July 24, 2008 and consisted of timed searches. Search effort was six person-hours at Buck Downstream 1 and 3.25 person-hours for Buck Downstream 2.

The number of mussels by species found at Buck Downstream 1 and 2 is presented in Table 7. A total of 275 mussels from four species were found between both survey sites. Abundance at Buck Downstream 2 (n = 180, CPUE = 55.4) was almost double that of Buck Downstream 1 (n = 95, CPUE = 15.8) and almost four times greater CPUE. *Cyclonaias tuberculata* (n = 134) and *Tritogonia verrucosa* (Pistolgrip, n = 125) were the most abundant species (Table 7). Alderman (2008) noted that most of the *Tritogonia verrucosa* at Buck Downstream 2 were found along the island near the upstream limit of the survey area. The study did not report size data for mussels at sites within the Project area but did state that only relatively mature specimens of each species were found as evidenced by the lack of observed smaller individuals (e.g. < 40 mm) (Alderman 2008).

Table 7. Live Mussels by Species Found by Alderman (2008) Within the Project area

Species	Buck Downstream 1	Buck Downstream 2
Cyclonaias tuberculata	11	123
Eurynia dilatata	1	6
Lampsilis ovata	4	5
Tritogonia verrucosa	79	46
Total	95	180

3.2.2 Stantec 2015 and 2017 Surveys

During the fall of 2015 and 2017, Stantec conducted mussel surveys at seven sites in the New River for aquatic studies related to the Claytor Hydroelectric Project (Stantec 2016, 2017). Two of the sites surveyed for these studies were within the Byllesby-Buck Project area, corresponding to sites Buck Downstream 1 and 2 (Figure 6).

3.2.2.1 Stantec 2016

During October 2015, Stantec (2016) surveyed Buck Downstream 1 and 2 using a two-staged approach to focus on higher quality habitats. During Stage 1, ten 40-meter-long transects were divided into 10 m segments and surveyed at a rate of 1 minute per meter (m). Total search effort at each site was a minimum of 6.7 person-hours. Stage 2 sampling consisted of quantitative surveys targeting the best mussel habitat identified during Stage 1. Quadrat samples were excavated near the four transect segments with the highest mussel densities during Stage 1, resulting in a total quantitative survey area of 25 m^2 for each site (Stantec 2016).

Table 8 presents the total number of live mussels found by species during Stage 1 and 2 surveys of Buck Downstream 1 and 2 during October 2015. A total of 65 live mussels from three species were found downstream of Buck Dam. No additional species were found that differed from those found by Pinder et al. (2002) and Alderman (2008). As was the case for Alderman (2008), abundance was greater at Buck Downstream 2 (n = 52) than Buck Downstream 1 (n = 13). *Cyclonaias tuberculata* (n = 40) and *Tritogonia verrucosa* (n=24) were the most abundant species, with only one *Eurynia dilatata* specimen found (Table 8).

Table 8. Mussels Found at Buck Downstream 1 and 2 by Stantec (2016)

Species	Buck Downstream 1	Buck Downstream 2	Total
Cyclonaias tuberculata	1	39	40
Eurynia dilatata	1	-	1
Tritogonia verrucosa	11	13	24
Total	13	52	65

3.2.2.2 Stantec 2017

During September 2016, Stantec (2017) conducted additional mussel surveys at Buck Downstream 2 (Buck Downstream 1 was discontinued as a survey site after 2015 surveys). Survey methods followed the same two-staged approach used by Stantec (2017). A total of 82 mussels were found during transect and quadrat surveys, consisting of 49 *Cyclonaias tuberculata*, three *Eurynia dilatata*, and 30 *Tritogonia verrucosa*.

3.2.3 Impoundment Drawdowns

3.2.3.1 Byllesby Drawdown 2018

Mussel salvage and relocation was conducted within the Byllesby Dam impoundment from April 30 – May 1, 2018 during a planned reservoir drawdown for installation of Obermeyer crest gates. The dam pool was lowered approximately nine feet over a 48-hour (hr) period. Stantec (2018a) relocated freshwater mussels stranded on habitat exposed by the impoundment drawdown to outside the disturbance limits. The total search effort was 27.2 person-hours and covered approximately 5,000 linear meters of stream, focusing on exposed channel margins and islands towards the upstream end of the dam pool (Figure 6). Four live mussels were collected, consisting of three *Cyclonaias tuberculata* and one *Lasmigona subviridis*. *Lasmigona subviridis* is listed as threatened in the state of Virginia (VDWR 2020) and was a new finding within the Project area. All collected mussels, both shells and living, were observed at the upstream end of the impoundment, above the New River Trail foot bridge. Higher quality mussel habitat (e.g. sand, gravel, and cobble) was observed more frequently along the upstream end of the search area and silt deposits were common closer to the dam (Stantec 2018a).

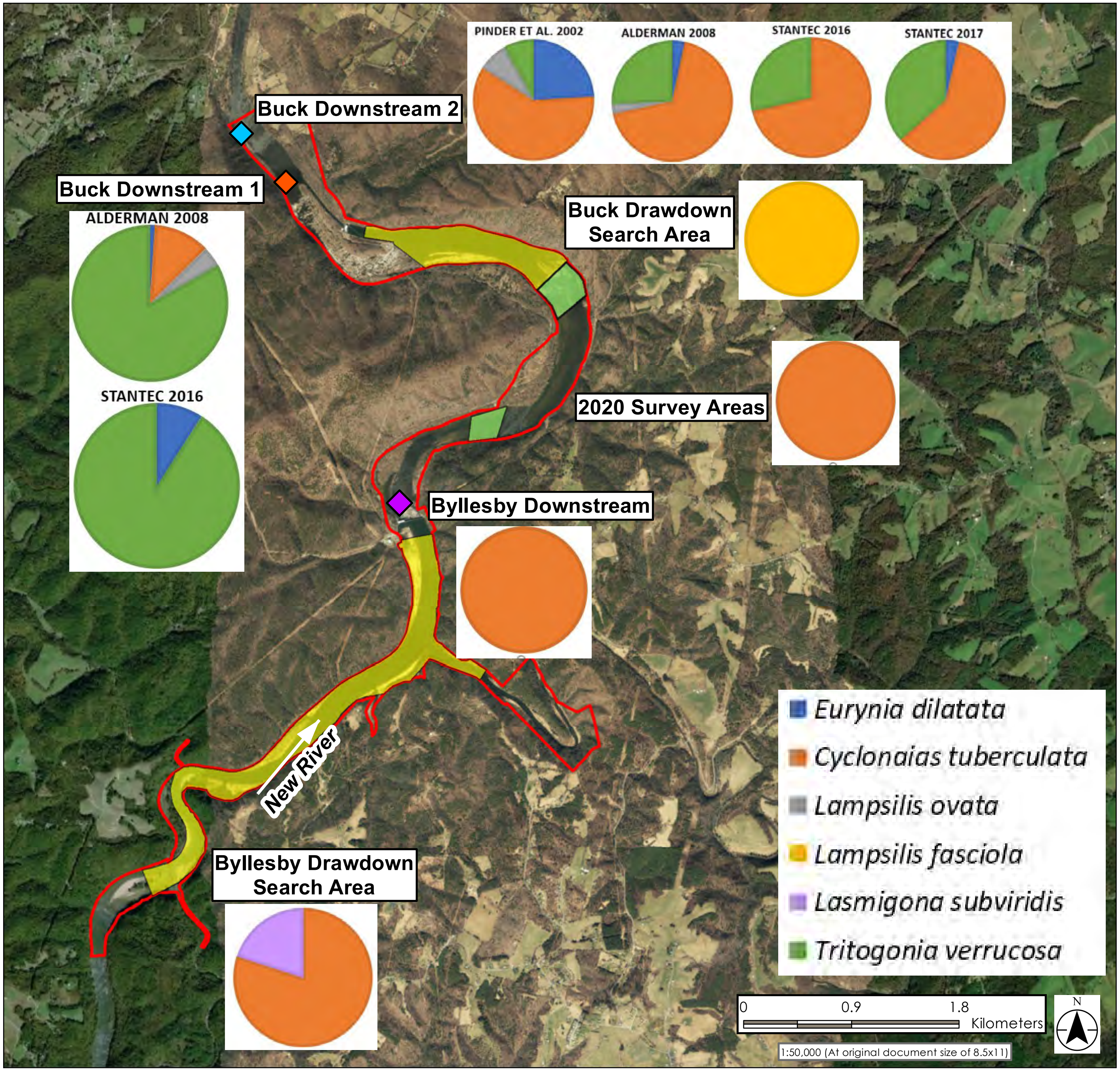
3.2.3.2 Buck Drawdown 2018

Between July 10 and July 11, 2018, Stantec (2018b) conducted a mussel salvage and relocation during a drawdown at the Buck Dam impoundment performed for installation of Obermeyer crest gates. The dam pool was lowered approximately nine feet over a 24-hr period. The search effort focused on potential mussel habitat along channel margins and islands above Buck Dam (Figure 6). The total search effort was 15.5 person-hours, covering approximately 2,700 linear meters of streambank upstream of Buck Dam. Two live mussels, both *Lampsilis fasciola*, were collected and relocated outside the dewatered area. Both specimens were found along the mid-channel island near the upstream limits of the impoundment. This area is slightly downstream of Shallow Shoal 1 from the Stantec 2020 survey (Section 2.0). The island contained pockets of flow refugia and gravel substrate which offered more suitable mussel habitat than the silt deposits that were dominate downstream of the island. *Cyclonaias tuberculata* was also found as a shell only (Stantec 2018b).

3.2.4 Mussel Abundance and Species Composition

A total of 452 live mussels from six species were found during mussel surveys within the Project area between 1997 and 2020 (Pinder et al. 2002, Alderman 2008, Stantec 2016, Stantec 2017, Stantec 2018a, Stantec 2018b, and Stantec 2020). The most widespread species across all survey years were *Cyclonaias tuberculata* (n = 242) and *Tritogonia verrucosa* (n = 179). These two species accounted for 421 of the 452 mussels found within the Project area. *Lampsilis ovata* (Pocketbook) was found in small numbers downstream of the Buck Dam during 1997 and 2008 surveys but was not found during more recent surveys between 2015 and 2020 (Pinder et al. 2002, Alderman 2008). The only *Lasmigona subviridis* found within the Project area was encountered along an island at the upstream limits of the Byllesby impoundment (Stantec 2018a). Likewise, *Lampsilis fasciola* was only found near an island upstream of Buck Dam (Stantec 2018b, Figure 7).

Overall, species richness and abundance were greater at sites downstream of Buck Dam than elsewhere in the Project area. Mussel densities within the dam impoundments were some of the lowest observed within the Project area. Mussel observations during drawdown surveys were limited to coarser habitats found along upstream islands. No federally listed threatened or endangered species were found within the Project area. *Tritogonia verrucosa* and *Lasmigona subviridis* are listed as threatened in Virginia (VDWR 2020).



Stantec

Legend

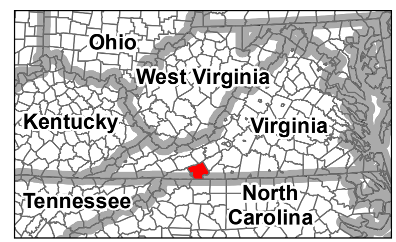
Study Area Boundary

Historical Survey Locations

- Stantec 2016, 2017, Alderman 2008, Pinder et al. 2002
- Stantec 2016, Alderman 2008
- Pinder et al. 2002
- Stantec 2018a, 2018b
- 2020 Survey Areas

Notes

1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Base Imagery: ESRI Map Services.



Project Location
Carroll County, Virginia
New River

Prepared by EKD on 2020-11-24

Client/Project
Byllesby & Buck Hydroelectric Project
(FERC No. 2514)

Figure No.
7

Title
Species Compostion by Survey Site

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3.2.5 Mussel Lengths

Figures 8 and 9 show the distribution of mussel lengths for the two most abundant species within the Project area (*Cyclonaias tuberculata* and *Tritogonia verrucosa*) found during surveys at Buck Downstream 1 and 2 (Stantec 2016, 2017, and 2020). Pinder et al. (2002) and Alderman (2008) did not report mussel sizes, so data from these studies were not included in this length assessment. Both *Cyclonaias tuberculata* and *Tritogonia verrucosa* were collected across a wide range of size classes during 2015, 2017, and 2020 field surveys. Although the size distribution of *Cyclonaias tuberculata* is skewed towards larger individuals, the presence of smaller or younger individuals suggests recent recruitment has occurred downstream of Buck Dam (Figure 8). The three *Cyclonaias tuberculata* collected during the Byllesby drawdown were also a range of sizes (34 – 71 mm), further confirming the presence of a reproducing mussel population within the Project area (Stantec 2018a).

The four *Eurynia dilatata* specimens collected during 2015 and 2017 surveys were all larger individuals (85 – 95 mm) (Stantec 2016, 2017). The small sample size of *Lasmigona subviridis* (n = 1) and *Lampsilis fasciola* (n = 2) precluded a viable assessment of mussel size distribution and recruitment for these species within the Project area. The lone *L. subviridis* appeared to be approximately 8 years old based on growth rings, which would suggest recruitment in 2010. *Lampsilis ovata* was only found live during earlier studies that did not report length data (Pinder et al. 2002 and Alderman 2008).

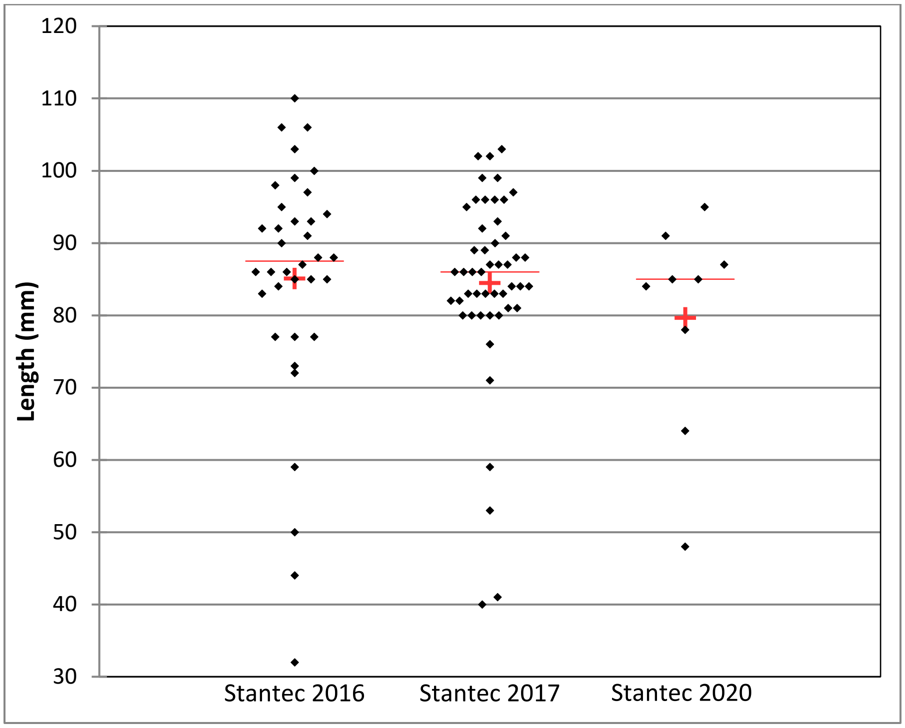

Figure 8. Shell lengths of *Cyclonaias tuberculata* Found Downstream of Buck Dam by Stantec (2016, 2017, 2020)

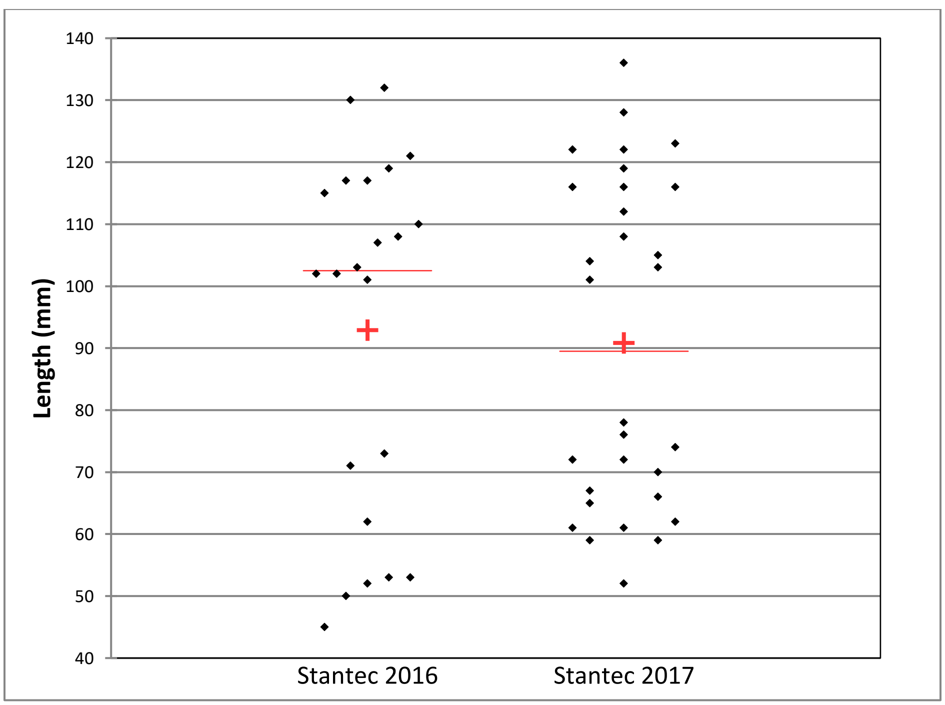

Figure 9. Shell lengths of *Tritogonia verrucosa* Found Downstream of Buck Dam by Stantec (2016, 2017)

3.2.6 Community Metrics

Table 9 presents a summary of mussel community metrics, including richness, abundance, Catch per Unit Effort (CPUE), and mussel density, for all studies assessed within the Project area. While direct comparison of mussel abundance and density between studies is difficult due to different survey methods, general observations about the quality of mussel habitat and composition of the mussel community can still be made.

Overall species richness within the Project area is low, with a maximum of four species found during any one survey. Richness was slightly higher for Pinder et al. 2002 and Alderman 2008 surveys than more recent surveys downstream of Buck Dam in 2015 and 2017 (Table 9). Abundance and CPUE was generally higher for survey sites directly downstream of Buck Dam, with the greatest abundance observed for Alderman (2008) (n = 275). For surveys within the dam pools (Stantec 2018a, 2018b), richness was limited to one or two species and CPUE was < 1.0 mussels/hr.

Table 9. Comparison of Mussel Community Metrics for Surveys within the Project area by Study Year Between 1997-2020

	Pinder et al. 2002	Alderman 2008	Stantec 2016	Stantec 2017	Stantec 2018a	Stantec 2018b	Stantec 2020
Species Richness	4	4	3	3	2	1	1
Abundance	26	275	53	82	5	1	9
Search effort (hours)	5	9.25	6.7	6.7	27.2	15.5	33.3
CPUE	5.2	29.7	3.9	11.0	0.18	0.13	0.27
Density (mussels/m^2)	-	-	0.24	0.32	-	-	-

Repeat surveys at Buck Downstream 1 and 2 allowed for assessment of potential temporal changes in the mussel community between survey dates. Table 10 compares species richness, CPUE, and mussel density for 2008 and 2015 surveys of Buck Downstream 1. While abundance was low for both survey years, both CPUE and richness were slightly higher in 2008 than 2015 (Table 10).

Table 10. Comparison of Mussel Community Metrics at Buck Downstream 1

Metric	Alderman 2008	Stantec 2016
Richness	4	2
CPUE	6.0	1.6
Density (mussels/m^2)	-	0.10

Buck Downstream 2 was surveyed during four different studies between 1997 and 2017. Table 11 compares richness, CPUE, and mussel density observed at Buck Downstream 2 for all four studies. CPUE ranged from 4.0 to 55 mussels per hour of searching among all survey dates. Species were limited for all survey years, with no more than four species observed during each survey (Table 11).

Table 11. Comparison of Mussel Community Metrics at Buck Downstream 2

Metric	Pinder et al. 2002	Alderman 2008	Stantec 2016	Stantec 2017
Richness	4	4	2	3
CPUE	4.0	55	6.3	11
Density (mussels/m^2)	-	-	0.4	0.32

Examining CPUE from downstream to upstream shows that the most mussels were found downstream of Buck Dam (Figure 10). Despite differences between the four surveys (some of which is due to different methods), the Buck Downstream 2 site has the greatest CPUE through time. Upstream of the Buck Dam and continuing to upstream of the Byllesby Dam shows low CPUE's throughout the Project area. Note that for display purposes this figure ignores the Buck Tailrace and eight hydraulic units that contained zero mussels.

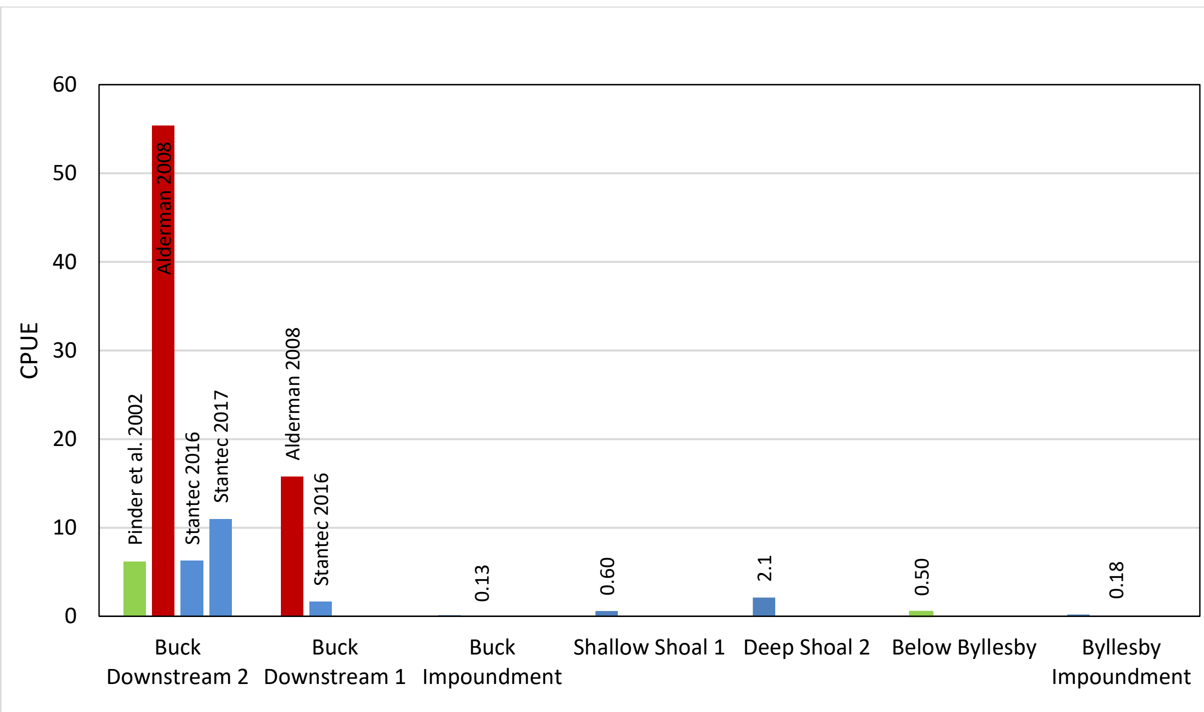

Figure 10. CPUE Across all Survey Sites from Downstream to Upstream.

Distinct differences in CPUE from downstream to upstream is further illustrated by averaging the CPUE's across all surveys (Figure 11). Downstream of Buck Dam is where mussel communities really become abundant enough for higher CPUE's.

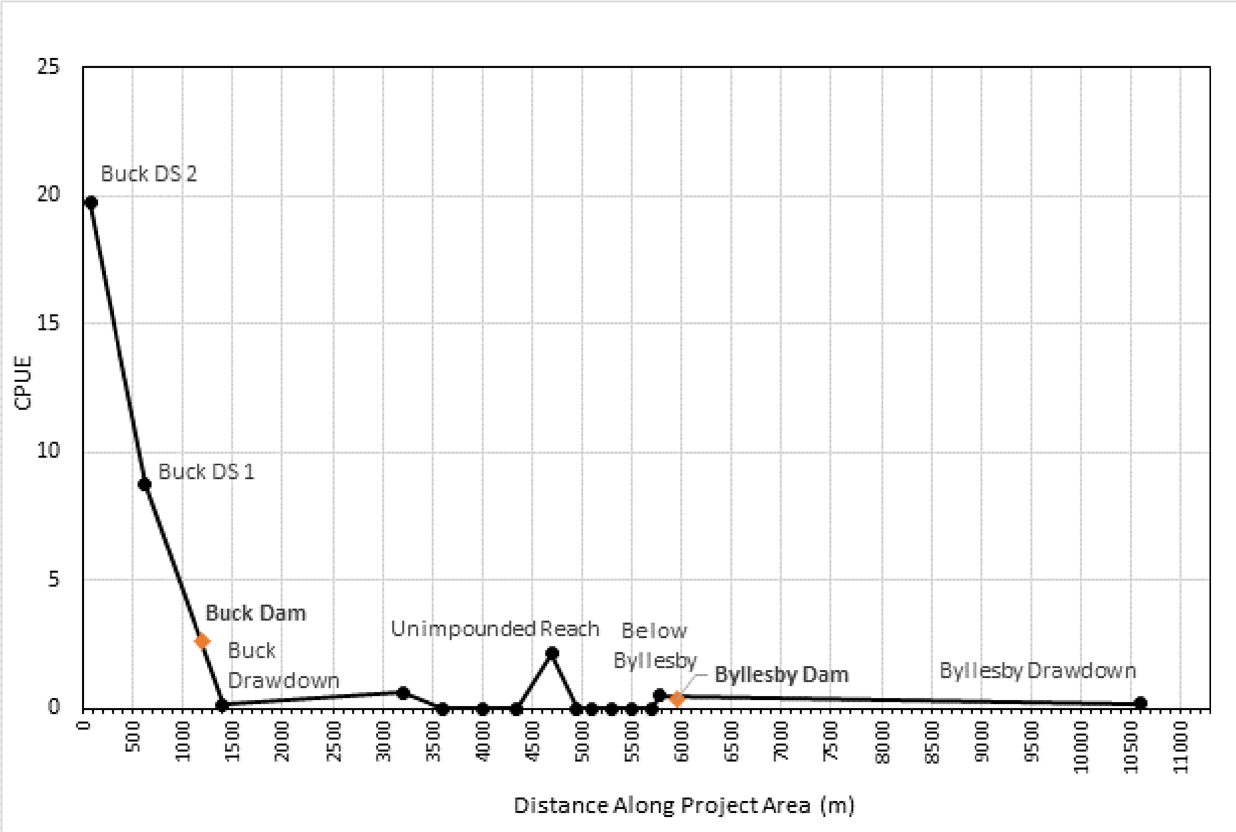

Figure 11. Average CPUE by Site from Downstream to Upstream Through the Project Area.

Four sampling periods at Buck Downstream 2 allows for temporal comparisons unavailable at other specific sites (Figure 12). CPUE's were similar between 1997 (4), 2015 (6.3), and 2017 (11) surveys, with the 2008 Alderman study being the outlier (55.4). Species richness varied between two and four species but may be tied to overall survey effort.

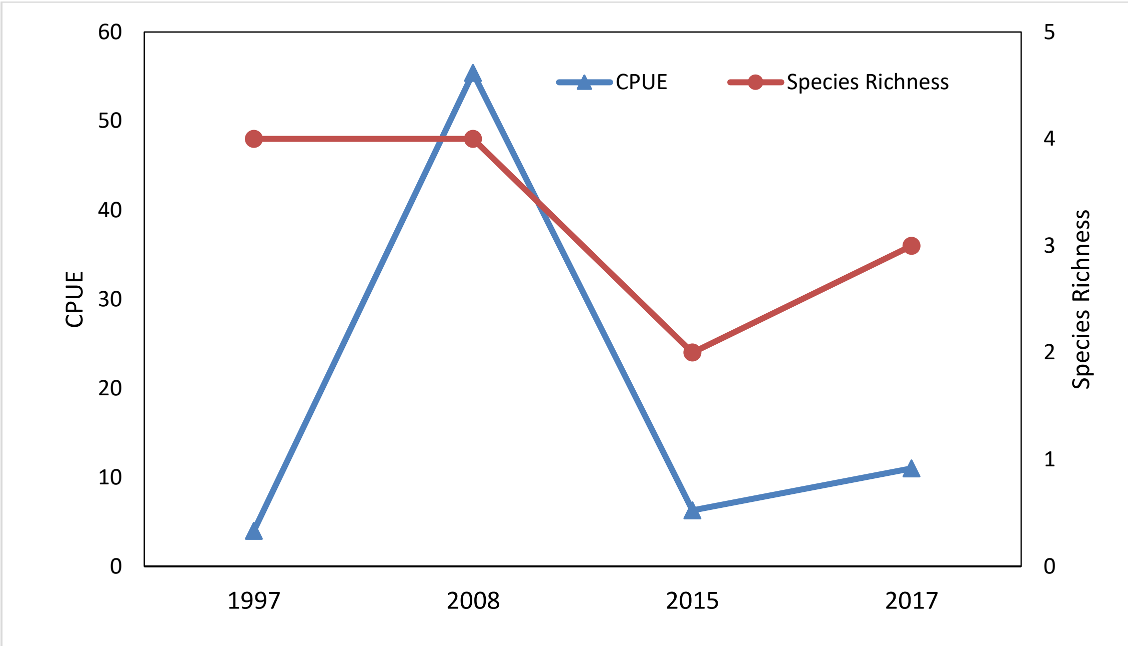

Figure 12. CPUE and Species Richness at Buck Downstream 2 (1997 – 2017)

3.3 DISCUSSION

Results of mussel surveys of the New River from 1997 to 2020 demonstrate that overall abundance and density of freshwater mussels within the Project area is low. Species rarity and the low number of collected mussels presents challenges for understanding population dynamics within the Project area. However, a broad assessment of the habitat quality and spatial distribution of aquatic resources within the Project area can still be made. Six species were observed in the Project area, with only *Cyclonaias tuberculata* and *Tritogonia verrucosa* found in large numbers. Quality mussel habitat within the Project area appears to be limited. Coarser substrates (e.g. cobble and boulder) were observed at Buck Downstream 2 where some of the highest densities of mussels were observed. Habitat at Buck Downstream 1 was not as productive as Buck Downstream 2 with large amounts of rubble noted at the site by Stantec (2016).

Some of the lowest observed mussel densities were encountered in the riverine reach between Buck and Byllesby facilities during surveys in 2020. Despite the targeted approach of surveying hydraulic habitat units, CPUE (0.27 mussels/hr) and abundance (n = 9) were still low and consistent with findings of historical studies. Much of the habitat in this reach consisted of silt deposits on top of bedrock. Pockets of more habitable substrate did not correspond to mussel abundance. The side channel near Byllesby Dam contained perceived high quality substrates of gravel/sand/cobble in a riffle/run sequence, however almost no invertebrate life was observed. This potentially could be due to these side channels being intermittent during summer but has not been directly observed by Stantec.

Within the dam impoundments, substrates were predominantly thick deposits of silt with some bedrock outcroppings. While such backwater habitat is often capable of supporting lentic species, such as *Pyganodon grandis* and *Utterbackia imbecillis*, none were observed and overall counts of both live animals and spent shells along the impoundments were low. The only mussels observed in the drawdown studies were found in flow refugia and coarser substrates along islands at the upper limits of the impoundments.

Different survey methods between studies make assessment of temporal trends in abundance and composition of the mussel community difficult. While slightly greater abundances were observed downstream of Buck Dam during earlier studies conducted in 1997 and 2008 than during more recent studies, this may be an artifact of survey methods and not necessarily an indication of mussel population declines. Surveys in 2015 and 2017 downstream of Buck Dam suggest that *Cyclonaias tuberculata* and *Tritogonia verrucosa* are still abundant and reproducing in these locations. *Eurynia dilatata, Lampsilis Fasciola,* and *Lasmigona subviridis* were not found in sufficient abundances to gain insights into population dynamics.

Spatial distribution of mussels appears to be concentrated downstream of Buck Dam (Figures 10 & 11). These figures suggest that the Byllesby-Buck Project may be influencing the mussel communities within the Project area, however the Buck Downstream 2 site is similar to those seen during the 2020 study between Buck and Byllesby Dams.

The decline in CPUE from 2008 to 2015-2017 at Buck Downstream 2 may be due to differences in survey methodologies, as Alderman's timed searches allow for locating and focusing on areas of high mussel concentrations, while Stantec (2016, 2017) used transects at fixed distances where all habitats were sampled regardless of quality. Species Richness was lower in 2015 (2) and 2017 (3) compared to 1997 and 2008 surveys, despite having higher effort than the 1997 survey. Surveys in 1997 (N = 2) and 2008 (N = 5) managed to locate *Lampsilis ovata*, which is uncommon throughout the basin and normally found in low numbers. Shifts in species richness over time may be due to the probability of detecting these rare species rather than shifts in the assemblage or local extirpation.

3.4 CONCLUSIONS

Since 1997, six species have been collected within the Project area: *Cyclonaias tuberculata*, *Eurynia dilatata, Tritogonia verrucosa, Lampsilis fasciola, Lasmigona subviridis,* and *Lampsilis ovata. Cyclonaias tuberculata* and *Tritogonia verrucosa* were observed most frequently within the Project area, particularly downstream of Buck Dam. The range of sizes recorded for these species demonstrates that juvenile recruitment is occurring for these species. Other species were observed in too low of abundances (e.g. < 10) to accurately depict assemblage status. *Lampsilis fasciola* and *Lasmigona subviridis* were the least abundant species and were only found along mid-channel islands upstream of the dams. As was demonstrated by 2020 field efforts and historical studies, quality mussel habitat is limited within the impounded portion of the Project area. Furthermore, areas with suitable habitat did not always support mussel inhabitance. Species composition and abundance were relatively consistent across survey years, with some rarer species not occurring during some surveys. However, low overall abundances throughout the Project area doesn’t mean these species are extirpated. The low number of shells observed within the Project area supports the conclusion that the mussel community has not undergone a significant die-off in recent years and abundances and species have always been low. Spatial trends within the Project area suggest that downstream of Buck Dam is the highest quality mussel community, having relatively high species richness and CPUE. Within the impoundments, reaches between the two dams, and upstream of Byllesby Dam are all seemingly lower quality mussel communities. The appearance of mussel declines at the Buck Downstream 2 site, which has been sampled four times over the past 23 years may simply be due to differences in survey methods, as project operations have not differed in this area during that time frame.

4.0 REFERENCES

Alderman, J. M. (2008). Freshwater Mussel and Crayfish Surveys for Appalachian Power Company, Claytor Lake Relicensing. Prepared for Devine Tarbell & Associates. 1-179.

Appalachian Power Company. (2019). Byllesby-Buck Hydroelectric Project (FERC No. 2514) Notice of Intent and Pre-Application Document. Prepared for Federal Energy Regulatory Commission. January 2019.

Haag, W. R. (2012). North American freshwater mussels: natural history, ecology, and conservation. Cambridge University Press.

HDR. (2019). Byllesby-Buck Hydroelectric Project (FERC No. 2514) Revised Study Plan. Prepared for Appalachian Power Company. October 18, 2019.

Pinder, M. J., Wilhelm, E. S., & Jones, J. W. (2002). Status survey of the freshwater mussels (Bivalvia: Unionidae) in the New River Drainage, Virginia. *Walkerana*, 13:189-223.

Stantec Consulting Services, Inc. (2016). Final Report: Claytor Hydroelectric Project FERC No. 739 Mussel Survey. Prepared for: Appalachian Power Company. June 17, 2016.

Stantec Consulting Services, Inc. (2017). Final Report: Claytor Hydroelectric Project FERC No. 739 Mussel Survey Year 3 Monitoring. Prepared for Appalachian Power Company. December 21, 2017.

Stantec Consulting Services, Inc. (2018a). Byllesby/Buck Project No. 2514 Byllesby Dam Repair Mussel Survey and Relocation. Prepared for Appalachian Power Company.

Stantec Consulting Services, Inc. (2018b). Byllesby/Buck Project No. 2514 Buck Dam Repair Mussel Survey and Relocation. Prepared for Appalachian Power Company.

Stantec Consulting Services, Inc. (2020). Claytor Hydroelectric Project FERC No. 739 Freshwater Mussel 2019 Work Proposal. Delivered to VDGIF April 26, 2019.

Virginia Department of Wildlife Resources (VDWR). (2020). Special Status Faunal Species in Virginia. https://dwr.virginia.gov/wp-content/uploads/media/virginia-threatened-endangered-species.pdf. July 9, 2020. Accessed: November 24, 2020.

Appendix A - AGENCY CORRESPONDENCE

From:	Symonds, Daniel
To:	Symonds, Daniel
Subject:	RE: Buck/Byllesby Dam Mussel Survey Study Plan
Date:	Wednesday, December 2, 2020 4:41:36 PM

From: Watson, Brian <brian.watson@dwr.virginia.gov>
Sent: Monday, September 21, 2020 2:05 PM
To: Symonds, Daniel <Daniel.Symonds@stantec.com>
Cc: Fleece, Cody <Cody.Fleece@stantec.com>; Kiser, James <James.Kiser@stantec.com>; brian.watson@dgif.virginia.gov
Subject: Re: Buck/Byllesby Dam Mussel Survey Study Plan

Dan,

I'm fine with the mussel survey plan. Let me know when you guys get out and I might be able to help if you need an extra set of eyes.

Brian

On Tue, Sep 8, 2020 at 2:37 PM Symonds, Daniel <Daniel.Symonds@stantec.com> wrote:

> Hello Brian,
> I'm sending this study plan on behalf of Cody, who is stuck driving today. Attached is our plan to sample for mussels between Buck and Byllesby Dams, as part of Appalachian Power
>
> Company's Revised Study Plan from 2019. We plan on conducting this survey sometime in the next month or so, pending your approval.
>
> Please let us know if you have any questions or comments.
>
> Thanks,
> Dan
> Daniel Symonds
>
> Aquatic Ecologist
> Direct: (614) 282-3215
>
> Daniel.Symonds@stantec.com

--
Brian T. Watson
Aquatic Resources Biologist/State Malacologist
Office: 434.525.7522, x 114
Mobile: 434.941.5990
Fax: 434.525.7720

Virginia Department of Wildlife Resources

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Forest, VA 24551
www.VirginiaWildlife.gov

Stantec

Stantec Consulting Services Inc.
1500 Lake Shore Drive Suite 100, Columbus OH 43204-3800

September 8, 2020
File: 173430067

Attention: Brian Watson
Virginia State Malacologist
Virginia Department of Wildlife Resources
1132 Thomas Jefferson Road
Forest, VA 24551
(434) 941-5990

Dear Brian Watson,

Reference: Byllesby-Buck Hydroelectric Project – Mussel Survey Study Plan

Stantec Consulting Inc. has been contracted by HDR, Inc. to conduct freshwater mussel surveys in the vicinity of Buck Dam and Byllesby Dam, Wythe and Carroll Counties, Virginia. These surveys are a component of Appalachian Power Company's Revised Study Plan (RSP) filed with the Federal Energy Regulatory Commission (FERC) on October 18, 2019. The RSP included provisions for an Aquatic Resources Study, including the freshwater mussel surveys that will be detailed in this study plan. Per conditions outlined in Stantec's Scientific Collecting Permit (#065183) and Threatened and Endangered Species Permit (#067427) this letter seeks Virginia Division of Wildlife Resource (VDWR) approval to conduct the work outlined below, with the overall goal to determine the distribution and abundance of freshwater mussels in the area.

FIELD SAMPLING

Due to historic documentation of mussels in large portions of the project area, this study will focus on the tailrace and approximately 3,000 meter long reach between Byllesby Dam and the Buck Reservoir Islands. By examining these two reaches, it should provide a more complete picture of the overall mussel community in this area of the New River.

Stantec proposes a two-step approach for surveying the Byllesby-Buck Project Area. Initially, a boat-based habitat survey will be performed to visually identify potential mussel habitats in the transition area between Byllesby Dam and the Buck Dam Reservoir. This will facilitate surveying in the best habitats within the survey area. Review of aerial photography shows a number of different hydraulic habitat types (e.g. fast velocity/deep depth, slow/shallow, etc., See Attachment A) that may yield different mussel community compositions. Initial boat surveys will choose specific locations within each of these hydraulic habitat types. A total of ten sites will be selected, one from each distinct hydraulic habitat area. Each area will be searched using wandering timed searches, a total of 200 person-minutes per area. This will result in a total of 33.3 person-hours of searching in the area between the two dams. These searches will involve snorkeling, tactile searches, or diving (SCUBA or surface supplied) depending on conditions in each habitat. Substrates will be searched by moving cobble and woody debris; hand sweeping away silt, sand

Reference: Byllesby-Buck Hydroelectric Project – Mussel Survey Study Plan

and/or detritus; and disturbing/probing the upper two inches of substrate to better view resident mussels. All mussels (live and shell) will be placed in a mesh bag, taken to the streambank/boat, and identified to species and sized for data collection. Mussels will be returned to the approximate location they were found. Each species will be photographed as vouchers.

An additional search will take place in the tailrace of Buck Dam, which has not previously been surveyed. This stretch of river extends approximately 500m along a vegetated island from the Buck Dam powerhouse until it reaches a wider channel with a wetted width more typical of the New River. This narrow cross sectional area and large volume of discharge suggests that the reach does not provide suitable habitat for freshwater mussels. Surveyors will conduct a reconnaissance level habitat assessment of the channel to assess potential freshwater mussel habitat. Notes will be taken about substrate composition and habitat quality. Shell and any live mussels encountered will be recorded. Due to the high flow's normally encountered in this area, no diving is scheduled to take place during this search.

Upon completion of the survey a technical report will be prepared and submitted to FERC and VDWR. This project will be conducted under Senior Malacologist Cody Fleece's Scientific Collecting permit (#065183, Attachment B) and Threatened and Endangered species permit (#067427, Attachment B).

Regards,

Stantec Consulting Services Inc.

W. Cody Fleece
Senior Malacologist
Phone: (513) 262-3994
Cody.Fleece@stantec.com

Attachment: A – Survey Area Figure
B – Collecting Permits

Appendix B - COLLECTING PERMITS

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-568 of the Code of Virginia & DGIF Policy E-1-90

Threatened/Endangered Species Permit

Permit Type: **Renewal** Fee Paid: **$20.00** VADGIF Permit No. **067427**

Permittee: **William Cody Fleece**
Address: **11687 Lebanon Road**
Sharonville, OH 45241
Email:

Office: **(513) 262-3994**
City/County:

Business: **Stantec Consulting Services, Inc.**
11687 Lebanon Road
Sharonville, OH 45241

Biomonitoring/Contract Environmental Impact/Contract Species Surveys

Authorized Collection Methods: By Hand/Scuba/Snorkel/View Scope
Authorized Waterbodies: New River
Authorized Marking Techniques: N/A

NO LIVE MUSSELS MAY BE PRESERVED

Permittee MUST notify VDGIF within the 7 day period prior to each sampling event. Notification must be made via email to: collectionpermits@dgif.virginia.gov

Report Due: 31 January 2021

ANNUAL REPORTS MUST BE SUBMITTED VIA: https://vafwis.dgif.virginia.gov/collection_permits/

STANDARD CONDITIONS ATTACHED APPLY TO THIS PERMIT.

Authorized Counties / Cities:
Carroll
Giles
Montgomery
Pulaski
Wythe
Radford

Authorized Species:

Description	ID Number	Scientific Name
Threatened & Endangered Aquatic Mollusk Species		
Threatened & Endangered Freshwater Mussels		

Authorized Sub-Permittees:
Aaron Kwolek, Stantec
Daniel Symonds, Stantec
James Kiser, Stantec

Approved by: Randall T. Francis

Applicants may appeal permit decisions within 30 days of issuance. The appeal must be in writing to the Director, Department of Game and Inland Fisheries.

Title: **Randall T. Francis - Permits Manager** **Date:** **3/20/2020**

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778

(804) 367-1000 (V/TDD)

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-568 of the Code of Virginia & DGIF Policy E-1-90

Threatened/Endangered Species Permit

Permit Type: **Renewal** Fee Paid: **$20.00** VADGIF Permit No. **067427**

20 Permit Effective **3/20/2020** through **12/31/2020** **20**

Virginia Department of Game and Inland Fisheries
P O Box 3337 Henrico, VA 23228-3337
(804) 367-6913

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-568 of the Code of Virginia and Policy E-1-90

THREATENED/ENDANGERED SPECIES PERMIT -- STANDARD CONDITIONS

1. Permits are issued to permittees with the understanding that if the principal permittee leaves the project the permit will be null and void and anyone desiring to continue the activities must apply for a new permit.

2. This permit, or a copy, must be carried by the permittee(s) during collection activities.

3. Permittee MUST notify the Virginia Department of Game and Inland Fisheries (VDGIF) within the seven (7) day period prior to EACH sampling event. Notification must be made via email to: collectionpermits@dgif.virginia.gov.

4. The permittee is required to submit to VDGIF a report of all specimens collected under this permit by the report due date. Report form may be found https://vafwis.dgif.virginia.gov/collection_permits/.asp. FAILURE TO RETURN THIS REPORT WILL RESULT IN NON-ISSUANCE OF FUTURE PERMITS. If no activity occurs under this permit, an email should be sent to collectionpermits@dgif.virginia.gov containing the following statement: No activity occurred under Permit #*insert permitID* during insert year (i.e. 2017). Permit reports are due by January 31.

5. Permittees shall give any and all changes of name, address, and/or phone number to the VDGIF Permits Section within no more than seven (7) days of those changes. All permittees (to include sub-permittees) shall provide DGIF with a complete home address, contact telephone number (home or cellular), and a valid e-mail address.

6. This permit does not support any activities outside of those associated with the application and proposal submitted to and approved by DGIF.

7. If incidental death or injury of threatened or endangered species occurs, the permittee is required to notify VDGIF at collectionpermits@dgif.virginia.gov within twenty-four (24) hours of occurrence. The following information must be reported: collector, date, species, location (county, quad, waterbody, and latitude and longitude to nearest second), and number collected.

8. If incidental *collection and live release* of threatened or endangered species occurs *for species other than those authorized under this permit*, the permittee is required to notify VDGIF at collectionpermits@dgif.virginia.gov within four (4) working days. The following information must be reported: collector, date, species, location (county, quad, waterbody, and specific location, either in latitude and longitude to nearest second, or by way of a photocopied 7.5' topographic map), general habitat associations, and number collected.

9. No species may be retained unless specifically authorized by this permit.

10. All traps must be marked with the name and address of the trapper or an identification number issued by VDGIF (Code of Virginia §29.1-521.7). Steel foothold traps, Conibear-style body gripping traps, and snares must be marked with a nonferrous metal tag bearing this information (Virginia Administrative Code 4 VAC 15-40-170).

11. All traps must be checked at least once a day and all captured animals removed, except completely submerged body-gripping traps which must be checked at least once every 72 hours (Code of Virginia §29.1-521.9).

12. The permittee is required to report any incidences of wildlife deaths or diseases observed during the course of collection activities. Reports should be made to: collectionpermits@dgif.virginia.gov within four (4) working days.

13. This permit satisfies only VDGIF's requirement for collection permits and is issued with the understanding that no collections will be made on Federal, state, or private property without the prior approval and necessary permits from the landowners involved. The permittee is responsible for obtaining any additional permits required for collection.

14. Sampling gear, boats, or trailers which have been used in states harboring zebra mussels must be cleaned and prepared following the guidelines specified in the attached summary prior to use in waters in the Commonwealth.

15. For safety reasons, it is recommended that all permittees display at least 100 square inches of solid blaze orange material at shoulder level within body reach and visible from 360 degrees, especially during hunting season.

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **Renewal** Fee Paid: **$40.00** VADGIF Permit No. **065183**

Permittee: **William Cody Fleece**
Address: **Stantec Consulting Services, Inc.**
11687 Lebanon Road
Sharonville, OH 45241
Email: **cody.fleece@stantec.com**

Home:
Office: **(513) 842-8238**

Appalachian Power Company - Biomonitoring/Contract Environmental Impact/Contract Species Surveys

Authorized Collection Methods: By Hand/Scuba/Snorkel/Hooka
Authorized Waterbodies: New River
Authorized Marking Techniques: N/A

NO LIVE MUSSELS MAY BE PRESERVED

Permittee MUST notify VDGIF within the 7 day period prior to each sampling event. Notification must be made via email to: collectionpermits@dgif.virginia.gov

Report Due: 31 January 2020, 31 January 2021

ANNUAL REPORTS MUST BE SUBMITTED VIA: https://vafwis.dgif.virginia.gov/collection_permits/

STANDARD CONDITIONS ATTACHED APPLY TO THIS PERMIT.

Authorized Counties / Cities:
Carroll
Giles
Montgomery
Pulaski
Wythe
Radford

Authorized Species:

Description	ID Number	Scientific Name
Freshwater Mussels		

Annual Report Due End of Each Year

Authorized Sub-Permittees:
James Kiser, Stantec
Dillon McNulty, Stantec
Aaron Kwolek, Stantec
Elizabeth Dilbone, Stantec
Daniel Symonds, Stantec

Approved by: [signature]

Applicants may appeal permit decisions within 30 days of issuance. The appeal must be in writing to the Director, Department of Game and Inland Fisheries.

Title: Randall T. Francis - Permits Manager **Date: 4/29/2019**

20 Permit Effective **4/29/2019** through **12/31/2020** **20**

Virginia Department of Game and Inland Fisheries

P O Box 3337 Henrico, VA 23228-3337
(804) 367-6913

Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

SCIENTIFIC COLLECTION PERMIT – STANDARD CONDITIONS

1. Permits are issued to permittees with the understanding that if the principal permittee leaves the project the permit will be null and void and anyone desiring to continue the activities must apply for a new permit.

2. This permit, or a copy, must be carried by the permittee(s) during collection activities.

3. Permittee MUST notify the Virginia Department of Game and Inland Fisheries (VDGIF) within the seven (7) day period prior to EACH sampling event. Notification must be made via email to: collectionpermits@dgif.virginia.gov.)

4. The permittee is required to submit to this Department a report of all specimens collected under this permit by the report due date. Report form may be found at https://vafwis.dgif.virginia.gov/collection_permits/. FAILURE TO RETURN THIS REPORT WILL RESULT IN NON-ISSUANCE OF FUTURE PERMITS. If no activity occurs under this permit, an email should be sent to collectionpermits@dgif.virginia.gov containing the following statement: No activity occurred under Permit #*insert permit ID* during insert year (i.e. 2017). Permit reports are due by January 31.

5. Permittees shall give any and all changes of name, address, and/or phone number to the VDGIF Permits Section within no more than seven (7) days of those changes. All permittees (to include sub-permittees) shall provide DGIF with a complete home address, contact telephone number (home or cellular), and a valid e-mail address.

6. This permit does not support any activities outside of those associated with the application and proposal submitted to and approved by DGIF.

7. No species currently listed by the U.S. Fish and Wildlife Service or VDGIF as threatened or endangered may be intentionally collected under this permit. If incidental d*eath or injury* of threatened or endangered species does occur, the permittee is required to notify VDGIF at collectionpermits@dgif.virginia.gov within twenty-four (24) hours of occurrence. The following information must be reported: collector, date, species, location (county, quad, waterbody, and latitude and longitude to nearest second), and number collected.

8. If incidental *observation or collection and live release* of threatened or endangered species occurs, the permittee is required to notify VDGIF at collectionpermits@dgif.virginia.gov within four (4) working days, providing the same information as the Condition No. 7.

9. If incidental *mortality or injury of specimens intended to be taken live* occurs, the permittee is required to notify VDGIF at collectionpermits@dgif.virginia.gov within 48 hours, providing the same information as the above conditions. In addition, the permittee must provide the cause of mortality or injury and steps that are being taken to address the problem.

10. No species may be retained unless specifically authorized by this permit.

11. Game birds/game mammals/game fish protected by State and/or Federal laws must be taken during authorized hunting and trapping seasons and under applicable daily and seasonal bag/number limits by properly licensed persons unless otherwise specifically authorized. A valid Virginia fishing license is required for each person collecting samples by hook-and-line.

12. All traps must be marked with the name and address of the trapper or an identification number issued by VDGIF (Code of Virginia §29.1-521.7). Steel foothold traps, Conibear-style body gripping traps, and snares must be marked with a nonferrous metal tag bearing this information (Virginia Administrative Code 4 VAC 15-40-170).

13. All traps must be checked at least once a day and all captured animals removed, except completely submerged body-gripping traps which must be checked at least once every 72 hours (Code of Virginia §29.1-521.9).

14. The permittee is required to report any incidences of wildlife deaths or diseases observed during the course of collection activities. Reports should be made to: collectionpermits@dgif.virginia.gov within four (4) working days.

15. This permit satisfies only VDGIF's requirement for collection permits and is issued with the understanding that no collections will be made on Federal, state, or private property without the prior approval and necessary permits from the landowners involved. The permittee is responsible for obtaining any additional permits required for collection.

16. Sampling gear, boats, or trailers which have been used in states harboring zebra mussels must be cleaned and prepared following accepted guidelines for removal of zebra mussels, prior to being used in Virginia.

17. For safety reasons, it is recommended that all permittees display at least 100 square inches of solid blaze orange material at shoulder level within body reach and visible from 360 degrees, especially during hunting season.

Appendix C - SITE AND SPECIES PHOTOS

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 1

Photo Location:
Shallow Shoal 1

Direction:

Survey Date:
9/24/2020

Comments:
Cyclonaias tuberculata (Purple Wartyback)

Photograph ID: 2

Photo Location:
Shallow Shoal 1

Direction:
East

Survey Date:
9/24/2020

Comments:
Both live and the shell specimen were found along the east bank of the river (left side of photo)

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 3	
Photo Location: Shallow Shoal 1	
Direction: South	
Survey Date: 9/24/2020	
Comments:	
Photograph ID: 4	
Photo Location: Shallow Shoal 1	
Direction: North	
Survey Date: 9/24/2020	
Comments:	

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 5 **Photo Location:** Shallow Shoal 1 **Direction:** Southwest **Survey Date:** 9/24/2020 **Comments:**	
Photograph ID: 6 **Photo Location:** Shallow Shoal 2 **Direction:** North **Survey Date:** 9/25/2020 **Comments:**	

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 7

Photo Location:
Shallow Shoal 2

Direction:
South

Survey Date:
9/25/2020

Comments:

Photograph ID: 8

Photo Location:
Deep Shoal 2 & Shallow Shoal 2

Direction:
East

Survey Date:
9/24/2020

Comments:

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 9

Photo Location:
Deep Shoal 2

Direction:
East

Survey Date:
9/24/2020

Comments:

Photograph ID: 10

Photo Location:
Pool 2 & Deep Shoal 1

Direction:
Southwest

Survey Date:
9/24/2020

Comments:

Client:	**Appalachian Power Company**	**Project:**	**Buck/Byllesby Dam Mussel Survey**
Site Name:	**New River**	**Site Location:**	**Carroll County, Virginia**

Photograph ID: 11

Photo Location: Pool 2

Direction: North

Survey Date: 9/24/2020

Comments:

Photograph ID: 12

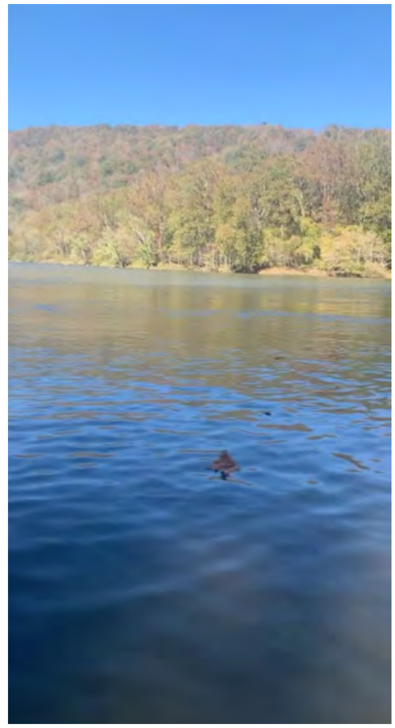
Photo Location: Pool 2

Direction: East

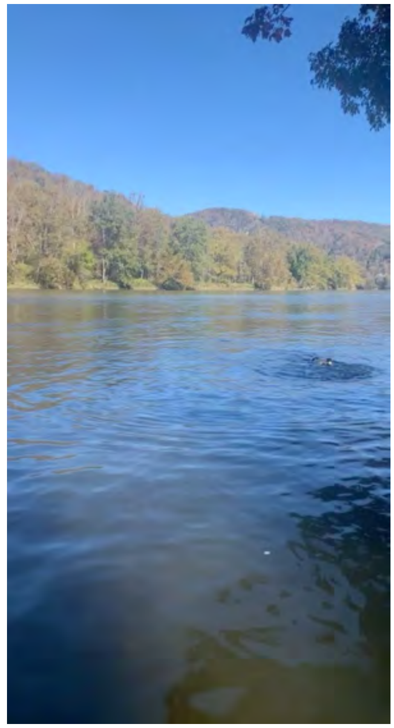
Survey Date: 9/24/2020

Comments:

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 13	
Photo Location: Deep Shoal 3	
Direction: East	
Survey Date: 10/21/2020	
Comments:	
Photograph ID: 14	
Photo Location: Shallow Shoal 3	
Direction: East	
Survey Date: 10/21/2020	
Comments:	

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 15 **Photo Location:** Deep Shoal 3 **Direction:** South East **Survey Date:** 10/21/2020 **Comments:**	
Photograph ID: 16 **Photo Location:** Deep Shoal 3 **Direction:** North **Survey Date:** 10/21/2020 **Comments:**	

Client:	**Appalachian Power Company**	**Project:**	**Buck/Byllesby Dam Mussel Survey**
Site Name:	**New River**	**Site Location:**	**Carroll County, Virginia**

Photograph ID: 17 **Photo Location:** Pool 3 **Direction:** East **Survey Date:** 10/21/2020 **Comments:**	
Photograph ID: 18 **Photo Location:** West Side Channel **Direction:** South **Survey Date:** 9/25/2020 **Comments:**	

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 19

Photo Location: Downstream Extent of West Side Channel

Direction: Northwest

Survey Date: 9/25/2020

Comments:

Photograph ID: 20

Photo Location: Middle of West Side Channel

Direction: Southwest

Survey Date: 9/25/2020

Comments:

Client:	**Appalachian Power Company**	**Project:**	**Buck/Byllesby Dam Mussel Survey**
Site Name:	**New River**	**Site Location:**	**Carroll County, Virginia**

Photograph ID: 21

Photo Location:
East Side Channel

Direction:
South

Survey Date:
9/25/2020

Comments:

Photograph ID: 22

Photo Location:
East Side Channel

Direction:
West

Survey Date:
9/25/2020

Comments:

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 23	
Photo Location: Downstream Extent of East Side Channel	
Direction: Northwest	
Survey Date: 9/25/2020	
Comments:	
Photograph ID: 24	
Photo Location: Tailrace	
Direction: Southeast	
Survey Date: 9/24/2020	
Comments:	

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 25 **Photo Location:** Tailrace **Direction:** Northeast **Survey Date:** 9/24/2020 **Comments:**	
Photograph ID: 26 **Photo Location:** Tailrace **Direction:** **Survey Date:** 9/24/2020 **Comments:** Riprap lining edge of tailrace	

Photographic Log

Client:	Appalachian Power Company	Project:	Buck/Byllesby Dam Mussel Survey
Site Name:	New River	Site Location:	Carroll County, Virginia

Photograph ID: 27

Photo Location:
Tailrace

Direction:
Northwest

Survey Date:
9/24/2020

Comments:

Attachment 5

Attachment 5 – Germane Correspondence

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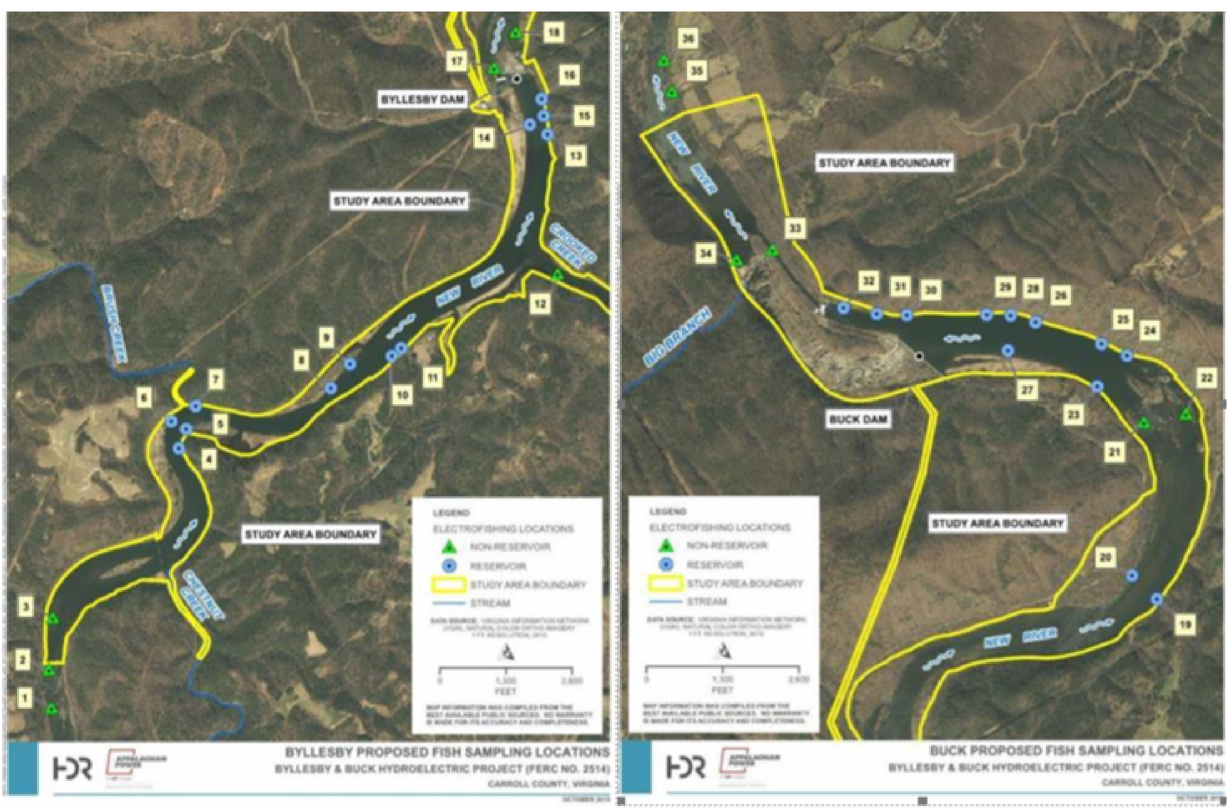
Yayac, Maggie

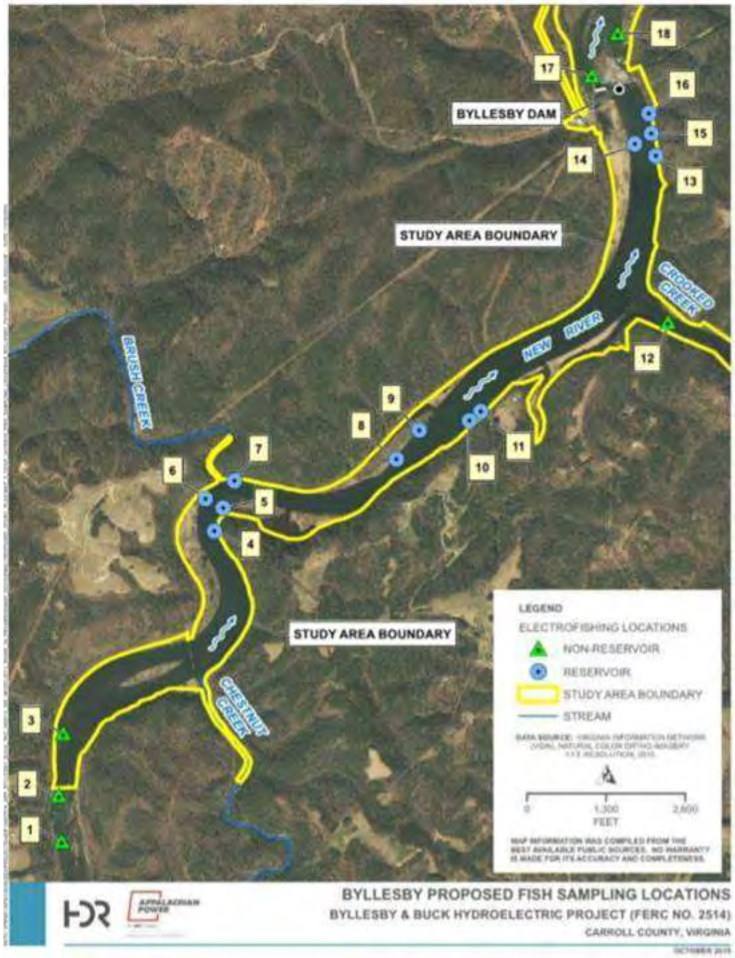
Subject: FW: Walleye gill net methods (Byllesby Reservoir)

From: Jon Studio [mailto:JStudio@envsi.com]
Sent: Friday, April 3, 2020 2:23 PM
To: Copeland, John <john.copeland@dgif.virginia.gov>; Huddleston, Misty <Misty.Huddleston@hdrinc.com>
Cc: Bill.Kittrell@dgif.virginia.gov; John Spaeth <jspaeth@envsi.com>; Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Jonathan M Magalski <jmmagalski@aep.com>; Elizabeth B Parcell <ebparcell@aep.com>
Subject: RE: Walleye gill net methods (Byllesby Reservoir)

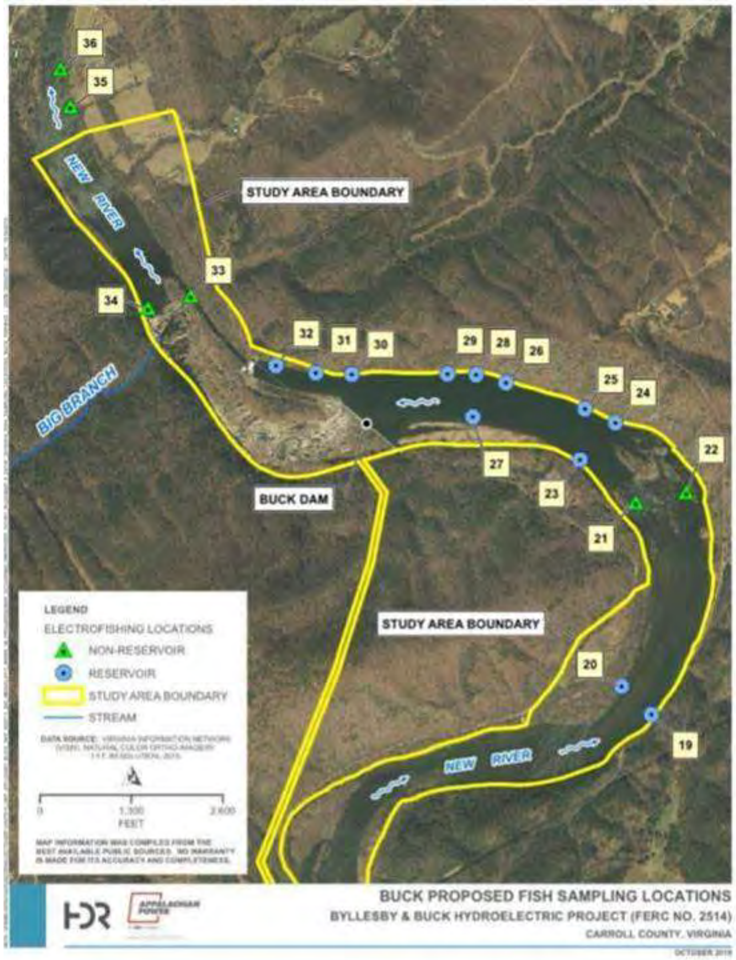
John,

Below are the tentative field sampling sites. Non-reservoir (green; backpack electrofishing) and Reservoir (blue; boat electrofishing) sites are shown. Tentative gill net sites coincide with Figure 4 from the 1991 report. It was agreed upon during development of the Study Plan that hoop netting will not be used because hoop net methods did not yield novel information in the previous study. We will be in touch at the beginning of next week regarding gill net mesh sizes. Enjoy your weekend.





BYLLESBY DAM
STUDY AREA BOUNDARY
NEW RIVER
CROOKED CREEK
BRUSH CREEK
STUDY AREA BOUNDARY
CHESTNUT CREEK
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
LEGEND
ELECTROFISHING LOCATIONS
NON-RESERVOIR
RESERVOIR
STUDY AREA BOUNDARY
STREAM
0
1,300
2,600
FEET
BYLLESBY PROPOSED FISH SAMPLING LOCATIONS
BYLLESBY & BUCK HYDROELECTRIC PROJECT (FERC NO. 2514)
CARROLL COUNTY, VIRGINIA



Thank you,
Jon Studio

From: Copeland, John <john.copeland@dgif.virginia.gov>
Sent: Tuesday, March 31, 2020 1:00 PM
To: Huddleston, Misty <Misty.Huddleston@hdrinc.com>
Cc: Jon Studio <JStudio@envsi.com>; Bill.Kittrell@dgif.virginia.gov; John Spaeth <jspaeth@envsi.com>; Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Jonathan M Magalski <jmmagalski@aep.com>; Elizabeth B Parcell <ebparcell@aep.com>; John Copeland <john.copeland@dgif.virginia.gov>
Subject: Re: Walleye gill net methods (Byllesby Reservoir)

I appreciate the summary Misty provided. In my earlier email I meant to say that **Walleye were NOT a factor** during the 1990 fisheries sampling. We did not start stocking New River strain Walleye intensively in the Upper New River area (including Byllesby Reservoir) until the early 2000's. I think Byllesby was experimentally stocked with Walleye from another source in the mid-late 1990's. Since we started our New River strain Walleye work, we have stocked Byllesby occasionally, but most of the Walleye using Byllesby are coming from stockings at the low water bridge downstream from Fries Dam, which we try to stock annually.

With this background in mind, take a look at the attached spreadsheet from Claytor Lake gill net surveys from 2010 to 2019. In order to collect the smaller size Walleye, the 3/4 in bar mesh net is important. As you can see, the 1.25 in bar mesh net is very important as well, so **I think adding these sizes (0.75 and 1.25 in bar mesh) to gill nets used in the current survey in addition to the ones proposed below by Misty Huddleston will provide better length data on Walleye in Byllesby Reservoir and not detract from collecting other species or comparisons to historic data.** At Claytor Lake, plenty of Walleye are collected in the 1.0, 1.5. 2.0, and 2.5 in bar mesh nets, but the smaller net sizes are important. We always get larger size Walleye in a variety of mesh sizes due to their propensity to get lip hung and roll in the nets, but collecting the smaller Walleye requires using smaller mesh sizes. I see you are planning for 120 foot nets with 6 panels, so adding panels will limit either the mesh sizes or the panel sizes. In the 1990 survey, each mesh size had 30 foot panels that were 6 feet deep (180 square feet of panel). Since you are planning 8 foot deep nets instead of the 6 foot deep nets used in the 1990 survey, if you employ 8 mesh sizes of 15 feet each (120 feet total length) it will still yield 120 square feet of each mesh panel, instead of what you propose with 6 mesh sizes of 20 feet each, which will yield 160 square feet of each mesh panel.

I would like to see the other planned methods for the 2020-2021 fisheries survey (electrofishing, hoop netting) and what sites will be sampled for each technique. I'm particularly interested in what reference sites will be sampled upstream and downstream from the Project. **If you are planning to replicate the 1990 fisheries study locations and techniques shown in Figure 4 of the 1991 report, then you can simply let me know that is your plan.**

If you think we need to resolve anything in a conference call, I am available tomorrow (Wednesday, April 1), but not Friday, April 3. We appreciate the coordination of this study in advance of sampling.

Thanks.

John R. Copeland
Fisheries Biologist III
P 540.961.8304
M 540.871.6064
Virginia Department of Game & Inland Fisheries
A **2206 South Main Street, Suite C, Blacksburg, VA 24060**
www.dgif.virginia.gov
CONSERVE. CONNECT. PROTECT.

On Tue, Mar 31, 2020 at 9:31 AM Huddleston, Misty <Misty.Huddleston@hdrinc.com> wrote:

Jon/John,

Following up on the email chain below.

The 1991 fisheries study at Byllesby/Buck used electrofishing, gillnet, and hoop net gear types. No Walleye were collected during the study.

For the upcoming fisheries work at Byllesby/Buck it is important that we have parity with previous collection methods. However, there is room for deviation as long as the gear changes are not expected to decrease the representativeness of the fish community.

The 1991 study report does not clarify if the gillnet mesh used was bar or stretch measurements; however, the measurements are consistent with typical bar mesh sizes used in experimental gill nets.

I have summarized the information from the 1991 study, provided by John from Claytor Lake surveys, and for reference purposes included gillnet specifications used by the USGS National Water Quality Assessment.

At the bottom of the table, I have provided my thoughts on gillnet specifications that could be used to meet the fish community study goals and target Walleye.

Summary of gillnet information:

Gillnet Source	Depth (feet)	Width (feet)	Number and Width (feet) of Panels	Bar Mesh Size (inches)	Notes
1991 study	6	120	4 – 30’	1 to 4	
Claytor Lake	8	100	4 – 25’	0.5 to 2.5	Walleye collected on 0.75 in, 1.0 in, 1.25 in, 1.5 in, 2.0 in, and 2.5 mesh
NAWQA (for reference)	6	120	6 – 20’	0.5 to 4	0.5-in, 1.0-in, 1.5-in, 2.0-in, 3.0-in, 4.0
Potential Specifications for 2020-2021 Byllesby/Buck Sampling	**8**	**120**	**6 – 20’**	**1 to 4**	**Mesh sizes of 1.0-in, 1.5-in, 2.0-in, 2.5-in, 3.0-in, 4.0-in**

*NAWQA: US Geological Survey, National Water Quality Assessment Methodology

If we need to have a call to discuss further, I am available anytime on Wednesday, April 1st or Friday, April 3rd.

I have quite a bit of availability next week if we need to push a discussion to sometime next week.

Thanks,

Misty

Misty Huddleston, PhD

Associate, SR. Environmental Scientist

HDR

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Misty.Huddleston@hdrinc.com

hdrinc.com/follow-us

From: Jon Studio [mailto:JStudio@envsi.com]
Sent: Friday, March 27, 2020 2:46 PM
To: Copeland, John <john.copeland@dgif.virginia.gov>
Cc: Bill.Kittrell@dgif.virginia.gov; John Spaeth <jspaeth@envsi.com>; Huddleston, Misty <Misty.Huddleston@hdrinc.com>; Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Jonathan M Magalski <jmmagalski@aep.com>; Elizabeth B Parcell <ebparcell@aep.com>
Subject: RE: Walleye gill net methods (Byllesby Reservoir)

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.

John,

I appreciate your timely response. One objective of the fish community study for this project is "*Compare current aquatic resources data to historical data to determine any significant changes to species composition or abundance*." Using similar methods may allow us to make more direct comparisons (e.g., CPUE); however, it is also important to use the best methodology to sample and quantify the current aquatic resources.

Sarah and Misty, can you speak to the importance of parity with previous collection methods?

Attached is the 1991 fisheries study from the Byllesby-Buck Project Area. After looking over the paper, please propose a few times that work for you and I will try to make myself available for a phone conversation.

Thank you,

Jon Studio

From: Copeland, John <john.copeland@dgif.virginia.gov>
Sent: Friday, March 27, 2020 2:23 PM
To: Jon Studio <JStudio@envsi.com>
Cc: Bill.Kittrell@dgif.virginia.gov; John Spaeth <jspaeth@envsi.com>; Huddleston, Misty <Misty.Huddleston@hdrinc.com>; Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Jonathan M Magalski

<jmmagalski@aep.com>; Elizabeth B Parcell <ebparcell@aep.com>; John Copeland <john.copeland@dgif.virginia.gov>
Subject: Re: Walleye gill net methods (Byllesby Reservoir)

Jon:

I think parity with previous collection methods is one factor to consider, but, since walleye were a developed fishery during the last relicensing studies, that's less of a concern for me for walleye.

Were walleye collected during the previous relicensing studies?

Do you know if the mesh sizes described in the previous methodology were bar mesh sizes or stretch mesh sizes?

If your gill netting is targeting fish across the fish community, then parity with previous collection methods is a good idea.

In annual sampling at Claytor Lake, I use 100 ft by 8 ft experimental nets with varying bar mesh sizes in 25 ft panels from 0.5 inch (1 inch stretch mesh) up to 2.5 inch bar mesh (5 inch stretch mesh). The mesh sizes include the following bar mesh sizes in inches: 0.5, 0.625. 0.75, 1.0, 1.25, 1.5, 2.0, and 2.5. Not all of these mesh sizes are useful for collecting walleye. Most of the Walleye I catch in those nets are in the 0.75 in, 1.0 in, 1.25 in, 1.5 in, 2.0 in, and 2.5 in mesh sizes, since the smaller mesh sizes are primarily catching gizzard shad and alewife.

Walleye could also be collected using night electrofishing, which could be effective in Byllesby Reservoir in April. At Claytor Lake, we also collect some walleye during day electrofishing, but not frequently, since they tend to be deeper during the day.

I'm not sure where to find the previous fisheries study in my files.

If you send me the previous fisheries study, I can take a look early next week and we can talk about it by phone.

John R. Copeland

Fisheries Biologist III
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M 540.871.6064

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A 2206 South Main Street, Suite C, Blacksburg, VA 24060
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On Thu, Mar 26, 2020 at 10:27 AM Jon Studio <JStudio@envsi.com> wrote:

Good morning Bill and John,

Environmental Solutions & Innovations, Inc. (ESI) anticipates conducting gill net surveys targeting walleye in the Byllesby Reservoir at the dam relicensing Project Area (New River) during the 2020 field season. ESI understands you participated in Study Plan review for this Project. To obtain representative information on the relative abundance and size structure of the walleye population (per VDGIF requests), sampling as early in April as possible is necessary. ESI also requests your recommendations for the following gill net methods at the Byllesby Reservoir Project Area: 1) gill net length, height, and float line height, 2) gill net mesh sizes, and 3) gill net duration.

The following gill net methods were used in the fish community study in 1991: "*Gill nets were 6 ft x 120 ft monofilament, with four 30-ft panels of mesh size ranging from 1-4 inches. Net sets were placed at two sites each on the upper, middle, and lower portions of the Byllesby Reservoir… Each net was checked after 24 hours, reset, and checked and removed after 48 hours*". ESI requests your advice regarding the most effective methods/techniques for sampling walleye in the Byllesby Reservoir. Please feel free to contact us if you have questions or additional information is required. Thank you.

Kind regards,

ESI
Jon Studio
Aquatic Scientist
Environmental Solutions & Innovations, Inc.

4300 Lynn Road | Ravenna, OH 44266 | USA
office: 513.591.6134 **direct:** 440.413.4609
jstudio@envsi.com | www.envsi.com

Yayac, Maggie

Subject: FW: New River Update

From: Brian Watson <brian.watson@dwr.virginia.gov>
Sent: Thursday, October 8, 2020 11:01 AM
To: Fleece, Cody <cody.fleece@stantec.com>; Brian Watson <brian.watson@dgif.virginia.gov>
Cc: Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Huddleston, Misty <Misty.Huddleston@hdrinc.com>; Symonds, Daniel <Daniel.Symonds@stantec.com>; Elizabeth B Parcell <ebparcell@aep.com>; Yayac, Maggie <Maggie.Yayac@hdrinc.com>
Subject: RE: New River Update

Cody,

I can see the notes now that I am back at my computer and not viewing the PDF thru my phone. Since two of the areas include shoal habitat, DWR does recommend surveying the 3 areas that were not surveyed in September due to rain and poor river conditions. Despite a low number of mussels being founds so far, DWR would prefer to see those areas surveyed to get a more complete assessment. If you have any questions, let me know. And if you need any assistance, let me know when you guys do the surveys as I may be able to make it out.

Brian

Brian T. Watson
Aquatic Resources Biologist/State Malacologist
P 434.525.7522, x114 / M 434.941.5990 / F 434.525.7720

Virginia Department of Wildlife Resources
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A 1132 Thomas Jefferson Road, Forest, VA 24551
www.VirginiaWildlife.gov

From: Fleece, Cody <Cody.Fleece@stantec.com>
Sent: Tuesday, September 29, 2020 1:05 PM
To: Brian Watson <brian.watson@dgif.virginia.gov>
Cc: Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Huddleston, Misty <Misty.Huddleston@hdrinc.com>; Symonds, Daniel <Daniel.Symonds@stantec.com>; Elizabeth B Parcell <ebparcell@aep.com>; Yayac, Maggie

<Maggie.Yayac@hdrinc.com>
Subject: FW: New River Update

Brian

As discussed on the phone we were able to complete surveys in 8 of the 11 planned areas. Heavy rainfall and reduced visibility caused us to abandon the last day of survey (we completed 3 of 4). I attached a map with notes of what we found and how much time was spent searching. Dan Symond's initial survey summary is also presented below.

Based on what we're finding so far we have been wondering about the necessity of re-mobilizing to assess the 3 missing areas. Let us know if you think we need to get back out to finish the work or if the information in hand will suffice to inform decisions in the relicensing process.

Thanks for your time and attention.

Cody

From: Symonds, Daniel <Daniel.Symonds@stantec.com>
Sent: Monday, September 28, 2020 11:09 AM
To: Fleece, Cody <Cody.Fleece@stantec.com>
Subject: New River Update

We completed 8 of the 11 target areas on the New River (That's including the Buck Tailrace). We have surveyed at least one area of each type (shallow/deep shoal, pool, side channel). Six of the areas yielded zero mussels, and zero shells. Habitat varied from very poor (80-100% drifting sand) to very good (gravel/sand/cobble riffles) in the areas with no evidence of mussels.

Two live and one shell C. tuberculata were found in the most downstream shallow shoal. They were found in the flow refuge behind boulders, where sand/gravel accumulates in small amounts.

Six live C. tuberculata were found in the middle deep shoal. Similar story to the shallow shoal, the mussels were found in the silt that accumulated behind larger cobble/boulders.

To summarize, 25.3 people-hours of searching has occurred, with a catch-per-unit-effort of 0.35 mussels/hr and species diversity of one.

Daniel Symonds
Aquatic Ecologist

Direct: (614) 282-3215
Daniel.Symonds@stantec.com

Stantec
1500 Lake Shore Drive Suite 100
Columbus OH 43204-3800

Yayac, Maggie

Subject: FW: Fish Community Study at Byllesby/Buck Project (FERC No. 2514)

From: Copeland, John <john.copeland@dwr.virginia.gov>
Sent: Monday, November 9, 2020 8:32 AM
To: Huddleston, Misty <Misty.Huddleston@hdrinc.com>
Cc: Jonathan M Magalski <jmmagalski@aep.com>; Elizabeth B Parcell <ebparcell@aep.com>; jon Studio (jastudio@edge-es.com) <jastudio@edge-es.com>; John Spaeth <jpspaeth@edge-es.com>; Kulpa, Sarah <Sarah.Kulpa@hdrinc.com>; Yayac, Maggie <Maggie.Yayac@hdrinc.com>; John Copeland <john.copeland@dwr.virginia.gov>; Kittrell, Bill (DGIF) <bill.kittrell@dwr.virginia.gov>; Pinder, Mike (DGIF) <mike.pinder@dwr.virginia.gov>
Subject: Re: Fish Community Study at Byllesby/Buck Project (FERC No. 2514)

I understand your planned course of action for gill net sampling. If that sampling cannot be completed this week, it is acceptable to target Walleye with your gill net sampling as late as early December. Walleye will continue to move around when the water temperatures drop into the 50 degree range. Catch of other species (Catfish and other species) will likely not be as high if you delay into early December.

Regarding backpack electrofishing, deciding to postpone that work until August/September of 2021 is acceptable to us. The boat electrofishing and gill net sampling are targeting the reservoir habitat so the lack of overlap in sampling periods with the lotic areas sampled by backpack electrofishing is acceptable.

John R. Copeland

Fisheries Biologist III

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Virginia Department of Wildlife Resources

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Yayac, Maggie

Subject: FW: Notification of Collection of State Threatened Pistolgrip Mussel on AEP Byllesby-Buck project
Attachments: pistolgrips.jpg

From: David Foltz [mailto:dafoltz@edge-es.com]
Sent: Thursday, October 8, 2020 11:30 PM
To: Brian Watson <brian.watson@dwr.virginia.gov>; john_mccloskey@fws.gov; richard_mccorkle@fws.gov; janet_norman@fws.gov; collectionpermits@dgif.virginia.gov; scott.smith@dgif.virginia.gov
Cc: John Spaeth <jpspaeth@edge-es.com>; Jon Studio <jastudio@edge-es.com>; Casey Swecker <cdswecker@edge-es.com>; Huddleston, Misty <Misty.Huddleston@hdrinc.com>; Kay, Jenessa <Jenessa.Kay@hdrinc.com>
Subject: Notification of Collection of State Threatened Pistolgrip Mussel on AEP Byllesby-Buck project

All, Edge and HDR employees conducted benthic macroinvertebrate surveys approximately 1.35 kilometers downstream from the Buck Dam as part of the relicensing project today on 10/8/2020. During the survey efforts multiple freshwater mussels were discovered in the substrates sampled, including Virginia state listed Pistolgrip (*Tritogonia verrucosa*). Mussels were removed from the water briefly for photographic voucher (please see attachment) before being placed back in the substrates.

Please let us know if you need any further information on the animals or site.

Thank you.

DAVID A. FOLTZ II
Project Manager/ Senior Malacologist/ Astacologist
Weirton, West Virginia
D: 304.479.3268
edge-es.com

EDGE ENGINEERING & SCIENCE further insight.

On Wed, Nov 4, 2020 at 12:49 PM Huddleston, Misty <Misty.Huddleston@hdrinc.com> wrote:

Good afternoon John,

I wanted to follow up with you regarding the status of the data collection efforts for the Byllesby/Buck (FERC No. 2514) Fish Community Study and to request your input on the path forward for completing the study.

As Jon Studio (Edge Engineering) has previously discussed with you, the boat shocking portion of the study has been completed, but weather and high flows have prevented the field crews from completing the gillnet or backpack electrofishing samples at the site. Based on your conversations with Jon Studio, I understand that you support the collection of gillnet data in November as the target organism (Walleye) will still be mobile at that time.

Can you confirm that this is still acceptable and provide any additional criteria or threshold where you believe the collected data would no longer be valid?

Regarding backpack electrofishing efforts, recent weather forecasts indicate additional precipitation and cooler temps are present or moving into the watershed this week. Based on the predicted flows and colder temperatures, we believe that it is appropriate to move this sampling effort to August/September 2021. As a result, we will have boat electrofishing and gillnet samples (likely) collected in fall 2020 and backpack electrofishing samples collected in August/September 2021.

Do you foresee any issues or concerns with the proposed revised approach and the use of these data to support the relicensing effort at Byllesby-Buck?

Let us know if you have any other recommendations or concerns or if you would prefer to have a call to discuss this issue in further detail.

Thanks,

Misty

Misty Huddleston, PhD

Associate, SR. Environmental Scientist

HDR