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Via Electronic Filing October 18, 2019

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Subject: Byllesby-Buck Hydroelectric Project (FERC No. 2514-186)
Filing of Revised Study Plan for Relicensing Studies

Dear Secretary Bose:

Appalachian Power Company (Appalachian or Applicant), a unit of American Electric Power (AEP) is the Licensee, owner, and operator of the 30.1 megawatt (MW) Byllesby-Buck Hydroelectric Project (Project No. 2514-186) (Project or Byllesby-Buck Project), located on the New River in Carroll County, Virginia. The Byllesby development is located about nine miles north of the City of Galax, and the Buck development is located approximately three river miles (RM) downstream of Byllesby and 43.5 RM upstream of Claytor Dam.

The existing license for the Project was issued by the Federal Energy Regulatory Commission (FERC or Commission) for a 30-year term, with an effective date of March 28, 1994 and expires February 29, 2024. Accordingly, Appalachian is pursuing a new license for the Project pursuant to the Commission's Integrated Licensing Process (ILP), as described at 18 Code of Federal Regulations (CFR) Part 5. In accordance with 18 CFR §5.11 of the Commission's regulations, Appalachian is filing the Revised Study Plan (RSP) describing the studies that the Licensee is proposing to conduct in support of relicensing the Project.

Background

Appalachian filed a Pre-Application Document (PAD) and associated Notice of Intent (NOI) with the Commission on January 7, 2019, to initiate the ILP. The Commission issued Scoping Document 1 (SD1) for the Project on March 8, 2019. SD1 was intended to advise resource agencies, Indian tribes, non-governmental organizations, and other stakeholders as to the proposed scope of FERC's Environmental Assessment (EA) for the Project and to seek additional information pertinent to the Commission's analysis.

On April 10 and 11, 2019, the Commission held public scoping meetings in Galax, Virginia. During these meetings, FERC staff presented information regarding the ILP and details regarding the study scoping process and how to request a relicensing study, including the Commission's study criteria. In addition, FERC staff solicited comments regarding the scope of issues and analyses for the EA. Pursuant to 18 CFR §5.8(d), a public site visit of the Project was conducted on April 10, 2019.

Resource agencies, Indian tribes, and other interested parties were afforded a 60-day period to request studies and provide comments on the PAD and SD1. The comment period was initiated with the Commission's March 8, 2019 notice and concluded on May 7, 2019. During the comment period, a total of ten stakeholders filed letters with the Commission providing general comments, comments regarding the PAD, comments regarding SD1, and/or study requests. FERC issued Scoping Document 2 (SD2) on June 21, 2019 to provide information on the proposed action and alternatives, the environmental analysis process FERC staff will follow to prepare the EA, and a revised list of issues to be addressed in the EA.

In accordance with 18 CFR §5.11, Appalachian developed a Proposed Study Plan (PSP) for the Project that was filed with the Commission and made available to stakeholders on June 21, 2019. The purpose of the PSP was to present the studies proposed by Appalachian and to address the comments and study requests submitted by resource agencies and other stakeholders. The PSP described Appalachian's proposed approaches for conducting studies and addressed agency and stakeholder study requests. Pursuant to 18 CFR §5.11(e), Appalachian held a PSP Meeting on July 18, 2019, for the purpose of clarifying the PSP, explaining any initial information gathering needs, and addressing any outstanding issues associated with the PSP. Appalachian distributed additional information requested during the meeting to FERC staff and agencies by email communications subsequent to the PSP meeting.

Resource agencies and stakeholders were afforded 90 days from the date of the PSP filing (i.e., until September 19, 2019) to provide comments on the PSP or to request additional studies. The Commission's regulations require that comments on the PSP include an explanation of any study plan concerns and any accommodations reached with Appalachian regarding those concerns (18 CFR §5.12). Any proposed modifications to the PSP are also required to address the Commission's criteria as presented in 18 CFR §5.9(b).

Appalachian received timely formal comments on the PSP from FERC, the U.S. Fish and Wildlife Service (USFWS), and the Virginia Department of Game and Inland Fisheries (VDGIF), as described and included in the enclosed RSP. In developing the RSP, Appalachian has carefully evaluated and considered all agency and stakeholder comments and study requests received, as well as discussions during and communications following the PSP meeting.

Revised Study Plan

In developing the RSP, Appalachian evaluated all the study requests and comments submitted by the stakeholders, with a focus on the requests that specifically addressed the seven criteria for study requests as set forth at 18 CFR §5.9(b) of the Commission's ILP regulations. For the study requests that did not address the seven study criteria, where appropriate, Appalachian considered the study in the context of providing the requested information in conjunction with one or more of Appalachian's proposed studies.

This RSP takes into account the Commission's June 21, 2019 SD2 as well as comments on the PSP filed by stakeholders. Based on Appalachian's review of the requested studies, the FERC criteria for study requests under the ILP, the discussions during the PSP meeting, and formal comments on the PSP, Appalachian is proposing to conduct the following studies as described in detail in the RSP:

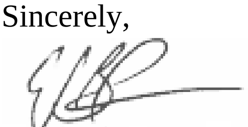
1. Flow and Bypass Reach Aquatic Habitat Study;
2. Water Quality Study;
3. Aquatic Resources Study;
4. Wetlands, Riparian, and Littoral Habitat Characterization Study;
5. Terrestrial Resources Study;
6. Shoreline Stability Assessment Study;
7. Recreation Study; and
8. Cultural Resources Study.

Appalachian is filing the RSP with the Commission electronically and is distributing this letter to the parties listed on the attached distribution list. For parties listed on the attached distribution list who have provided an email address, Appalachian is distributing this letter via email; otherwise, Appalachian is distributing this letter via U.S. mail. All parties interested in the relicensing process may obtain a copy of the RSP electronically through FERC's eLibrary system at https://elibrary.ferc.gov/idmws/search/fercgensearch.asp under docket number P-2514-186, or on Appalachian's website at http://www.aephydro.com/HydroPlant/ByllesbyBuck.

Comments on the RSP must be filed within 15 days of the filing date of this RSP which is no later than November 3, 2019. The Commission will issue a final Study Plan Determination by November 18, 2019.

If there are any questions regarding the RSP or the overall relicensing process for the Project, please do not hesitate to contact me at (540) 985-2441 or via email at ebparcell@aep.com.

Sincerely,



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Revised Study Plan

Byllesby-Buck Hydroelectric Project

FERC No. 2514

October 18, 2019

Prepared by:

HDR

Prepared for:

Appalachian Power Company

APPALACHIAN POWER

An AEP Company

BOUNDLESS ENERGY

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Contents

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Figures

Appendices

List of Acronyms

1-D	one-dimensional
2-D	two-dimensional
3-D	three-dimensional
ACHP	Advisory Council on Historic Preservation
AEP	American Electric Power
APE	Area of Potential Effects
Appalachian	Appalachian Power Company (or Licensee)
BEHI	Bank Erosion Hazard Index
CFR	Code of Federal Regulations
cfs	cubic feet per second
CRMP	Cultural Resources Management Plan or Management Plan
DLA	Draft License Application
DO	dissolved oxygen
EA	Environmental Assessment
FERC	Federal Energy Regulatory Commission (FERC or Commission)
FLA	Final License Application
FR	Federal Register
GIS	Geographic Information System
GPS	Global Positioning System
ILP	Integrated Licensing Process
ISR	Initial Study Report
NAGPRA	Native American Graves Protection and Repatriation Act
NEPA	National Environmental Policy Act of 1969
NGOs	non-governmental organizations
NGVD	National Geodetic Vertical Datum
NOI	Notice of Intent
NPS	National Park Service
NRC	New River Conservancy
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
PAD	Pre-Application Document
PCBs	polychlorinated biphenyls
PM&E	protection, mitigation and enhancement
Project	Byllesby-Buck Hydroelectric Project
PSP	Proposed Study Plan
RM	river mile
RSP	Revised Study Plan
SD1	Scoping Document 1
SD2	Scoping Document 2
SHPO	State Historic Preservation Office
Stantec	Stantec Consulting Services, Inc.
TMDL	total maximum daily load
TCP	Traditional Cultural Property
U.S.C.	United States Code

USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USR	Updated Study Report
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VDGIF	Virginia Department of Game and Inland Fisheries
Virginia Tech	Virginia Polytechnic Institute and State University

1 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 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 18 CFR §5.13 of the Commission's regulations, Appalachian is filing this Revised Study Plan (RSP) with the Commission in support of relicensing the Project.

1.1 Study Plan Overview

Appalachian filed a Pre-Application Document (PAD) and associated Notice of Intent (NOI) with the Commission on January 7, 2019, to initiate the ILP. The PAD provides a description of the Project and summarizes the existing, relevant, and reasonably available information to assist the Commission, resource agencies, Indian Tribes, non-governmental organizations (NGOs), and other stakeholders in identifying issues, determining information needs, and preparing study requests.

The National Environmental Policy Act of 1969, the Commission's regulations, and other applicable statutes require the Commission to independently evaluate the environmental effects of issuing a subsequent license for the Project and to consider reasonable alternatives to relicensing. At this time, the Commission has expressed its intent to prepare an Environmental Assessment (EA) that describes and evaluates the site-specific and cumulative potential effects (if any) of issuing a subsequent license, as well as potential alternatives to relicensing. The EA is supported by a scoping process to identify issues, concerns, and opportunities for resource enhancement associated with the proposed action. Accordingly, the Commission issued Scoping Document 1 (SD1) for the Project on March 8, 2019. SD1 was intended to advise resource agencies, Indian Tribes, NGOs, and other stakeholders as to the proposed scope of the EA and to seek additional information pertinent to the Commission's analysis. As provided in 18 CFR §5.8(a) and §5.18(b), the Commission issued a notice of commencement of the relicensing proceeding concomitant with SD1.

On April 10 and 11, 2019, the Commission held public scoping meetings in Galax, Virginia. During these meetings, FERC staff presented information regarding the ILP, details regarding the study scoping process, and how to request a relicensing study, including the Commission's study criteria. In addition, FERC staff solicited comments regarding the scope of issues and analyses for the EA. Pursuant to 18 CFR §5.8(d), a public site visit of the Project was conducted on April 10, 2019.

Resource agencies, Indian Tribes, NGOs, and other interested parties were afforded a 60-day period to request studies and provide comments on the PAD and SD1. The comment period was initiated with the Commission's March 8, 2019 notice of commencement and concluded on May 7, 2019.

During that time period, a total of ten stakeholders filed letters with the Commission providing general comments and comments regarding the PAD, SD1, and/or study requests. Seven formal study requests were received from U.S. Fish and Wildlife Service (USFWS), Virginia Department of Game and Inland Fisheries (VDGIF), and Virginia Polytechnic Institute and State University (Virginia Tech) during the comment period. Copies of the letters filed with the Commission are provided in Appendix A of this document.

FERC issued Scoping Document 2 (SD2) on June 21, 2019 to provide information on the proposed action and alternatives, the environmental analysis process FERC staff will follow to prepare the EA, and a revised list of issues to be addressed in the EA.

In accordance with 18 CFR §5.11, Appalachian developed a Proposed Study Plan (PSP) for the Project that was filed with the Commission and made available to stakeholders on June 21, 2019. The purpose of the PSP was to present the studies proposed by Appalachian and to address the comments and study requests submitted by resource agencies and other stakeholders. The PSP described Appalachian's proposed approaches for conducting studies and addressed agency and stakeholder study requests. Pursuant to 18 CFR §5.11(e), Appalachian held a PSP Meeting on July 18, 2019, for the purpose of clarifying the PSP, explaining any initial information gathering needs, and addressing any outstanding issues associated with the PSP. The meeting was held at the AEP Service Center in Wytheville, Virginia. Attendees included representatives from FERC, USFWS, VDGIF, and the New River Conservancy (NRC). Resource agencies and stakeholders were afforded 90 days from the date of the PSP filing (i.e. until September 19, 2019) to provide comments on the PSP or request additional studies.

Appalachian received timely formal comments on the PSP from FERC, USFWS, and VDGIF, which are included in Appendix B. In developing this RSP, Appalachian has carefully evaluated and considered all agency and stakeholder comments and study requests received, as well as discussions during the PSP meeting.

Relicensing participants may file comments on the RSP within 15 days of this filing (i.e., on or before November 3, 2019). Appalachian notes that FERC's ILP regulations require that stakeholders who provide study requests include specific information in the request in order to allow the Licensee, as well as Commission staff, to determine a requested study's appropriateness and relevancy to the Project and proposed action. As described in 18 CFR §5.9(b) of the Commission's ILP regulations, and as presented by FERC staff during the April 10 and 11, 2019 scoping meetings, the required information to be included in a study request is as follows:

(1) Describe the goals and objectives of each study and the information to be obtained (§5.9(b) (1));

This section describes why the study is being requested and what the study is intended to accomplish, including the goals, objectives, and specific information to be obtained. The goals of the study must clearly relate to a need to evaluate the effects of the Project on a particular resource. The objectives are the specific information that needs to be gathered to allow achievement of the study goals.

(2) If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied (§5.9(b) (2));

This section must clearly establish the connection between the study request and management goals or resource of interest. A statement by an agency connecting its study request to a legal, regulatory, or policy mandate needs to be included that thoroughly explains how the mandate relates to the study request, as well as the Project's potential impacts.

(3) If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study (§5.9(b) (3));

This section is for non-agency or Indian Tribes to establish the relationship between the study request and the relevant public or tribal interest considerations.

(4) Describe existing information concerning the subject of the study proposal and the need for additional information (§5.9(b) (4));

This section must discuss any gaps in existing data by reviewing the available information presented in the PAD or information relative to the Project that is known from other sources. This section must explain the need for additional information and why the existing information is inadequate.

(5) Explain any nexus between project operation and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirements (§5.9(b) (5));

This section must clearly connect Project operations and Project effects on the applicable resource. This section can also explain how the study results would be used to develop PM&E measures that could be implemented under a new FERC license. The PM&E measures can include those related to any mandatory conditioning authority under Section 401 of the Clean Water Act[1] or Sections 4(e) and 18 of the Federal Power Act, as applicable.

(6) Explain how any proposed study methodology is consistent with generally accepted practices in the scientific community or, as appropriate, considers relevant tribal values and knowledge. This includes any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration (§5.9(b) (6));

This section must provide a detailed explanation of the study methodology. The methodology may be described by outlining specific methods to be implemented or by referencing an approved and established study protocol and methodology.

(7) Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs (§5.9(b) (7));

This section must describe the expected level of cost and effort to conduct the study. If there are proposed alternative studies, this section can address why the alternatives would not meet the stated information needs.

1.2 Appalachian's Revised Study Plan

In developing the PSP, Appalachian evaluated the study requests submitted by the stakeholders, with a focus on the requests that specifically addressed the seven criteria set forth in §5.9(b) of the Commission's ILP regulations, as discussed above. Appalachian considered the comments made on the proposed studies for possible incorporation into the study and in the development of the study plan. Regarding the comments made on Appalachian's proposed studies, where appropriate, Appalachian considered the comment in the context of providing the requested information or methods in conjunction with one of Appalachian's proposed studies.

This RSP takes into account the Commission's June 21, 2019 SD2 and comments on the PSP, as well as comments on the PSP filed by relicensing participants, including USFWS and VDGIF.

Based on Appalachian's review of the requested studies, FERC criteria for study requests under the ILP, and other available information (e.g., associated with the previous licensing effort or resulting from ongoing monitoring activities), the discussion during the PSP meetings, and formal and informal comments on the PSP, Appalachian is proposing eight studies to be performed in support of issuing a new license for the Project. Information regarding each of these studies is provided in Sections 4 through 11 of this RSP. For each of Appalachian's proposed studies, this RSP describes:

[1] 33 U.S.C. §1251 et seq.

1. The goals and objectives of the study;
2. The defined Study Area;
3. A summary of background and existing information pertaining to the study;
4. The nexus between Project operations and potential effects on the resources to be studied;
5. The proposed study methodology; and
6. Level of effort, cost, and schedules for conducting the study.

1.3 Project Description, Location, and Study Area

The Project is located on the upper New River in Carroll County, Virginia, approximately 60 miles south-southwest of the city of Roanoke (Figure 1-1). 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. Aerial views of the Project facilities and the FERC Project boundary, described in Section 4.3 of the PAD, are provided in Figure 1-1 through Figure 1-3.

In comments filed on the PAD, USFWS, Virginia Department of Environmental Quality (VDEQ), VDGIF, National Park Service (NPS), NRC, and Virginia Tech stated that the existing Project boundary does not adequately capture the area affected by project operations, and that the uppermost 1-mile-long stretch of the Buck reservoir should be included in the FERC Project boundary. In comments filed on the PAD and SD1 and/or on the PSP, USFWS, VDGIF, and NRC further stated that the study area should extend further upstream and downstream of the Project to capture all potential impacts of Project operations. Appalachian is not proposing to modify the Project boundary at this time, as lands along this reach of the river do not presently serve any Project purposes, but expects to reevaluate this during the course of this relicensing. To address stakeholders' comments for purposes of the ILP study plans, Appalachian proposes, unless otherwise noted within an individual study plan, to use a continuous "Study Area" that encompasses both developments and includes additional specific, adjacent areas of potential interest to FERC or other stakeholders (Figure 1-4). Appalachian believes that, consistent with ILP Study Criteria No. 7, the tasks and activities within the proposed study areas described in this RSP are sufficient to inform agency recommendations and FERC license conditions for the Project, and focusing the geographic scope of the proposed studies on this Study Area and the Project boundary is consistent with generally accepted practice in the scientific community and within FERC relicensing criteria (ILP Study Criteria No. 6).

Figure 1-1. Byllesby-Buck Project Location Map

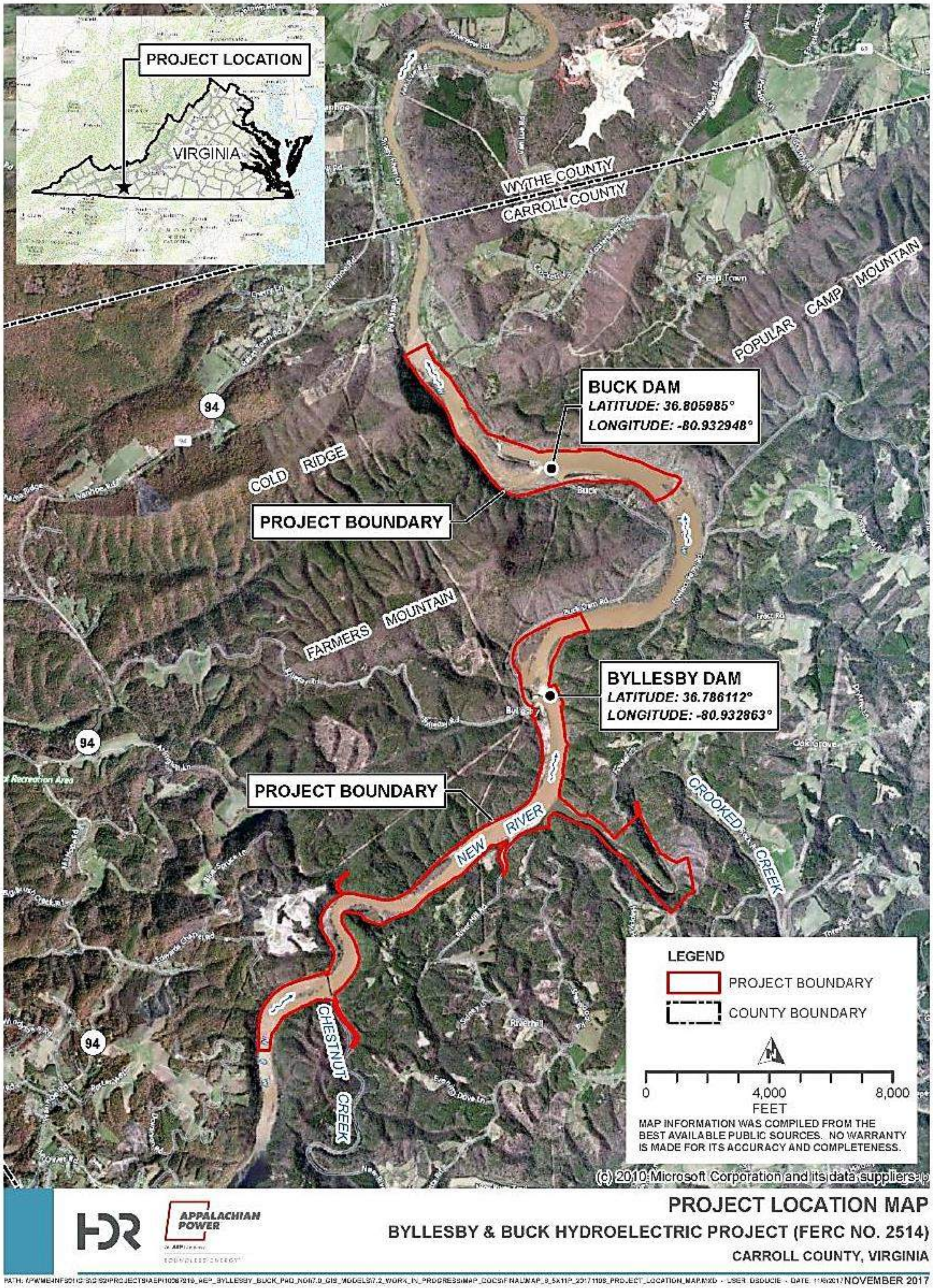


Figure 1-2. Byllesby Project Facilities

Figure 1-3. Buck Project Facilities

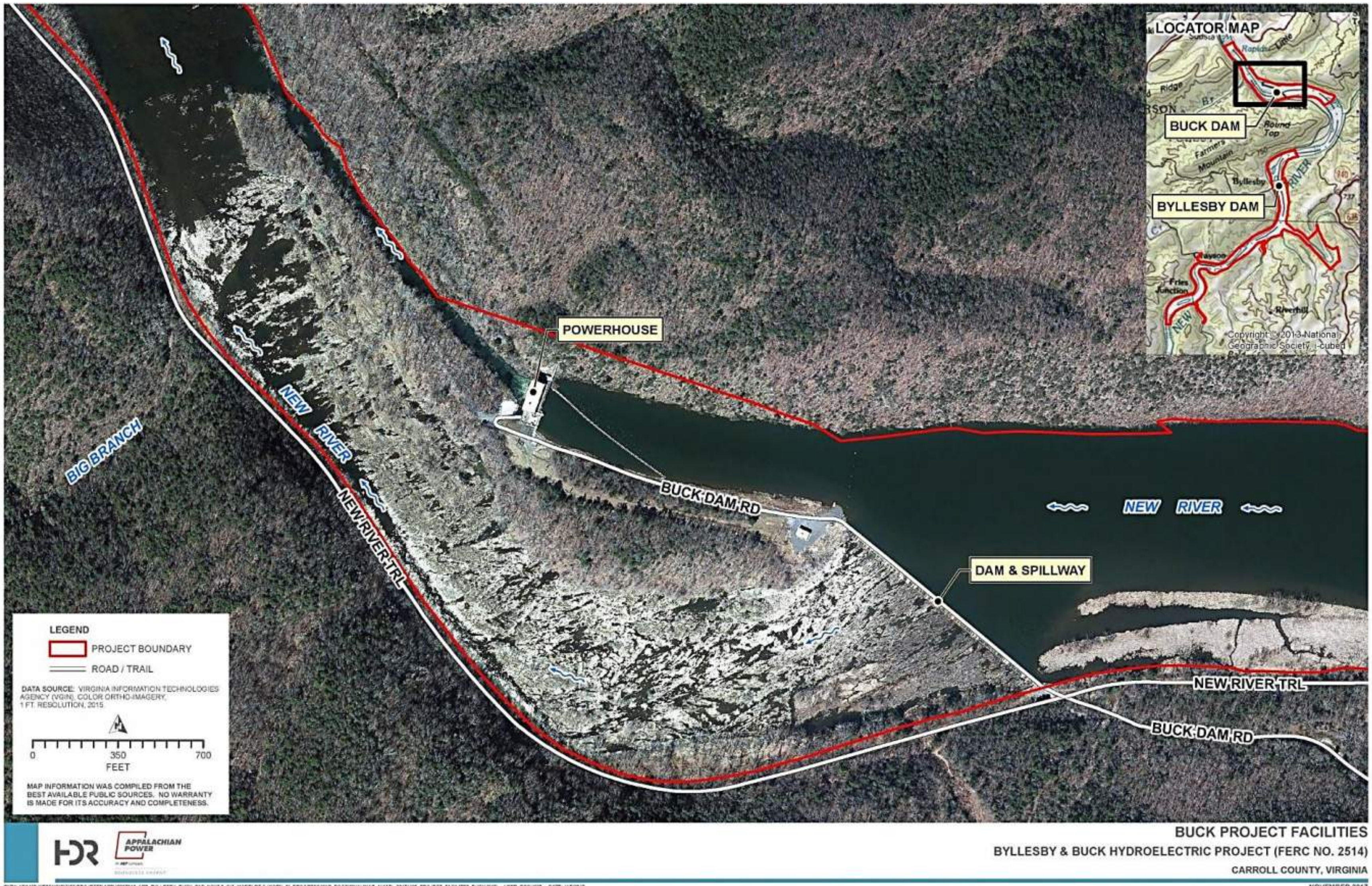
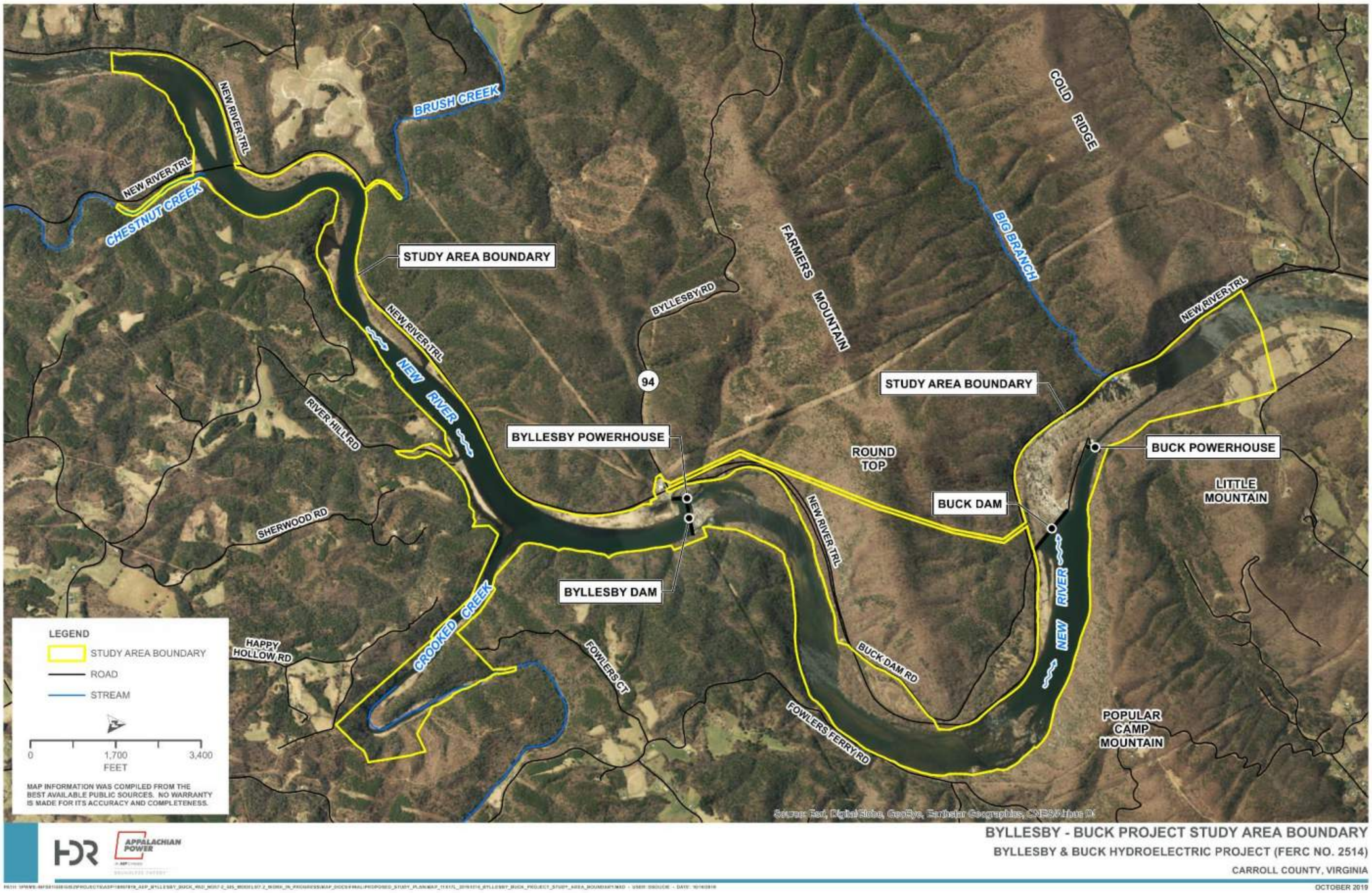


Figure 1-4. Byllesby-Buck Project Study Area



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2 Execution of the Study Plan

As required by Section 5.15 of FERC's ILP regulations, Appalachian will prepare progress reports on a quarterly basis, file an Initial Study Report (ISR), hold an ISR Meeting with stakeholders and FERC staff to discuss the initial study results, and prepare and file an Updated Study Report (USR), and convene an associated USR Meeting as appropriate. Appalachian will submit all study documents that must be filed with the Commission via FERC's eFiling system.

2.1 Process Plan and Schedule

The Process Plan and Schedule, as appended to FERC's SD1, is presented in Table 2-1. Gray shaded milestones are unnecessary if there are no study disputes. If the due date falls on a weekend or holiday, the due date is the following business day. Early filings or issuances will not result in changes to these deadlines.

Table 2-1. Process Plan and Schedule

Milestone	Responsible Party	Time Frame	Estimated Date
File NOI and PAD (18 CFR §5.5, 5.6)	Appalachian	As early as 5.5 years but no later than 5 years prior to license expiration	January 7, 2019
Initial Tribal Consultation Meeting (18 CFR §5.7)	FERC	No later than 30 days of filing NOI and PAD	February 6, 2019
Issue Notice of PAD/NOI and SD1 (18 CFR §5.8(a))	FERC	Within 60 days of filing NOI and PAD	March 8, 2019
Conduct Scoping Meetings and Site Visit (18 CFR §5.8(b) (viii))	FERC	Within 30 days of NOI/PAD notice and SD1 issuance	April 10-11, 2019
Comments on PAD, SD1, and Study Requests (18 CFR §5.9)	Stakeholders	Within 60 days of NOI/PAD notice and issuance of SD1	May 7, 2019
Issuance of Scoping Document 2 (SD2) (18 CFR §5.10) (if necessary)	FERC	Within 45 days of deadline for filing comments on SD1	June 21, 2019
File PSP (18 CFR §5.11(a))	Appalachian	Within 45 days of deadline for filing comments on PAD	June 21, 2019
Study Plan Meeting(s) (18 CFR §5.11(e))	Appalachian	Meeting to be held within 30 days of filing PSP	July 21, 2019
Comments on PSP (18 CFR §5.12)	Stakeholders	Within 90 days of filing PSP	September 19, 2019
File RSP (18 CFR §5.13(a))	Appalachian	Within 30 days of deadline for comments on PSP	October 19, 2019

Milestone	Responsible Party	Time Frame	Estimated Date
Comments on RSP (18 CFR §5.13(b))	Stakeholders	Within 15 days following RSP	November 3, 2019
Issuance of Study Plan Determination (18 CFR §5.13(c))	FERC Director	Within 30 days of RSP	November 18, 2019
Formal Study Dispute Resolution Process (18 CFR §5.14(a)) (if necessary)	Agencies and Tribes with mandatory conditioning authority	Within 20 days of study plan determination	December 8, 2019
Third Dispute Resolution Panel Member Selection (18 CFR §5.14(d)) (if necessary)	Dispute Resolution Panel	Within 15 days of a notice of study dispute	December 23, 2019
Convene Dispute Resolution Panel (18 CFR §5.14(d)(3)) (if necessary)	Dispute Resolution Pan	Within 20 days of a notice of study dispute	December 28, 2019
Comments on Study Plan Disputes (18 CFR §5.14(i)) (if necessary)	Appalachian	Within 25 days of notice of study dispute	January 2, 2020
Dispute Resolution Panel Technical Conference (18 CFR §5.14(j)) (if necessary)	Dispute Resolution Panel, Appalachian, Stakeholders	Prior to engaging in deliberative meetings	January 7, 2020
Dispute Resolution Panel Findings and Recommendations (18 CFR §5.14(k)) (if necessary)	Dispute Resolution Panel	No later than 50 days after notice of dispute	January 27, 2020
Study Dispute Determination (18 CFR §5.14(l)) (if necessary)	FERC Director	No later than 70 days after notice of dispute	February 16, 2020
Conduct First Season of Studies (18 CFR §5.15(a))	Appalachian	N/A	Spring-Fall 2020
Study Progress Report (18 CFR §5.15(b))	Appalachian	Appalachian will provide summary updates every three months	Quarterly, beginning in Quarter 2 of 2019 through filing of the USR

Milestone	Responsible Party	Time Frame	Estimated Date
ISR (18 CFR §5.15(c)(1))	Appalachian	Pursuant to the Commission-approved study plan or no later than 1 year after Commission approval of the study plan, whichever comes first	November 17, 2020
ISR Meeting (18 CFR §5.15(c)(2))	Appalachian and Stakeholders	Within 15 days of filing the ISR	December 2, 2020
File ISR Meeting Summary (18 CFR §5.15(c)(3))	Appalachian	Within 15 days of ISR meeting	December 17, 2020
File Meeting Summary Disagreements (18 CFR §5.15(c)(4)) (if necessary)	Stakeholders	Within 30 days of study results meeting summary	January 16, 2021
File Responses to Meeting Summary Disagreements (18 CFR §5.15(c)(5)) (if necessary)	Appalachian	Within 30 days of filing meeting summary disagreements	February 15, 2021
Resolution of Disagreements (18 CFR §5.15(c)(6)) (if necessary)	FERC Director	Within 30 days of filing responses to disagreements	March 17, 2021
Conduct Second Season of Studies (18 CFR §5.15(a)) (if necessary)	Appalachian	N/A	Spring-Fall 2021
File Preliminary Licensing Proposal or Draft License Application (DLA) (18 CFR §5.16(a))	Appalachian	No later than 150 days prior to the deadline for filing the Final License Application (FLA)	October 1, 2021
File Updated Study Report (18 CFR §5.15(f)) (if necessary)	Appalachian	Pursuant to the Commission approved study plan and schedule provided in §5.13 or no later than two years after Commission approval	November 17, 2021
Updated Study Report Meeting (18 CFR §5.15(f)) (if necessary)	Appalachian and Stakeholders	Within 15 days of updated study report	December 2, 2021
File Updated Study Report Meeting Summary (18 CFR §5.15(f)) (if necessary)	Appalachian	Within 15 days of study report meeting	December 17, 2021

Milestone	Responsible Party	Time Frame	Estimated Date
Comments on Preliminary Licensing Proposal or DLA Due (18 CFR §5.16(e))	Stakeholders	Within 90 days of filing Preliminary Licensing Proposal or DLA	December 30, 2021
File Meeting Summary Disagreements (18 CFR §5.15(c)(4)) (if necessary)	Stakeholders	Within 30 days of study results meeting summary	January 16, 2022
File Responses to Meeting Summary Disagreements (18 CFR §5.15(f)(5)) (if necessary)	Appalachian	Within 30 days of filing meeting summary disagreements	February 15, 2022
File FLA (18 CFR §5.17)	Appalachian	No later than 24 months before the existing license expires	February 28, 2022
Issue Public Notice of FLA Filing (18 CFR §5.17(d)(2))	Appalachian	Within 14 days of filing FLA	March 14, 2022
Resolution of Disagreements (18 CFR §5.15(f)) (if necessary)	FERC Director	Within 30 days of filing responses to disagreements	March 17, 2022

2.2 General Concepts and Procedures

The following general understandings, concepts, and practices will apply to the study:

- Personal safety is the most important consideration of each fieldwork team.
- Access to the Buck development bypass reach is limited in some portions of the reach. The primary access is either in-channel or by descending banks with no defined trails, and fieldwork will require traversing uneven, wet, and often slick surfaces. As a result, field logistics will be an extremely important consideration in selecting study sites and locations for measuring calibration flows.
- Appalachian or their consultant will make a good faith effort to obtain permission to access private property if and where needed well in advance of entering the property.
- Field crews may make minor variances to the FERC-approved study in the field to accommodate actual field conditions and unforeseen problems. When minor variances are made, the Project's field crew will follow the protocols in the FERC-approved study and the variances will be subsequently communicated to relicensing participants through the quarterly progress reports.

- Global Positioning System (GPS) data will be collected and exported into a Geographic Information Systems (GIS)-compatible file format in an appropriate coordinate system, using desktop software.

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3 Responses to Stakeholder Study Requests

In developing this RSP, Appalachian has carefully evaluated and considered agency and stakeholder comments and study requests filed in response to the PAD, SD1, PSP, and as discussed during the PSP meetings.

3.1 Response to Comments and Study Requests Received in Response to the PAD and SD1

Appalachian filed the PAD for the Project on January 7, 2019. FERC issued SD1 on March 8, 2019 and conducted public scoping meetings on April 10 and 11, 2019 in Galax, Virginia. In accordance with ILP regulations, comments on the PAD and SD1 and study requests were due to FERC by May 7, 2019. Appalachian received study requests and or comment letters from the following stakeholders:

- Cherokee Nation
- Virginia Department of Conservation and Recreation (Division of Planning and Recreation Resources and Division of Natural Heritage)
- Delaware Nation
- Virginia Tech College of Natural Resources and Environment and Fish and Wildlife Conservation
- Virginia Department of Health
- National Park Service
- U.S. Fish and Wildlife Service
- Virginia Department of Environmental Quality
- New River Conservancy
- Virginia Department of Game and Inland Fisheries

In preparation of the PSP, Appalachian reviewed the stakeholder comments and study requests included in the FERC record. A summary of study requests and study-related comments is provided in Table 3-1. (Note that comments filed in response to the PSP are addressed in Section 3.2.)

Table 3-1. Summary of Study Requests and Study-Related Comments on the PAD and SD1

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Criteria Met?[2]	Addressed in RSP? (Y/N)[2]	Response
Operations					
Comments on Flow and Bypass Reach Aquatic Habitat Study regarding incorporation of the Inflatable Obermeyer Crest Gate Operational Effectiveness Evaluation, assessment of fish stranding, surface water connectivity, and flow modeling.	G. LaRouch, USFWS W. Kittrell, VDGIF L. Walters, NRC	May 7, 2019 May 7, 2019 May 7, 2019	N/A	Y	Methods for evaluating configuration of flow releases and effects to aquatic habitat are evaluated in the Flow and Bypass Reach Aquatic Habitat Study.
Request for Instream Flow Study to determine effects of proposed discharge to the bypass and/or reduced spillage to the tailwater.	G. LaRouch, USFWS	May 7, 2019	Y	Y (alt)	Methods for evaluating effects of flows released to the bypass are included in the Flow and Bypass Reach Aquatic Habitat Study.
Sediment					
Comment on proposed studies regarding including monitoring concentrations of polychlorinated biphenyls (PCBs) within the sediment that may be dredged or present in wetlands or behind dams.	J. Grist, VDEQ	May 7, 2019	N/A	N	A draft total maximum daily load (TMDL) developed for the New River in September 2018 indicates PCB impairment is downstream of the Project. No dredging of reservoir sediment is proposed at this time. Any future dredging and disposal would be coordinated with the U.S. Army Corps of Engineers (USACE) and VDEQ.
Comments on Shoreline Stability Assessment regarding the need to include a sediment transport assessment.	G. LaRouch, USFWS W. Kittrell, VDGIF L. Walters, NRC	May 7, 2019 May 7, 2019 May 7, 2019	N/A	N	See discussion in Section 3.2.
Requests for Comprehensive Sediment Study to Develop a Sediment Management Plan.	W. Kittrell, VDGIF (requested) G. LaRouch, USFWS (supports) L. Walters, NRC (supports)	May 7, 2019 May 7, 2019 May 7, 2019	Y	N	See discussion in Section 3.2.

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Criteria Met?[2]	Addressed in RSP? (Y/N)[2]	Response
Request for PCB contamination and pollution minimization plan.	D. Orth, Virginia Tech	March 15, 2019	N- does not discuss level of effort or cost (study criteria no. 7).	N	A draft TMDL developed for the New River in September 2018 indicates PCB impairment is downstream of the Project. No dredging of reservoir sediment is proposed at this time. Any future dredging and disposal would be coordinated with the USACE and VDEQ.
Water Quality					
Comment on Water Quality Study regarding study design and location of water quality data loggers.	C. Carey, Virginia Tech	May 1, 2019	N/A	N	Refer to the Water Quality study plan for details regarding study design and location of water quality data loggers.
Comments on Water Quality Study regarding incorporating thermal, chlorophyll a, and turbidity sampling to the proposed study plan.	G. LaRouch, USFWS W. Kittrell, VDGIF L. Walters, NRC	May 7, 2019 May 7, 2019 May 7, 2019	N/A	Y	Temperature, chlorophyll a, and turbidity parameters are included in the proposed study plan.
Comment providing clarification that several surface water intakes and sources are located within a 5-mile radius of the project site and that Best Management Practices should be implemented where appropriate to prevent impacts to nearby surface waters.	VDH	April 30, 2019	N/A	N/A	Information is outside the scope of the PSP.
Biology					
Comments on studies not proposed: broad aquatic studies including surveys on fauna (fish, macroinvertebrates, mussels, hellbender, crayfish) and aquatic vegetation beds.	D. Orth, Virginia Tech C. Carey, Virginia Tech W. Kittrell, VDGIF G. LaRouch, USFWS L. Walters, NRC	March 15, 2019 May 1, 2019 May 7, 2019 May 7, 2019 May 7, 2019	N/A	Y	The Aquatic Resources Study and Wetlands, Riparian, and Littoral Habitat Characterization Study will include fish and macroinvertebrate sampling, as well as wetlands, riparian, and littoral zone (i.e., vegetation aquatic bed) habitat surveys.

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Criteria Met?[2]	Addressed in RSP? (Y/N)[2]	Response
Requests for Biological and Aquatic Vegetation Surveys, including the survey of multiple fauna and foundational aquatic vegetation beds within the Project area.	G. LaRouch, USFWS W. Kittrell, VDGIF L. Walters, NRC	May 7, 2019 May 7, 2019 May 7, 2019	Y	Y	The Aquatic Resources Study and Wetlands, Riparian, and Littoral Habitat Characterization Study will include fish and macroinvertebrate sampling, as well as wetlands, riparian, and littoral zone (i.e., vegetation aquatic bed) habitat surveys.
Request for Enhancement Plan for Biodiversity and Sport Fishing in Project area.	D. Orth, Virginia Tech	March 15, 2019	N- does not discuss level of effort or cost (study criteria no. 7).	Y (alt)	An assessment of the fish and macroinvertebrate community composition and abundance will be performed in the Aquatic Resources Study, as well as an assessment of recreational (potentially including angler) use in the Recreation Study. Continuous monitoring and management within the Project boundary is not planned at this time.
Request for Fish Protection and Downstream Passage Study.	G. LaRouch, USFWS	May 7, 2019	Y	Y (alt)	The potential (i.e., risk) for fish entrainment or impingement will be evaluated in the Aquatic Resources Study. Fish protection measures may be considered following the entrainment and impingement assessment. Fish passage measures are not being considered at this time due to downstream impediments.
Request of Rare Dragonflies and Multi-Taxa Survey.	D. Orth, Virginia Tech	March 15, 2019	N- does not discuss level of effort or cost (study criteria no. 7).	Y	The Aquatic Resources Study and Wetlands, Riparian, and Littoral Habitat Characterization Study will include fish and macroinvertebrate sampling, as well as wetlands, riparian, and littoral zone (i.e., vegetation aquatic bed) habitat surveys.

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Criteria Met?[2]	Addressed in RSP? (Y/N)[2]	Response
Comment on studies not proposed: updated Virginia spiraea surveys.	C. Carey, Virginia Tech	May 1, 2019	N/A	Y (alt)	The Wetlands, Riparian, and Littoral Habitat Characterization Study will encompass potential habitat of Virginia spiraea. No additional surveys are proposed (see Section 3.2.2).
Comments on Wetlands and Riparian Habitat Characterization study requesting the inclusion of emergent and submerged aquatic vegetation beds within the Project area.	G. LaRouch, USFWS W. Kittrell, VDGIF L. Walters, NRC	May 7, 2019 May 7, 2019 May 7, 2019	N/A	Y	The Wetlands, Riparian, and Littoral Habitat Characterization Study will include riparian and littoral zone habitat for aquatic vegetation surveys.
Request for Water Willow Propagation, Rehabilitation, and Water Level Plan.	D. Orth, Virginia Tech	March 15, 2019	Y	Y	The shorelines potentially benefiting from vegetative plantings to reduce erosion will be surveyed during the Shoreline Stability Assessment Study. Existing Water Willow within the Study Area will be surveyed during the Wetland and Riparian Habitat Characterization Study.
Comment on Flow and Bypass Reach Aquatic Habitat Study, regarding the need for field studies.	C. Carey, Virginia Tech	May 1, 2019	N/A	Y	Field studies are proposed in the PSP for the Flow and Bypass Reach Aquatic Habitat Study.
Request for Target Biological Community in the Two Bypass Reaches and Rehabilitation of the Foundational Plan, Riverweed.	D. Orth, Virginia Tech	March 15, 2019	N- does not discuss level of effort or cost (study criteria no. 7).	Y (alt)	The bypass reach flows and associated aquatic habitat will be evaluated in the Flow and Bypass Reach Aquatic Habitat Study. Rehabilitation via plantings is not planned at this time.
Recreation					
Comments on Recreational Needs Assessment regarding proposed effort and need for additional information.	G. LaRouch, USFWS W. Kittrell, VDGIF L. Walters, NRC K. Mendik, NPS	May 7, 2019 May 7, 2019 May 7, 2019 May 7, 2019	N/A	Y	Methods and effort to assess recreational needs in the Study Area are described in the Recreation Study Plan.

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Criteria Met?[2]	Addressed in RSP? (Y/N)[2]	Response
Comment on Recreational Needs Assessment recommending the development of a Recreation Plan.	R. Rhur, Virginia Department of Conservation and Recreation (VDCR)	February 11, 2019	N/A	Y (alt)	A Recreation Study Report will summarize results of the study as well as identify opportunities for recreational enhancement.
Request for Recreational Value and Access Development Mitigation Plan.	D. Orth, Virginia Tech	March 15, 2019	Y	Y (alt)	A Recreation Study Report will summarize results of the study as well as identify opportunities for recreational enhancement.

[1]USFWS: U.S. Fish and Wildlife Service; NPS: National Park Service; VDGIF: Virginia Department of Game and Inland Fisheries; VDEQ: Virginia Department of Environmental Quality; Virginia Tech: Virginia Tech; NRC: New River Conservancy; VDH: Virginia Department of Health.
[2]N/A: not applicable; Y: yes; N: No; Y (alt): the comment or request was incorporated with partial or alternative methodology from what was proposed.

3.1.1 Study Requests Deemed Not Appropriate for Study

Appalachian proposed eight studies in the PSP to address study requests and comments by Project stakeholders. Study requests that were not incorporated in the PSP or RSP are discussed below.

3.1.1.1 Sediment Study

In their May 7, 2019 letter, VDGIF requested a Comprehensive Sediment Study to inform the development of a Sediment Management Plan. The goals of the study would be to: (1) determine the extent of aggradation/sedimentation of the upstream channel and the extent of downstream bed-material deficit, and (2) provide an estimate of volume and size distribution of material that would be needed to be removed from or augmented to the channel to mitigate for these impacts, for the benefit of aquatic populations that VDGIF is charged with managing. VDGIF further suggested that one mitigation approach would be periodic (e.g., semi-annual) augmentation of the channel below the dams with the average bed material (appropriate sediment-size distribution and volume) trapped by the impoundment in that given period of time, and that this augmentation could be done within the bypass reaches as well as the mainstem reaches to restore appropriate habitat conditions. By letters dated May 7, 2019, USFWS and NRC stated support for this study request.

For the reasons listed below, Appalachian has not adopted this study request.

- The extensive watershed sedimentation modeling conducted for the relicensing of the Claytor Project (Appalachian 2008) demonstrates that the Project reservoirs have little additional retention capacity. Partial infilling of the Project reservoirs likely occurred soon after emplacement of the dams (USDA 1950) and during subsequent land use changes in the vicinity (e.g., conversion of forest to agriculture/pasture). The present-day run-of-river operation of the Project, which does not significantly affect hydraulic residence time, appears to pass adequate amounts of fine and coarse-grained sediment and this is consistent with the recently published findings of Magilligan et al. (2018), which found that downstream reaches of smaller run-of-river dams, although different in morphology and sediment characteristics compared to control reaches, can establish equilibrium following dam emplacement, in part reflecting the relatively short residence time of suspended load in the reservoir. On this basis, Appalachian believes that existing information is adequate (ILP Study Criteria No. 4).
- That the Project reservoirs are not retaining significant additional sediment is also supported by the following:
    - Appalachian is aware of only two past dredging efforts upstream of Byllesby Dam (the second of which was the result of significant flooding), as described later in this RSP in Section 5.4.

  - During pre-relicensing field work conducted by Appalachian's consultant in the fall of 2019 (see Section 5.4) depth measurements in the forebay area were found to be 30 to 35 feet in front of the spillway Tainter gate and flashboard sections, at a distance approximately 30 to 50 feet upstream of the dam. This measurement suggests that the river channel is in alignment with the spillway gates, and significant sedimentation does not appear to be occurring behind the dam.
  - As discussed at the PSP meeting, while not its primary purpose, operation of the drag trash rake system installed at the Byllesby intake is believed to facilitate the passage of sediment during operation. Sediment removal (dredging) has not been required since installation of this trash rake system by Appalachian.

- The results of the requested study are not expected to inform reasonable and necessary protection, mitigation, and enhancement measures for the new license (ILP Study Criteria No. 5). VDGIF states that the study will inform development of a sediment management plan, including the required frequency of significant dredging upstream within the reservoirs and coarse sediment augmentation in the bypass reaches and downstream channel. Appalachian does not believe that significant, regular dredging of reservoir sediment or a coarse sediment augmentation program for the bypass reach and downstream channel are appropriate or feasible for the Project. VDGIF's recommended coarse sediment augmentation / sediment management plan appears to be an overarching approach based on the idea that the New River needs to be restored to create spawning habitat and/or balance the long-term coarse sediment budget.
- Appalachian conducted preliminary evaluation and literature reviews of the types of mitigation measures potentially applicable to this study request (e.g., stream/habitat restoration, gravel augmentation) in preparation of the PSP and highlights the following findings and conclusions.

  The streambed gradient along the river reach is fairly steep and the New River in the vicinity of the Project has an average discharge of 2,500 cubic feet per second (a velocity of 1.1 feet per second) (Appalachian 2019). High velocity flows and steep gradients facilitate the transport of both coarse and fine-grained sediment. While the dams impound a portion of the sediment from upstream sources, the run-of-river operation of the dams facilitates the passage of a percentage of this sediment, especially during high flows. Additionally, the river's sediment load is most likely replenished by abundant tributaries with confluences in between the Byllesby and Buck dams as well as between the Buck and Claytor dams. Stable, well-vegetated banks along this river reach, as well as predominantly coarse-grained stable riffles and shoals, are indicative of a geomorphologically healthy system.

  Given the high cost of preparing and placing in-channel gravel, and to reduce the potential for gravel entrainment and prevent loss of the augmented gravel to erosion, coarse sediment augmentation projects tend to focus on streams with low gradients and wide channels. Spawning gravels may also be placed in low-gradient areas with little upstream sediment supply and a relatively stable flow regime. As described in the PAD (Appalachian 2019), the river has an average gradient of approximately 6.3 feet per mile throughout the upper New River Basin, compared to an average gradient of 24 feet per mile in the Buck bypass reach and 20 feet per mile approximately 1 mile downstream of the Project. The Buck bypass reach is also subject to annual flood flows, due to natural seasonal conditions and the run-of-river operation of the Project. Maintaining a supply of coarse sediment in the bypass reach is not feasible due to hydraulic conditions (i.e., turbulence, gradient, and velocity) that occur as a result of the natural streambed gradient and seasonal and periodic high flow events (USFS 2004). Further, the bypass reaches largely consist of scoured bedrock substrate, which would make it difficult to establish and maintain suitable gravel beds given the periodic high flow events.

High stream competence, which refers to the heaviest particles a stream can carry, and stream capacity, which is the amount of sediment a stream can carry, are characteristic of this river reach and, similar to many high-gradient Piedmont streams in the eastern U.S., the New River likely transports its entire annual sediment load over just a few flooding events, or 5 to 10 days per year. While field investigations of channel morphology and sedimentology downstream of run-of-river dams are few and limited in geographic scope, the reach near the Project is considered a sediment transport zone (not a sediment deposition zone) and any gravel added to the system would likely be moved downstream during the next high flow event under present-day conditions. Due to the absence of stream braiding and lack of instream sand shoals, this section of the New River is not considered transport-limited like many eastern U.S. streams affected by historic legacy sediment, and has a stable longitudinal profile and adequate sediment transport capacity.

Continuing on the ideas above, gravel placed in the bypass reach or downstream channel would be expected to be scoured and transported by high flow events, eventually settling in a lower stream gradient location (e.g., Claytor Lake).

Adding sediment in one time, large volume applications has potential to smother substrates that support mussels, macroinvertebrates, and provide spawning substrates for fish.

Optimizing benefits of this mitigation measure and minimizing potential damage such as that noted above would require a long-term adaptive management approach that would impose a high degree of uncertainty for the economic viability of the Projects (USFS 2004).

- Construction of the Project dams over a century ago, combined with the construction of other dams on the New River, unarguably caused changes in water and sediment supply, the shape of the river, bed material size-distribution, and the river gradient.

  Additionally, other anthropogenic and natural instream or watershed disturbances have affected the New River. Aquatic resources have adapted over time to these conditions, and the river maintains its ecological functions. If the river does not fully achieve all of the characteristics and uses established by the Virginia Code (9VAC250260-10), this is typically due to a combination of factors and influences.

- Appalachian does not believe that aquatic resources are presently being significantly impacted by Project operations. The lack of suitable coarse sediment deposits in the bypass reach or immediately below the Project, in areas of high stream gradient, is not clearly connected with adverse impacts to aquatic species or overall stream stability (ILP Study Criteria No. 5).

3.1.1.2 Virginia Spiraea (*Spiraea virginiana*)

The riparian plant Virginia spiraea (Spiraea Virginiana), which is federally listed as threatened, is of interest for the Project, as this species is known or believed to occur in Carroll County, Virginia. Historically, Virginia spiraea may have occurred upstream of the Byllesby dam; however, there has been no documentation or verification of its presence or exact location.

As described in Section 5.6.2 and Section 5.7.1.4 of the PAD (Appalachian 2019), following consultation with the USFWS in support of the non-capacity license amendment application for installation of the inflatable Obermeyer crest gates at both developments, a habitat suitability assessment and a presence/absence survey for Virginia spiraea was conducted by Appalachian in 2017. The geographic scope of this survey was from Fries dam, which is upstream of the Byllesby development, to the downstream extent of the Project boundary for the Buck development. No instances of Virginia spiraea were observed within any habitat patches identified as having at least low or moderate suitability for this species (ESI 2017). An additional rare plant field survey, which included Virginia spiraea, was completed by Appalachian in July 2017 in support of a non-Project related transmission project in the vicinity of Buck Dam Road. Neither presence nor suitable habitat for the Virginia spiraea was observed in the survey area.

Comments received on proposed studies identified and those not identified in the PAD were received from the USFWS, Virginia Department of Conservation and Recreation (VDCR), and Virginia Tech emphasizing the occurrence of Virginia spiraea in the New River watershed. In comments on Scoping Document 1, the USFWS noted that they consider the results of the 2017 study described above valid for two years, and may request a new survey. VDCR also supports updated Virginia spiraea surveys.

Based on the non-presence findings of the 2017 surveys conducted by Appalachian (ESI 2017), and the uncertainty around the documentation of the historical occurrence record upstream of Byllesby dam, Appalachian believes that an additional survey for Virginia spiraea is not justified or warranted. As indicated in Section 4.7 of the PAD (Appalachian 2019), there are no new Project facilities or upgrades proposed at this time and no changes are proposed to operations; as such, no impacts to Virginia spiraea that may occur within the Project boundary are anticipated at this time. In the event that Appalachian decides to propose new facilities, upgrade facilities, or modify operations in a way that could impact this determination, Appalachian will coordinate with agencies to determine the need for additional surveys at that time.

The proposal not to conduct updated Virginia spiraea surveys was stated by Appalachian and discussed at the PSP meeting. During these discussions, Appalachian's consultant noted that shoreline surveys conducted for the Wetlands, Riparian, and Littoral Habitat Study would be performed by a field team with the awareness to specifically be cognizant of Virginia spiraea in the study areas covered by the shoreline surveys. No further comments or study requests related to Virginia spiraea were received in response to the PSP.

3.1.2 Study Requests Deemed Appropriate with Alteration

In some instances, the proposed methodology in the PSP deviates from the methodology submitted with, or does not incorporate all elements of, the study requests. In these cases, Appalachian has proposed an alternate methodology that can provide the requested or necessary information buy may be more efficient or effective than the recommended methodology. Study requests deemed appropriate with alterations are identified in Table 3-1.

3.2 Response to Comments and Study Requests Received in Response to the PSP

Appalachian received timely formal comments on the PSP from USFWS, VDGIF, and FERC. In preparation of this RSP, Appalachian reviewed the stakeholder comments and study requests included in the FERC record. A summary of study requests and study-related comments is provided in Table 3-2. Copies of comments and other consultation correspondence received since the filing of the PSP are provided in Appendix B.

Table 3-2. Summary of Study-Related Comments on the PSP

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Plan Revision Incorporated in RSP? (Y/N)[2]	Response
Flow and Bypass Reach Aquatic Habitat Study				
Describe the methodology that will be used to demonstrate the efficacy of the existing ramping rates for the Buck bypass reach.	A. Conner and J. Smith, FERC	September 19, 2019	Yes	Added text to study plan: Conducting flow tests under lower flow conditions will help in assessing existing, and potentially modified, gate operations as it relates to flow patterns and wetted area resulting from ramping rate requirements. The hydraulic model is capable of simulating reservoir inflow and rate of reservoir rise, dynamic gate operations scenarios, release travel times, and rates of rise at locations within and downstream of the bypass reach.
Explain why three calibration flows are believed to be sufficient to provide data of sufficient resolution to determine how both aquatic suitability and hydraulic connectivity vary with flow in the bypass reaches, particularly at the Buck development.	A. Conner and J. Smith, FERC	September 19, 2019	Yes	Removed language regarding three calibration flows. Added text to study plan: Calibration flows will be released into the tailwater and bypass reaches for purposes of collecting depth and wetted area data under various powerhouse and spillway flow regimes and spillway flow release points. The model will enable a comparison between powerhouse operations (i.e., flow releases into the tailwater areas) and dam operations (i.e., flow releases into the bypass reaches via spillway gates). Appalachian or their consultant will develop a proposed framework for model scenarios and provide interested relicensing participants the opportunity to review and comment on the framework prior to collecting field data under the calibration flows.

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Plan Revision Incorporated in RSP? (Y/N)[2]	Response
Leakage is being proposed as part of the minimum flow component into the bypass reaches. The study must sufficiently quantify seepage and leakage rates into the bypass reaches.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	Added text: Leakage flow measurements (using an appropriate velocity meter) will also be conducted in each bypass reach to determine flow and wetted area at the low end of the flow regime.
The proposed usage of a 21-year hydrographic record has not been proven to be a sufficient period of record to examine for modelling scenarios and does not provide enough info to characterize the range of flows typical for the Project. Data from the Galax, VA gage may be useful as well. Provide more information about why the 21-yr period will be sufficient.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	Added text: Using the more recent 24-year period of record from the Ivanhoe gage is recommended because it's closer geographically to the Byllesby-Buck Project (i.e., requires a smaller drainage area adjustment), is reflective of current land use and water use practices, and uses more modern data collection and recording methods compared to the 1929 – 1978 timeframe. The more recent period of record also contains a sufficient number of dry and wet periods that are sufficient for purposes of evaluating flow regimes relevant to the flow and bypass reach aquatic habitat study goals and objectives.
Consider that the 1997 Ramping Rate Effectiveness Study may not apply under current Walleye population conditions.	W. Kittrell, Jr, VDGIF	September 18, 2019	Yes	Acknowledged in text that ramping rate report may no longer apply to current Walleye population.
Questioned how the bypass reach substrate information may be analyzed without an adequate reference data set in a free-flowing section of the New River.	W. Kittrell, Jr, VDGIF	September 18, 2019	No	See response in Section 3.2.1

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Plan Revision Incorporated in RSP? (Y/N)[2]	Response
Water Quality Study				
Vertical temperature and DO profiles may need to be done bi-weekly to determine stratification depths.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	Added text: Note the depths of the data sondes (used for continuous monitoring) may be adjusted, if necessary, during the study based on a comparison of the continuous temperature and DO results with the monthly depth profile measurements. In addition, if it appears that brief periods of stratification may be occurring, collection of forebay depth profiles may be increased to bi-weekly.
Stated that one season of sampling [within the tailrace] may not be adequate to capture water quality conditions in these areas during dry years.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	Appalachian notes that if 2020 is not a suitable year for collecting water quality data, the 2021 field season would be used.
The study fails to provide a plan for assessing turbidity effects.	W. Kittrell, Jr, VDGIF	September 18, 2019	Yes	Turbidity will be measured at each sampling location during monthly sampling events.
Aquatic Resources Study				

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Plan Revision Incorporated in RSP? (Y/N)[2]	Response
Please indicate if you plan to sample for Candy Darter as part of the proposed fishery surveys, and if so, what sampling gear and methodology would be used.	A. Conner and J. Smith, FERC	September 19, 2019	No	The location of the nearest known critical habitat or species occurrence is in Cripple Creek, a tributary stream located approximately 5 miles downstream of the Project. Candy Darter populations once occurred in the mainstem of the New River, but results of the Species Status Assessment Report for the Candy Darter, Version 1.4 (USFWS 2017), indicate that extant populations are currently known only from tributary streams. As such, Candy Darter are not anticipated to occur within tributaries or the mainstem of the New River near the Project's developments. Candy Darter will not be a target of the proposed fish community study, however, should a Candy Darter specimen be collected, sampling will be halted and VDGIF and USFWS will be notified. Sampling will be reinitiated after consultation with the agencies and receipt of necessary protected species permits.
Please indicate if size (shell length) of data are available from these prior mussel collection efforts, and if so, whether size data would be included and analyzed as part of the desktop study.	A. Conner and J. Smith, FERC	September 19, 2019	Yes	These data are available for some of the historical mussel data and will be provided or summarized with study results where available and accessible.
A mussel community study should be conducted for the relicensing process, especially for the area between Buck Dam and Lake, and Byllesby Dam.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	A mussel study has been added in the RSP to include a summary of historical sampling efforts and results and a new survey for a portion of the New River between Byllesby Dam and Buck Dam where prior mussel surveys have not been performed. The new survey will employ a two-step approach. A boat-based habitat survey will first be performed to identify potential mussel habitat. If potential habitat is identified, roving surveys of potential habitat will be conducted to identify the presence of mussels.

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Plan Revision Incorporated in RSP? (Y/N)[2]	Response
Explain the rationale for not including the Eastern hellbender in the multi-taxa study to assess its presence within the project area.	A. Conner and J. Smith, FERC	September 19, 2019	No	No eastern hellbender surveys are proposed in this RSP. Due to challenges with implementing the currently acceptable survey methodology (i.e., surveys at night, require lifting of large and heavy boulders, safety concerns, and potential for specimen injury or damage to habitat), AEP has assumed that eastern hellbender are likely present within the Project boundary in lieu of performing a field study. In discussion at the PSP meeting and in comments filed on the PSP, VDGIF and USFWS were agreeable with this approach.
Commenters agreed that the presence of this species in the Project area should be assumed by all parties, and considered for habitat water quality and quantity issues. No surveys are recommended.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	No	As suggested in the comment and discussed in detail during the PSP meeting, AEP assumes that eastern hellbender are likely present within the Project boundary. No surveys are proposed.
The Impingement and Entrainment analysis should include the usage of the USFWS Turbine Blade Strike Analysis model to assist in the review of fish injury and mortality through turbines.	J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	As noted in Section 6 of this RSP, the impingement and entrainment evaluation will include a blade strike evaluation using the USFWS Turbine Blade Strike Analysis Model (USFWS 2018b). 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.
VDGIF discontinued Muskellunge stocking in the New River downstream of Claytor Dam in 2011; upstream of Claytor Dam was suspended in 2018.	W. Kittrell, Jr, VDGIF	September 18, 2019	Yes	Text in the RSP (Section 6) was revised to reflect the information provided.

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Plan Revision Incorporated in RSP? (Y/N)[2]	Response
Spring fish surveys should commence in April for comparability to VDGIF data and for adequate assessment of resident Walleye populations downstream of Buck Dam. Also suggest total length measurements of up to 100 individuals of each game fish (specifically Walleye, Smallmouth Bass, and Rock Bass) to allow assessment of angling potential. This will provide data for calculating size structure indices and length-frequency diagrams.	W. Kittrell, Jr, VDGIF	September 18, 2019	Yes	The spring fish survey has been revised to show commencement of sampling in April to facilitate comparison to VDGIF data and to facilitate assessment of resident Walleye during their most active time downstream of Buck Dam. As described in Section 6, length data will be collected on up to 25 individuals for non-game fish species and for up to 50 individuals of game fish species. For taxa collected in excess of 50 individuals, field personnel will select the 50 specimens for length measurements to be representative of the size range (e.g., minimum, maximum, and median) observed in the sample.
Wetlands, Riparian, and Littoral Habitat Characterization Study				
Revise the study window from April-June to August-September for submerged aquatic vegetation beds, and clarify whether the transect-based sampling will be used.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	The study window was revised to reflect this request and will be coordinated with the late summer/early fall fish community survey effort. Additional text added to clarify that transect–based methodology will be used in the study.
Recreation Study				
Notice of the online survey should be advertised in other ways than only posting in kiosks, such as local outfitters and river guides, and social media outlets.	W. Kittrell, Jr, VDGIF	September 18, 2019	Yes	Notice of the survey will be posted on the Project's relicensing website and relevant social media outlets maintained by Appalachian. Appalachian will also make a good faith effort to communicate with local outfitters and regional organizations to complete the survey and distribute notice of the survey to their members or clients.
Trail cameras should be used for monitoring recreational use of the tailrace areas, particularly given FERC's interest in recreational use of these areas, as expressed in SD2.	W. Kittrell, Jr, VDGIF	September 18, 2019	Yes	Trail cameras have been placed at both the Buck and Byllesby canoe portages to capture use of the portages and tailraces. Additionally, Appalachian's consultant installed a third camera on river-left, below Buck Dam, facing river-right's tailrace area to capture any recreational use in or around the tailrace (see Figure 10-2).

Summary of Study Request or Comment	Stakeholder[1]	Date	Study Plan Revision Incorporated in RSP? (Y/N)[2]	Response
USFWS supports the NPS in their May 7, 2019 comments and VDGIF in their comments on the PSP.	J. Norman & G. LaRouche, USFWS	September 18, 2019	Yes	Additional detail on methods and effort to assess recreational needs, as requested by NPS in their May 7, 2019 comments, is incorporated into the RSP. Additions and revisions to the study plan were incorporated based on VDGIF's comments received on the PSP (see above responses).
Additional Comments				
The PSP does not address the magnitude and spatial scale of project influence. Determining the spatial scale will help determine adequate reference conditions for ecological comparisons. Determining the downstream spatial influence will involve consideration of Project flow attenuation and downstream turbidity effect of Project operations, as well as other downstream water quality and recreational impacts. Also effects on coolwater fishes, endemic fishes, eastern hellbender, mussels/host fish, and New River Walleye spawning area, migration, and increased cost of VDGIF efforts in hatchery rearing and stocking. Making this determination needs to be high priority before study plans are finalized.	W. Kittrell, Jr, VDGIF; J. Norman & G. LaRouche, USFWS	September 18, 2019	No	Appalachian's proposed study area is described in Section 1.3. Appalachian does not propose to further extend the study area.
In our May 7, 2019 comments on the Pre-Application Document, VDGIF requested a Comprehensive Sediment Study, providing the needed justification for that study. We request that FERC determine whether this study is appropriate for the Project.	W. Kittrell, Jr, VDGIF	September 18, 2019	No	See response in Section 3.2.2

3.2.1 Study Requests Deemed Appropriate for Study

As outlined in Table 3-2, PSP comments were received from FERC, USFWS and VDGIF on the Flow and Bypass Reach Aquatic Habitat Study, Water Quality Study, Aquatic Resources Study, Wetlands, Riparian, and Littoral Habitat Characterization Study, and Recreation Study. Comments were not received on the Terrestrial Resources Study, Shoreline Stability Assessment Study, or the Cultural Resources Study. Appalachian continues to propose eight studies, which are detailed in Sections 4 to 11 of this RSP, to address study requests and comments by Project Stakeholders:

(1) Flow and Bypass Reach Aquatic Habitat Study

(2) Water Quality Study

(3) Aquatic Resources Study

(4) Wetlands, Riparian, and Littoral Habitat Characterization Study

(5) Terrestrial Resources Study

(6) Shoreline Stability Assessment Study

(7) Recreation Study

(8) Cultural Resources Study

3.2.2 Study Requests Deemed Not Appropriate for Study

3.2.2.1 Sediment Study

In their September 18, 2019 letter, VDGIF reiterated their request for a Comprehensive Sediment Study and that FERC determine whether this study is appropriate for the Project. For the reasons described in Section 3.1.1, and on the basis of the ILP Study Criteria, Appalachian does not propose to conduct this study and respectfully requests that FERC provide concurrence with this recommendation in the forthcoming Study Plan Determination.

VDGIF's September 18, 2019 comments on the Flow and Bypass Reach Aquatic Habitat Study also pointed out that for the substrate characterization task associated with this study, no reference condition information is proposed. VDGIF asked how bypass reach substrate information would be analyzed without an adequate reference data set in a free-flowing section of the New River. Appalachian does not propose to incorporate a reference reach for substrate characterization into the Flow and Bypass Reach Aquatic Habitat Study on the basis of the ILP Study Criteria as follows:

- The results of the requested study activity are not expected to inform reasonable and necessary protection, mitigation, and enhancement measures for the new license (ILP Study Criteria No. 5). As described in Section 3.1.1, Appalachian does not believe that mechanical placement of sediment in the bypass reaches is appropriate or feasible for the Project, and it is not possible to operate the spillways during high flow events in a manner that would not scour sediment from the bypass reaches, given river conditions, gradient, and the prevailing substrate in these reaches.

- Appalachian does not expect that a suitable reference reach, with comparable gradient and substrate conditions, proximate to the Project for purposes of study execution, is reasonably available (ILP Study Criteria No. 7). As previously noted, the river has an average gradient of approximately 6.3 feet per mile throughout the upper New River Basin, compared to an average gradient of 24 feet per mile in the Buck bypass reach and 20 feet per mile approximately 1 mile downstream of the Project. Even if a river reach of comparable characteristics were located, Appalachian notes that it is not the intent of the relicensing process, given that decommissioning is not proposed, to restore the bypass reaches to their pre-Project conditions.

3.2.3 Response to FERC Requests for Additional Information

In addition to FERC's comments on the PSP, staff also included Additional Information Requests (AIRs) in Schedule B of their September 19, 2019 letter.

In item number 1 of FERC's AIRs, staff requested that Appalachian clarify how and where Project power currently connects to AEP's distribution system and specify the Project components where the connection is made; whether the battery storage facility, the switchyard, and related components should be considered Project facilities, and if and how Project operation is affected by the presence of the battery storage facility and what factors limit its capacity. Given that response to this AIR by Appalachian will require technical information and documentation outside the scope of this, Appalachian proposes to provide FERC with the requested additional information under separate cover, within 60 days of the date of filing of this RSP. For the purposes of this RSP, and upland survey or study activities proposed within, Appalachian has revised the study area to encompass these additional features.

In AIR item number 2, FERC staff requested that the results of any PCB testing conducted in support of previous sediment removal projects at the Project (1997 and 2014) be filed with the RSP. Appalachian has reviewed available files and documentation for the Project and provided additional information in Section 5.4 of this RSP.

In AIR item number 3, FERC staff noted that USFWS indicated in a letter dated May 7, 2019, that there may be potential impacts to the bog turtle due to proposed drawdown activities, and that the bog turtle may be found in Carroll County. FERC staff requested that Appalachian provide any information (including past consultation with USFWS) on the occurrence of bog turtles within the vicinity of the Project.

Although the bog turtle is identified as occurring in Carroll County, no known occurrences within the Project boundary have been documented. Wetland habitats identified in the Project boundary are illustrated (see Figure 5.6-1 in Section 5.6 of the PAD). The larger documented wetland was created using spoils generated during the 1997 dredging by Appalachian. True to the species name, bog turtles typically inhabit very specific bog-type wetland habitats. Bog turtle habitat is characterized by an open canopy and may include slow, shallow, muck-bottomed rivulets of sphagnum bogs, calcareous fens, marshy/sedge-tussock meadows, wet cow pastures, spring seeps, and shrub swamps. Bog turtles require a mosaic of microhabitats for foraging, nesting, basking, hibernation, and shelter (often provided by an abundance of sedges or mossy cover). Unfragmented riparian systems subject to dynamic disturbances sufficient enough to allow natural creation of open habitat are necessary to compensate for ecological succession. Use by beaver, deer, and cattle are often instrumental in creating the disturbance needed to maintain the open-canopy conditions required for these types of wetlands (USFWS 2000).

None of the wetland areas identified within the Project boundary provide the specific type of wetland habitat (i.e., bogs, fens, swamps) utilized by the bog turtle. Further, Appalachian notes that the winter pool, 1-foot reservoir drawdown that was the subject of USFWS May 7, 2019 comment is no longer proposed by Appalachian.

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4 Flow and Bypass Reach Aquatic Habitat Study

4.1 Study Requests

The Commission's March 8, 2019 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing:

- Adequacy of the existing 360-cubic feet per second (cfs) minimum flow for aquatic resources, including resident fish species, downstream of each development consisting of the tailwater areas below each powerhouse and the bypass reaches below the main spillways, but excluding the Byllesby auxiliary emergency spillway channel.
- Whether there is a need for a minimum flow (beyond leakage) in the Buck bypass reach.
- Adequacy of the existing ramping rate to prevent fish stranding in the Buck bypass reach.

Comments or study requests related to this study in response to the PAD and SD1 were received from USFWS, VDGIF, VDEQ, NRC, and Virginia Tech. Requests and comments included recommendations to identify the target biological community of the bypass reaches, determine aquatic habitat availability in each bypass reach, and evaluate the potential impacts of various gate opening and sequencing scenarios. Comments were also provided regarding the need to assess the adequacy of existing minimum flow requirements, flow management, and habitat availability at the Project. Comments and study requests are summarized in detail below:

- USFWS requested an instream flow study (two-dimensional [2-D] hydraulic model coupled with Physical Habitat Simulation [PHABSIM] analysis) to (1) determine the impacts of modifying the discharge location and configuration of the flow discharges on the current velocity and direction, sediment transport and deposition patterns, aquatic species and habitats, and recreation in the tailwater and bypass reach, and (2) determine if the proposed discharge or reduced spillage to the tailwater and bypass reach would have an adverse effect on fish and mussel communities or recreational fishing opportunities. Virginia Tech commented that the assessment proposed by Appalachian should include field surveys as well as desktop assessments and consider habitat restoration.
- Regarding the study proposed by Appalachian in the PAD, USFWS, VDGIF, and NRC noted that this study should also evaluate fish and Walleye stranding concerns following bypass reach spill events; how the spillway gates can be used to limit stranding and create upstream and downstream connectivity; and how habitat (in particular substrate) in the bypass reach is modified relative to reference conditions.
- USFWS, VDGIF, and NRC recommended that the Inflatable Obermeyer Crest Gate Operational Effectiveness Evaluation proposed by Appalachian in the PAD be

integrated with the Flow and Bypass Reach Aquatic Habitat Study and include a modeling component to determine how the spillway and crest gates can be used to modify and/or create “seasonally appropriate” bypass reach flows. USFWS, VDGIF, and NRC requested that additional information be provided to estimate downstream flows and ramping rates for a range of spillway gate openings and operating scenarios.

- USFWS, VDGIF, NRC, and Virginia Tech noted that minimum flows are not provided to the bypass reaches when all flow is diverted through the powerhouses, resulting in a lack of habitat and connectivity to the pools and recommended an instream flow study to evaluate impacts to aquatic species, including fish, mussels, and macroinvertebrates, including flow fluctuation effects on fish and mussel spawning.
- Virginia Tech requested information be provided on daily trends of inflow and outflow discharge from the individual developments to better understand the modifications to the natural flow regime. USFWS, VDGIF, and NRC requested that additional information be provided for a period of record longer than 30 years to capture representative data for wet, dry, and average years.

Additional comments or requests related to this study were received from USFWS, VDGIF, and FERC in response to Appalachian’s filing of the PSP. These comments are summarized as follows:

- FERC requested that Appalachian describe the methodology that will be used to demonstrate the efficacy of the existing ramping rates for the Buck bypass reach.
- FERC questioned how three calibration flows would provide enough data to determine how aquatic habitat suitability and hydraulic connectivity vary with flow in the bypass reaches.
- USFWS and VDGIF requested that this study quantify seepage and leakage rates into the bypass reaches. Both asked for more information as to how the 21-year hydrographic record is a sufficient period to model flow scenarios.
- VDGIF noted that the 1997 Ramping Rate Effectiveness Study may not apply under the current Walleye population conditions. They also asked about Appalachian’s intent to use a reference bypass reach.

In addition to the formal comments filed, the following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- VDGIF and USFWS expressed interest in understanding sequencing of gate operations to minimize negative impacts to aquatic species from spillway releases.
- VDGIF agreed that the currently proposed USGS 03165500 New River at Ivanhoe, VA gage is the most representative of the Project and noted it covered the 2000-2003 period, which was extremely dry.
- The management goal in the bypass reaches was discussed and whether the focus should be on avoiding fish stranding (i.e., by maintaining in-channel connectivity) or creating habitat. Group agreed a 2-D model will be sufficient to evaluate connectivity in the bypass reaches over an appropriate range of flows.

- VDGIF and USFWS expressed interest in a study meeting in spring 2020 prior to conduct of the flow tests.
- USFWS reminded Appalachian to not ignore non-game species, especially macroinvertebrates.

4.2 Goals and Objectives

The objectives of this study are to conduct a flow and habitat assessment for each of the development's tailwaters and bypass reaches (excluding the Byllesby auxiliary spillway channel) using a combination of desktop, field survey, and hydraulic modeling methodologies with the following goals:

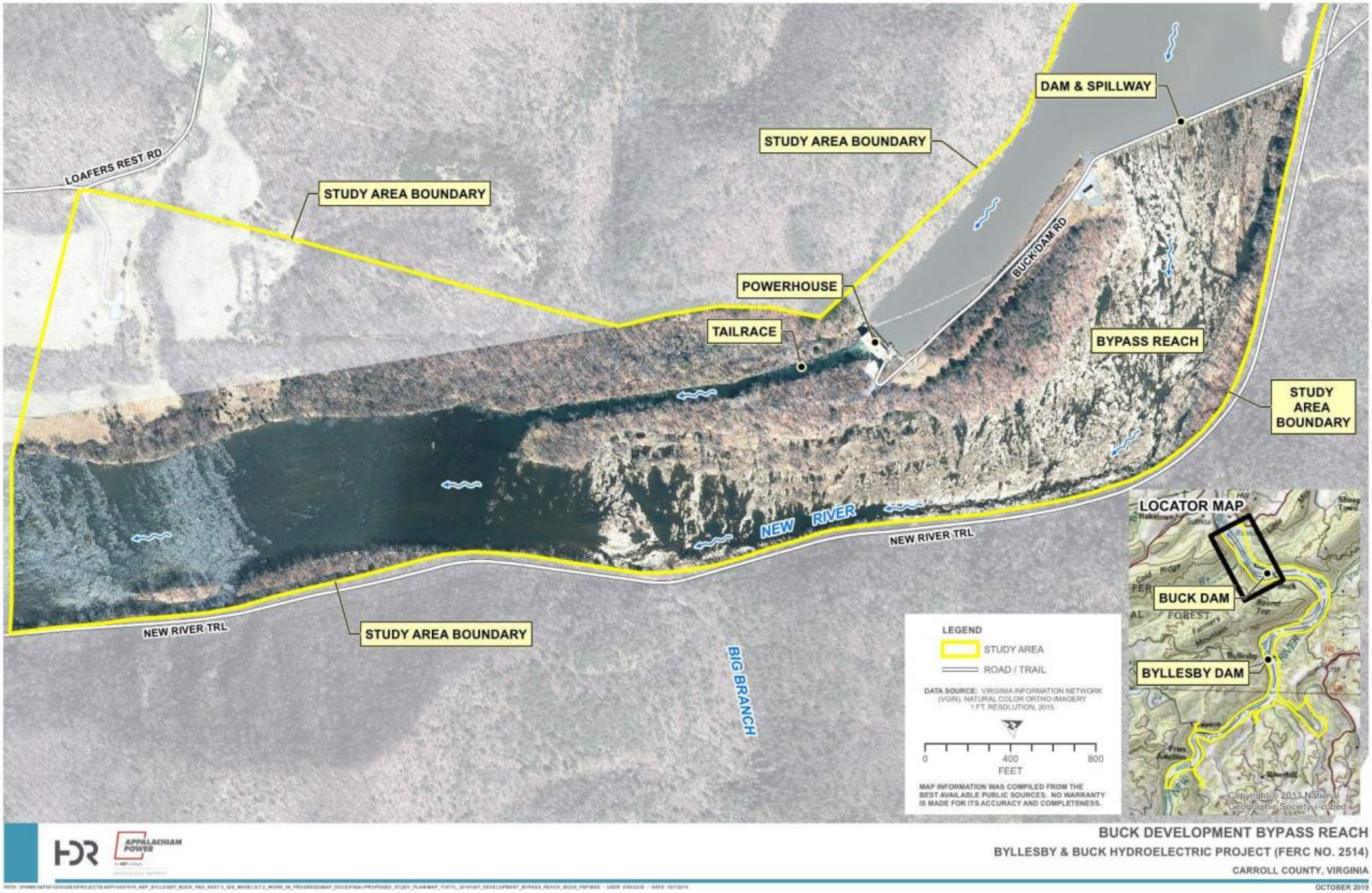
- Delineate and quantify aquatic habitats and substrate types in the Byllesby and Buck bypass reaches.
- Identify and characterize locations of habitat management interest located within each bypass reach.
- Develop an understanding of travel times and water surface elevation responses for different base flow and spillway release flow combinations in the tailwater and bypass reach study areas to:
    - Demonstrate the efficacy of existing ramping rates.
    - Demonstrate the efficacy of the existing powerhouse minimum flow requirement.
    - Evaluate the impacts of providing seasonal minimum flows to the bypass reaches.

4.3 Study Area

The Study Area for the Flow and Bypass Reach Aquatic Habitat Study includes the tailwater, bypass reach, and a short stream segment downstream of where the tailwater and bypass reach join back together (see Figure 4-1 and Figure 4-2). Note the proposed study area downstream from the Buck development has been extended approximately 0.5-miles (from what was proposed in the PSP) to evaluate the potential impact Project operations may have on an area of VDGIF interest from a mussel habitat perspective.

Figure 4-1. Byllesby Development Bypass Reach Study Area

Figure 4-2. Buck Development Bypass Reach Study Area



4.4 Background and Existing Information

The Byllesby bypass reach is approximately 475 feet long, consisting primarily of exposed bedrock and rock outcroppings. The Buck bypass reach is approximately 4,100 feet long, with a steep gradient (approximately 24 feet per mile) and consisting primarily of exposed bedrock. Both bypass reaches normally receive seepage and leakage, unless flows are being spilled at the dams or the flashboards are breached. Under Appalachian’s normal operating conditions, the developments use available flows for powerhouse generation, maintaining the elevation of the Byllesby reservoir between 2,078.2 feet and 2,079.2 feet National Geodetic Vertical Datum (NGVD) and the Buck reservoir between 2,002.4 feet and 2,003.4 feet NGVD.

Under Article 403 of the current license, Appalachian is also required to maintain 360 cfs minimum flow release or inflow, whichever is less, downstream of the Project powerhouses. When inflow to either Project exceeds the powerhouse discharge capacity (5,868 cfs for Byllesby and 3,540 cfs for Buck), the Tainter gates are opened to pass the excess flow into the respective bypass reaches (Figure 4-3 and Figure 4-4).

Flow releases to the bypass reaches can vary substantially depending on season and precipitation, as demonstrated in Table 4-1.

In addition to the minimum flow requirements, and to further protect fish communities, ramping rates are required for the Buck bypass reach. Appalachian is required to discharge flows through a 2-foot gate opening for at least three hours following any spills released through a gate opened two feet or more. Appalachian is then required to reduce the opening to 1 foot for at least an additional three hours, after which Appalachian may close the gate. The gradual reduction of flow allows time for fish to respond to the receding water levels, thus avoiding stranding that can occur with sudden flow discontinuation.

Figure 4-3. Byllesby Dam Spillway Gates

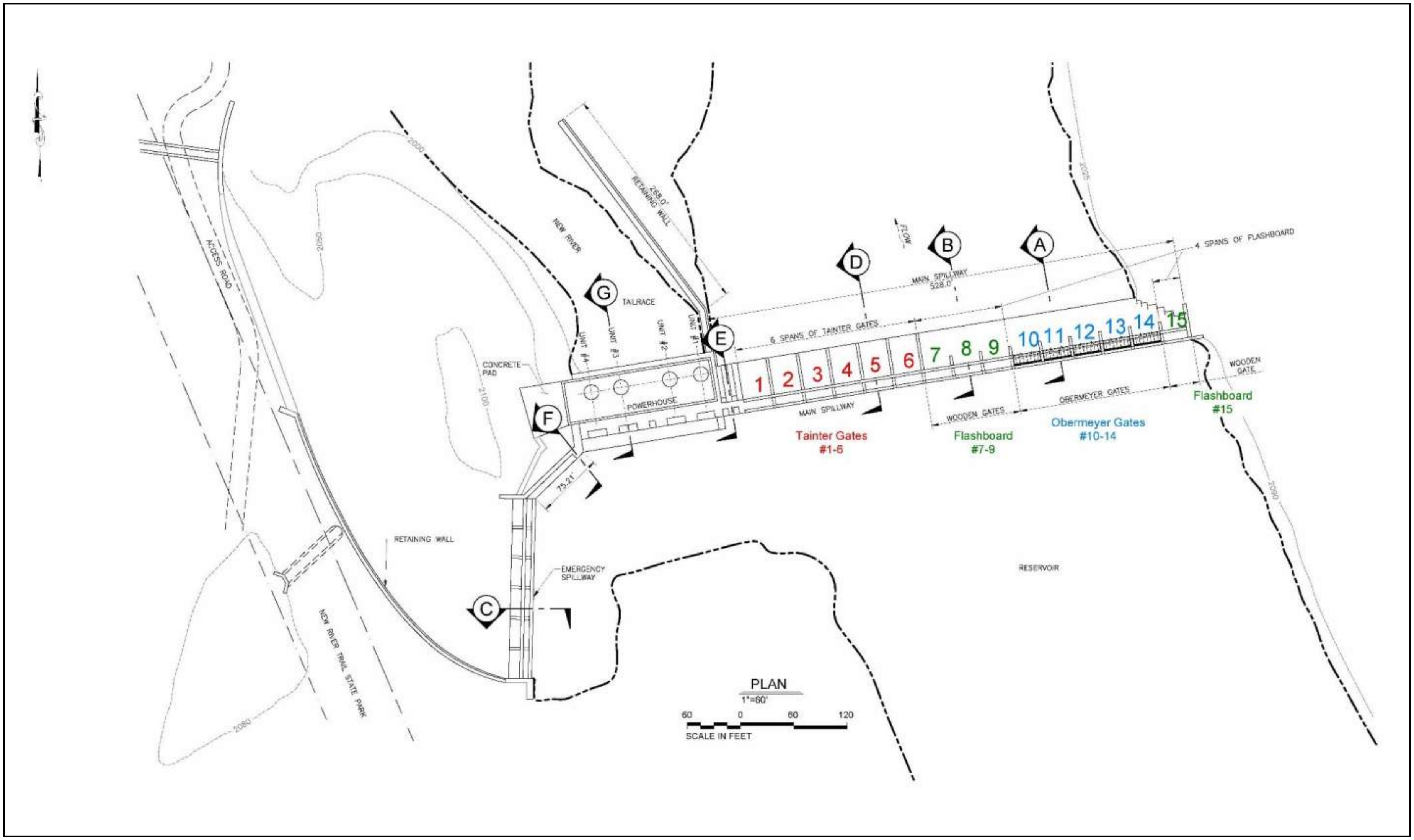


Figure 4-4. Buck Dam Spillway Gates

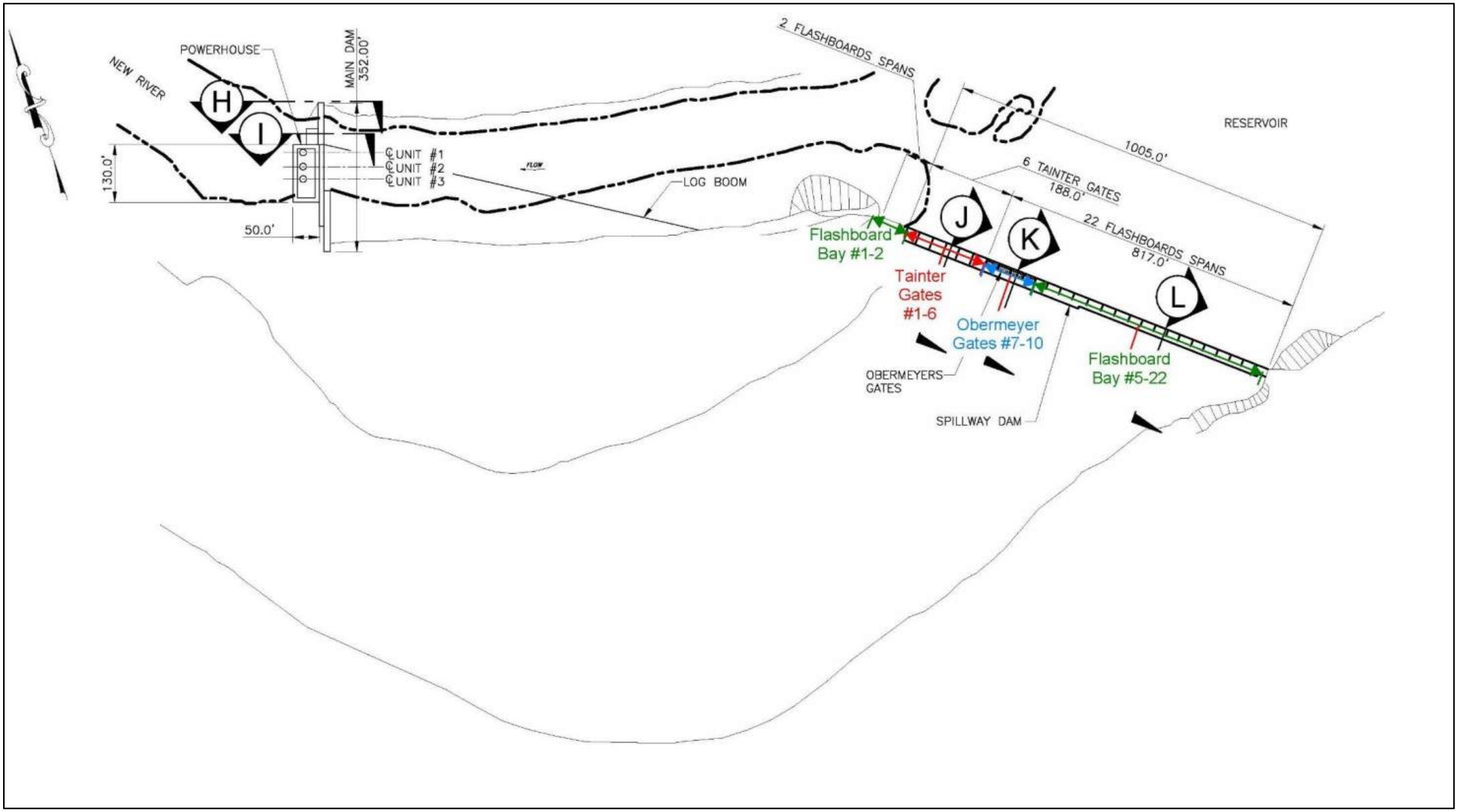


Table 4-1.Percentage of Time of Spillage to the Bypass Reaches for Byllesby and Buck Developments

Facility	Byllesby (5,868 cfs)			Buck (3,540 cfs)		
Time Period	1986-2016	2002 (dry year)	2013 (wet year)	1986-2016	2002 (dry year)	2013 (wet year)
Annual	4.1	0.8	12.4	12.9	2.2	35.5
Jan	5.3	0.0	16.1	18.1	8.0	32.4
Feb	5.9	0.0	5.7	18.9	0.0	16.9
Mar	8.1	6.0	0.0	25.4	10.8	25.9
Apr	6.5	0.0	7.4	24.8	0.0	63.4
May	2.8	0.0	31.1	15.1	0.0	66.3
Jun	3.3	0.0	11.1	9.8	0.0	41.5
Jul	3.1	0.0	59.3	6.0	0.0	98.0
Aug	1.3	0.0	9.8	4.4	0.0	73.8
Sep	2.3	0.9	0.0	5.3	4.3	0.0
Oct	2.5	0.0	0.0	5.8	0.0	2.3
Nov	3.1	0.0	0.0	8.8	0.0	0.0
Dec	3.8	0.0	0.0	12.6	0.0	4.6

An assessment of the effectiveness of the ramping procedure for the protection of aquatic organisms in the Buck bypass was performed in 1997 (Appalachian 1997). Backpack electrofishing was conducted following the cessation of bypass releases in the range of 4,300 to 6,140 cfs. A total of 734 fish representing 24 species were collected. Several species, including Central Stoneroller (*Campostoma anomalum*), White Shiner (*Luxilus albeolus*), White Sucker (*Catostomus commersonii*), Northern Hogsucker (*Hypentelium nigricans*), darters, and Walleye (*Sander vitreus*) were collected in the flowing-water habitat immediately downstream of the spillway, whereas species such as Rock Bass (*Ambloplites rupestris*), Redbreast Sunfish (*Lepomis auritus*), Green Sunfish (*L. cyanellus*), and Bluegill (*L. macrochirus*) were collected in locations further downstream in habitat dominated by pools. The study concluded that fish stranding is not a substantial problem within the Buck bypass when ramping procedures are followed. On March 27, 1998, FERC approved Appalachian's ramping rate assessment report, which included recommendations for Appalachian to continue to retain the ramping rate protocol assessed in the 1997 study. VDGIF noted in comments on the PSP that this historical assessment may not apply under current Walleye population conditions.

In preparation for this relicensing, an operations model of the Project has been developed for Appalachian by HDR, using HDR's proprietary Computerized Hydro Electric Operations Planning Software (CHEOPS™) platform.[2] While the primary

[2] During the PSP Meeting on July 18, 2019, USFWS requested that Appalachian provide a listing or examples of other relicensings where similar models were developed and used to evaluate operating scenarios. CHEOPS has previously been employed to evaluate the physical and operational changes considered during the FERC relicensing of over 75 individual hydropower developments, including Appalachian's Kanawha River Projects (London-Marmet, FERC No.1175 and Winfield, FERC No. 1290) and Claytor Project (FERC No. 739), as well as Brookfield Renewable's Hawks Nest Project (FERC No. 2512).

purpose of this model is to evaluate the effects of operational changes and physical modifications at the developments on power generation, the model also provides useful data and tools to support evaluation of spillway gate operations and flows in each bypass reach. The model uses historical inflows to simulate likely future conditions. The model for these developments relied on inflow data retrieved from U. S. Geological Survey (USGS) river flow gage USGS 03165500 New River at Ivanhoe, VA. This gage is located approximately 2.8 miles downstream of the Buck development and reports daily average flow data starting in October 1929 through present, with a data gap from September 1978 through January 1996, providing a discontinuous 74 year period of record. A summary of monthly average flow data recorded at the Ivanhoe gage is provided in Table 4-2. These data were prorated (i.e., reduced) based on the incremental drainage area between the Byllesby development (1,310 square miles) and the Ivanhoe gage location (1,350 square miles). Two different periods of record are presented: October 1929 – June 2019 (approximate 74-year period of record excluding the data gap years) and February 1996 – June 2019 (approximate 24-year period of record). In addition, for comparison purposes, streamflow data from USGS 03164000 NEW RIVER NEAR GALAX, VA (approximately 15 miles upstream from Byllesby) was also evaluated over similar periods: October 1929 – February 2019 (approximate 91-year period of record) and January 1996 – February 2019 (approximate 24-year period of record).

Table 4-2. Byllesby-Buck Project Monthly Average Flows[1]

Facility	USGS 03165500 New River at Ivanhoe, VA			USGS 03164000 New River Near Galax, VA		
Time Period	1929-2019 (74 Years)	1996-2019 (24 Years)	Variance (%)	1929-2019 (91 Years)	1996-2019 (24 Years)	Variance (%)
Annual	**2,103**	**2,138**	**1%**	**2,207**	**2,208**	**0%**
Jan	2,428	2,469	2%	2,563	2,643	3%
Feb	2,775	2,758	-1%	2,907	2,774	-5%
Mar	2,997	2,680	-12%	3,224	2,906	-11%
Apr	2,881	2,996	4%	3,044	3,071	1%
May	2,383	2,616	9%	2,496	2,657	6%
Jun	1,885	2,041	8%	1,959	2,031	4%
Jul	1,550	1,626	5%	1,620	1,695	4%
Aug	1,495	1,364	-10%	1,537	1,408	-9%
Sep	1,409	1,530	8%	1,482	1,592	7%
Oct	1,580	1,509	-5%	1,608	1,533	-5%
Nov	1,764	1,767	0%	1,874	1,825	-3%
Dec	2,084	2,303	10%	2,166	2,364	8%

[1] Flows are prorated to the Byllesby powerhouse location.

Variances between the full period of record and more recent (i.e., last 24 years) flow data are within approximately +/- 10 percent on a monthly basis and within approximately +/- 1 percent on an annual basis for both the Ivanhoe and Galax gages. Using the more recent 24-year period of record from the Ivanhoe gage is recommended because it's closer geographically to the Byllesby-Buck Project (i.e., requires a smaller drainage area adjustment), is reflective of current land use and water use practices, and uses more modern data collection and recording methods compared to the 1929 – 1978 timeframe. The more recent period of record also contains a sufficient number of dry and wet periods that are sufficient for purposes of evaluating flow regimes relevant to the flow and bypass reach aquatic habitat study goals and objectives.

Additional physical data inputs to the operations model relevant to this study include reservoir storage volume, spillway capacity, and tailwater rating curves. The operations model simulates Project operations, including releases at the dam, under potential inflow conditions and operating requirements or constraints, including reservoir level restrictions and minimum or bypass flow requirements. In 2019-2020, Appalachian expects to have the operations model updated to include updated spillway rating curve data for the newly installed Obermeyer inflatable crest gates at each of the Byllesby and Buck developments and additional available historical data on flashboard activations and powerhouse generation. The operations model will provide a means to model spillway gate releases with the new Obermeyer inflatable crest gates installed.

4.5 Project Nexus

Diversion of water to each powerhouse for generation and operation of the dams alters the timing, rate, and spatial distribution of Project inflows. Such alterations may negatively impact aquatic species and habitat in the bypass reaches and tailwater areas, particularly during periods of low flow or periodic or intermittent release of flows over the spillways.

4.6 Methodology

The USFWS requested an instream flow study with the goal of determining the impacts of modifying the discharge location and configuration (gate operation) on the current velocity and direction, sediment transport and deposition patterns, aquatic species and habitats, and recreation in the tailwaters and bypass below the Project dams.

Appalachian’s goal in selecting a process for evaluating flows at the Project is to develop a technical basis for systematically evaluating and balancing the needs and priorities of the various flow-related resources. The goal of the study will be to characterize changes in habitat quantity over a range of flows and operational scenarios. There are several types or combinations of methodologies that could be used to meet the study objectives, ranging from very quantitative to relatively qualitative data. Appalachian believes that the approach proposed will provide the requested information at an appropriate level of effort. This approach will still allow for an assessment of potential Project protection, mitigation, and enhancement measures for the benefit of the range of resources in the bypass reaches.

4.6.1 Task 1 – Literature Review and Desktop Assessment

A literature review of available information will be performed to support the study goals, methodologies, and planning of field portions of the study. This task will include a review of the hydrologic record for the Project reaches, existing spillway gate operating procedures maintained by Appalachian, existing topographic and geologic maps, and available recent and historical aerial imagery.

Several pieces of information will be considered in the field study planning process. First, a desktop analysis of mesohabitat (i.e., pools, riffles, runs, bedrock, shoals) mapping of the bypass reaches will be completed using high-resolution aerial imagery and topographic contour data, if available. Second, a selection of species of interest will be made depending on management objectives (e.g., Walleye spawning, game or endemic fish species habitat, minimizing fish stranding, etc.). The life history characteristics and habitat preferences of selected species, as well distribution of mesohabitat types, will be considered in the selection of targeted flows and locations for field data collection. GIS figures delineating mesohabitat types and proposed field study locations will be developed.

4.6.2 Task 2 – Topography Mapping and Photogrammetry Data Collection

Light detection and ranging (LiDAR) or similar technology and photogrammetry data, if not already available and achievable, will be collected during a period of no releases at the dams and minimal water levels in the bypass reaches) to support development of comprehensive three-dimensional (3-D) elevation and visual surface layers of each bypass reach. Field survey data may also need to be collected in areas that are underwater during the topographic mapping flyover. This data will be used to produce a topographic map of each bypass reach which in turn will be used in as a base layer or foundation for subsequent field data collection and hydraulic modeling efforts.

4.6.3 Task 3 – Field Data Collection

4.6.3.1 Mesohabitat Mapping Verification

A representative selection of mesohabitats identified during the desktop habitat assessment will be selected for field verification, in proportion to their availability (frequency of occurrence and total area). This habitat mapping may potentially be performed concurrent with field activities being completed for other studies. Examples of mesohabitat types will be documented via photographs and GIS mapping. Specific habitat types of interest, such as suitable spawning habitat for Walleye or mussel habitat, will be documented.

4.6.3.2 Flow and Water Level Assessment

In this task, field data will be collected to support development of a two-dimensional (2-D) hydraulic model (described in Task 4) of each development's tailwater and bypass reach. Calibration flows will be released into the tailwater and bypass reaches for purposes of collecting depth and wetted area data under various powerhouse and spillway flow regimes and spillway flow release points. The model will enable a comparison between powerhouse operations (i.e., flow releases into the tailwater areas) and dam operations (i.e., flow releases into the bypass reaches via spillway gates). Appalachian or their consultant will develop a proposed framework for model scenarios and provide interested relicensing participants the opportunity to review and comment on the framework prior to collecting field data under the calibration flows. The framework is expected to include provisions for the following:

- Water level data loggers (pressure transducers that measure water stage changes) will be strategically deployed in the tailwater, bypass, and downstream study reaches in late-spring/early-summer to begin collecting depth information under a variety of flow regimes (i.e., powerhouse operations and spillway gate openings). Based on monthly average flow data provided in Table 4-2, higher flows typically occur during this time of year, and collecting depth information under these conditions will help calibrate the higher 2-D model flow regimes.
- A level logger will also be placed at the downstream end of the Buck study area to capture changes in water surface elevations created by Project operations. This downstream boundary was requested by the VDGIF to help better understand the potential effect Project operations may have on mussel habitat in this area.
- Documentation of powerhouse and spillway operations will be collected and analyzed to inform flow tests that will be conducted to further support the 2-D model calibration needs. Development of flow test scenarios will be done in consultation with interested relicensing participants.
- The flow tests will be designed and conducted to gather information on additional flow regimes (i.e., different from those captured by level loggers). For example, releasing flows into the bypass reaches via the existing spillway gates and new Obermeyer gates, or combinations of gates, may be of interest. The objective of the flow tests in the bypass reaches will be to obtain data under a variety of lower flow conditions that may be more challenging to model given the complex terrain (i.e., geometry). As flows increase, the model parameters are easier to adjust; so capturing higher flow events are not as critical from a modeling perspective.
- Conducting flow tests under lower flow conditions will also help in assessing existing, and potentially modified, gate operations as it relates to flow patterns and wetted area resulting from ramping rate requirements.
- Gate openings and changes will comply with any existing operating procedures maintained by Appalachian with respect to requirements such as ramping rates.
- The flow tests will be designed to collect data under steady-state conditions, with the time interval at each gate opening or change to be designed to provide ample travel

time to reach constant flow conditions and to allow time for observation and any required discharge measurements at designated locations.

- Total flow in the tailwater and bypass reaches under each test flow scenario will be determined by generation and spillway gate opening calculations and/or direct flow measurements using an appropriate velocity meter.
- Leakage flow measurements (using an appropriate velocity meter) will also be conducted in each bypass reach to determine flow and wetted area at the low end of the flow regime.
- It is anticipated that the tailwater and bypass flow tests will be conducted within one normal four-day work week (i.e., Monday – Thursday), or equivalent if flows are not sufficient over a consecutive four-day period, at each development.
- During the defined flow testing period, date- and time-stamped photographs or time-lapse video will be collected in the study areas.
- The level loggers will remain in place through fall 2020 to further characterize the hydraulics of the bypass reach under additional flow regimes that may occur during this period.

4.6.3.3 Substrate Characterization and Mapping

A Wolman pebble count (Wolman 1954) will be performed along transects (three transects in each bypass reach unless site conditions warrant more) to characterize the existing surface grain size distribution of substrates in the bypass reaches. The locations of and need for additional transects will be determined based on mesohabitats identified and mapped in Task 1, such that habitats will be sampled in proportion to their availability. Substrate particle sizes will be plotted by size class and frequency to determine distributions within the mesohabitats of each of the bypass reaches.

4.6.4 Task 4 – Hydraulic Model Development

Development of a 2-D hydraulic model is proposed as part of this flow and bypass reach aquatic habitat study. A 2-D model incorporates detailed characterization of terrain obtained by topographic mapping technologies, and provides options for building both one-dimensional (1-D) and 2-D geometries. A 2-D model incorporates detailed characterization of terrain obtained by topographic mapping technology, and using a combined 1-D/2-D model development approach optimizes the simulation of observed hydraulic behavior for specific project requirements. Models such as the USACE's HEC-RAS software (version 5.0.3), or the Innovyze ICM software (version 7.0) (or similar computational models) are capable of simulating depth and velocities in a 2-D grid pattern over a wide range of flow conditions.

One of the study goals is to provide an instream flow study. The approximately 4,100-foot long Buck bypass reach extending from the spillway to the vicinity of the powerhouse tailwater is characterized by significant channel morphology variability, including deep and shallow pools, runs, shoals, steep cascades, and side channels with large boulders. This variability impacts travel times differently at various flows and is most accurately represented by a 2-D model. A 2-D model often provides more stable results over a wider range of flows than a 1-D model, thus reducing troubleshooting during model development; however, simulation speed is generally slower. The model software performs 2-D unsteady flow hydraulic calculations to dynamically route the spillway release flood wave downstream. The 2-D model uses a finite-volume solution algorithm to allow for 2-D cells to be wet or dry and handle a sudden rush of water, subcritical, supercritical, and mixed-flow regimes.

The 2-D unsteady flow calculations are based on conservation of mass and momentum. A spillway release is a highly dynamic flood wave that will rise and fall quickly, as such the 2-D unsteady flow calculation will use the full momentum form of the St. Venant equations. The full momentum equation accounts for the change in velocity both spatially and temporally.

The model geometry is defined by digital terrain model elevation values, user inputs based on Project drawings and survey information, and Manning's roughness coefficient inputs; these are used to establish terrain roughness. The 2-D model calculates the flood wave hydrograph resulting from a spillway release based on input gate operation parameters.

Flow and water depth data collected in Task 3 will be used to calibrate and validate the hydraulic model to allow simulation of flow conditions and gate operations other than those that were explicitly sampled during data collection. Recorded gate operations (provided by Appalachian), flow, and level-logger data from each tailwater and bypass study reach will be processed to provide operation sequences and flow and elevation hydrographs used for the calibration of gate and bypass reach model hydraulic parameters.

Another goal of the study is to determine operational procedures for spilling and ramping rates that affect upstream-downstream connectivity. The hydraulic model is capable of simulating reservoir inflow and rate of reservoir rise, dynamic gate operations scenarios, release travel times, and rates of rise at locations within and downstream of the bypass reach. Analyzing the results of varying spill events and spill configurations can provide insight to potential adverse effects on the fish and mussel communities or recreational fishing opportunities in the bypass reach.

Appalachian or their consultant will apply the calibrated model in coordination with interested relicensing stakeholders to simulate a variety of tailwater and bypass flow scenarios. Simulations will be used to establish matrices of travel time, rise in water surface elevation, and velocities at locations of interest under the different flow regimes.

It is noted that any model is a representation of actual physical processes and has inherent uncertainty, especially when used to simulate conditions that were not explicitly observed and recorded. The level of model accuracy is influenced by the quality of data used to build the model, such as channel geometry, geometry and hydraulic parameters of controlling structures (i.e. gates and spillways), the quality of data used to calibrate the model, and choice of model (uncertainty inherent in numerical methods, flow calculation equations, etc.).

4.6.5 Task 5 – Aquatic Habitat Evaluation

Activities described in Tasks 1 – 4 (i.e., literature review and desktop assessment, topographic mapping and photogrammetry, field data collection, and hydraulic model development) will be used to develop a flow and aquatic habitat assessment of the tailwater and bypass reach. Specifically, for each flow scenario evaluated, incremental changes in depth and wetted area will be determined. The water level logger data in combination with the 2-D model results will be used to determine rate of rise and fall of water elevation (i.e., water depth) in the tailwater and bypass reach and evaluate flow patterns and hydraulic connectivity under each flow regime evaluated. In addition, substrate and mesohabitat mapping along with the 2-D model depth and velocity simulation results will be used in combination with aquatic species habitat suitability indices (i.e., using depth, velocity, and habitat preferences) to evaluate potential available habitat under each modeled flow scenario in the study reach.

4.7 Analysis and Reporting

Appalachian anticipates that the Flow and Bypass Reach Aquatic Habitat Study report will include Project information and background, a description of each Study Area, study methodologies, analyses and results, discussion, and references. Study results will include:

1. Literature review and desktop mesohabitat mapping results illustrating the types and size (acres) of available mesohabitats.
2. A summary of the topographic and photogrammetry results.
3. The relationship between flow and water level / wetted area for each target flow evaluated.
4. Development of a gate opening spreadsheet for computation of discharge under a range of headwater elevations and gate opening combinations, if necessary.
5. Substrate characterization and mapping of the bypass reaches (including Wolman pebble count data).
6. Development of a 2-D model for each tailwater and bypass reach (including a description of model development and calibration). The 2-D model runs will evaluate the relationship between minimum flow releases to the tailwater areas versus bypass reaches. Within the bypass reaches, simulations will be performed to evaluate flow releases from various spillway gates to determine flow patterns, hydraulic connectivity, travel time and the timing of flow releases on rise and rates of rise at downstream locations of interest.

7. An evaluation of potential available aquatic habitat for species of interest using substrate, depth, and velocity parameters developed in Tasks 1 – 4.

4.8 Schedule and Level of Effort

The preliminary schedule for this study is outlined in Table 4-3. The estimated level of effort for this study is approximately 2,000 hours and Appalachian estimates that the Flow and Bypass Reach Aquatic Habitat Study will cost approximately $300,000 to complete.

Table 4-3. Proposed Flow and Bypass Reach Aquatic Habitat Study Schedule

Task	Proposed Timeframe for Completion
Desktop Habitat Assessment	November 2019 – March 2020
Topographic Mapping and Photogrammetry Data Collection	Fall 2019
Mesohabitat Mapping and Substrate Characterization Field Data Collection	Summer 2020
Distribute Proposed Flow Test Scenario Framework to Interested Parties for Review	May 2020
Conduct Flow and Water Level Assessment and Hydraulic Model Development	June - October 2020
Distribute Draft Study Report with the ISR	November 2020

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5 Water Quality Study

5.1 Study Requests

The Commission's March 8, 2019 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Effects of continued Project operation and maintenance on water quality, including dissolved oxygen (DO) and water temperature, upstream and downstream of each development, including the Buck bypass reach.
- Whether there is a need for an increase in minimum flow release requirements.

In Section 6.2.2 of the PAD, Appalachian proposed to conduct a Water Quality Study within the Study Area. More specifically, depending on sampling location, Appalachian proposed to monitor temperature, DO, water level, depth profiles, pH, and specific conductance. No formal study requests were received regarding water quality; however comments were received from VGDIF, USFWS, Virginia Tech, and NRC, which are summarized as follows:

- USFWS, VDGIF, and NRC recommended that this study include a thermal aspect that considers how the Project affects the thermal regime of the New River and potential effects on coolwater endemic fishes.
- USFWS, VDGIF, and NRC recommended that this study also consider turbidity and chlorophyll a.
- VDEQ and Virginia Tech recommended that PCB concentrations in sediment deposits behind the dams be investigated.
- Virginia Tech recommended that water level loggers be installed at several locations in the Project boundary (including above and below the powerhouses and in the bypass reaches) for continuous monitoring over a minimum one year period.

Additional comments related to this study were received from USFWS and VDGIF in response to Appalachian's filing of the PSP. These comment are summarized as follows:

- The USFWS and VDGIF noted that vertical temperature and DO profiles may need to be completed bi-weekly and that one season of sampling within the tailrace may not adequately capture the highs and lows over the license terms, especially the dry years.

In addition to the formal comments filed, the following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- VDGIF noted they would prefer that the level loggers are installed in the fall of 2019 to ensure the best data is gathered in case 2020 is too dry or too wet. Appalachian noted if

2020 is not a suitable year for collecting water quality data, the 2021 field season would be used.

- FERC noted importance of annotating water quality results using summaries and graphs in study report to note project operations and inflow conditions.
- Discussion of drag rake operation relative to sediment disturbance/release. Clarify that the rake is not intended to clear sediment, but that some sediments are incidentally scraped/mobilized during operation.

5.2 Goals and Objectives

Appalachian's proposed study employs standard methodologies that are consistent with the scope and level of effort of water quality monitoring conducted at hydropower projects in the region. Appalachian believes that this study will provide sufficient information to support an analysis of the potential Project-related effects on water quality. The goals and objectives of this study are to:

- Gather baseline water quality data sufficient to determine consistency of existing Project operations with applicable Virginia state water quality standards and designated uses.
- Provide data to determine if the Byllesby and Buck impoundments undergo thermal and/or DO stratification and, if so, determine the presence and location of the metalimnion.
- Provide data to support a Virginia Water Protection Permit application (Clean Water Act Section 401 Certification).
- Provide information to support the evaluation of whether additional or modified protection, mitigation, and enhancement measures may be appropriate for the protection of water quality at the Project's developments.

5.3 Study Area

The Study Area for the Water Quality Study is shown on Figure 1-4, and includes the reservoirs, bypass reaches, and tailwaters downstream of Byllesby and Buck dams.

5.4 Background and Existing Information

Existing relevant and reasonably available information regarding water quality in the Project vicinity was presented in Section 5.3 of the PAD (Appalachian 2019). The PAD included historical water quality data collected in support of the existing license and recent water quality data collected during mussel salvage and relocation efforts, and other data collection efforts. These data indicate that temperatures and DO concentrations did not differ between impoundments and tailraces, and no evidence of thermal stratification was observed in either impoundment. Data from the historical studies also demonstrated that the Project waters meet the state water quality standards, including temperature maximums and DO minimums.

On August 29, 2019, a site visit was conducted by HDR for Appalachian to attempt to collect pre-relicensing study season water quality data and evaluate field logistics associated with potential water quality monitoring locations for the Byllesby and Buck developments. During the site visit, a calibrated multiparameter water quality data sonde was used to collect depth profiles in each development's forebay and also spot measurements in each development's tailwater. These data are summarized on Figure 5-1 for Byllesby and Figure 5-2 for Buck. Flow during the site visit was approximately 1,500 cfs measured at the New River at Ivanhoe, Virginia USGS gage (03165500) which is typical of average flow conditions in August at this location (mean monthly discharge for August as shown in Table 4-2 is 1,495 cfs; 1929 – 2019).

During the site visit, the Byllesby forebay elevation was in the normal operating range,[3] however, the Buck forebay elevation was approximately 9 feet lower than the normal operating range[4] to facilitate construction activities associated with installation of the new Obermeyer gates.

All water quality measurements during the site visit were within applicable Virginia state water quality standards. As Figure 5-1 and Figure 5-2 indicate, the depth profiles in each forebay did not show any significant difference in water quality from top to bottom, or from side-to-side. Given that these depth profiles were collected during peak summer conditions and under a relatively low flow, it is not expected that there would be differences in water quality from side-to-side in the forebay areas during the summer months. The tailwater measurements were reflective of the water quality in each forebay.

[3] Normal operating range for the Byllesby impoundment is between 2,078.2 – 2,079.2 feet above mean sea level.

[4] Normal operating range for the Buck impoundment is between 2,002.4 – 2,003.4 feet above mean sea level. During the August 29, 2019 water quality sampling site visit, the forebay elevation was approximately 1994 feet above mean sea level; or approximately 9 feet below the normal operating range.

Figure 5-1. Water Quality Parameters for Byllesby

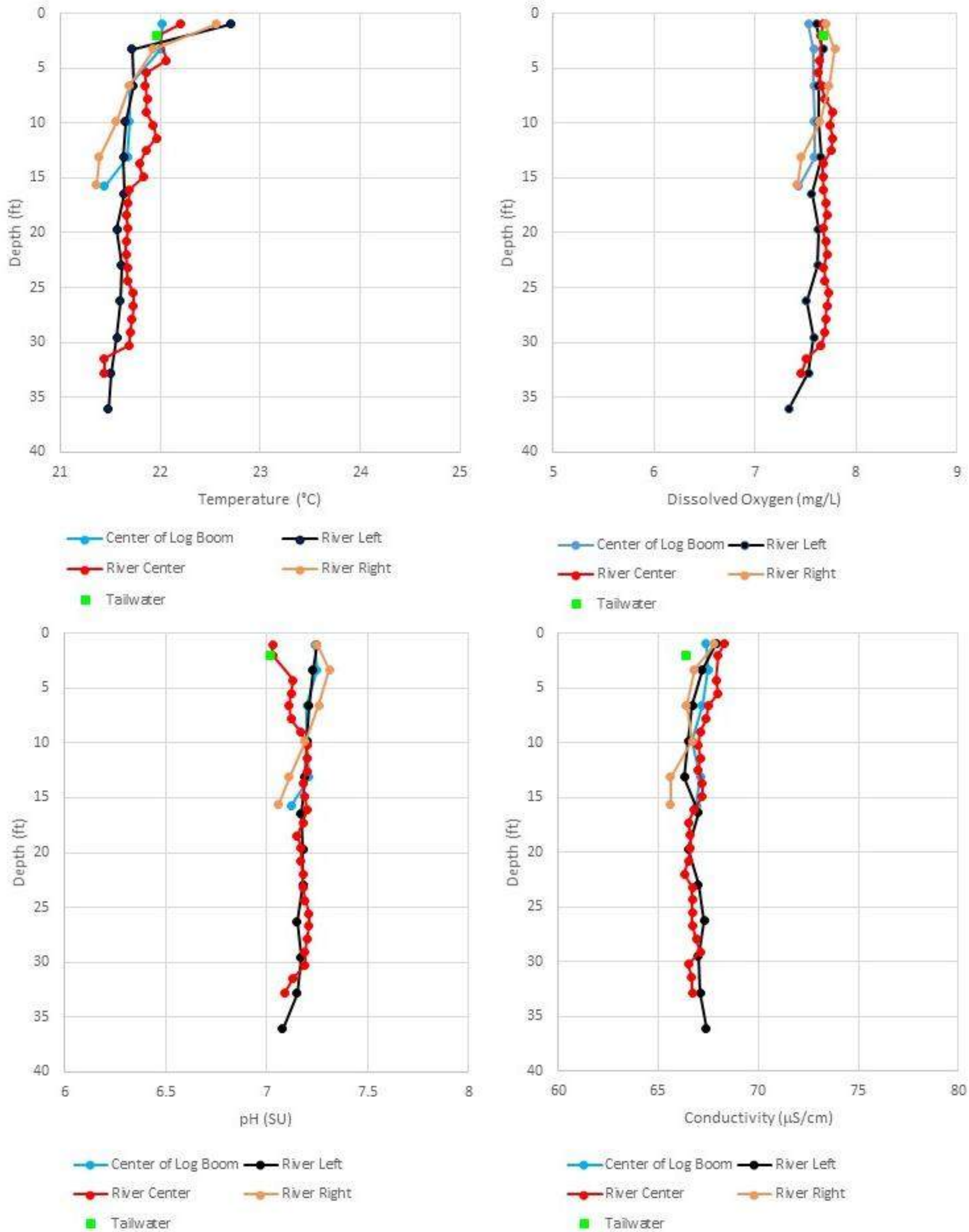
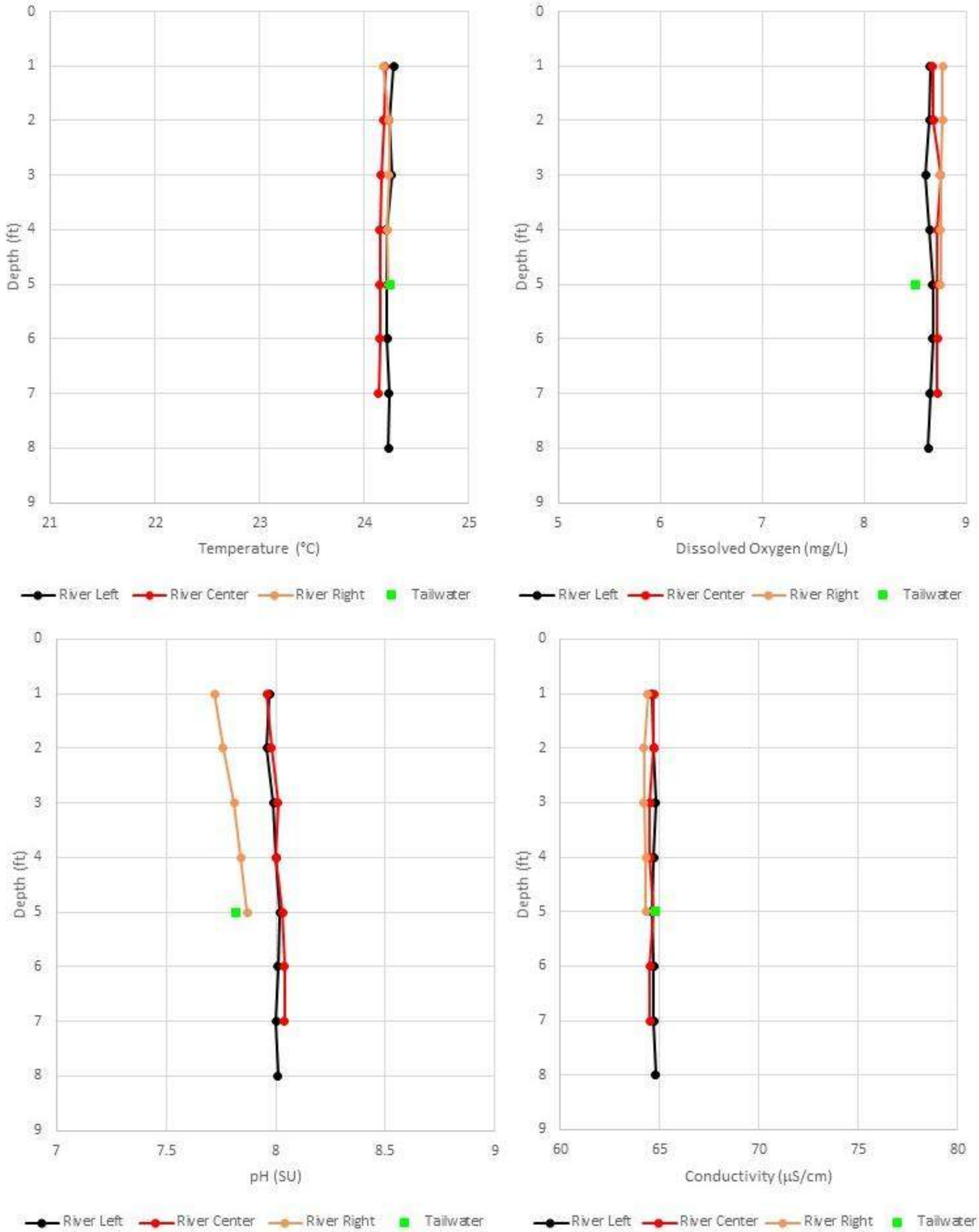


Figure 5-2. Water Quality Parameters for Buck



Multiple segments of the New River are listed as impaired for aquatic life or recreation uses due to *E. coli* concentrations. However, the source of *E. coli* is not associated with the Project and it is expected that continued operation of the Project will have no effect on *E. coli* concentrations in the New River.

From 2003 to 2006, VDEQ collected 209 samples to evaluate organic chemicals in sediment (VDEQ 2018). A low percentage of stream miles had concentrations above the Probable Effects Concentration and sampling has since been suspended due to low concentrations and high sampling costs.

A TMDL study for PCBs was performed for VDEQ by Virginia Tech in the New River watershed and a draft TMDL was developed and last updated in September 2018. According to results of the TMDL study, the PCB impaired segment of the New River in Virginia is located downstream of the Project, beginning where U.S. Interstate 77 crosses the river, and continuing downstream to where the river crosses the Virginia/West Virginia state line (Virginia Tech 2018).

No dredging of reservoir sediment is proposed by Appalachian at this time, nor does Appalachian propose any construction or maintenance activities that could cause the mobilization of reservoir sediments. It is noted that prior dredging activities (1997 and 2014) and associated constituent testing received approval for placement of dredged sediments which were then used for the creation of an emergent wetland upstream of Byllesby and for offsite beneficial reuse.

FERC staff requested that Appalachian provide the results of any PCB testing conducted in support of previous sediment removal projects at the Project (1997 and 2014) in the RSP. Appalachian has reviewed available files and documentation for the Project and provides the following additional information.

Extensive sediment core sampling and testing was conducted during the 1997 dredging at Byllesby. Appalachian is unable to locate the original report or data for this testing; however, the Clean Water Act Section 404 permit issued by USACE for this project includes several agency letters and references to the 1997 toxicity testing, including VDEQ concurrence that the tested material was essentially clean. Documentation of agency consultation in this permit also notes that Appalachian was certain no dredging had been done within the 30 years prior to this effort. A copy of this permit and associated documentation was filed with FERC on October 21, 1997 and is available on FERC's eLibrary.[5]

Permits issued for the dredging conducted at Byllesby in 2014 did not include specific requirements to test the material. Appalachian did, however, perform testing according to the U.S. Environmental Protection Agency (USEPA) SW-846 Test Method 1311: Toxicity Characteristic Leaching Procedure on composite samples from within the forebay. While not specifically tested for PCBs, these tests resulted in no actionable levels for heavy

[5] Accession number 19971021-0377

metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). Furthermore, based on the material composition removed (sand, gravel, etc.), Appalachian does not believe PCB's would be present in the dredged material as PCB's do not have an affinity to bind to such coarse-grained material.

As stated in the PAD, any necessary future dredging and disposal would be coordinated with the U.S. Army Corps of Engineers and VDEQ pursuant to license Article 12 to obtain any required permits and approval. Although prior testing indicated the material was safe for other uses, Appalachian understands that proposed new dredging authorization may require additional testing for constituents of concern in the sediments being proposed for dredging prior to, and depending on the results of such testing, determining the appropriate fate of the material.

5.5 Project Nexus

The Byllesby and Buck developments are operated in a run-of-river mode under all flow conditions, with operation of the two developments closely coordinated. Due to the small size and short retention time of the Project reservoirs, the lack of thermal stratification demonstrated by past studies, and the mode of operation, Appalachian does not expect that operation of the Project affects ambient water quality in the New River above or below the Project.

The Project impounds water at the Buck and Byllesby dams. Meteorological and hydrological conditions (flow) and operation of the Project, including diversion of flows to the powerhouse for generation and resultant reduction of flows to the bypass reaches, may combine to impact water quality parameters such as temperature and DO in the Project reservoirs, powerhouse tailraces, and bypass reaches.

5.6 Methodology

5.6.1 Task 1 – Continuous Water Temperature and DO Monitoring

Appalachian proposes to monitor temperature and DO using multiparameter water quality instrumentation (i.e. sondes) at the following locations:

- One location in the upstream extent of the Byllesby reservoir
- Two locations in the Byllesby forebay (upper and lower portion of the water column)
- One location in the Byllesby tailrace below the powerhouse
- One location in the Byllesby bypass reach (approximate mid-point)
- Two locations in the Buck forebay (upper and lower portion of the water column)
- One location in the Buck tailrace below the powerhouse
- Two locations in the Buck bypass reach (one upstream area and one downstream area)

The approximate locations are depicted on Figure 5-3 and Figure 5-4. Appalachian expects to verify these locations during the initial field deployment and will communicate any substantive changes to the VDEQ and other interested relicensing participants.

All water quality monitoring locations will be geo-referenced using GPS. GPS locations will be included in a GIS database layer to support the documentation and reporting of collected data and to facilitate comparisons with future monitoring efforts.

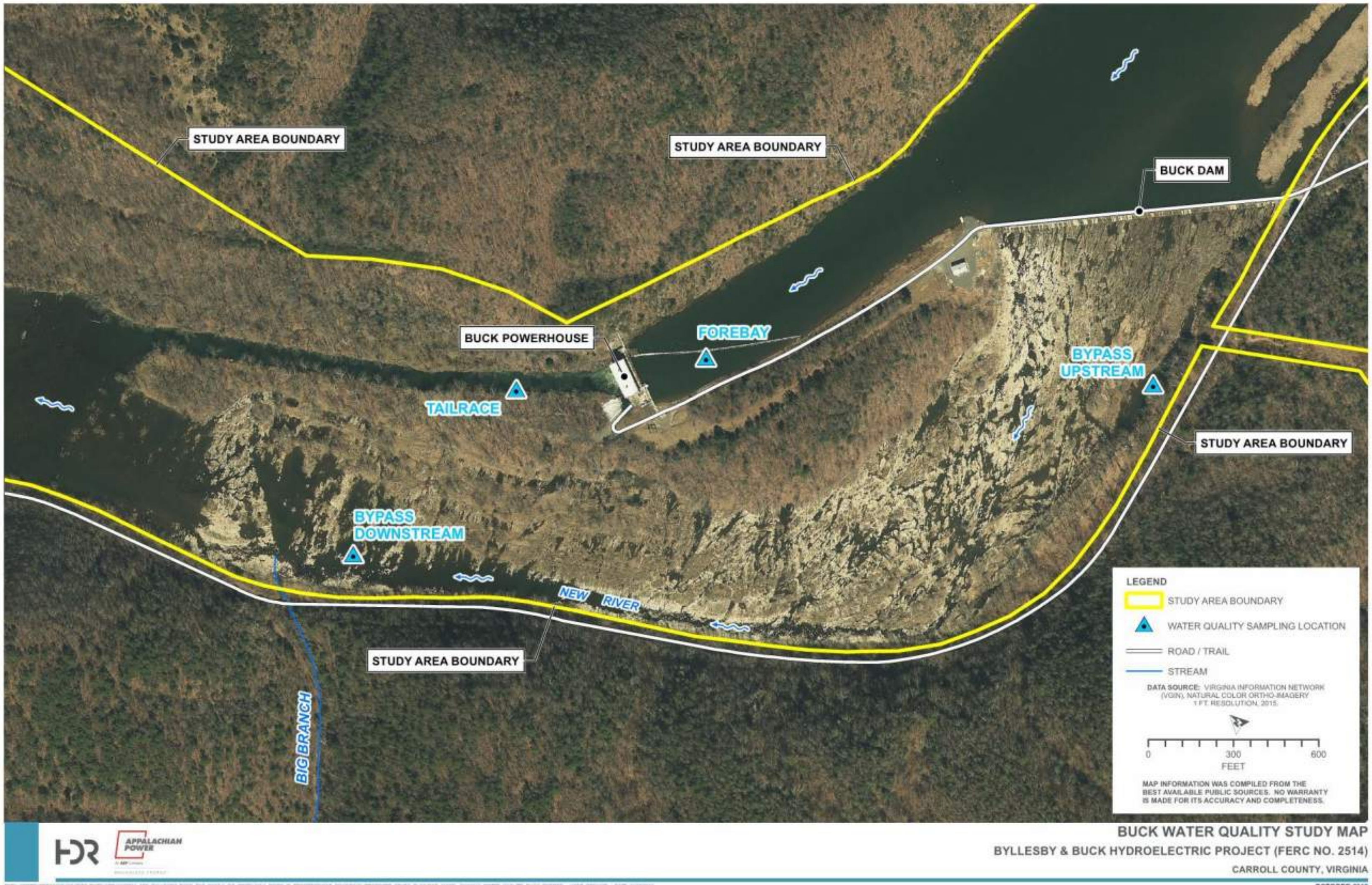
Water temperature and DO data sondes will be deployed for a single season, from May 1, 2020 through September 30, 2020 and will collect data at 15 minute intervals. Each of the data sondes will be cleaned and calibrated prior to deployment and checked each month during data retrieval. As necessary, protective measures may be employed, such as weighting the data sondes or attaching them to permanent structures (where feasible) to maintain position during high flow events. Note the data sondes deployed in the tailwater and bypass reach locations will also collect temperature and DO data during the flow test events described in the Flow and Bypass Reach Aquatic Habitat Study (Section 4). If a data sonde is lost due to vandalism or a high flow event, Appalachian will replace the instrumentation one time only.

Data sondes deployed in the Byllesby and Buck forebays will be set at two discrete depths to determine the existence and extent, if any, of thermal and DO stratification. Based on the August 29, 2019 site visit described above, the depth of the Byllesby forebay at approximately the mid-point of the spillway structure is approximately 35 feet. As a result, the upper data sonde will be placed approximately 12 feet below the surface and the lower data sonde will be placed approximately 24 feet below the surface. The depth of the Buck forebay near the center of the intake channel is approximately 17 feet.[6] As a result, the upper and lower data sondes will be placed at approximately 6 feet and 12 feet below the surface, respectively.

[6] During the August 29, 2019 water quality sampling site visit, the Buck pool level was at approximately 1994 feet above mean sea level; or approximately 9 feet below the normal operating range of 2002.4 – 2003.4 feet above mean sea level (the impoundment was drawn down to facilitate construction activities at the spillway). At the time of the site visit, the depth measured near the center of the intake channel was approximately 8 feet. Therefore, at normal pool levels, the depth at the same location will be approximately 17 feet (i.e., 8 feet + 9 feet).

Figure 5-3. Byllesby Water Quality Study Locations

Figure 5-4. Buck Water Quality Study Locations



5.6.2 Task 2 – Monthly Water Quality Monitoring

In addition to continuous monitoring, once per calendar month (May through September), in situ water quality measurements of temperature, DO, pH, and specific conductance will be collected at each of the locations described above with a Hydrolab or similar data sonde. At the forebay monitoring locations, depth profiles will be collected each month. Note the depths of the data sondes (used for continuous monitoring) may be adjusted, if necessary, during the study based on a comparison of the continuous temperature and DO results with the monthly depth profile measurements. In addition, if it appears that brief periods of stratification may be occurring, collection of forebay depth profiles may be increased to bi-weekly.

Turbidity will also be measured at a single depth of approximately one meter using a portable turbidity meter at each of the continuous water quality monitoring locations. Turbidity measurements will be recorded in Nephelometric turbidity units.

Chlorophyll a will also be measured in the forebay of each development during the monthly sampling events. Chlorophyll a will be collected via grab samples at a single depth of approximately one meter and samples will be subsequently analyzed at an off-site laboratory.

Individual water quality measurements (temperature, DO, pH, conductivity) will also be collected during fisheries and macroinvertebrate field sampling events.

5.7 Analysis and Reporting

Results of this study will be summarized in a final study report. Appalachian anticipates that the Water Quality Study report will include Project information and background, a depiction and descriptive narrative of the Study Area, methodology, results, analysis, and discussion. In addition, stakeholder correspondence and/or consultation will be included, as well as any literature cited. Raw data will be provided in appendices to the study report.

5.8 Schedule and Level of Effort

The preliminary schedule for this study is outlined in Table 5-1. The estimated level of effort for this study is approximately 500 hours. Appalachian estimates that the Water Quality Study will cost approximately $110,000 to complete. If the proposed study period is deemed anomalous due to abnormally wet and/or cool weather conditions, a second study year may be necessary to capture water quality conditions representative of typical summer conditions. Additionally, if the water quality data collected during the proposed study period does not meet the goals and objectives described in Section 5.2, a second year of data collection may be necessary.

Table 5-1. Proposed Water Quality Study Schedule

Task	Proposed Timeframe for Completion
Study Planning and Existing Data Review	January – March 2020
Continuous and Monthly Water Quality Monitoring (DO and temperature)	May – September 2020
Distribute Draft Study Report with the ISR	November 2020

6 Aquatic Resources Study

6.1 Study Requests

The Commission's March 8, 2019 SD1 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing.

- Effects of continued Project maintenance (periodic impoundment drawdowns to replace flashboards and periodic dredging to remove sediments from the impoundments) on aquatic resources, particularly freshwater mussels and fish spawning habitat in the impoundments of each development.
- Effects of continued Project operation on aquatic resources, including entrainment and impingement mortality of resident fishes, such as Walleye, Smallmouth Bass, and Spotted Bass at each development.
- Effects of continued Project operation and maintenance on species of special concern such as the eastern hellbender.
- Adequacy of the existing 360-cfs minimum flow for aquatic resources, including resident fish species, downstream of each development (Byllesby and Buck).
- Adequacy of the existing ramping rate to prevent fish stranding in the Buck bypass reach.

In Section 6.2.3 of the PAD, no aquatic species surveys were proposed by Appalachian. Formal study requests were received from USFWS, VDGIF, and Virginia Tech during the scoping process, including requests for assessments of species diversity and abundance for aquatic flora and fauna (i.e., fish, macroinvertebrates, shellfish (crayfish), mussels, eastern hellbender, and aquatic vegetation) in the Project area. Additional comments and informal study requests were also received from USFWS, NRC, Virginia Tech, VDEQ, and VDGIF related to aquatic resources. Requests and comments are further summarized as follows:

- USFWS, VDGIF, NRC, Virginia Tech requested an Aquatic Resources Study to gather information on fish, crayfish, macroinvertebrate, mussels, eastern hellbender, and foundational aquatic vegetation.
- Virginia Tech requested an Enhancement Plan for Biodiversity and Sport Fishing, a Water Willow Study, and a determination of the Target Biological Community in the bypass reaches of Byllesby and Buck.
- NRC requested a Fish Protection and Downstream Passage study, to include an assessment of impingement and entrainment and a literature review of fish passage designs and their species-specific effectiveness.
- USFWS, VDGIF, and NRC stated that they will consider PM&E measures to aid in species recover for the federally endangered Candy Darter, recommended a multi-taxa biologic survey including the eastern hellbender, and recommended discussions of the state-listed Green Floater due to its potential for federal listing in 2020.

- Virginia Tech stated that coolwater endemic fishes are potentially influenced by the Project and that fish population enhancement through creation of spawning and rearing habitats, and habitat rehabilitation/diversification are effective mitigation strategies in hydropower projects.

Comments on the Aquatic Resources Study Plan were received from USFWS, VDGIF, and FERC in response to the filing of the PSP. These comments are summarized as follows:

- USFWS and VDGIF commented that there are potential cumulative effects on aquatic resources from the Project, and stated that dams contribute to effects on fish, mussel, macroinvertebrate and hellbender populations (migration, entrainment, habitat, stranding in bypass reaches).
- FERC requested clarification if Appalachian plans on sampling for Candy Darter as part of the Fish Community Study, and if so, what sampling gear and methodology would be used.
- FERC asked if the desktop mussel literature review would include size measurements (shell length) from previous efforts, and if so, would they be used as part of the desktop study. VDGIF and USFWS requested a mussel community study be completed as part of the Aquatic Resources Study.
- FERC requested that Appalachian explain the rationale for not including the eastern hellbender in the multi-taxa study to assess its presence with the Project Area. USFWS and VDGIF noted that Appalachian agreed to assume positive presence of the eastern hellbender. No surveys were recommended. Due to lack of acceptable survey methodology, VDGIF recommended that AEP assume presence of eastern Hellbender within the Project boundary.
- USFWS requested that Appalachian include the usage of the most recent version of the USFWS Turbine Blade Strike Analysis model.
- VDGIF noted that New River Muskellunge stocking was discontinued downstream of Claytor Dam in 2011 and upstream of Claytor Dam in 2018.
- VDGIF requested that fish surveys begin in April for adequate assessment of resident Walleye populations downstream of Buck Dam. Additionally, VDGIF asked that total length measurements of 100 game fish is included as part of the study and final report.

In addition to the formal comments filed, the following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- The USFWS and VDGIF requested additional information on the Fish Community Study, specifically, a map identifying proposed sampling locations and the methodology to be used during sampling.
- VDGIF noted there is a considerable amount of existing information for Cripple Creek, so they would prefer focusing Candy Darter sampling locations in the mainstream of the river upstream/downstream of Cripple Creek, in addition to historical fish community locations previously studied. They noted that known extant Candy Darter populations are restricted to Ridge & Valley streams, and extent of distribution is expected to

terminate just upstream of Cripple Creek. Kanawha darter may be present in other tributaries.

- Meeting participants agreed that if there is available habitat and adequate water quality, Appalachian would assume presence of Hellbender rather than survey specifically for them. Other targeted surveys will document any incidental hellbender occurrences should they occur.
- USFWS agreed with Appalachian's methodology of sampling for macroinvertebrates. Appalachian noted that sampling locations will not be included in RSP, but will be determined through desktop and field habitat assessment. PSP meeting participants indicated that additional data on macroinvertebrates in the New River are available from the upstream Fries Project, while data on the Crayfish community are available from the downstream Claytor Project.
- VDGIF expressed concerned regarding absence of existing mussel data for the area located between the upper extent of the Buck pool and the downstream side of Byllesby dam, which includes a small island approximately 1.9 miles downstream of Byllesby dam (potential habitat).
- USFWS asked about the potential for unit upgrades or runner replacements during the term of the new license, and whether replacements would be in-kind or different sizes or types (that would affect entrainment). Appalachian, VDGIF, and USFWS agreed that the target operational scenarios of interest are the efficient and maximum flows through all installed units at each powerhouse.

6.2 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.

6.3 Study Area

The Study Area for the Aquatic Resources Study includes the New River and lower reaches of larger tributary streams within the Study Area shown on Figure 1-4. The Study Area for the mussel community survey includes two shallow shoal areas, three deep shoal areas, three pools, and two side channels located in the reach between the Byllesby and Buck dams (Figure 6-1). The Study Area for the impingement and entrainment analysis will include the areas of influence created by the intake structures at the Byllesby and Buck developments.

6.4 Background and Existing Information

6.4.1 Fish Community

Existing relevant and reasonably available information regarding the aquatic species community in the Project vicinity was summarized in Section 5.4 of the PAD (Appalachian 2019). The New River is characterized as a warm water stream with designated uses that include recreation, aquatic life, production of commercial natural resources, and hydroelectric generation (Virginia Code 9VAC25-260-10). The portion of the New River from the Montgomery-Giles County line to the Virginia-North Carolina state line supports a coolwater fishery (i.e., trout) and has separate water quality standards that apply per Virginia Code 9VAC25-260.

The New River, although characterized as having a low number of native fish species (44 native fish species) compared to similarly sized rivers in the eastern U.S. (Carey et al. 2017), supports a high number of endemic species (8 endemic species) in comparison to other eastern U.S. rivers (Orth 2017). The endemic species of fish in the New River include three minnows, two sculpins, and three darters, as follows: Bigmouth Chub (*Nocomis platyrhynchus*), Kanawha Minnow (*Phenacobius teretulus*), New River Shiner (*Notropis scabriceps*), Kanawha Sculpin (*Cottus kanawhae),* Bluestone Sculpin (*Cottus sp.),* Candy Darter (*Etheostoma osburni),* Kanawha Darter *(Etheostoma kanawhae),* and Appalachian Darter *(Percina gymnocephala)* (Orth 2017).

The Candy Darter, as stated in Section 5.4.1 of the PAD, is an endemic fish found in the New River drainage basin that was federally listed in the federal register (83 FR 58747) as endangered on November 21, 2018 (USFWS 2018a). Extant populations of Candy Darter are currently threatened from a variety of factors including in habitats where they co-occur with the Variegate Darter (*Etheostoma variatum)* which hybridizes with this species, swamping the gene pool. The Candy Darter is associated with clean rock, rubble, or gravel riffles with swift flows in creeks or small to medium rivers (Rohde et al. 1996) and are intolerant of excessive sedimentation and substrate embeddedness (USFWS 2018). Five watersheds, located in the Ridge and Valley physiographic province, and that contain known Candy Darter habitats are listed as critical habitat; all five watersheds are tributaries to the New River (USFWS 2018a). The nearest critical habitat to the Project is Cripple Creek, which confluences with the New River 5 RM downstream of Buck dam. The Ridge and Valley province terminates just upstream of Cripple Creek, and Candy Darter are not known to occur upstream of this location, currently or historically. Based on these data, Candy Darter are not anticipated to occur in the New River within the Project boundary.

The New River is a popular sport fishery with recreational fishing targeting multiple bass species (i.e., Smallmouth Bass [*Micropterus dolomieu]*, Spotted Bass [*Micropterus punctulatus]*, Largemouth Bass [*Micropterus salmoides]*, Rock Bass [*Ambloplites rupestris]*, Striped Bass [*Morone saxatilis*], and hybrid bass [Striped Bass x White Bass hybrid]), in addition to Muskellunge (*Esox masquinongy*), Walleye (*Sander vitreus*), Black Crappie (*Pomoxis nigromaculatus*), Channel Catfish (*Ictalurus punctatus*), Flathead

Catfish (*Pylodictis olivaris*), Redbreast Sunfish (*Lepomis auritus*), and Bluegill (*Lepomis macrochirus*). Trophy Smallmouth Bass and Channel Catfish are known to occur between the Fries and Byllesby dams. State record Walleye have been caught near Buck dam, while trophy-size catfish and Muskellunge have been caught in the deep pools downstream of the dam (VDGIF 2017).

VDGIF has been stocking and managing the Walleye fishery from Fries dam downstream to Claytor Lake dam since 2000 in efforts to restore it to a self-sustaining population size (VDGIF 2013). Since 2003, over one million indigenous Walleye from upstream spawning sites have been stocked in the New River between Allisonia, in Pulaski County, upstream to Fields dam, near the community of Mouth of Wilson, in Grayson County (VDGIF 2017). Creel and slot limits are managed by river reach so that certain populations are protected for spawning and/or during spawning seasons.

Since the 1970s, VDGIF had also been stocking Muskellunge in the New River with the goal of establishing a reproducing, self-sustaining population. Muskellunge are managed primarily as a trophy fish and secondarily as a predator for forage fish control (Brenden 2005). In the New River, Muskellunge exhibit fast growth rates and regularly reach trophy sizes, suggesting that the conditions of the New River are well-suited to support this species (Brenden 2005). Management is implemented by minimum length and creel limit regulations. As with stockings into other Virginia rivers, Muskellunge are stocked into the New River on a rotating priority system, where waterbodies not stocked the previous year are given higher priority than those that were stocked (Brenden 2005). According to the latest (available) warmwater fish production and stocking information from VDGIF (2014), 500 9-inch-long Muskellunge were stocked in the upper New River in Wythe and Carroll counties in 2014. However, as noted in VDGIF’s September 18, 2019 comments, as of 2014, in response to an increase in the population and evidence of natural reproduction, Muskellunge stockings were discontinued in the New River downstream of Claytor Dam in 2011 and upstream of Claytor Dam in 2018 (VDGIF 2019).

There are no long-run anadromous fish species in the Project area as upstream movement of fish is currently limited by dams upstream and downstream of the Project. There are currently no plans on record to install fish passage at any other dam on the New River.

Appalachian is proposing to conduct a fisheries survey to characterize the fish species composition and abundance in the vicinity of the Project. At this time, Appalachian believes that a fish migration/passage study is not warranted as requested by the USFWS. Based on the results of this study, Appalachian will consult with stakeholders during the ISR Meeting to determine if further study is required related to fisheries resources. Additionally, Appalachian expects that a standard license article will be included in the new FERC license regarding fishway prescriptions under Section 18 of the Federal Power Act.

6.4.2 Macroinvertebrate and Crayfish Community

Benthic macroinvertebrates and crustaceans such as crayfish are an important component of riverine systems where they serve as a food resource for fish and as useful indicators of water quality and environmental stressors. Often, the presence of pollution-intolerant macroinvertebrates, or EPT taxa (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) can be indicative of a healthy stream.

Existing relevant and reasonably available information regarding the macroinvertebrate community in the Project vicinity was summarized in Section 5.4.5 of the PAD (Appalachian 2019). No recent macroinvertebrate data is available for the Project area. However, during the 2016-2017 aquatic resource surveys conducted at the Fries Project, 17 species of Odonata representing 4 families were collected from various reaches (Carey et al. 2017). The pygmy snaketail (*Ophiogomphus howei*), Allegheny River cruiser (*Macromia alleghanensis*), spine-crowned clubtail (*Gomphus abbreviates*) and green-faced clubtail (*G. viridifrons*) were also collected in the surveys.

Specific to the Project area, a letter dated September 23, 2017 from the VDCR identified two species of aquatic insect as “species of greatest conservation need” with the potential to occur within the Project vicinity: the mustached clubtail (*Gomphys adelphus*) and the pygmy snaketail (*Ophiogomphus howei*). Additional information regarding these rare species is provided in Section 5.7.2 of the PAD.

Existing relevant and reasonably available information regarding the crayfish community in the Project vicinity was summarized in Section 5.4.5 of the PAD (Appalachian 2019). No recent crayfish community data is available for the Project boundary. However, a 2008 crayfish survey was performed at the downstream Claytor Project. Six hundred and ninety crayfish representing three species were identified during the survey (DTA 2008). Three crayfish taxa were documented at multiple sites downriver from the Claytor Lake dam including the invasive Northern virile crayfish (*Orconectes virilis*), spiny stream crayfish (*Orconectes cristavarius*), and the federally protected New River crayfish (*Cambarus chasmodactylus*). The invasive Northern virile crayfish dominated overall densities at sites (DTA 2008).

Additionally, concurrent to aquatic resources and fisheries surveys at the Fries Project, crayfish surveys were also completed using a variety of sampling gear and methodologies (e.g., kick-net, seine-haul, D-frame dip nets, and snorkel surveys) (Carey et al. 2017). Over 800 live Spiny Stream Crayfish were collected within the study reaches upstream and downstream of the Fries Project, but not within the Fries Project reservoir or bypass reach. The Spiny Stream Crayfish was the only taxon of crayfish collected in the New River during the surveys.

6.4.3 Mussel Community

Existing relevant and reasonably available information regarding the mussel community in the Project vicinity was summarized in Section 5.4.5 of the PAD (Appalachian 2019). Eleven species of freshwater mussels have been documented in the upper New River in recent surveys of the upper New River (Pinder et al. 2002; Alderman 2008; Stantec 2016, 2017, 2018a, 2018b).

A 2007-2008 survey by Alderman (2008) identified six extant mussel species in Claytor Lake: giant floater (*Pyganodon grandis*), paper pondshell (*Utterbackia imbecillis*), purple wartyback (*Cyclonaias turberculata*), pistolgrip (*Tritogonia verrucosa*), pocketbook (*Lampsilis ovata*), and spike (*Eurynia dilatata*). In 2008, two of 16 sites surveyed in the New River located downstream of Buck Dam (Buck Downsteam 1 and Buck Downstream 2) produced a total of 125 pistolgrip, 134 purple wartyback, nine pocketbook, and seven spike mussels (Alderman 2008). Alderman (2008) did not report length data for any of the specimens collected at these sites.

In October 2015, Stantec Consulting Services, Inc. (Stantec) (2016) performed a mussel survey on the New River in Virginia. Two of the seven sample sites (Buck Downsteam 1 and Buck Downstream 2) were located less than a mile downstream of Buck dam (Figure 6-1) and were previously surveyed by Alderman (2008). Sites were surveyed with a combination of transect and quadrat sampling either by scuba diving or snorkeling. After transects were surveyed, the areas with the highest abundance of mussels was determined and selected for quantitative sampling. A total of 130 live mussels were observed in the New River during the survey. The purple wartyback was the most abundant species with 96 individuals documented, followed by the pistolgrip with 26 mussels documented. Recruitment was observed for these two species as measured lengths indicated multiple-year classes were present.

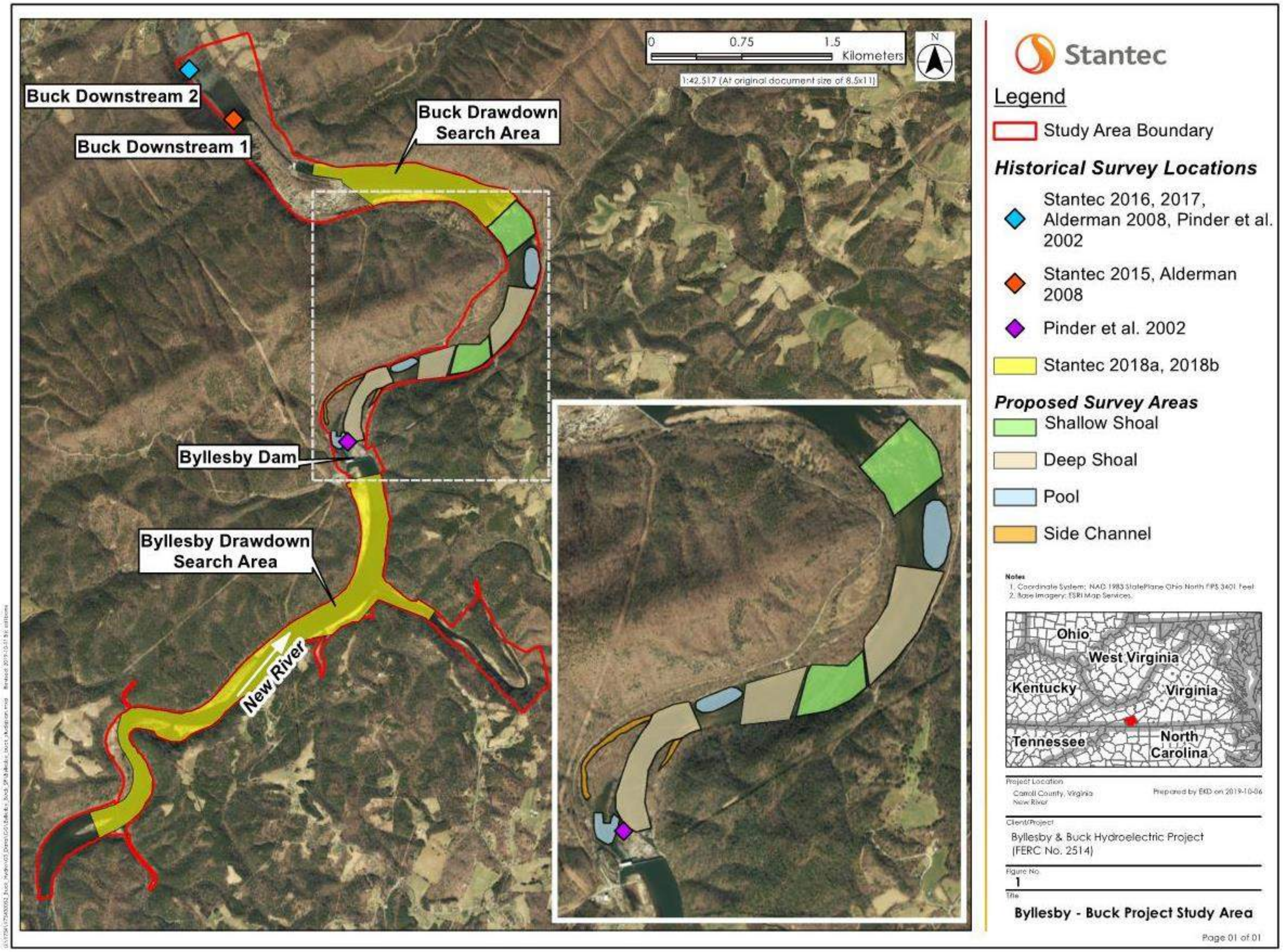
In June and September 2017, Stantec (2017) reassessed the mussel assemblage at sites along the New River (Figure 6-1). The primary objective of the sampling in June was to document reproductive behaviors, whereas September sampling focused more on overall abundance and population dynamics. In June, two upstream sites were sampled, one of which was close to RM 32, and the other near RM 2 downstream of Claytor Lake. A total of 129 live mussels were collected, with reproductive status assessed on 59 of those, none of which were observed to brood glochidia and divers did not observe any displaying females.

Appalachian consulted with USFWS and VDGIF regarding freshwater mussels at the Byllesby-Buck Project in 2016 in support of the non-capacity amendment application for the installation of the inflatable Obermeyer crest gates. In correspondence to Appalachian, dated November 15, 2016, USFWS stated that green floater may be present in the Byllesby-Buck Project reservoirs. During a riparian habitat assessment conducted at the Byllesby-Buck Project in April 2017, it was reported to Appalachian (and in turn reported to VDGIF, USFWS, and FERC) that a weathered, dead shell of a green floater was found on a dry gravel bar along the New River, upstream of the

Byllesby dam (correspondence from W. Baltzersen of Environmental Solutions & Innovations, Inc. [ESI] to AEP, dated May 2, 2017).

Mussel salvage and relocation activities were conducted in the Byllesby reservoir from April 30-May 1, 2018, during a planned reservoir drawdown for the above-mentioned Obermeyer crest gate replacement at Byllesby dam (Stantec 2018a). The mussel salvage and relocation effort was performed along 500-meter-long areas of the exposed channel margins above Byllesby dam (Figure 6-1). Search areas were surveyed, and where suitable substrates were observed, a visual search for mussels was performed. Four live mussels, three purple wartyback and one green floater, were identified and measured, and then relocated upstream of the impoundment in areas with suitable substrate with a similar mussel assemblage.

Figure 6-1. Historical and Proposed Mussel Survey Locations



A mussel rescue was performed in the pool upstream of Buck dam during a drawdown on July 10-11, 2018 (Stantec 2018b) (Figure 6-1). Surveys for mussels were performed along exposed channel margins, in addition to a section of islands above Buck dam. Two live mussels, one wavy-rayed lampmussel and one purple wartyback were removed and held until post-drawdown, when they were returned to wetted areas in suitable habitat that was similar to that which was exposed during mussel surveys.

In the spring of 2019, Stantec conducted additional surveys to document reproductive behaviors. Several gravid purple wartybacks and spikes were collected and taken to the USFWS mussel propagation facility in Marion, Virginia for captive rearing. Glochidia were extracted from females for parasitization of host fish. Transformed and excysted juveniles were collected and held in rearing tanks to facilitate growth. In the spring of 2020, mussels will be returned to the river, placed in protective enclosures, and monitored for growth and survival. The objective of these studies is to assess growth and survival at representative locations upstream and downstream of Claytor Lake. One of the upstream monitoring locations will likely be Buck Downstream 2 (Figure 6-1).

In summary, of the 11 species historically documented in the New River Basin, 6 species have been collected within a mile of the Project since 2002: the purple wartyback, spike, pocketbook, pistolgrip, wavy-rayed lampmussel, and green floater (Table 6-1).

Table 6-1. Summary of Documented Occurrence for Six Mussel Species in the Byllesby-Buck Study Area

Common Name	Survey Areas				
	Byllesby Drawdown	Byllesby Tailrace	Buck Drawdown	Buck Downstream 1	Buck Downstream 2
Purple wartyback	X	X	X	X	X
Pistolgrip				X	X
Spike				X	X
Pocketbook				X	X
Wavy-rayed lampmussel			X		
Green floater	X				

(x) indicates organism was identified in the survey area

6.4.4 Impingement and Entrainment

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 does not pass through the trash rack or intake screen (entrained), but is instead held or impinged on the screens due to forces created by the intake velocities. A gradient of fish entrainment potential exists both temporally and spatially at intake structures. Smaller-sized fish may be more abundant during certain portions of the year, thus increasing their potential for 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, stratification, and intake proximity to feeding and rearing habitats also affect the potential for a fish to become entrained. These factors and several others are used to make general assessments of entrainment and impingement potential at hydroelectric projects using a desktop study approach.

In support of the original licensing in the early 1990's, Appalachian conducted a fish entrainment study in which it was determined that the amount of entrainment and mortality at the Project was insignificant and would not have a measureable effect on the fish community (FERC 1994).

6.5 Project Nexus

Potential Project effects on aquatic resources may include insufficient flows within downstream reaches, habitat impacts due to water quality or sedimentation, fluctuations in reservoir elevations, and possible effects from impingement and entrainment. Information on the species diversity, abundance, and distribution of the existing fisheries community will help identify the aquatic species potentially affected by Project operations.

6.6 Methodology

6.6.1 Task 1 – Fish Community Study

6.6.1.1 Collector's Permits

No species-specific effort is proposed for Candy Darter or other federally-protected species at this time, and as such, no additional permits are anticipated to be required. However, there is potential for additional taxa to be added to state or federal species listings or revisions or other changes to be made between development of the study plans and the initiation of field work in spring 2020. As such, prior to commencing field work, Appalachian or Appalachian's consultant will coordinate with USFWS and VDGIF regarding potential for encountering federal or state-protected fish species and to identify/obtain specific permits that may be required prior to initiating fisheries field sampling work.

6.6.1.2 Field Sampling

Appalachian proposes to conduct one year of fish data collection following the National Rivers and Streams Assessment protocol (USEPA 2019). Sampling will be conducted during daylight hours in the late spring/early summer (April – May) and the late summer/early fall (August – September) of 2020. Specific sampling dates within these timeframes will be 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 general public.

Appalachian or their consultant will conduct sampling in the reservoirs, tailraces, and wetted portions of bypass reaches of the Buck and Byllesby developments using boat and backpack electrofishing (into seines where appropriate) methods. Sampling locations were selected to overlap with historical electrofishing sampling locations and includes both near-shore (shallow) and mid-channel (deep) habitats to characterize fish communities and life stages that use these different habitat types.

Gillnet deployments below Buck dam in the historical fish community study (Appalachian 1991) were originally proposed; however, due to difficulties associated with net fouling and at least one record of a missing net (believed stolen) during historic field efforts, these gear types were excluded. Hoop nets were also used in the historical study, which only resulted in the collection of four additional fish taxa (Largemouth Bass, Black Crappie, Yellow Perch, and Muskellunge), all of which are susceptible to electrofishing gear. The previous study also included both day and nighttime boat electrofishing samples, however results were not reported separately for the diel periods.

Given the limitations and challenges associated with gillnet and hoop net methods, Appalachian proposes to perform the fish community study using a combination of boat electrofishing (reservoirs) and backpack electrofishing with seines in non-reservoir, wadeable habitats. Electrofishing samples will be collected during daylight hours to minimize safety concerns associated with nighttime boat work on the New River. The proposed study replaces the gillnet (six in Byllesby reservoir, eliminated in Buck reservoir) and hoop net (six per reservoir) methodologies with boat electrofishing (three additional boat electrofishing sites per reservoir) in the same pool habitats sampled during the historical study.

Based on input received to date on the PSP, additional sites were added to provide increased representation of riffle/run habitats where non-game species are often collected, to evaluate the tailrace and bypass reaches of each development, and to include a site in Crooked Creek. These additional sites also serve to balance the study design.

The proposed sample survey design is presented for Byllesby in Figure 6-2 and for Buck in Figure 6-3. The proposed study will include 12 boat electrofishing sample sites in each reservoir and 6 backpack electrofishing sample sites in non-reservoir (i.e., riverine) portions of each development (4 sites upstream of each dam and 2 sites downstream of each dam).

Supporting data will be collected at each sampling site including location via GPS, sampling gear type(s); habitat characterization; representative photographs; time and date of sampling; weather; general descriptions of depth, flows, and substrate; and cover type including submerged and emergent aquatic vegetation and estimated percent cover.

Figure 6-2. Location of Proposed Fish Community Sampling at Byllesby

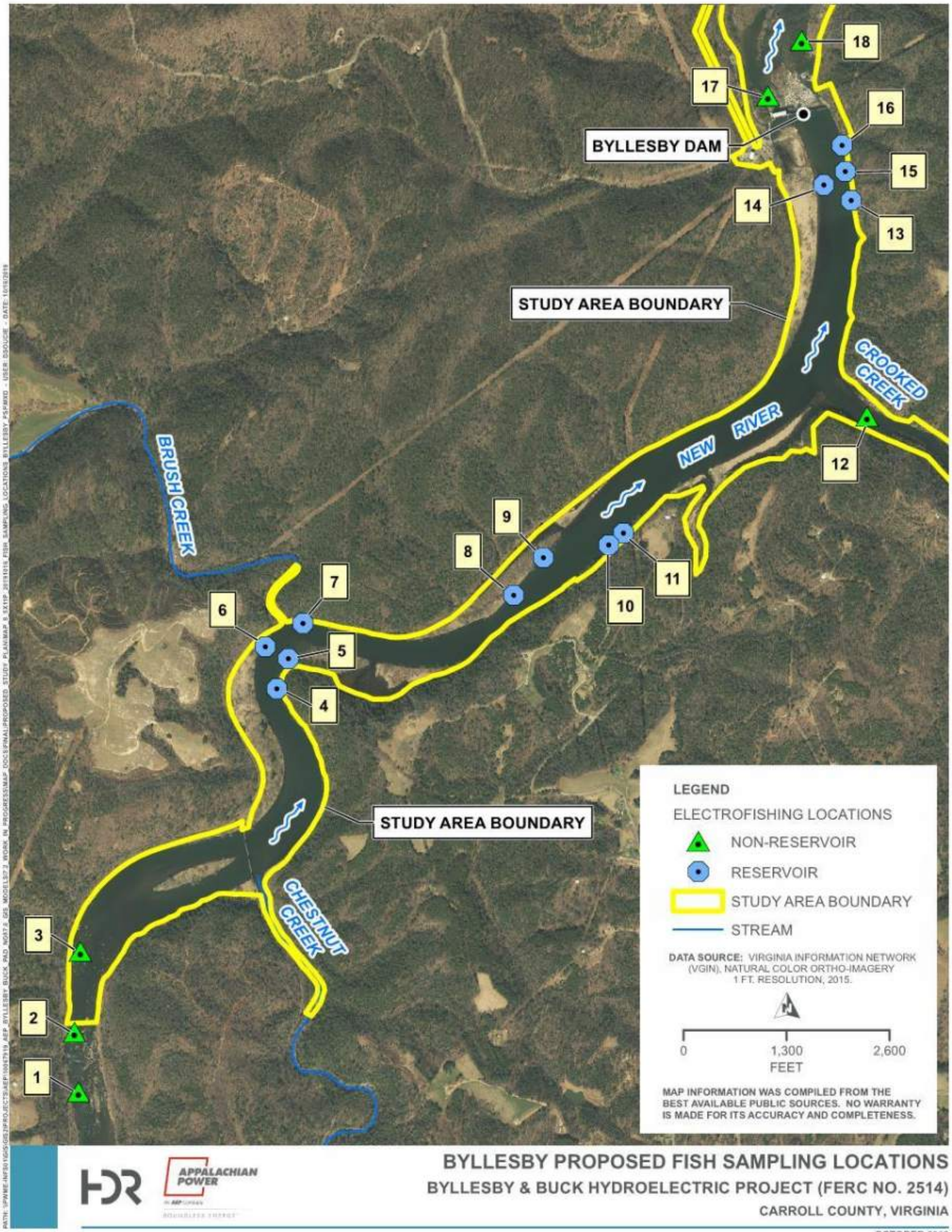
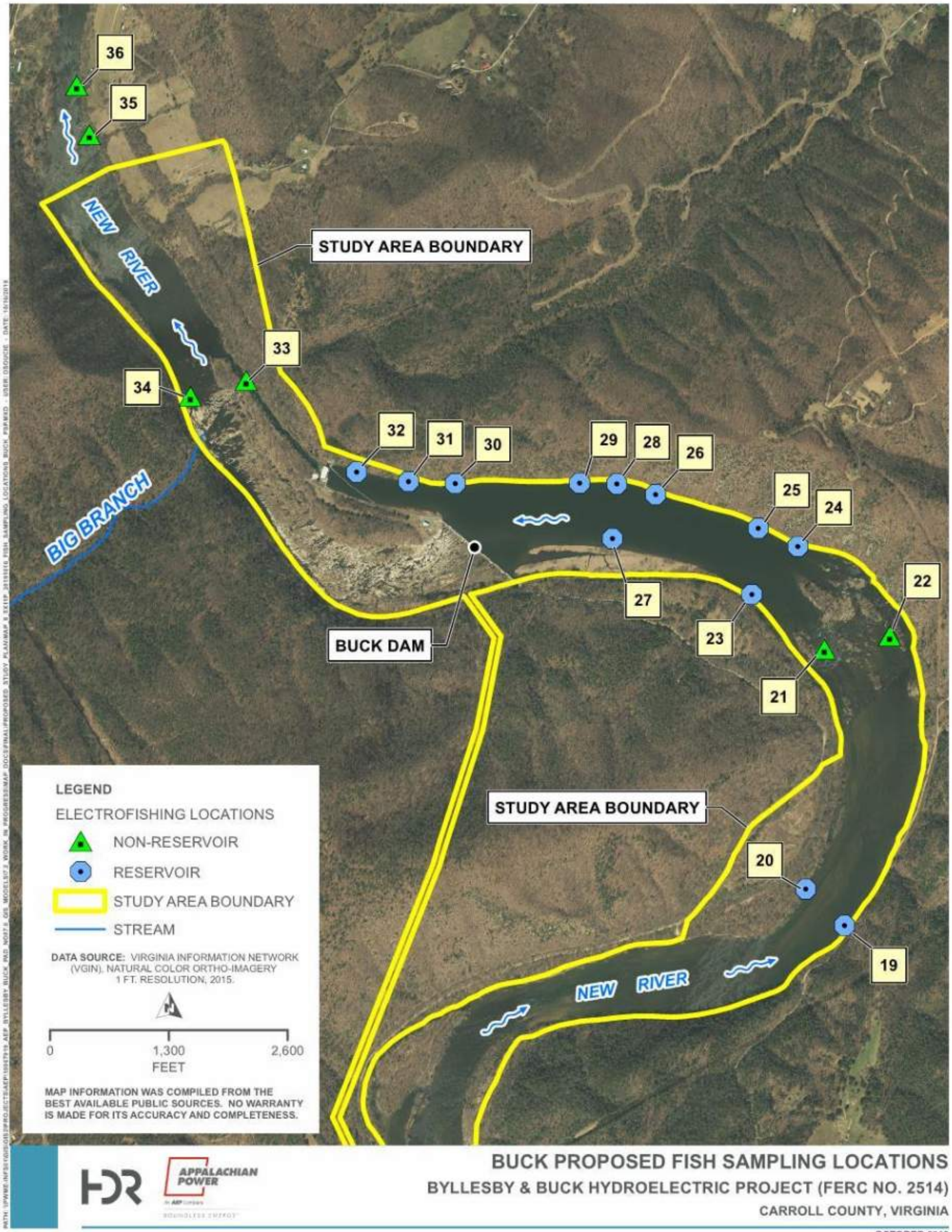


Figure 6-3. Location of Proposed Fish Community Sampling at Buck



In addition to this supporting data, Appalachian or their consultant will collect discrete water quality measurements of temperature, DO, pH, and specific conductance at each sampling location using an appropriate instrument calibrated per the manufacturer's instructions. A Secchi disk reading will be taken at each site at the time of sampling. These water quality samples are specific to the fish sampling efforts and are in addition to efforts identified in the Water Quality Study presented in Section 5.

For each sample site, all fish collected will be enumerated and identified to species, and up to 25 individuals of non-game fish and up to 50 individuals of each game species will be measured (total length in millimeters), weighed (grams) and examined for external parasites, disease, or physical abnormalities. In the event that more than 50 individuals of a single species of game fish are collected at a given sample site, the additional fish will be counted and length measurements will be recorded for specimens that exceed the upper or lower maximum recorded lengths from the first 50 individuals.

Collected fish will either be released back into the river or maintained for additional laboratory evaluation. Photo vouchers will be taken of all species in the field, and for those that cannot be identified to species, representative specimens will be preserved and identified in a laboratory setting based on any sampling permit specifications. Minnows and small juvenile fish that cannot be readily identified in the field will be preserved and returned to the laboratory for identification. All other fish will be held in an aerated container until processed and then returned as near as possible to the place of capture.

6.6.1.3 Comparison of Study Results

Data from the fisheries study will be compiled, converted to catch per unit effort, and compared to data from the historical fisheries surveys performed in the Study Area to identify trends or changes in species composition, abundance, or distribution over time.

6.6.2 Task 2 – Macroinvertebrate and Crayfish Community Study

6.6.2.1 Collector's Permits

Appalachian's consultant will obtain any necessary collector/survey permits that may be required prior to initiating field sampling for benthic macroinvertebrates and crayfish.

6.6.2.2 Field Sampling

Appalachian proposes to conduct two macroinvertebrate sampling events. Sampling will be performed during the sample index periods defined by VDEQ in the spring (March 1 – May 31) and fall (September 1 – November 30) of 2020 (VDEQ 2008). Specific sampling dates within these timeframes will be 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 general public. A variety of sampling techniques will be used during this study such as kick netting, dip netting, Hester-Dendy samplers, and rock picking.

Given the general similarity of habitats found throughout the New River and the proximity of the two previous crayfish surveys (Fries and Claytor projects discussed in Section 6.4.2), crayfish species diversity is anticipated to be comparably low throughout the Project boundary. To assess the crayfish community in the Project boundary, crayfish will be targeted by sampling in appropriate habitats using kicknetting, seine hauling, and dipnetting techniques. Additionally, crayfish are often collected during backpack electrofishing efforts. Crayfish collected during fish community sampling will be processed and added to the macroinvertebrate data for inclusion as a qualitative data point.

Appalachian or their consultant will also perform sampling in the lower reaches of streams entering the reservoirs that fall within the Project boundary. Qualitative (multi-habitat) and quantitative (riffles/runs) sampling will be completed following VDEQ's (2008) standard operating procedures. Appalachian or their consultant will also complete habitat assessment evaluations during macroinvertebrate sampling following VDEQ's "Methods for Habitat Assessment for Streams" protocol. Supporting data will be collected at each sampling site including upstream and downstream reach limits recorded via GPS; sampling gear type; habitat characterization; representative photographs, time and date of sampling; weather conditions; general descriptions of depth, flow, and substrate; cover type and estimated percentage of cover.

In addition to this supporting data, Appalachian or their consultant will collect discrete water quality measurements of temperature, DO, pH, and specific conductance at each sampling location using an appropriate instrument calibrated per the manufacturer's instructions. These water quality samples are specific to the macroinvertebrate and crayfish sampling efforts and are in addition to efforts identified in the Water Quality Study presented in Section 5.

All samples collected will be preserved and placed in labeled jars and returned to a laboratory for taxonomic identification to the lowest practicable taxonomic level. Laboratory processing will be performed in accordance with the VDEQ standard operating procedures "Methods for Laboratory Sorting and Subsampling of Benthic Macroinvertebrate Samples" (VDEQ 2008). Photo vouchers will be taken of all unique or rare species collected. A summary of species and numbers collected will be provided to VDGIF in compliance with the scientific collection permit specifications.

6.6.2.3 Comparison of Study Results

Data from the Macroinvertebrate and Crayfish Community Study will be processed following the Virginia Stream Condition Index protocol to develop common metrics and indices used to evaluate benthic macroinvertebrate community health and similarity (e.g., percent EPT, percent intolerant species, Hilsenhoff Biotic Index) (VDEQ 2008). Study data will be compared to historical macroinvertebrate surveys performed in the Project vicinity to identify trends or changes in species composition, abundance, or distribution over time.

6.6.3 Task 3 – Mussel Community Study

6.6.3.1 Collector's Permits

Appalachian's consultant will obtain any necessary collector/survey permits that may be required prior to initiating field sampling for mussels.

6.6.3.2 Field Sampling

Appalachian proposes to follow a two-step approach for this survey. A boat-based habitat survey will first be performed to identify potential mussel habitat. If potential habitat is identified, roving surveys of potential habitat will be conducted to identify the presence of mussels during the recommended time period of April 1 to October 1, 2020 (USFWS and VDGIF 2013). The objective of the reconnaissance and potential survey will be to assess the distribution and abundance of freshwater mussels in 1) the tailrace immediately below Buck Dam and 2) the free flowing reach of the New River between Buck pool and Byllesby Dam (Transition Reach) (Figure 6-1). Specific study dates within these timeframes will be 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 general public.

Buck Dam Tailrace Assessment

A narrow, single thread channel runs approximately 500 meters along a vegetated island from the Buck Dam powerhouse to a wider channel with a wetted width more typical of the New River. This small reach appears to convey most of the New River flow during base flow conditions. Because of the narrow cross sectional area and the large volume of discharge, the reach is not expected to provide suitable habitat for freshwater mussels. Surveyors will conduct a reconnaissance level habitat assessment of the channel to assess its potential to support freshwater mussels. Surveyors will walk the length of the reach while looking for evidence of mussel presence such as live animals or spent valves. Surveyors will visually assess habitat characteristics such as substrate composition and record observations regarding habitat quality.

Transition Reach Field Surveys

The reach of the New River between Byllesby Dam and the Buck Reservoir Islands is approximately 3,000 meters (9,700 feet) long. A review of aerial photography revealed a number of potential hydraulic habitat types (e.g. fast velocity/deep depth, slow velocity/shallow depth, etc.) in the transition reach (Aadland 1993; Hawkins et al. 1993). A total of 10 distinct hydraulic habitats were identified in this assessment (Table 6-2) Field personnel will conduct a reconnaissance level field assessment to verify or adjust the approximate geographic limits of the hydraulic habitat types identified in the desktop assessment. Field personnel will then survey representative habitats, based on perceived potential to support mussels, within the geographic extent of each hydraulic habitat type.

Table 6-2. Hydraulic Habitat Types and Sampling Intensity for the Transition Reach between Byllesby Dam and the Buck Dam pool

Hydraulic Habitat Type	Depth	Velocity	Hydraulic Habitat Reach Count	Search Time by Reach (Minutes)	Total Search Time (Minutes)
Pool	Deep	Slow	3	200	600
Deep Shoal	Deep	Fast	3	200	600
Shallow Shoal	Shallow	Fast	2	200	400
Side Channel	Shallow	Variable	2	200	400
Total			**10**		**2,000**

Snorkeling (contingent upon AEP approval for this methodology and acceptable field conditions), tactile searches, and/or viewing scopes will be used to survey shallow water habitats for live freshwater mussels. Deep water habitats (i.e., greater than 3 feet) will be surveyed by divers using SCUBA or Surface Supplied Air. Surveyors will conduct wandering timed searches of channel substrates for a minimum of 30 person-minutes per search for a total of 200 minutes per hydraulic habitat reach. Substrates will be searched by moving cobble and woody debris; hand sweeping away silt, sand and/or small detritus; and disturbing/probing the upper two inches of substrate to better view the mussels which may be there. All live mussels, fresh dead, and weathered mussels found within the search area will placed in a mesh bag and taken to the stream bank for identification and data entry. Mussels will be identified to species levels, sexed (where possible), measured for length, and returned to the approximate location where found.

Upon completion of the field survey, a brief technical report will be prepared describing:

- Habitat conditions at the survey site;
- River discharge;
- Methods used to complete the survey;
- Level of effort;
- Species found;
- Species lengths and evidence for recruitment (if any);
- Photographs of representative specimens; and
- Counts of species present and their relative abundance.

Based on the abundance of existing data summarized in Section 5.4.6 of the PAD, Appalachian is not proposing to perform mussel surveys in other areas within the Study Area. Instead, Appalachian or their consultant will perform a desktop literature review to identify, review, and synthesize available data on the mussel communities of the New River into a comprehensive summary report. Based on the availability of data, the report will include maps illustrating locations previously surveyed, potential or confirmed habitats, and locations of mussel collections identified in the literature review. The report will also include number and types of species identified and specimen length data (if available) from historic and recent surveys.

6.6.4 Task 4 – Impingement and Entrainment Desktop Study

6.6.4.1 Develop Characterization of Existing Intake

Appalachian or their consultant will document the intake dimensions and provide information on operational parameters as they are related to assessing the risk for impingement and entrainment at the Project's intake structures.

6.6.4.2 Perform Verification of Intake Velocities

Appalachian or their consultant will measure the average approach velocity immediately upstream of the existing trash racks. Measurements will be collected using an Acoustic Doppler Current Profiler or similar technology to measure 3-D velocity vectors. At least one parallel transverse transect for the velocity measurements will be positioned immediately upstream of the intake, as close to the trash rack surface as the instrumentation will allow. Measurements will be collected at the Project's maximum and efficient generation rates, as feasible based on Project conditions.

6.6.4.3 Perform Assessment of Entrainment and Impingement Potential at the Intakes

Results of the Fish Community Study will be used to describe the fish community that may be susceptible to impingement and entrainment. A targeted species list will be compiled based on fish community composition and abundance of the reservoirs in recent and historical surveys, as well as any other species of interest identified through consultation with resource agencies. Selected species will be evaluated for potential of entrainment and impingement based on swim speed, behavior, habitat preferences, life stages, and other life history characteristics. Risk assessment of impingement and entrainment will also consider seasonal, diel, or temperature behavior changes in fish species. The evaluation will include a blade strike evaluation using the USFWS Turbine Blade Strike Analysis Model (USFWS 2018b). 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.

6.6.4.4 Comparative Analysis of the Historical Study and Current Study Results

Velocities measured at the intake will be compared with results from the previous entrainment study to evaluate any changes in fish community risk.

6.7 Analysis and Reporting

Results of this study will be summarized in a final study report. Appalachian anticipates that the Aquatic Resources Study report will include Project information and background, a depiction and descriptive narrative of the Study Area, methodology, results, analysis, and discussion for each subsection. In addition, stakeholder correspondence and/or consultation will be included, as well as any literature cited.

6.8 Schedule and Level of Effort

The preliminary schedule for this study is provided in Table 6-3. The estimated level of combined effort for this study is approximately 1,150 hours. Appalachian estimates that the Aquatic Resources Study will cost approximately $205,000 to complete.

Table 6-3. Proposed Aquatic Resources Study Schedule

Task	Proposed Timeframe for Completion
Desktop Literature Review	January – March 2020
Macroinvertebrate and Crayfish Community Study	March – August 2020
Fish Community Study	April – September 2020
Mussel Community Study	April – October 2020
Desktop Impingement and Entrainment Evaluation	August – November 2020
Distribute Draft Study Report with the ISR	November 2020

7 Wetlands, Riparian, and Littoral Habitat Characterization Study

7.1 Study Requests

The Commission's March 8, 2019 SD1 identified the following as an environmental resource issue and concern to be analyzed in the EA for the Project:

- Effects of continued Project operation, including impoundment fluctuations, on riparian and wetland habitat and associated wildlife.

In Section 6.2.5 of the PAD, Appalachian proposed to conduct a Wetland and Riparian Habitat Characterization of the Project area. No formal study requests were received regarding wetland, riparian, or littoral habitat resources. Regarding the study proposed by Appalachian in the PAD, USFWS, VDGIF, and NRC commented that this study should include documentation of littoral habitat, including emergent and submerged aquatic vegetation beds within the Project area. Virginia Tech requested that Appalachian determine shoreline habitats within the Project boundary where American water willow (*Justicia americana*) occurs or that may be suitable for propagation and planting of this species for bank stabilization and nursery habitat for aquatic species. The USFWS, Virginia Tech, and VDCR emphasized the potential for occurrence of Virginia spiraea in the New River watershed, and USFWS indicated a potential to request a new survey for this species when the 2017 survey results expire.

Additional comments or requests related to this study were received from USFWS and VDGIF in response to Appalachian's filing of the Proposed Study Plan. These comments are summarized as follows:

- Discuss whether transect-based sampling will be performed on submerged aquatic vegetation beds. Additionally, the PSP study window from April to June should be adjusted to August to September when submerged aquatic vegetation beds are fully developed.

In addition to the formal comments filed, the following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- Although there is no Virginia spiraea survey proposed, Appalachian confirmed that the field team performing shoreline surveys will be trained on the accurate identification of Virginia spiraea.
- VDGIF noted that full development of the aquatic beds would not occur until late summer.

7.2 Goals and Objectives

The goal of the Wetlands, Riparian, and Littoral Habitat Characterization Study is to identify and characterize the existing wetlands, waterbodies, and riparian and littoral vegetative habitats (including emergent and submerged aquatic vegetation beds) in the Study Area. Specific study goals and objectives are to:

- Perform a desktop characterization using the USFWS (2019) National Wetlands Inventory (NWI), the Wetland Condition Assessment Tool (WetCAT) (VDEQ 2019), and other resources such as GIS-based topographic maps, hydrography, aerial imagery, and soil surveys to identify and describe, approximate, and classify wetlands and waterbodies (i.e., streams, creeks, rivers) within the Study Area (including upland, littoral, and riparian zones of the Study Area);
- Perform a field verification survey to confirm the location, dominant vegetative community and vegetation classification identified in the desktop survey and resulting maps;
- The field verification will include identification of littoral and instream vegetation in the Study Area to characterize the availability of littoral, submerged, and emergent vegetative habitat;
- Using the results of the desktop characterization and field verification, develop a GIS-based map identifying wetlands, waterbodies, and riparian, littoral, and instream vegetative community composition according to the Cowardin Classification System (Cowardin et al. 1979). The map will also identify the location and species of any invasive aquatic vegetation identified in the literature review or during the field verification efforts; and
- Using the results of the desktop and field verification efforts, evaluate the potential for Project effects on wetlands, riparian, and littoral habitat in the Study Area.

7.3 Study Area

The Study Area for this Wetlands, Riparian, and Littoral Habitat Characterization Study includes the riparian zone on each bank of the New River and tributary segments located in the Study Area as shown in Figure 1-4; the near-shore littoral zone on each side of the New River; and any potential wetland areas identified during the initial desktop analysis.

7.4 Background and Existing Information

Existing relevant and reasonably available information regarding wetlands in the Project vicinity is presented in Section 5.6 of the PAD (Appalachian 2019). Wetland, riparian, and littoral habitats within the study area are associated with the margin and near-shore areas of the impoundments. Wetlands are defined as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support… vegetation typically adapted for life in saturate soil conditions” (USACE 1987). The USACE and VDEQ have jurisdiction over wetlands in Virginia. The littoral zone, in the context of a large river system, is the habitat between approximately a half-meter of depth and the depth of light penetration (Wetzel 1975). Riparian habitats are areas found along waterways such as lakes, reservoirs, rivers, and streams (NRCS 1996).

According to the NWI and review of digital orthoimagery, wetlands, riparian and littoral habitat within the Project area may include palustrine forested (Cowardin Classification PFO [Cowardin et al. 1979]) wetlands along the New River, palustrine emergent wetlands along the edge of the river channel, and aquatic beds in the impoundments. Sediment deposition in the backwater areas of the project reservoirs has created sites suitable for wetland vegetation, including about 27 acres of emergent wetland vegetation bordering the Byllesby reservoir and about 15 acres bordering the Buck reservoir (Appalachian 1991). Additional wetlands are also created by sediment deposition at other areas, such as a small area approximately 100 yards upstream of the gated spillway dam at the Buck development. Additional information on wetland resources is provided in Section 5.6 of the PAD.

The riparian plant Virginia spiraea, which is federally listed as threatened, has been reported by USFWS to have potentially occurred upstream of the Byllesby dam historically; however, there is no documentation or verification of any historical presence or exact location. A habitat assessment performed in 2017 found few areas suitable for this species within the Project boundary (ESI 2017). Additional information regarding the Virginia spiraea survey and potential habitat within the Project boundary is included in Sections 5.6.2 and 5.7.1.3 of the PAD.

Invasive aquatic plants are known to exist in the New River, including hydrilla (*Hydrilla verticillata*), curly-leaf pondweed (*Potamogeton crispus*), and brittle naiad (*Naja minor*). An aquatic plant community study performed in 2012 between Buck dam and upper Claytor Lake identified 13 macrophyte species, including curly-leaf pondweed (Weberg et al. 2015). Additional information regarding invasive aquatic plants found in the New River is provided in Section 5.6.2 of the PAD.

7.5 Project Nexus

Project operations may affect water levels and velocities, as well as the timing and location of releases. These factors can affect aquatic vegetation and wetlands, which are important habitats for fish and wildlife. This study will be used to assist in the evaluation of potential Project effects on wetlands.

7.6 Methodology

Appalachian is proposing this study as a desktop analysis followed by field verification of streams and wetland areas within the Study Area. The desktop study will use several data resources and GIS databases to identify areas likely to contain wetlands, riparian, and littoral habitat. The desktop study will estimate the areas of riparian and littoral zones. Wetland areas identified in the desktop study will be field-verified, but not formally delineated. The study methods proposed by Appalachian will provide adequate information to assess potential Project operations-related effects to wetlands, riparian, and littoral habitats in the Study Area.

7.6.1 Task 1 - Desktop Characterization of Wetland, and Riparian, and Littoral Habitats

A desktop characterization of existing and potential wetlands and waterbodies, and existing riparian and littoral vegetation will be performed. For the purposes of this study, the riparian zone will be defined as terrestrial areas 100 feet from the shoreline (VDCR 2006) or to the Project boundary, whichever is closer. The littoral zone, for this study, will be defined as the shallow shoreline area of the New River from the stream bank down to the maximum depth of light penetration (typically less than 20 feet) in the water column (Armantrout 1998), and will also include instream emergent or submerged aquatic vegetation beds.

Information sources may include the USFWS NWI, the VDEQ Wetland Condition Assessment Tool or WetCAT (VDEQ 2019), USGS topographic quadrangles, topographic mapping and elevation data, high-resolution orthoimagery, Natural Resources Conservation S (NRCS) soil surveys, USGS National Hydrography Dataset, or other resources referenced in the PAD (Appalachian 2019).

These data will be used to create a preliminary habitat characterization map that will be used to perform the field verification efforts identified below in Task 2.

7.6.2 Task 2 - Field Verification

7.6.2.1 Wetlands and Waterbodies

Potential streams and wetland areas not confirmed previously (i.e., USACE, prior licensing, other sources) identified in Task 1 will be field-verified by qualified wetland scientists. A visual assessment of potential wetlands and waterbodies (intermittent, ephemeral, or persistent streams) will be performed to assess the presence of wetland hydrology, hydrophytic vegetation, and hydric soil characteristics. During the evaluation, the dominant vegetation observed will be documented.

7.6.2.2 Littoral Zone

Transect-based surveys will be performed to characterize the availability of littoral zone aquatic habitats including emergent and submerged aquatic vegetation beds occurring within the Study Area. Up to seven transect lines will be evaluated in each of the Project reservoirs and up to three additional transect lines will be evaluated in the tailrace and bypass portions downstream of Byllesby and Buck dams. In the reservoirs, transects will be placed parallel to the shoreline in areas that are accessible by boat, with transects distributed to represent both shorelines of the reservoirs. In the more riverine tailrace and bypass reaches of the river, transects will be situated perpendicular to the shoreline to include littoral zones along the stream margins and potential instream shallows where emergent or submerged vegetation may occur.

Each survey transect line will be 100 meters in length, with samples collected at 1-meter-squared survey points equally spaced along the transect line at 10-meter intervals. The sample at each of the 10-meter intervals will consist of a visual presence/absence assessment for emergent or visible submerged aquatic vegetation. A vegetation sampling throw rake will also be deployed at each 10-meter sample point on transect lines to capture any non-visible submerged aquatic vegetation. The location and scientific name of each positive sample vegetation sample will be recorded and will also be sketched on a field map during the survey. The species and general location of invasive aquatic vegetation observed during the field assessment will also be noted.

7.6.2.3 Riparian Zone

The vegetative communities identified in the land cover maps created for the Terrestrial Resources Study (see Section 10) will be used to perform the riparian habitat field verification. To facilitate the field verification of the preliminary vegetative cover maps, the riparian habitat within each vegetative community type will be characterized by recording the dominant species of vegetation at three strata (tree, sapling/shrub, and herb). Invasive species identified during the assessment will also be noted on the field data sheets. These data will be compared to the general vegetative community types identified in the preliminary map to verify their accuracy. Documented differences in the vegetation will be field sketched and used to revise the map of riparian vegetative communities. The list of vegetation by strata will be provided in the final report.

Vegetative communities documented in wetlands, streams, littoral, or riparian zones will be categorized using Cowardin Classification (Cowardin et al. 1979). Data collected during the field verification efforts will be used to revise preliminary vegetation cover type maps, which will provided in the study report.

7.7 Analysis and Reporting

Wetland, riparian, and littoral habitats and emergent and submerged vegetation beds within the Study Area will be used to create vegetation and habitat availability maps and will include a GIS-based estimate of total area. Appalachian or their consultant will prepare a report that includes Project wetland and habitat cover-type maps based on results of the desktop study and field verification results. Appalachian anticipates that the Wetlands, Riparian, and Littoral Habitat Characterization Study report will include Project information and background, a depiction and descriptive narrative of the study area, methodology, results, analysis, and discussion. In addition, stakeholder correspondence and/or consultation will also be included, as well as any literature cited.

7.8 Schedule and Level of Effort

The preliminary schedule for this study is outlined in Table 7-1. The estimated level of effort for this study is approximately 180 hours. Appalachian estimates that the Wetlands, Riparian, and Littoral Habitat Characterization Study will cost approximately $30,000 to complete.

Table 7-1. Proposed Wetland, Riparian, and Littoral Habitat Characterization Study Schedule

Task	Anticipated Schedule
Desktop Mapping of Wetland, and Riparian, and Littoral Habitats	January – March 2020
Field Verification of Preliminary Maps and Wetland Delineations and Riparian and Littoral Habitat Characterizations	August 2020 – September 2020
Distribute Draft Study Report with the ISR	November 2020

8 Terrestrial Resources Study

8.1 Study Requests

The Commission's March 8, 2019 SD1 identified the following as an environmental resource issue and concern to be analyzed in the EA for the Projects:

- Effects of continued Project operation and maintenance on upland wildlife habitat and associated wildlife such as bald eagles.

Comments received from USFWS provided support for continued adherence to the Wildlife Management Plan. No other comments regarding upland terrestrial vegetation, including wildlife resources, or formal study requests were received.

No comments or requests related to this study were received from Project Stakeholders in response to Appalachian's filing of the PSP. The following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- No clearing of vegetation presently proposed.
- Group noted usage and observation in bypass reach by bald eagles and migratory birds. Foster Falls is the closest known bald eagle nest location.

8.2 Goals and Objectives

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

- Perform a desktop characterization of the upland vegetation types within the Project boundary and classify plant communities according to "The Natural Communities of Virginia Classification of Ecological Groups and Community Types" by the VDCR Division of Natural Heritage (VDCR 2018a);
- Perform a characterization of the upland habitat types in relation to wildlife resources; and
- Develop a map of the vegetative community within the upland portions of the Study Area, identifying general location and community type. The map will also identify the location of any invasive terrestrial species identified in the Study Area based on the literature review or observed during the field verification efforts.

8.3 Study Area

The study area for this Terrestrial Resources Study includes the terrestrial upland habitats within the Study Area shown on Figure 1-4.

8.4 Background and Existing Information

Existing relevant and reasonably available information regarding upland vegetative communities in the Project vicinity was presented in Section 5.5 of the PAD (Appalachian 2019). Most of the land adjacent to the Project is steep and forested in mixed a chestnut-oak type community, although there are many bare rock exposures in the rugged terrain. The west side of the project is bounded by the Jefferson National Forest, and the east side consists of similarly forested terrain (Appalachian 1991). According to the EA prepared by FERC for the existing license (FERC 1994), the project upland forests are characterized by silver maple (*Acer saccharinum*), black willow (*Salix nigra*), and American sycamore (*Platanus occidentalis*) as the primary species. Up to 100 invasive plant species have been documented within Virginia (VDCR 2018b), and, therefore, some may occur within the Project boundaries.

The Project area supports a number of small mammals, avifauna, reptiles, and amphibians. Over 511 species were identified as potentially occurring within a 3-mile radius of the Project per a geographic search on the VDGIF's Fish and Wildlife Information Service (VDGIF 2017).

8.5 Project Nexus

Continued Project operation is not expected to adversely affect terrestrial resources; however, local improvements to recreational facilities could have the potential to disturb botanical and wildlife resources within the affected locations in the Project boundary. This study would assist in identifying plant species and their habitats within the Project boundary and provide baseline information from which to evaluate the effects of continued operation and maintenance of the Project on botanical resources and wildlife habitat.

8.6 Methodology

Appalachian is proposing this study as a desktop analysis followed by field verification and classification of upland terrestrial habitat types within the study area. The desktop study will use several data resources and GIS databases to identify high-level plant communities. The study may also incorporate information acquired through the Wetlands, Riparian, and Littoral Habitat Characterization Study. The study methods proposed by Appalachian below will provide adequate information to assess potential upland terrestrial resource impacts by Project operations.

8.6.1 Task 1 – Desktop Mapping of Vegetation

A high-level characterization of the upland vegetation communities within the Project boundary will be completed using a number of resources, including high-resolution orthoimagery, the USGS National Land Cover Database (USGS 2019), and other online databases (e.g., Virginia Natural Heritage Data Explorer [VDCR 2019], VegBank [ESA

2019], PLANTSDatabase [USDA 2019], NatureServe Explorer [NatureServe 2019]). A preliminary basemap will be generated depicting the major upland vegetation cover types present within the Project study area. This preliminary basemap will be used for field verification (Task 2) of plant communities.

8.6.2 Task 2 – Develop Species List

Upland vegetation cover types will be verified in the field and plant communities will be classified according to “The Natural Communities of Virginia Classification of Ecological Groups and Community Types” by the VDCR Division of Natural Heritage (VDCR 2018a). The dominant species of upland vegetation, and any invasive species observations, will be noted within each community type. The location of invasive species observed during the field verification will be georeferenced and photographed. A visual assessment of the approximate density and area of coverage by invasive species will be made and documented. Invasive species observed in the Project area will be reported using the Early Detection and Distribution Mapping System (EDDMapS [UGA 2019]), as recommended by the VDCR Division of Natural Heritage. Finalized cover type maps depicting plant community classifications and any protected or invasive species will be generated along with a summary list of the upland vegetative plant species documented during the field verification effort.

During the field verification activities, observations of avifauna, mammals, or observations of their tracks and scat will be recorded on field datasheets. General observations will also be noted regarding habitat and site conditions, including type, density, and quality. A summary list of the wildlife species or signs of their presence will be compiled along with the general vegetative community where the observation occurred.

8.7 Analysis and Reporting

Using GIS, approximate spatial extents of plant community types and classifications will be quantified, including any protected or invasive plant species. Appalachian anticipates that the Terrestrial Resources Study report will include Project information and background, a depiction and descriptive narrative of the study area, methodology, results, analysis, and discussion. The discussion will include an examination of potential Project effects to wildlife species and upland habitats. In addition, stakeholder correspondence and/or consultation will also be included, as well as any literature cited.

8.8 Schedule and Level of Effort

The preliminary schedule for this study is outlined in Table 8-1. The estimated level of effort for this study is approximately 240 hours. The preliminary estimated cost for this study is $25,000.

Table 8-1. Proposed Terrestrial Resources Study Schedule

Task	Anticipated Schedule
Desktop Mapping and Study Planning	February – March 2020
Field Verification	April – July 2020
Distribute Draft Study Report with the ISR	November 2020

9 Shoreline Stability Assessment Study

9.1 Study Requests

The Commission's March 8, 2019 SD1 identified the following environmental resource issue to be analyzed in the EA for the Project:

- Effects of continued Project operation and maintenance on shoreline erosion within the impoundments at each development (Buck and Byllesby).

In Section 6.2.1 of the PAD, Appalachian proposed to conduct a Shoreline Stability Assessment at the Project to identify sites of erosion or shoreline instability. No formal study requests were received regarding shoreline erosion and stability. Comments were received from USFWS, VDGIF, and NRC related to the proposed Shoreline Stability Assessment, specifically related to an evaluation of sediment transport to downstream areas and the sediment study and sediment management plan recommended by these parties. These comments are addressed in Section 3.1.1 of this RSP.

No comments or requests related to this study were received from Project Stakeholders in response to Appalachian's filing of the PSP. The following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- Appalachian is no longer considering operating the reservoir pond one-foot-lower during the winter.
- VDGIF would like Appalachian to consider water fowl hunting.

9.2 Goals and Objectives

The goals and objectives of the Shoreline Stability Assessment Study are to:

- Survey each development's reservoir, bypass reach, and tailrace area to characterize the shoreline, with the focus on erosion or shoreline instability using the Bank Erosion Hazard Index (BEHI; WVDEP 2015);
- Inventory, map, and document any areas of erosion or shoreline instability; and
- Prioritize any areas where remedial action or further assessment may be needed.

9.3 Study Area

The study area for the Shoreline Stability Assessment Study includes the Study Area shown on Figure 1-4, including the reservoir shorelines, bypass reaches, and tailrace areas downstream of the Byllesby and Buck powerhouses.

9.4 Background and Existing Information

Existing relevant and reasonably available information regarding geology and soils in the Project vicinity was presented in Section 5.2 of the PAD (Appalachian 2019). The New River within the vicinity of the Project has carved moderately steep valley walls, ranging in height of 50 to several hundred feet (FERC 1994). Soils along the Project shoreline largely consist of steep, stony Ramsey soil or quartzite rock. Established vegetative cover is extensive along the shorelines of the Project, which helps limit the extent and severity of erosion and movement of soils in the Study Area. Additionally, accumulation of sediment along some portions of the Project shorelines has formed permanent riparian wetland communities, providing additional protection against shoreline erosion. Areas of shoreline erosion are mainly concentrated in areas absent of vegetation.

In the PAD, Appalachian noted they were evaluating the feasibility and benefits of operating the developments with 1-foot-lower-reservoir levels during the winter months. The purpose of the lower winter reservoir level would be to reduce the risk of overtopping Project structures due to ice jams on the New River. Appalachian is no longer considering operating the reservoir pond one-foot-lower during the winter. Instead Appalachian will seek operational flexibility to modify reservoir operations in anticipation of icing, as needed.

9.5 Project Nexus

Shoreline erosion is a common concern at hydroelectric projects. Although operating in run-of-river mode provides protection against erosion, and Appalachian expects the installation of inflatable Obermeyer crest gates at each development to smooth Project operations, Appalachian recognizes that aspects of the Project’s geological setting may contribute to the potential for shoreline erosion.

9.6 Methodology

Appalachian is proposing this study as a desktop analysis followed by field confirmation of shoreline areas within the Study Area, including reservoirs, bypass reaches, and tailraces of Byllesby and Buck facilities identified in the desktop analysis as requiring confirmation or additional investigation. Shorelines will be assessed in the field for susceptibility to erosion, and for need and potential for remediation. The study methods proposed by Appalachian (below) will provide adequate information to assess shoreline-erosion effects by Project operations.

9.6.1 Task 1 – Literature Review

Appalachian or their consultant will review existing available information on the study area, to assess bank composition and erosion potential in the study area. Information sources include USGS topographic quadrangles, topographic mapping and elevation data, high-resolution orthoimagery, NRCS soil surveys, and the USGS National Hydrography Dataset.

9.6.2 Task 2 – Shoreline Survey

A field survey will be conducted to characterize the shoreline of the Project reservoirs, bypass reaches, and tailrace areas. Appalachian or their consultant will use the modified BEHI method to estimate erosion susceptibility (WVDEP 2015) at the Project. For each area observed, vegetative cover, quantity of material, height, and slope of bank; existing erosion control mechanisms, soil or rock type, composition, thickness of various bank materials or strata, and other relevant data will be noted. GPS data will be used to identify and record areas of erosion with photograph documentation. GIS maps will be produced to characterize the stream banks of the study area.

9.6.3 Task 3 – Determine Areas Potentially Needing Remediation

An analysis of erosion potential for the areas identified within the study area will be conducted. Recommendations for minimizing the effects of bank erosion from Project operations and/or enhancing bank stability will be assessed. A report characterizing bank erosion potential and stability in the study area will be provided to stakeholders. The final report will include an analysis of the degree of susceptibility to erosion for all shorelines in the study area.

9.7 Analysis and Reporting

Results of this study will be summarized in the final study report. Appalachian anticipates that the Shoreline Stability Assessment Study report will include Project information and background, a depiction and description of the study area, methodology, results, and analysis and discussion. The report will also include any stakeholder correspondence and/or consultation, as well as literature cited.

9.8 Schedule and Level of Effort

The preliminary schedule for this study is outlined in Table 9-1. The estimated level of effort for this study is approximately 200 hours. Appalachian estimates that the Shoreline Stability Assessment Study will cost approximately $25,000 to complete.

Table 9-1. Proposed Shoreline Stabilization Study Schedule

Task	Anticipated Schedule
Study Planning and Data Review	January – March 2020
Shoreline Survey and Determination of Areas Potentially Needing Remediation	April – July 2020
Distribute Draft Study Report with the ISR	November 2020

10 Recreation Study

10.1 Study Requests

The Commission's March 8, 2019 SD1 identified the following environmental resource issues related to recreation be analyzed in the EA for the Project relicensing:

- Effects of continued Project operation and maintenance on recreation, land use, and aesthetics within the Study Area.
- Adequacy of existing recreational facilities and public access to the Project to meet current and future recreational demand.

In Section 6.2.6 of the PAD, Appalachian proposed to conduct a Recreation Needs Assessment to assess recreational opportunities and potential improvements at Project recreation facilities. No stakeholders provided a formal recreation study request specifically addressing the seven criteria set forth in §5.9(b) of the Commission's ILP regulations. VDGIF, USFWS, NPS, Virginia Tech, VDCR, and NRC provided comments on the Recreation Needs Assessment proposed by Appalachian in the PAD, which are summarized as follows:

- USFWS, VDGIF, and NPS stated:
  - Currently available recreational use information is not adequate to assess existing recreational opportunities and potential improvements to facilities.
  - A more complete assessment of current use of the canoe portage, and altered reservoir use due to closures of USFS campground closure and improved Byllesby Pool boat launch is needed. The need for angler access in desirable fishing locations, including the tailrace areas should be evaluated.
  - Handicapped access is also not currently provided, and paddlers and anglers on the New River need riverside camping areas.
- VDCR recommended a recreation plan be created, including improving existing portage or additional access points for safe passage around the dams for boaters/paddlers. VDCR also recommended improving parking near the Project and coordination with the Division of Natural Heritage regarding potential impacts to their resources.
- Virginia Tech suggests meeting with stakeholder agencies VDGIF and VDCR to create an improved recreation access plan.
- Virginia Tech requested an enhancement plan for biodiversity and sport fishing in the Project area, including increased fishing access and quality in the reservoirs.
- NRC expressed support for VDGIF's requests for upgrades to boat launches and canoe portages at both dams.

Additional comments or requests related to this study were received from USFWS and VDGIF in response to Appalachian's filing of the PSP. These comments are summarized as follows:

- VDGIF requests that the online survey is advertised in other ways than just at the kiosks, such with local outfitters and river guides, and social media outlets. VDGIF agreed that trail cameras should be used for monitoring recreational use of these areas.
- USFWS supports the comments of NPS and VDGIF on the PAD and SD1, including consideration of recreational use of the river, expanded methods of survey outreach, and usage of trail cameras to monitor angler usage of tailrace areas.

In addition to the formal comments filed, the following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- Discussion of moving the timing of stakeholder site visit to the recreational facilities.
- Discussion of benefits trail cameras in lieu of in-person observations.
    - VDGIF noted they use trail cameras at other locations, and requested the RSP note how often data will be downloaded. VDGIF suggested taking pictures until motion stops to capture more information about the recreational usage.
    - VDGIF suggested installing cameras in October to work out any issues.
- VDGIF would like the study plan to evaluate the previous U.S. Forest Service (USFS) camping area/day use and discuss restoration of camping facility in this area.
- Appalachian agreed to update the study area as needed to include the Loafers Rest area and former USFS campground.

10.2 Goals and Objectives

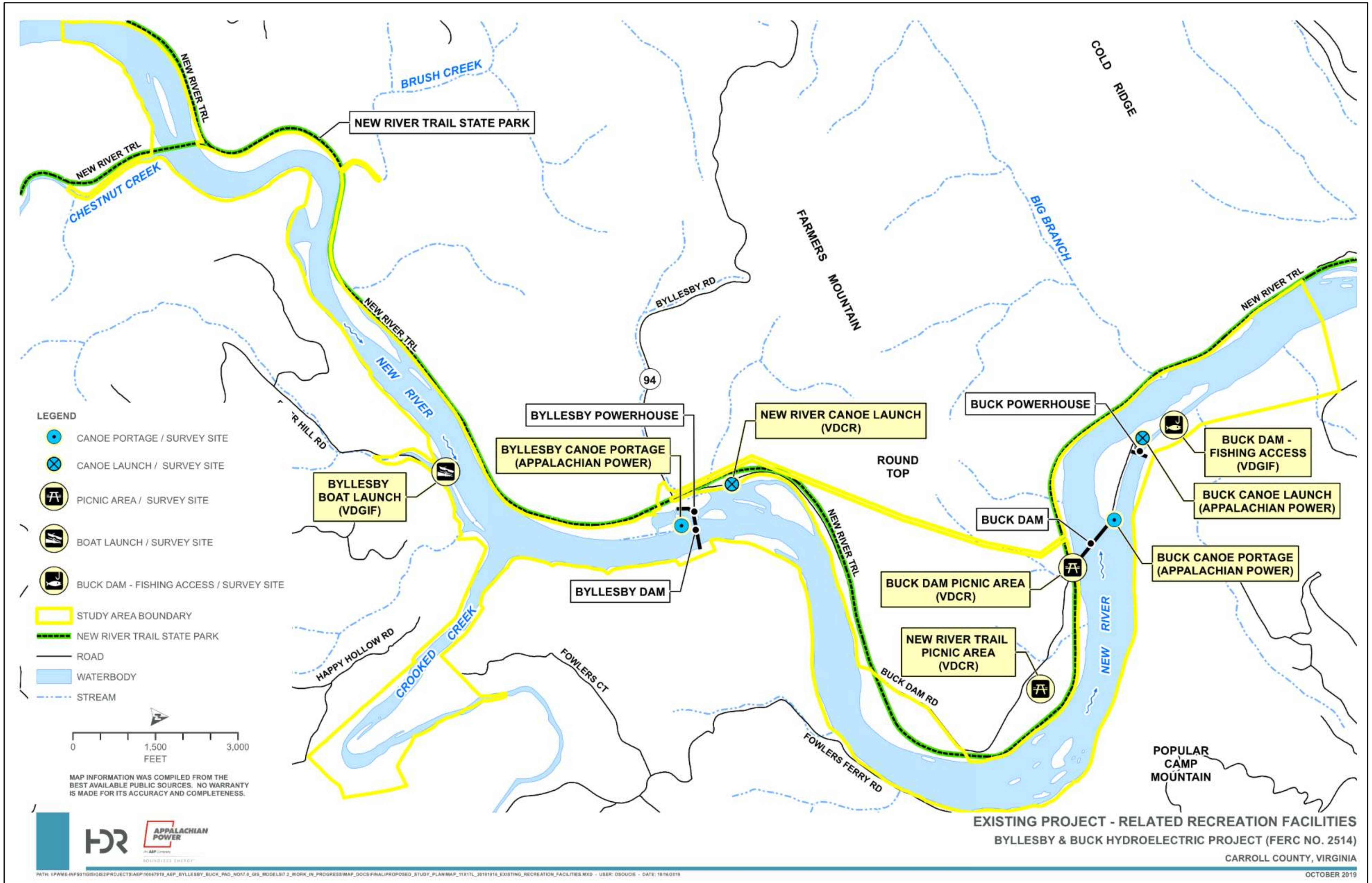
The goal of this study is to determine the need for enhancement to existing recreation facilities, or additional recreational facilities, to support the current and future demand for public recreation in the Project area. The objectives of this study are to:

- Gather information on the condition of the six Project-related public recreation facilities and identify any need for improvement;
- Characterize current recreational use of the Study Area;
- Estimate future demand for public recreation at the Project;
- Solicit comments from stakeholders on potential enhancements or new facilities; and
- Analyze effects of continued Project operation on Project-related recreation facilities.

10.3 Study Area

The study area for the Recreation Study includes the Study Area shown on Figure 1-4, including the six Project-related recreational facilities within and adjacent to the Project boundary (Figure 10-1). This is an appropriate study area as it includes lands and recreation facilities managed by Appalachian under the license and other recreational opportunities that may potentially be affected by Project operations. The study area was extended to include the previous USFS campground and the area locally known as Loafer’s Rest of river-right, downstream of Buck dam.

Figure 10-1. Recreational Facilities Within Study Area



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10.4 Background and Existing Information

Section 5.8 of the PAD describes existing information about recreation facilities and opportunities in the Study Area. The Project is accessible by a small secondary road and is located in a rural setting. The lands on both sides of the Project are steep, but there are some flat parcels along the river suitable for recreation. The former Norfolk & Western Railroad right-of-way extends along the western shore of the Project and has been converted to the New River Trail State Park. A majority of the land to the west of the Project is owned by the USFS and consists of the George Washington and Jefferson National Forest.

The Project supports six Project-related public recreation facilities (Table 10-1), two of which are owned and operated by Appalachian and the remaining sites are owned and operated by VDCR or VDGIF. Additionally, there is an informal recreation facility on river-right just downstream of Buck Dam (Buck Dam – Fishing Access or Loafer's Rest Access) leased to VDGIF by Appalachian in 2000 through 2023.

Table 10-1. Existing Recreation Facilities at Byllesby-Buck Project

Recreation Facility	Owner / Operator	Amenities	Relationship to Project Boundary
Byllesby Development			
Byllesby VDGIF Boat Launch	Leased and Operated VDGIF	Provides single-lane boat concrete boat launch with gravel parking area.	Within
Byllesby Canoe Portage	Owned and operated by Appalachian	Provides approximate 1,500-foot portage trail. Site consists of a hand-carry canoe take-out and an information trailhead kiosk for the New River Trail State Park.	Within
New River Canoe Launch	Owned and operated by VDCR	Provides small, gravel parking area with short trail leading to a hand-carry boat launch (also serves as put-in for the Byllesby Canoe Portage).	Adjacent to
Buck Development			
Buck Dam Picnic Area	Owned and operated by VDCR	Provides gravel parking for vehicles, information kiosk, and access to New River Trail. Also provides a picnic area with picnic table, trash can, portable restroom facility, and a hitching post for equestrian trail users.	Adjacent to

Recreation Facility	Owner / Operator	Amenities	Relationship to Project Boundary
New River Trail Picnic Area	Owned and operated by VDCR	Provides upper and lower recreation areas that include benches, picnic tables, bike rack, trash can, grill, and informal angling access to the Buck reservoir.	Adjacent to
Buck Dam Canoe Portage	Owned and operated by Appalachian	Provides crushed stone hand-carry take out and a hand-carry put in.	Within

10.5 Project Nexus

The Project currently provides public recreational opportunities. The results of this study, in conjunction with existing information, will be used to inform analysis in and recommendations for the license application regarding potential Project effects on public recreation and potential PM&E measures to be included in the new license.

10.6 Methodology

At this time, Appalachian is not proposing to take over the operation and maintenance of any existing recreation facilities within or adjacent to the Project boundary that are currently operated by other entities. However, these recreation facilities will be incorporated into the proposed Recreation Study as they support recreation in the Project area. Individual tasks of the study are discussed below.

10.6.1 Task 1 – Recreation Facility Inventory and Condition Assessment

Appalachian or their consultant will perform a field inventory to document the existing six Project-related public recreation facilities as identified in Table 10-1. Appalachian or their consultant will record the following information for each recreational facility including:

- A description of the type and location of existing recreation facilities;
- The type of recreation provided (boat access, angler access, picnicking, etc.);
- Length and footing materials of any trails;
- Existing facilities, signage, and sanitation;
- The type of vehicular access and parking (if any);
- Suitability of facilities to provide recreational opportunities and access for persons with disabilities (i.e., compliance with current Americans with Disabilities Act standards for accessible design); and
- Photographic documentation of recreation facilities and GPS location.

Additionally, a qualitative assessment of the condition of the recreation facilities will be performed using a Facility Inventory and Condition Assessment Form (Appendix C). Using the Facility Inventory and Condition Form, the recreation amenities available at each recreation facility will be rated using the following criteria: (N) Needs replacement (broken or missing components, or non-functional); (R) Needs repair (structural damage or otherwise in obvious disrepair); (M) Needs maintenance (ongoing maintenance issue, primarily cleaning); and (G) Good condition (functional and well-maintained). If a facility is given a rating of “N”, “R”, or “M”, an explanation for the rating will be provided.

10.6.2 Task 2 –Site Visit with Stakeholders to Discuss Existing and Future Recreational Opportunities

Appalachian proposes to convene a site visit with interested relicensing participants to discuss existing and future recreational opportunities at the Project. Appalachian and interested stakeholders will visit the existing six Project-related public recreation facilities as identified in Table 10-1. At each Project-related facility, Appalachian and participants will discuss potential conceptual level recreation enhancement and improvements. Appalachian tentatively proposes to hold this meeting in early spring and will notify interested relicensing participants at least three weeks in advance of the site visit.

10.6.3 Task 3 – Recreation Visitor Use Online Survey

Appalachian has developed an interview/survey instrument that draws from general concepts and guidance from the National Visitor Use Monitoring Handbook (USFS 2007) as well as from other relicensing studies approved by FERC for recreation visitor use surveys. This survey will be administered through a website (online) and will offer respondents the opportunity to provide survey responses electronically, which will allow respondents to complete a survey at a later time upon returning home from their visit.

The online survey will also provide a means to capture data from recreationists who do not frequent these facilities. Appalachian or their consultant will post a brief description of the purpose and intent of the survey, as well as the website address, at the existing six Project-related public recreation facilities identified in Table 10-1. Additionally, notice of the survey will be posted on the Project’s relicensing website and relevant social media outlets maintained by Appalachian. Appalachian will also make a good faith effort to communicate with local outfitters and regional organizations to complete the survey and distribute notice of the survey to their members or clients. Appalachian or their consultant will notify relicensing participants when the online survey is available through a quarterly ILP study progress report.

The proposed questionnaire to be used for the online survey is provided in Appendix D of this study plan. The questionnaire is designed to collect information about:

- General user information;
- Resident/visitor;

- Purpose and duration of visit;
- Distance traveled;
- Day use/overnight lodging;
- History of visiting the site or area;
- Types of recreational activities respondents participated in during their visit, including primary and secondary recreation activities;
- Other recreational sites that respondents visited during their trip;
- General satisfaction with recreational opportunities, facilities, and the respondents overall visit and/or areas that need improvement;
- Effects of Project operations on recreation use and access; and
- Accessibility of facilities.

10.6.4 Task 4 – Recreational Use Documentation

Due to the rural setting of the Project and generally low density recreational use, Appalachian plans to document usage of the recreational areas of interest through the use of trail cameras. As recommended by VDGIF during the PSP meeting, Appalachian's consultant deployed eight trail cameras on October 15 and 16, 2019 at the locations listed in Table 10-2, to provide a trial period in advance of the proposed study period and to determine the most appropriate monitoring locations and viewpoints. Appalachian's consultant plans to return to evaluate the data in mid-November 2019 and minor adjustments to the cameras and location may be required to capture optimal representative photographs. The cameras will be installed through November 2020 to collect site visitor data and document use patterns. The cameras will take photos when activated by motion. If a camera at any location is lost or destroyed due to apparent vandalism, a replacement camera will be installed. If the replacement camera is lost or destroyed a second time, a third camera will not be installed at that location.

Table 10-2. Locations of Trail Cameras

Location	Purpose	Number of Cameras
Byllesby Boat Launch	Collect data on vehicles entering and exiting the parking area	1
Byllesby Canoe Portage	Collect data on visitors utilizing New River Trail parking area and canoe portages	1
New River Canoe Launch	Collect data on visitors utilizing canoe portage	1
Buck Dam Picnic Area	Collect data on visitors utilizing the picnic area, bike rack, and hitching post	1
New River Trail Picnic Area	Collect data on visitors utilizing the picnic area, grill, informal angler location, and addition recreation features	2

Location	Purpose	Number of Cameras
Buck Dam Canoe Portage	Collect data on visitors utilizing portage and tailrace	1
Buck Dam – Fishing Access (informal recreation facility)	Collect data on visitors utilizing tailrace area for fishing; camera faces river-right to capture all types of recreation (of specific interest is fishing)	1

The trail cameras will record time and date-stamped photos and vehicle usage at the seven locations that can be analyzed to develop recreational use understanding.

10.7 Analysis and Reporting

Results of the facility inventory and condition assessment; stakeholder site visit; online surveys, and recreational use documentation will be summarized and incorporated into the Recreation Study Report. Appalachian anticipates that the Recreation Study Report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency correspondence and/or consultation
- Literature cited

10.8 Schedule and Level of Effort

The preliminary schedule for this study is outlined in Table 10-3. The estimated level of effort for this study is approximately 400 hours. Appalachian estimates that the Recreation Study will cost approximately $50,000 to complete.

Table 10-3. Proposed Recreation Study Schedule

Task	Proposed Timeframe for Completion
Study Planning and Existing Data Review	November 2019 – March 2020
Trail Camera Data Collection	November 2019 – November 2020
Recreation Facility Inventory and Condition Assessment	November – December 2019

Task	Proposed Timeframe for Completion
Stakeholder Site Visit	April 2020
Recreation Visitor Use (Online) Survey	April – October 2020
Distribute Draft Study Report with the ISR	November 2020

11 Cultural Resources Study

11.1 Study Requests

The Commission's March 8, 2019 SD1, Section 4.2.6 on Cultural Resources identified the following environmental resource issues to be analyzed in the EA for Project relicensing:

- Effects of Project operation and maintenance on historic properties and archeological resources that are included in, eligible for listing in, or potentially eligible for inclusion in the National Register of Historic Places.
- Effects of Project operation and maintenance on any previously unidentified historic or archaeological resources or traditional cultural properties (TCP) that may be eligible for inclusion in the National Register of Historical Places.

In Section 6.2.8.2 of the PAD, Appalachian proposed to review and update the Cultural Resources Management Plan (Management Plan or CRMP) developed in accordance with Article 409. Appalachian expects the updated Management Plan will continue to provide the appropriate measures for protection and as-needed consultation process for the protection of cultural and tribal resources over the term of the new license.

No formal study requests were received regarding historical or cultural resources. Comments were received from FERC, the Cherokee Nation, and the Delaware Nation.

No comments or additional requests related to this study were received in response to the filing of the PSP. The following points relevant to this study plan were discussed at the PSP meeting on July 18, 2019:

- Appalachian noted that SHPO consultation has been initiated under the CRMP during previous license term and no features were identified as significant. Additionally, it was noted that the Area of Potential Effects (APE) will be determined in consultation with Tribes/SHPO.

11.2 Goals and Objectives

The Management Plan dated December 1995 and approved by Virginia's Department of Historic Resources on February 2, 1996 currently provides Appalachian's preservation management strategy, including the following:

- Overview of the history of the Byllesby and Buck facilities;
- Measures for mitigation; and
- Management of facilities, with regard to historic preservation concerns.

The proposed Cultural Resources Study will identify reported historic properties within the Project's APE. This study will also assess the potential effects of continued Project operations and maintenance activities on historic and cultural resources. The goals and objectives of this updated study are to:

- Consult with the Virginia State Historic Preservation Office (SHPO), Cherokee Nation, and Delaware Nation to determine the appropriate APE for the Project.
- Conduct background research and an archival review.
- Conduct a Phase I Reconnaissance Survey of the APE.
- Consult with the Cherokee and Delaware Nations to develop and conduct an inventory of properties of traditional religious and cultural importance (often referred to as "traditional cultural properties") within the APE.
- Review the CRMP in consultation with the SHPO and Indian Tribes to determine if any revisions are appropriate for managing historic properties within the Project's APE, including specific PM&E measures.

11.3 Study Area

Appalachian proposes to use the same Study Area for the Cultural Resources Study as for the other studies described in this RSP (Figure 1-4). Appalachian believes that for study purposes, this area encompasses all lands that are necessary for Project purposes, all Project-related operations, potential enhancement measures, and routine maintenance activities associated with the implementation of a license issued by the Commission. The Commission has not yet defined an APE for the Project. Appalachian preliminarily proposes to define the APE as the Study Area and intends to formally define the APE in consultation with the SHPO and Indian Tribes as a component of the Cultural Resources Study and notes the APE may be refined through further consultation.

11.4 Background and Existing Information

A Phase 1A Archaeological Investigation was conducted by Appalachian for the previous relicensing (Louis Berger & Associates, Inc. 1991). As summarized in the Phase 1A report, only one archaeological site, approximately 0.75 miles downstream of the Buck powerhouse on the east bank of the New River, has been previously recorded in the vicinity of the Project. Additional sites have been recorded within lands managed by the USFS and in the vicinity of the Project.

At the Byllesby development, the potential for prehistoric archaeological sites is limited due to past disturbances, including Project construction. At the Buck development, the potential for prehistoric archaeological sites is also limited, particularly in the area adjacent to the powerhouse which has been previously disturbed by construction and maintenance activities. With respect to "Mountain Island" (in the middle of the channel, starting at and extending downstream of the Buck dam), the potential for intact cultural deposits on the eastern end of Mountain Island is low due to dam construction and past disturbances, though the remaining portion of Mountain Island was determined to be moderate due to its undisturbed nature and higher elevation areas that may have offered prehistoric populations well-drained areas for occupation.

In support of developing the 1991 license application and other relicensings, a comprehensive cultural resource evaluation of 19 hydroelectric power generating facilities of Virginia was conducted by Louis Berger & Associates, Inc. for Appalachian (Louis Berger & Associates 1991). Based on this assessment and investigations performed for the previous relicensing, the Byllesby-Buck (New River) spillways, dams, and powerhouses have been determined to meet National Register Criteria for Evaluation as set forth in 36 CFR §60.4, a finding with which the Virginia SHPO and FERC have previously concurred.

Under Article 409 of the current license, Appalachian filed for FERC approval a Cultural Resource Management Plan to avoid effects that may result from maintenance or repair work at the Byllesby-Buck Project (Appalachian 2019). Additionally, under Article 410 of the current license sets forth requirements if archaeological or historic sites are discovered during project operation (Appalachian 2019).

11.5 Project Nexus

At present, there is no evidence that archaeological or historic resources are currently being affected by the Project's operations. However, the Project has the potential to directly or indirectly affect historic properties listed in or eligible for inclusion in the Natural Resources Conservation Service (NRHP).

11.6 Methodology

11.6.1 Task 1 – APE Determination

Appalachian has tentatively proposed an APE in Section 13.3. Pursuant to the implementing regulations of Section 106 at 36 CFR § 800.4(a), Appalachian will consult with the Virginia SHPO and Indian Tribes, and other parties, as appropriate, to determine and document the APE for the Project as defined in 36 CFR § 800.16(d).

11.6.2 Task 2 – Background Research and Archival Review

Appalachian or their consultant will conduct background research and an archival review to inform the specific research design and the historic and environmental contexts. Appalachian or their consultant will review relevant sources of information that may include (but are not necessarily limited to):

- Information on archaeological sites, historic architectural resources, and previous cultural resources studies on file with Virginia SHPO;
- A review of Virginia's NRHP listings;
- Historic maps and aerial photographs of the APE;

- Relevant documents related to Project construction;
- Relevant information available from local repositories;
- Information on the current and historical environment, including mapped soils, bedrock geology, physiography, topography, and hydrology in the vicinity of the APE;
- Relevant historical accounts of the Study Area; and
- Any additional relevant information made available by the Virginia SHPO, Indian Tribes, or other stakeholders.

The results of the background research and archival review will be integrated into the Phase I Reconnaissance Survey Report (Task 3), as appropriate.

11.6.3 Task 3 – Phase I Reconnaissance Survey of the APE

Appalachian or their consultant will conduct a Phase I Reconnaissance Survey (Reconnaissance Survey) of the Project's APE to identify historic properties that may be affected by Project operations. The Reconnaissance Survey will be conducted by a qualified cultural resources professional[7] and geomorphologist retained by Appalachian and will be in accordance with the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 Federal Register [FR] 44716, Sept. 1983) and the Virginia's Department of Historic Resources Guidelines for Conducting Historic Resources Survey in Virginia (VDHR 2017).

The proposed methods for the Reconnaissance Survey take into account the nature and extent of potential effects on historic properties, and the likely nature and location of historic properties within the APE (36 CFR 800.4(b) (1)). Pursuant to the Advisory Council on Historic Preservation's (ACHP) Section 106 Archaeology Guidance, the identification of archaeological sites "should be conditioned by where effects are likely to occur and the likely impact of these effects on listed or eligible archaeological sites. For example, archaeological identification efforts for a license renewal from the Federal Energy Regulatory Commission likely would not involve the entire APE. Rather it would be directed to those locations within the APE that are experiencing project related effects associated with operation, usually along the shoreline" (ACHP 2007).

The Reconnaissance Survey will include a visual reconnaissance of the APE. Based on the results of the background literature review and field observations, Appalachian or their consultant will identify any geographic areas within the APE that (a) that have a high archaeological potential, and (b) where Project-related effects (e.g., shoreline erosion) that have the potential to adversely affect historic properties (should they be present) are occurring or have a reasonable potential to occur in the future. If any such areas of the APE are identified, Appalachian or their consultant will conduct subsurface testing of

[7] For this study, a "qualified cultural resources professional" is defined as an individual who meets the Secretary of the Interior's Professional Qualification Standards (48 FR 44738-44739, Sept. 1983).

those areas in accordance with the Phase I methodology as described in the Virginia SHPO's *Guidelines for Conducting Historic Resources Survey in Virginia* (VDHR 2017).

Appalachian or their consultant will conduct a preliminary assessment of any archaeological sites that will consist of the delineation of site boundaries. The maximum length and width of each site will be measured and recorded and the site's location geo-located. Site dimensions and elevations will be recorded on standardized field forms along with sketch maps of site settings and notations regarding landform, site aspect, temporal affiliations (if possible) and density of observed materials, site condition, any evidence of Project-related effects, and the nature of site deposits. Site boundaries will be located on Project maps and USGS topographic maps. Appalachian or their consultant will geo-locate, record, and collect any observed artifacts, features, or other pre-contact or historic period cultural material (as appropriate), and any new archaeological sites discovered will be documented on Virginia's Preliminary Information Form (Appendix E).

Treatment and disposition of any human remains that may be discovered will be managed in a manner consistent with the Native American Graves Protection and Repatriation Act (NAGPRA) (P.L. 101-601; 25 United States Code [U.S.C.] 3001 et seq.),[8] and the Council's Policy Statement Regarding Treatment of Burial Sites, Human Remains, and Funerary Objects (ACHP 2007). Any human remains, burial sites, or funerary objects that are discovered will at all times be treated with dignity and respect. In the event that any Native American graves and/or associated cultural items are inadvertently discovered, Appalachian will immediately notify the Virginia SHPO and potentially affected Indian Tribes.

As a component of the Reconnaissance Survey, Appalachian or their consultant will also review properties of architectural significance within the APE and if determined necessary, will update existing information on architectural resources in the Virginia SHPO's files. If new architectural resources are identified, Appalachian or their consultant will document properties of architectural significance using photographs, brief descriptions, condition, and location information. Additionally, Appalachian or their consultant will conduct limited research on the history of the buildings, sites, and features, and complete a survey form for each property. The location will be documented on Project maps and USGS topographic maps.

11.6.4 Task 4 – Inventory of Traditional Cultural Properties

Traditional Cultural Properties (TCPs) are properties of traditional religious and cultural importance to an Indian Tribe that meet the National Register criteria (36 C.F.R. §

[8] Pursuant to 43 C.F.R. Part 10, NAGPRA applies to human remains, sacred objects, and items of cultural patrimony (described as "cultural items" in the statute) located on federal or tribal lands or in the possession and control of federal agencies or certain museums. Regardless of where cultural items are discovered, the principles described in NAGPRA's implementing regulations will serve as guidance for Appalachian's actions should the remains or associated artifacts be identified as Native American and to the extent such principles and procedures are consistent with any other applicable requirements.

800.16(l)(1)). TCPs may be eligible for inclusion in the NRHP because of their association with cultural practices or beliefs of a living community that are (1) rooted in that community's history, and (2) important in maintaining the continuing cultural identity of the community.

Appalachian recognizes the special expertise that Indian Tribes have in identifying properties that have traditional and religious significance to their communities. As such, Appalachian will consult with the Cherokee and Delaware Nations to develop specific methods and approaches to conducting a TCP inventory for lands within the APE.

11.6.5 Task 5 – Review and Updates to the existing CRMP

Appalachian or their consultant will review the existing CRMP in consultation with the SHPO and Indian Tribes to determine if any revisions are appropriate for managing historic properties within the Project's APE, including specific PM&E measures. The measures provided in the CRMP will assist Appalachian in managing historic properties within the Project's APE throughout the term of the new license.

As part of the review process, Appalachian will revise the CRMP (as necessary) to in accordance with the Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects, promulgated by the Commission and the ACHP on May 20, 2002. At minimum the CRMP will address the following items (ACHP and FERC 2002):

- Potential effects on historic properties resulting from the continued operation and maintenance of the Project;
- Protection of historic properties threatened by future ground-disturbing activities;
- Protection of historic properties threatened by other direct or indirect Project-related activities, including routine Project maintenance and vandalism;
- The resolution of unavoidable adverse effects on historic properties;
- Treatment and disposition of any human remains that are discovered, taking into account any applicable state laws and the Council's Policy Statement Regarding Treatment of Burial Sites, Human Remains, and Funerary Objects (ACHP 2007);
- Compliance with the Native American Graves Protection and Repatriation Act (25 U.S.C. §3001), for tribal or federal lands within the Project's APE;
- Provisions for unanticipated discoveries of previously unidentified cultural resources within the APE;
- A dispute resolution process;
- Categorical exclusions from further review of effects;
- Public interpretation of the historic and archaeological values of the Project, if any; and
- Coordination with Virginia SHPO and other interested parties during implementation of the CRMP.

11.7 Analysis and Reporting

Based on the results of Task 3, Appalachian or their consultant will prepare a report of the results of the Phase I Reconnaissance Survey. The report will include: 1) a summary of information obtained through the background research and archival review, 2) maps and descriptions of reported archaeological and historic resources within the Project's APE, 3) an assessment of the APE's archaeological sensitivity and potential, 4) the results of any subsurface sampling conducted to identify archaeological resources within the APE, 5) an assessment of significant architectural resources within the APE, and 6) recommendations regarding additional cultural resource studies and/or management measures for identified resources. Appalachian will consult with Virginia SHPO, Indian Tribes, and other interested parties (as appropriate) regarding the Phase I report. Appalachian anticipates that the Cultural Resources study report will include the following elements:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any agency/tribal correspondence and/or consultation
- Literature cited

Pursuant to Task 4, Appalachian or their consultant will also document consultation with the Cherokee and Delaware Nations regarding the TCP inventory. If the Cherokee or Delaware Nation determine that a TCP inventory is appropriate, Appalachian will develop a scope in consultation with Indian Tribes, conduct an inventory of TCPs within the APE, and prepare a report documenting the findings of the TCP inventory. The TCP inventory report will include the following elements, as appropriate:

- Project information and background
- Study area
- Methodology
- Study results
- Analysis and discussion
- Any tribal/agency correspondence and/or consultation
- Literature cited

11.8 Schedule and Level of Effort

The preliminary schedule for this study is outlined in Table 11-1. Appalachian anticipates initiating Task 1 at the beginning of 2020. Task 1 and Task 2 will be completed by the spring of 2020. Task 3, the Phase 1 Reconnaissance Survey and Report will be prepared and provided to the applicable parties in conjunction with the ISR that will be distributed to stakeholders and filed with the Commission in accordance with the Commission's ILP Process Plan and Schedule. The first field season is anticipated to be the spring through fall in 2020.

Appalachian will consult with the Cherokee and Delaware nations regarding the TCP inventory in 2019 and, if necessary, will develop a scope for the TCP inventory on consultation with the Indian Tribes in Quarter 1 and Quarter 2 of 2020. Appalachian anticipates conducting any ethnographic studies associated with the TCP inventory in Quarters 3 and 4 of 2020. Appalachian will file any TCP inventory reports with the Commission concurrent with the DLA.

Pursuant to Task 5, Appalachian will review the CRMP in consultation with the Virginia SHPO and Indian Tribes. Appalachian will file a revised draft CRMP including any revisions with the DLA. A final revised CRMP will be filed with the FLA. Appalachian estimates that the Cultural Resources Study will cost approximately $75,000 to complete.

Table 11-1. Proposed Cultural Resources Study Schedule

Task	Proposed Timeframe for Completion
APE Determination	January – June 2020
Background Research and Archival Review	January – June 2020
Phase I reconnaissance Survey of the APE	May – October 2020
Inventory of Traditional Cultural Properties	October 2019 – October 2020
Review and Updates to the Existing CRMP	November 2020
Distribute Draft Study Report with the ISR	November 2020

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Appendix A

Stakeholder Comments Regarding PAD, SD1, and/or Study Requests

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Office of the Chief

Bill John Baker
Principal Chief
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S. Joe Crittenden
Deputy Principal Chief
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January 18, 2019

Kimberly Bose
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: Project 2514-186, Byllesby-Buck Hydroelectric Project

Dear Secretary Kimberly Bose:

The Cherokee Nation (Nation) is in receipt of your correspondence about **Project 2514-186, Byllesby-Buck Hydroelectric Project**, and appreciates the opportunity to provide comment upon this project. Please allow this letter to serve as the Nation's interest in acting as a consulting party to this proposed project.

In accordance with the National Historic Preservation Act (NHPA, 54 U.S.C. § 300101 et seq), and its implementing regulations (36 CFR part 800), undertakings subject to the review process are referred to in 54 U.S.C. § 306108, which clarifies that historic properties may have religious and cultural significance to Indian tribes. Additionally, Section 106 of NHPA requires federal agencies to consider the effects of their action on historic properties as does the National Environmental Policy Act (NEPA) (42 U.S.C. §4321 and §§4331-35 and 40 CFR 1501.7(a) of 1969).

To facilitate Section 106 review, the Nation requests a copy of the related cultural resources survey report. The Nation requires that cultural resources survey personnel and reports meet the Secretary of Interior's standards and guidelines. Additionally, the Nation requests a copy of the related Cultural Resources Management Plan approved on July 18, 1996 and written consultation records with the Virginia State Historic Preservation Office under such plan.

Additionally, the Nation requests that the Federal Energy Regulatory Commission conduct appropriate inquiries with other pertinent Tribal and Historic Preservation Offices regarding historic and prehistoric resources not included in the Nation's databases or records.

If you require additional information or have any questions, please contact me at your convenience. Thank you for your time and attention to this matter.

Wado,

Elizabeth Toombs

Elizabeth Toombs, Tribal Historic Preservation Officer
Cherokee Nation Tribal Historic Preservation Office
elizabeth-toombs@cherokee.org
918.453.5389

Molly Joseph Ward
Secretary of Natural Resources

Clyde E. Cristman
Director

Rochelle Altholz
Deputy Director of Administration and Finance

David C. Dowling
Deputy Director of Soil and Water Conservation and Dam Safety

Thomas L. Smith
Deputy Director of Operations

COMMONWEALTH of VIRGINIA
DEPARTMENT OF CONSERVATION AND RECREATION

MEMORANDUM

DATE: February 11, 2019

TO: Sarah Kulpa, HDR

FROM: Roberta Rhur, Environmental Impact Review Coordinator

SUBJECT: DCR 19-002, Byllesby-Buck Dam relicensing

Division of Planning and Recreation Resources

The Department of Conservation and Recreation (DCR), Division of Planning and Recreation Resources (PRR), develops the *Virginia Outdoors Plan* and coordinates a broad range of recreational and environmental programs throughout Virginia. These include the Virginia Scenic Rivers program; Trails, Greenways, and Blueways; Virginia State Park Master Planning and State Park Design and Construction.
The remaining DCR divisions have no comments regarding the scope of this project. Thank you for the opportunity to comment.

This is, in part, a repeat of comments we made in September 2017. The Byllesby-Buck Dams impounds the New River, which is an established water trail and is a potential scenic river. There are multiple water access points along the project limits, all of which are DCR and DGIF sites and the dams are adjacent to segments of New River Trail State Park. Given these factors, DCR recommends serious consideration for safe portage around the dams for the boating/paddling community, this includes improving existing portage and looking on both side of the river for better portage access. We also recommend improving parking in the project area to accommodate river users. Please be sure that safety measures are in place to allow a safe boating experience. We recommend coordination with the New River Tail State Park Manager, Sam Sweeney. He can be reached at sam.sweeney@dcr.virginia.gov. Further we recommend a recreation plan be created or updated by applicant, the Appalachian Power Company. If a recreation plan has been created, we request a copy.

We recommend coordination with the Division of Natural Heritage regarding potential impacts to their resources. You can find an on-line project review information at http://www.dcr.virginia.gov/natural-heritage/infoservices.

Thank you for the opportunity to comment.

Cc Sam Sweeney, DCR
Lynn Crump, DCR

The Delaware Nation
Cultural Resources /106 Department
31064 State Highway 281
Anadarko, OK 73005
Phone (405)247-2448 Fax (405) 247-8905

1 March 2019

To Whom It May Concern:

The Delaware Nation Cultural Preservation Department received correspondence regarding the following referenced project(s).

> **Project: Byllesby-Buck Hydroelectric Project (FERC No. 2514) Notice of Intent and Pre-Application Document**

Our office is committed to protecting tribal heritage, culture and religion with particular concern for archaeological sites potentially containing burials and associated funerary objects.

The Lenape people occupied the area indicated in your letter during prior to European contact until their eventual removal to our present locations. According to our files, the location of the proposed project does not endanger cultural, or religious sites of interest to the Delaware Nation. **Please continue with the project as planned** keeping in mind during construction should an archaeological site or artifacts inadvertently be uncovered, all construction and ground disturbing activities should immediately be halted until the appropriate state agencies, as well as this office, are notified (within 24 hours), and a proper archaeological assessment can be made.

Please note the Delaware Nation, the Delaware Tribe of Indians, and the Stockbridge Munsee Band of Mohican Indians are the only Federally Recognized Delaware/Lenape entities in the United States and consultation must be made only with designated staff of these three tribes. We appreciate your cooperation in contacting the Delaware Nation Cultural Preservation Office to conduct proper Section 106 consultation. Should you have any questions, feel free to contact our offices at 405/247-2448.

Dana Kelly

Dana Kelly
Historic Preservation/106 Asst.
Delaware Nation
31064 State Highway 281
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COLLEGE OF NATURAL RESOURCES AND ENVIRONMENT
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March 15, 2019

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Comments and Study Requests for Byllesby-Buck Dam Hydroproject Pre-Application Document (FERC NO. 2514).

Dear Ms. Bose:

The following is a brief numbered summary of comments on the Pre-Application Document for FERC No. 2514, Byllesby-Buck Dam project.

1. The effects of the Byllesby-Buck hydro project extend beyond the project boundary due to sediment storage, backwater effects, and barrier effects.
2. Little dredging has been done in the impoundments in recent times, which limits the project life and ecological and recreational values of the impounded section. Major concern about impoundments as source of continued PCB contamination and impairment was not addressed.
3. Water spilled over dams during higher flows is often heavily laden with fine sediments due to the shallow nature of the impoundment and lack of shoreline vegetation management.
4. The bypassed reaches receive no minimum instream flow and there are no gages available to measure the duration of bypass effects.
5. The bypassed reaches are sediment-starved and deficient in sand, gravel, and cobbles, essential components of habitats to support local fauna. There is no mention of existence of the foundational plant, the hornleaf riverweed *Podostemum ceratophyllum* in the PAD.
6. The unique biological resources in this reach are not adequately considered in the PAD. In particular these include the pygmy snaketail dragonfly (*Ophiogomphus howei*), Allegheny river cruiser (*Macromia alleghanensis*), spine-crowned clubtail (*Gomphus abbreviatus*), and green-faced clubtail (*Gomphus viridifrons*).

7. The project dam blocks the passage and, therefore, natural recovery of the river spawning Walleye *Sander vitreus* in the upper New River.
8. Cool water endemic fishes influenced by the Byllesby-Buck hydroelectric project are largely ignored in this document.
9. Appalachian Power Co. does not proposed to conduct aquatic surveys for odonates, crayfishes, or eastern hellbender within the Project boundary (PAD 6-5).
10. The project diminishes habitat for freshwater mussels due to a complete lack of sand and gravel immediately downstream of the dams and the heavy sedimentation in the impoundment. Yet, these impacts and proposed mitigation efforts were not mentioned in the PAD.
11. The impounded reaches buried much of the suitable gravel substrate that would provide habitat for insects, crayfish, mussels, hellbender, fish and spawning by numerous fish, including the native strain of Walleye.
12. The PAD does not recognize effects of project operations on the impoverishment of the local community and economy.
13. Rehabilitation of a fishable walleye population in this reach of the New River would have substantial economic benefits to the impoverished local economy and is a high priority of the Department of Game and Inland Fisheries.
14. PAD recommends studies to address Geology and Soils, Water Resources, Fish and Wildlife, Wildlife and Botanical Resources, Wetlands and riparian habitat, recreational land use, aesthetic resources, and cultural and tribal resources and Socioeconomic Resources (Section 6). Specifically, the PAD recommends a series of vaguely described studies that do not seem to recognize FERC's "clear mandate to balance both power interests and environmental considerations." In particular, the following study needs are requested and defined later in this letter:
    a. PCB contamination and pollution minimization plan
    b. Water Willow propagation, rehabilitation, and water level plan
    c. Define the target biological community in the two bypass reaches and determine minimum instream flow.

d. Enhancement plan for sport fish in project area

e. Survey of rare dragonflies or multi taxa survey. Haag et al. 2013

f. Feasibility of fish passage or enhanced Walleye stocking

g. Recreational value lost due to Project.

Detailed Comments

1. The effects of the Byllesby-Buck hydro project extend beyond the project boundary due to sediment storage, backwater effects, and barrier effects. Figure 4.20-1 (PAD p 4-2, and Exhibit G drawings in Appendix C) ignores much of the river between Buck Dam and Lake and Byllesby Dam. In fact, the river ecosystem in this section of river is highly modified due to the fluctuating flow created by operations of the two hydroelectric dams. The omitted segment of the New River includes Buck Falls and island habitats that are no longer accessible to upstream migrating suckers and walleyes. This section of the New River should be included in the area affected by project operations in all future efforts to develop study plans, determine what the project impacts are, and how to mitigate them through protection, mitigation, and enhancement measures.

2. Little dredging has been done in the two impoundments in recent times, which limits the project life and ecological and recreational values of the impounded section. "Significant maintenance dredging was performed at the Project in 1997 (p 5-9)." Furthermore, there is major concern from the Virginia Department of Environmental Quality about these and other New River impoundments as sources of continued PCB contamination. This nexus between the project operations and river impairment was not addressed in the PAD. In fact, nowhere in the PAD are PCBs even mentioned. This is a serious oversight on the part of the applicant. New River is impaired due to polychlorinated biphenyl (PCB) contamination; however, this was not included in section "5.3.7.1 Impaired Waters." Although banned since the 1970's PCBs persist in the environment and cause endocrine disruption and are suspected carcinogens. PCBs are hydrophobic and associate with soil and sediments which continue to contribute to PCB resuspension and desorption. The Virginia Department of Environmental Quality draft TMDL for PCBs states that "To address

contaminated bed sediments where localized hot spots exist (e.g., depositional area behind a dam), mechanical or vacuum dredging could be explored as an option to permanently remove PCBs from the system." (Department of Biological Systems Engineering, Virginia Tech 2018. p. 106). Therefore, the nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource (fishing for subsistence) and human health has clearly been shown by a stakeholder agency. Dredging and flushing sediments were among the effective mitigation measures to prevent reservoir sedimentation in a review of hydropower projects (Trussart et al. 2002).

3. Water spilled over dams during higher flows is often heavily laden with fine sediments due to the shallow nature of the impoundments and lack of any shoreline vegetation and erosion management plan. This is a direct influence of project operations and the impacts on aquatic flora and fauna should be mitigated in future project licensing conditions. The PAD states that "most of the sediment load that enters the Byllesby and Buck developments is expected to pass through the Project and be deposited downstream." (p. 5-9). In most other reaches of the New River, the American Water Willow *Justicia americana* (hereafter water willow) traps and consolidates sediments as it builds limited floodplain habitats and reduces erosion of stream banks. These shoreline zones are important shallow habitats for many fish and invertebrates (Fritz and Feminella 2003; Lobb and Orth 1991). Furthermore, the water willow beds provide for carbon sequestration. The elimination has increased the carbon footprint of the Project. Water willow flowers also attract pollinators and the plant is host for caterpillars, such as Hydrangea Sphinx moth (*Darapsa versicolor*).

   The project has operated for its duration with no restrictions on water level fluctuation. Consequently, the Project impoundments lack aquatic macrophytes and stable, vegetated shorelines. Water willow is resistant to these disturbances and has been planted in other reservoirs for erosion control. Native aquatic macrophyte establishment can benefit fish and a variety of other aquatic organisms by providing refugia from predation and abundant food resources. Stems and leaves provide increased surface areas for colonization by epiphytic bacteria and algae. The decomposition of macrophytes stimulates instream productivity by numerous filtering organisms. Water willow mortality increases during long periods of inundation, which can lead to eventual elimination with repeated water level fluctuations (Strakosh et al 2005). Shorelines with abundant water willow cover had higher abundance of young fishes (Strakosh 2006; Stahr and Shoup 2015; Stahr and Kaemingk 2017). Consequently, water willow re-establishment and a water level fluctuation plan are needed as there is a clear nexus between Project operations and effects (direct, indirect, and/or cumulative) on the biota in the Project impoundments.

4. The two by-passed reaches receive no minimum instream flow and there are no estimates in the PAD of the duration of bypass dewatering. These river reaches have been dewatered for much of the year for each of the past 107 years, resulting in an impoverished biotic community and minimum fish and wildlife benefits. The bypass reaches are in a section of the New River that is a very wide, shallow channel of resistant bedrock ledges. As such, they are unique geomorphic and biological resources. The applicant has written off these bypass reaches based on lack of concern expressed in previous licensing, which is not acceptable logic. Nowhere in the PAD could I find mention of a minimum instream flow study. Precedent exists for minimum flows in long-dewatered reaches of the New River. This is a requirement of 401 certification by the Virginia Department of Environmental Quality. The Hawks Nest Dam in West Virginia was completed in 1933; it created a 250-acre lake and a dewatered downstream reach, "the dries." The dries is 5.5 miles reach of New River that is bypassed to provide water to the powerhouse. Part of the FERC relicensing agreement of 2018 requires put-in and take-out facilities, a portage trail, changing rooms and other amenities to accommodate paddlers and anglers taking advantage of recreational releases from Hawks Nest Dam. License conditions require seasonally variable minimum instream flow in the formerly dewatered bypass. Furthermore, new requirements include nine annual pulsed releases of 2,200 to 2,500 cfs from the dam to accommodate whitewater rafting and kayaking. The releases will be made on to-be-announced weekend days, starting with two dates in late March, with the rest occurring sometime from late June through early August. (Colburn 2018: Steelhammer 2019). It is in keeping with the FERC mandate to balance power production with environmental protection that the applicant with local stakeholders define a target biotic community to be rehabilitated in the bypass reaches of the Project. Flow management is an effective mitigation in hydropower projects

(Trussart et al. 2002) and a bypass minimum instream flow should be established as part of the new license conditions.

5. The Project has left the bypassed reaches sediment-starved and deficient in sand, gravel, and cobble size particles, essential components to support the local flora and fauna. There is no mention of the unique channel geomorphology and loss of foundational plant, the hornleaf riverweed *Podostemum ceratophyllum,* within the project area. The New River basin was not covered by ice during the last glaciations, but would have experienced periglacial conditions during glacial maxima. This geologic history resulted in unique river morphology and unique endemic fauna, many of which reside in the reach near the Byllesby-Buck hydroelectric project. The channel profile of the New River in Virginia is punctuated with distinct segments with high slope and many river segments are dominated by resistant bedrock that results in a narrow deeper channel while other river segments are dominated by resistant sandstones formations that run perpendicular to water flow (Spotila et al. 2015). In these sections the New River erodes via plucking and abrasion creating in many reaches a very wide shallow incision plain. Channels are wider where bedrock is highly jointed and proficient plucking transforms the channel into an incision plain, which widens via quarrying at the margins.

   The unshaded bedrock channel morphology of the New River supports distinctive riverine flora. Three common and widespread plants serve as foundational species, those that play a strong role in structuring the community. These include the Hornleaf Riverweed *Podostemum ceratophyllum* (hereafter riverweed), American Water Willow *Justicia* americana (hereafter water willow), and American Water Celery *Vallisneria americana* (hereafter water celery). In the two Project bypass reaches, which are dominated by bedrock, the Hornleaf Riverweed *Podostemum ceratophyllum* would typically attach to bedrock in these fast, shallow rapids. Most of the macrophyte production in New River is riverweed (Hill and Webster 1983, 1984). Because of its abundance, the productivity of riverweed dominated both the primary productivity and the particulate organic matter input via decay to the New River. However, the species is declining across much of its range and stressors include flow alteration, sedimentation, and altered water quality (Connelly et al. 1999; Wood and Freeman 2017; Davis et al. 2018). Coarse sediment abrades riverweed during storm flows, but the stems and roots may regenerate in four days (Philbrick et al. 2015) and high turbidity limits plant growth. Riverweed is a foundational plant in rivers of the region and supports exceptionally high levels of macroinvertebrate production (Nelson and Scott 1962; Voshell et al. 1992; Grubaugh and Wallace 1995). Removal of riverweed reduced macroinvertebrate biomass by over 90% (Hutchens et al. 2004) and reduced benthic fish abundance (Argentina et al 2010). Biomass of riverweed was related to variation in duration of low flow events (Pahl 2009) and effects of hydrological alteration is likely expansive.

The riverweed is abundant in the New River and supports high productivity of macroinvertebrates and crayfishes and many crayfish are also harvested locally as bait (Roell and Orth 1992). The high productivity of crayfish and macroinvertebrates directly influences higher trophic levels, including sport fishes such as Rock Bass, Smallmouth Bass, and Flathead Catfish (Roell and Orth 1993, 1998; Orth 1995). Consequently, the altered conditions due to the operations of the Byllesby-Buck hydroelectric plants have eliminated the energy base and productivity for higher trophic levels and sport fishes of the New River.

Smallmouth Bass and Walleye are dominant preferred game fish in the New River upstream from Claytor Lake, but not within the project area. There is a close interaction between Byllesby-Buck hydroelectric plant operations and loss of habitat for foundational vegetation, crayfish, and a diverse macroinvertebrate fauna that should be mitigated in future license conditions. Across the US, it is estimated that 25% of sediment typically transported in streams is captured in impoundments (Renwick et al. 2005). In the Project impoundments, sediment does not create habitat – rather it smothers habitats. Fish species richness was positively related to river fragment length (McManamay et al. 2015) and many native fish species were absent in surveys of the nearby Fries dam impoundment (Carey et al. 2018). The dominant fish in the Byllesby and Buck pools was made up of Common Carp; the fish biomass was 32.4% common carp; Appalachian Power Company 1991, p 14). Therefore, there is strong evidence for the nexus between Project operations and effects (direct, indirect, and/or cumulative) on biotic productivity in the dewatered bypass reached. Little work has been done on methods for rehabilitation of lost riverweed beds; however, root fragments readily attach to substrates and could be propagated for introduction to the New River (Philbrick et al. 2015). Habitat rehabilitation is an effective mitigation in hydropower projects (Trussart et al. 2002).

6. The unique biological resources in the Project boundaries are not adequately considered in the PAD. In particular these include the pygmy snaketail dragonfly (*Ophiogomphus howei*), Allegheny river cruiser (M*acromia alleghanensis*), spine-crowned clubtail (*Gomphus abbreviatus*), and green-faced clubtail (*Gomphus viridifrons*). Carey et al. (2017) recently identified all four species on Virginia's State Wildlife Action Plan (VDGIF 2015) in New River surveys near Fries, Virginia. The pygmy snaketail dragonfly nymph was described from the New River near Galax (Kennedy and White 1979). Dragonflies are predators in their aquatic nymph and adult phases; they are also prey for bass, rock bass, and sunfishes. Dragonflies are sensitive to sediment, water quality, climatic factors, making this group a potential useful indicator (Bush et al. 2013). Dragonflies have been referred to as climate canaries for river management. Adults are highly mobile and can relocate to more favorable regions. Four rare dragonflies of the new River are listed in Virginia's wildlife action plan; yet no studies are planned for these rare dragonflies. Here there appears to be a clear nexus between Project operations and effects (direct, indirect, and/or cumulative) on the dragonfly assemblage of the New River. Doing specific inventories and acquiring better knowledge of the fauna, flora, and specific habitats is one of the most effective steps to avoid loss of biological diversity (Trussart et al. 20002).

7. A unique river-spawning strain of Walleye *Sander vitreus* is blocked from upstream migration by Buck and Byllesby Dams. Walleye is increasing in popularity among anglers in Virginia and elsewhere (Quinn 1992) and stocking is an important management tool. The New River Walleye demands special management upstream from Claytor Lake (Palmer et al. 2007; Copeland 2017) and provides the brood stock for statewide stocking.

   The assumption of the New River walleye management plan is that the unique walleye strain is a river-spawning Walleye and may have adaptive traits that permit it to survive better in the New River. For example, this unique genetic strain of Walleye has eggs with 65% larger volume, an adaptive trait for living in less productive waters

(Hopkins et al. in review). The yolk is the main source of energy and nutrients for the developing embryo and newly hatched larva and larger eggs would be correlated with larger fry (Kamler et al. 2005). This egg size may have little influence on hatchery production; however, it may play a larger role in the reproductive success of the Walleye spawning and rearing in New River.

However, management questions remain as first-year survival of stocked fingerlings is highly variable in other populations and presumable in the New River as well (Johnson et al. 1996; Jennings et al. 2005). The fisheries management target (15-25 walleye per hour electrofishing) is rarely achieved (Copeland 2017). Unanswered questions include the following: How much suitable habitat is there? What is an appropriate stocking rate? Can we restore a river-resident river spawning Walleye population above Buck and Byllesby dams (Ney et al. 1993). What is limiting natural reproduction? What predators contribute most to post-stocking mortality? What would Walleye population levels be in the absence of the Byllesby-Buck Project?

Today, sustained efforts to select and stock only New River strain Walleye have restored genetic integrity, but the population still requires annual stocking. Elsewhere, Fayram et al. (2005) recommended a stocking rate for walleye fingerlings of 75 fish/ha even though prevailing stocking rate was 125 fish/ha. Yet stocking rates for New River Walleye have never approached 10/ha due largely to limited size of the brood stock, which is likely limited by Byllesby-Buck hydroelectric project location and operations. Characterization of habitat quality and quantity for demersal stage fingerling walleye has not been done and effects of fluctuating flows below Buck Dam remains unresolved.

Studies on factors that limit recruitment in river spawning walleye suggest that temperature and flow may drive recruitment success (Mion et al. 1998; Gillenwater et al. 2006; Rutherford et al. 2016). In the Maumee River, as river discharge increased, the amount of suspended sediments increased, likely directly increasing larval mortality (Mion et al. 1998).

The unknown is the effect of altered habitat and warmer temperature conditions in the New River due to operation of Byllesby-Buck hydroelectric plant represents a clear nexus with Project operations. Freeman et al. (2001) discovered that summer-spawning fish species numerically dominated the fish assemblage at the flow-regulated site in the Tallapoosa River. With warming river temperature, coupled with non-native centrarchids, the New River may provide unsuitable habitats for fingerling stages of the walleye (Bozek et al. 2011). The New River has an abundance of centrarchids, many of which are large enough to be predators on fingerling walleye. Furthermore, the cover provided by instream vegetation (i.e., riverweed *Podostemum* and water celery *Valesneria*), two foundational species may be reduced in the New River due to high turbidity and water level fluctuations (Kimber et al. 1995; Wood and Freeman 2017).

Here there appears to be a clear nexus between Project operations and effects (direct, indirect, and/or cumulative) on the aquatic community in general and foundation plants and the unique Walleye population, in particular. Fish population enhancement and habitat rehabilitation are effective mitigation strategies in hydropower projects (Trussart et al. 2002).

8. A number of coolwater endemic fishes are likely influenced by the Byllesby-Buck hydroelectric project, although no pre-project data exists on these fishes. The New River was a refugium for flora and fauna during the last glacial period. Today it supports a relatively high number of endemic fishes due to (1) the presence of natural barriers and (2) the immobility of a species. Glaciers did not reach Virginia though the climatic and barrier effect was a strong influence in the New River fish fauna. During the Pleistocene, the climate cooled and for fish in the New River, it was "no way out and no way in." because of a large ice dam. New River animals had to stay, adapt, or die. The mainstem falls, cascades, rapids prevented upstream dispersal after the Pleistocene glaciation. Therefore many native New River fishes as cool-adapted. This New River above Claytor Lake supports 46 native fishes, 8 of which are endemic species. Multi-species surveys have suggested habitat limitations may exist for Walleye immediately post stocking (Carey et al. 2018). The 8 endemic fishes are coolwater specialists, preferring temperatures about 19 C or 66 F (Shingleton et al. 1981). Byllesby and Buck impoundments warm surface waters and limit potential of the New River to provide habitat for these coolwater endemic fishes (Figure 5.3-1). The Appalachia Darter is not

common at the few locations where they do exist. They occur most frequently in the Blue Ridge province and mainstem New River, where five dams block their movements through the mainstem (Frimpong et al. 2014).

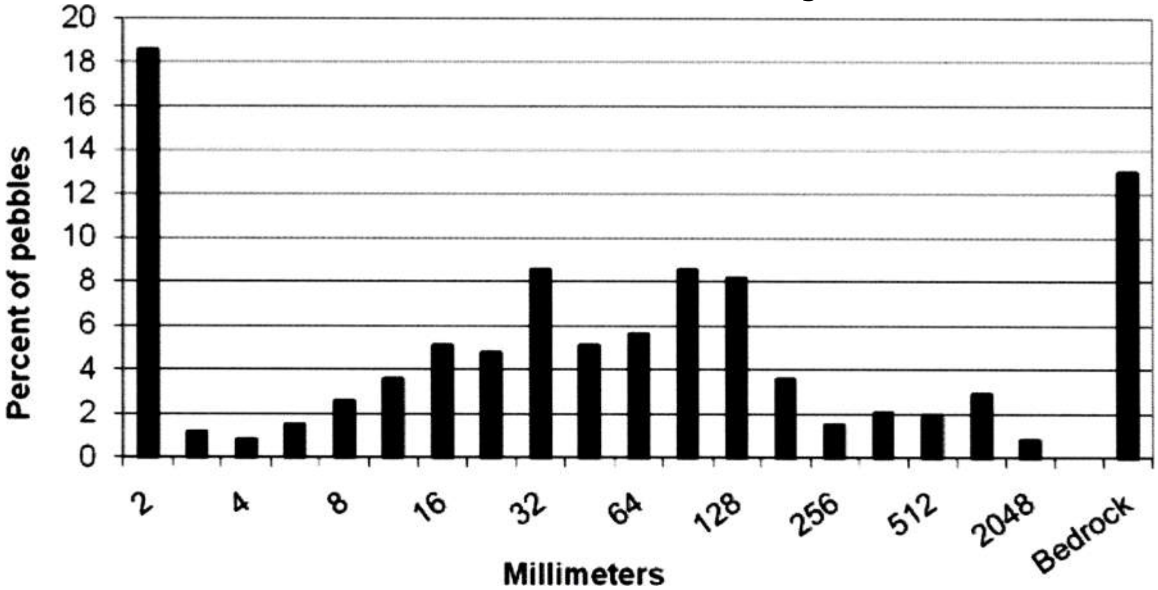
Candy Darter is an endangered species (FR 2018) that inhabits swift, shallow areas with little fine sediment and complex substrate (Dunn and Angermeier 2016). Candy darters were extirpated from at least seven streams in southern extent of range (Dunn and Angermeier 2018) and is threated with hybridization with the introduced Variegate Darter (Gibson et al. 2018). The project may influence population of Candy Darter in the Cripple Creek drainage (Wythe County).

There appears to be a clear nexus between Project operations and effects (direct, indirect, and/or cumulative) on the Walleye and the coolwater fish assemblage of the New River. Creation of spawning and rearing habitats and diversification of aquatic habitats were among the successful measures of mitigation that emerged in a review of hydropower projects (Trussart et al. 2002).

9. Appalachian does not proposed to conduct aquatic surveys for odonates, crayfishes, or eastern hellbender within the Project boundary (PAD 6-5). These types of surveys are more efficiently conducted via multi-taxa study designs and there is no compelling reason in the PAD not to do aquatic surveys. New River supports a unique fauna of coolwater specialists, including the New River crayfish (*Cambarus chasmodactylus*, Russ et al. 2016) and new species are still being identified (Loughman et al 20170 In a recent range-wide conservation status assessment of the New River crayfish, Russ et al. (2016) concluded that although the species is stable at this time, its geographical range is restricted—making them more vulnerable to threats. The New River crayfish is currently under federal review for listing under the Endangered Species Act (76 FR 59835). Furthermore, this assessment noted that data on New River crayfish distributions in Virginia were limited and recommended additional surveys in the state to fill these gaps in knowledge. Virile crayfish (*Orconectes virilis syn. Faxonius virilis*) were introduced in the New River in Virginia (Pinder and Garriock 1998) in the late 1990s and surveys are needed to document current distributions. Based on the absence of suitable crayfish habitat (i.e., gravel and cobble substrates) in the Byllesby and

Buck bypass reaches, Appalachian does not expect crayfish to be present in these Reaches (PAD p. 5-39). This stated rationale suggests the need for mitigation and habitat rehabilitation and repatriation of the species lost from the project area. The endemic fishes of the New River are unique and their limited distribution means many anthropogenic activities may have a disproportionate influence on species viability. The construction of dams on the mainstem and its tributaries fragmented populations and reduced coolwater habitats. In addition to hydropower dams, emerging threats to the restoration of walleye include introduction of nonnative species and climate change (Angermeier and Pinder 2015; Buckwalter et al. 2017), the same threats to indigenous fauna and flora in the upper New River and the upper Clinch River.

And eastern hellbender is a species of special concern in Virginia and under review by the U.S. Fish and Wildlife Service. The PAD also has no mention of the Eastern Hellbender *Cryptobranchus alleganiensis*. The Eastern Hellbender is are large, fully aquatic salamanders that occur in parts of the eastern United States; in Virginia it is a species of state concern. This species is near threatened (Hammerson and Phillips 2004) and occurs in the New River (Jachowski and Hopkins 2014). They require cool, rocky, swift-flowing streams and rivers with high levels of dissolved oxygen. Eastern Hellbender presence was documented in the New River in the vicinity of Fries, Virginia (Carey et al. 2018). Recent sampling by Catherine Jachowski (Virginia Tech Fish and Wildlife Conservation, personal communication) confirms their existence in the New River at two locations in vicinity of Independence, Virginia. Juvenile and adult Eastern Hellbenders eat crayfish. Eastern Hellbenders appear to move little throughout the year and remain close to shelter rocks (Burgmeier et al. 2011). In the Blue River of southern Indiana, Burgmeier et al. (2011) found that 79.5% of Eastern Hellbender locations were found on a gravel substrate (Figure below). In a recent study of the population genetics, Unger et al. (2013) found that greatest partitioning of genetic variation of Eastern Hellbender was within streams (~94–98) though they recognized genetic differences between Ohio and Tennessee drainages and differentiation in populations at the edges of the range. The Unger et al. study, however, did not sample Eastern Hellbenders from the New River drainage. Due to multiple dams that limit gene flow in the upper New River, isolated demes of hellbenders may be susceptible to the Allee effect. Crayfish, Hellbenders, gravel substrates, and population fragmentation are certainly at the nexus of biological resources and power production in this hydropower case and the absence of attention in the PAD is disturbing.



From Burgmeier et al. 2011.

10. The project diminishes habitat for freshwater mussels due to a complete lack of sand and gravel immediately downstream of the dams and the heavy sedimentation in the impoundment. Yet, these impacts and proposed mitigation efforts were not mentioned in the PAD. A marked loss of mussels was evident in contemporary surveys (Jirka and Neves 1990; Pinder et al. 2002) compared with surveys done by Arnold Ortmann one hundred years ago. Five mussel species have historical records above Claytor Lake. This includes two state threatened mussels, green floater (*Lasmigona subviridis*, under federal review) and pistolgrip (*Tritogonia verrucosa*). Others include the rare elktoe (*Alasmidonta marginata*), spike (*Elliptio dilitata*), pocketbook (Lampsilis ovata), and purple wartyback (*Cyclonaias tuberculata*; Pinder et al. 2002; Carey et al. 2018). These freshwater mussels depend on a host fish to complete the larval phase of its life history. Fish are essential to permit colonization of mussels after dieoffs (Hove et al. 2011). Creation of aquatic habitats were among the successful measures of mitigation that emerged in a review of hydropower projects (Trussart et al. 2002) and introduction and monitoring of rare mussels should be discussed as mitigation efforts.

11. The impounded reaches buried much of the suitable gravel substrate that would provide habitat for insects, crayfish, mussels,

hellbender, fish and spawning by numerous fish, including the native strain of Walleye. Furthermore, the depositional filling has substantially reduced depth and surface area, caused backwater isolation and habitat fragmentation. Eroding shorelines continue to add to sediment loads and fluctuating water levels due to project operations limits to colonization of foundational plants, such as the water willow. In general, fishing quality declines with functional age of impoundments (Miranda and Krogman 2015) and neither Buck nor Byllesby impoundments have had a comprehensive fish or fishing or aquatic macrophyte surveys conducted since the Appalachian Power Company (1991) to compare conditions with upstream and downstream reference conditions. Water celery (*Vallisneria americana*) provides oxygen and supports distinct invertebrate communities and waterfowl feeding grounds (Strayer, et al. 2003; Spoonberg et al. 2005). Both water celery and riverweed are eaten by introduced Grass Carp (Weberg et al. 2015). Even conditions described in the 1991 report suggest the need for rehabilitation of the impoundment habitat to counteract the effects of sedimentation and reservoir aging and avoid the lakes becoming dominated by Common Carp (Weber and Brown 2009; Pegg et al. 2015). Other sections of the New River support healthy and abundant populations of carnivorous fishes that are targeted by various sport anglers; these include Muskellunge, Flathead Catfish, Channel Catfish, Smallmouth Bass, Walleye (Orth and Newcomb 2002; Brendan et al. 2004; Copeland et al. 2006; Palmer et al. 2006, 2007; Dickinson et al. 2015; 2018; Doss et al. 2019). Michigan stream anglers respond to differences in fish abundance between sites and the probability of visiting a site increases with targeted biomass (Melstrom et al. 2015). The nexus of project operations has diminished to sport fishing potential in the Project impoundments and warrants a plan for rehabilitation.

12. The PAD does not recognize effects of project operations on the impoverishment of the local – regional economy and ecosystem services provided by the New River (Breslow et al. 2017). The PAD provides no evaluation of ecosystem services provided by the river with or without project operations. Nor does it contain any potential studies. Consequently, it appears that it expects FERC to balance by assuming "an implicit value of zero" being placed on ecosystem services. There is no explanation on how inevitable trade-offs between competing environmental, economic, and recreational ends be made and no studies to define these ends. Yet, Loomis (2000) maintained

that nonmarket valuation studies should play a significant role in such dam relicensing decisions. The information provided on price analysis of the project is not balanced with comparable studies that adopt conventional demand analysis of alternative or expanded recreational opportunities (Stephenson 2000; Stephenson and Shabman 2001). This is a major omission in the PAD and proposed studies.

Stephenson (2000) outlined a rational decision framework that could be adopted as an approach for scoping studies. This approach recognizes that licensing hydropower is stakeholder-driven and relies on building consensus among various stakeholders of different expertise, technical language, and values. "A rational analytic approach would create systems of structured analysis and a corresponding set of decision rules that would guide decisions about dam operations. The rational analytic approach begins with a limited number of decision participants that follow a formal decision logic. These participants conceptually identify objectives, formulate alternatives to meet those objectives, evaluate the consequences of each alternative, develop procedures to weigh the many different consequences and then choose an alternative based on some a priori decision criteria. Formal rules and procedures would be devised that would identify the rules of analysis that would evaluate, weigh, and choose between competing alternatives. These rules would provide the basis for an "objective" analysis and identify the "best" answers to the above questions." (Stephenson 2000). This type of stakeholder driven approach will satisfy the fundamental principles of the integrated license process, in particular "Early issue identification and resolution of studies needed to fill information gaps, avoiding studies post-filing." There are several measures for sharing development benefits of hydropower. These include but are not limited to the following: (1) Developing equity-sharing partnership solutions with local and regional institutions, and (2) Creating a jointly managed environmental mitigation and enhancement fund (Trussart et al. 2002).

13. Rehabilitation of a fishable walleye population in this reach of the New River would have substantial economic benefits to the impoverished local economy and is a high priority of the Department of Game and Inland Fisheries. The Byllesby-Buck project prevents spawning migration to the upper New River and increases the cost of the marker-assisted selection of brood stock because fingerlings have to be stocked above project boundary. Furthermore, the Project

creates habitat for invasive species that may negatively affect Walleye. Invasive species of concern in the New River include Hydrilla, Asiatic clams, and recent introduction of Quillback *Carpioides cyprinus* and Notchlip Redhorse *Moxostoma collapsum* – impacts as yet unknown (Easton et al. 1993; Weberg et al. 2015; Hilling et al. 2018; Buckwalter et al. 2018). Developing plans for invasive species management requires broad impact from stakeholders (Fouts et al 2017), yet there is no mention of this in the PAD. These unintended introductions are unsustainable – these have costs but no benefits. Finally, there was no mention of analysis of the feasibility of fish passage in the PAD. Mitigation of the Project effects should consider alternative mitigation or compensation measures such as fish passage for Walleye or enhanced stocking programs. The highly modified project reach has dramatically reduced biomass of sport fish targeted by local anglers. As mentioned earlier, Michigan stream anglers respond to differences in fish abundance between sites and, specifically, the probability of visiting a site increases with targeted biomass (Melstrom et al. 2015). The losses of recreational fishing benefits from the Project was not mentioned in the PAD but are likely to be substantial. Von Haefen (2003) estimates that recreational fishing in the lower Susquehanna River is worth about $30 per trip.

14. PAD recommends studies to address Geology and Soils, Water Resources, Fish and Wildlife, Wildlife and Botanical Resources, Wetlands and riparian habitat, recreational land use, aesthetic resources, and cultural and tribal resources and Socioeconomic Resources (Section 6). With the passage of the Electric Consumers Protection Act of 1986 (ECPA), FERC's consideration of environmental impacts with the requirement that equal consideration be given to the protection and enhancement of, and mitigation of damage to, wildlife, environmental quality, and recreational opportunity (Blum and Nadol 2001; Tarlock 2012). Specifically, these study plans, as written, do not appear to recognize FERC's "clear mandate to balance both power interests and environmental considerations." (Kosnik 2010) and no time frames for completion are indicated. As Tarlock (2012, p. 1765) wrote "species conservation and ecosystem restoration must be subject to continuing, rigorous assessment using adaptive management…. The central idea is that management decisions must be constantly monitored, evaluated, and modified or reversed when new information so counsels."

I thereby request a number of potential studies be conducted by the applicant so that power production can be balanced with protection of riverine biota and recreation. These study proposals include measurements that are likely important for understanding the potential environmental effects of the Byllesby-Buck project. These environmental metrics are included in the extensive list environmental metrics uncovered during a hydropower literature review conducted across several sectors (Parish et al. 2019).   As outlined in the NOI and PAD, the study request are described below with all requisite information.

Study Requests

PCB contamination and pollution minimization plan

i. Describe the goals and objectives of each study proposal and the information to be obtained;
    a. Determine the PCB load that exists in the total sediment deposited in the two project impoundments and develop a plan for removal and safe disposition.

ii. If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied;

Virginia Department of Environmental Quality.   PCB TMDL coordinator is Mark Richards at Mark.Richards@deq.virginia.gov or 804-698-4392.

iv. If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study;

New River is an impaired water body and health advisories exist for fish caught from the New River.

v. Describe existing information concerning the subject of the study proposal and the need for additional information;

The New River PCB TMDL has been conducted and is available online at https://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/PCBTMDLs/NewRiverTMDLPCB.aspx

vi. Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirement.

The project has been storing sediment which limits the project life and ecological and recreational values of the impounded section. which limits the project life and ecological and recreational values of the impounded section.

“Significant maintenance dredging was performed at the Project in 1997 (p 5-9).” However, there is no mention of the impoundments as source for in the TMDL PCB load model. The draft TMDL report stated that “PCBs in streambed sediments are contributing to the system through the dynamic relationship between the sediment and water processes. This occurs through sediment resuspension and/or partitioning from sediment through desorption. To address contaminated bed sediments where localized hot spots exist (e.g., depositional area behind a dam), mechanical or vacuum dredging could be explored as an option to permanently remove PCBs from the system.” (Department of Biological Systems Engineering, Virginia Tech 2018).

vii. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge; and

A model has been developed and calibrated to hydrology, sediment, and PCB levels in the upper New River. Many uncharacterized sources and streambed sediments represent a load in the PCB load model and the Byllesby-Buck project would PCB source is a boundary condition in the model. The study would estimate PCB load in sediments behind both Byllesby and Buck reservoirs using methods similar to those used in Department of Biological Systems Engineering, Virginia Tech (2018) .

viii. Describe considerations of the level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

There are no alternative studies proposed in the PAD that deal with the question of PCB loads in Project impoundments.

Water Willow propagation, rehabilitation, and water level plan

i. Describe the goals and objectives of each study proposal and the information to be obtained;

Determine shoreline habitats within the Project boundary that would be suitable for propagation and planting of American water willow for bank stabilization and nursery habitat for shoreline fish and other aquatic life.

ii. If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied;

Enhance fish and wildlife productivity and biological diversity by stabilizing eroding banks and reducing sediment additions to the New River.

iv. If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study;

Enhanced habitat for wildlife viewing and fishing and increased water clarity in the New River.

v. Describe existing information concerning the subject of the study proposal and the need for additional information;

The PAD provides aerial photos but did not include vegetation map that indicated current location of American water willow in the project area. However, American water willow is a foundational plant that is common in many segments of the New River and provides habitat for many aquatic invertebrates and juvenile fishes (Lobb and Orth 1991). Water willow is resistant to these many disturbances and is now being extensively planted in reservoirs for shoreline stabilization.

vi. Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirement

Water level fluctuations and long periods of inundation will cause mortality of the American water willow. With proper water level management extensive beds of water willow will grow and reduce shoreline erosion. Many agencies and lake management firms are propagating and planting water willow to reduce shoreline erosion (Collingsworth et al. 2009).

vii. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge; and

A survey with LIDAR or drones during June through August can provide a map of current distribution of the water willow. Water willow can be transplanted to areas where shoreline erosion treatments are needed.

viii. Describe considerations of the level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

There were no alternative studies proposed. The methods described are readily applicable for reasonable costs.

Target biological community in the two bypass reaches and rehabilitation of the foundational plant, riverweed.

i. Describe the goals and objectives of each study proposal and the information to be obtained;

Define the metrics for a restorable biological community in the bypass reach below Byllesby Dam and Buck Dam.

Develop minimum instream flow requirements for bypass reaches.

Propagate and replant the bypass reaches with the foundational plant, Hornleaf riverweed *Podostemum ceratophyllum.*

Monitor compliance with minimum instream flow and biological metrics for bypass reach.

ii. If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied;

Ecosystem productivity to support aquatic biodiversity and the downstream sport fish production.

iv. If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study;

Healthy aquatic ecosystems for easily accessible riverine fishing.

v. Describe existing information concerning the subject of the study proposal and the need for additional information;

The bypass reaches are dewatered much of the year and provide little biological productivity to the river. No information was provided in the PAD to assess the biological resources in these bypass reaches.

vi. Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirement

The Project has operated since 1912 with no minimum instream flow requirement. Therefore, the aquatic community expected in this bedrock-dominated river section has been totally lost and needs to be rehabilitated. Conditions on the new license should include minimum instream flow to support the metrics for a restorable biological community in the bypass reaches.

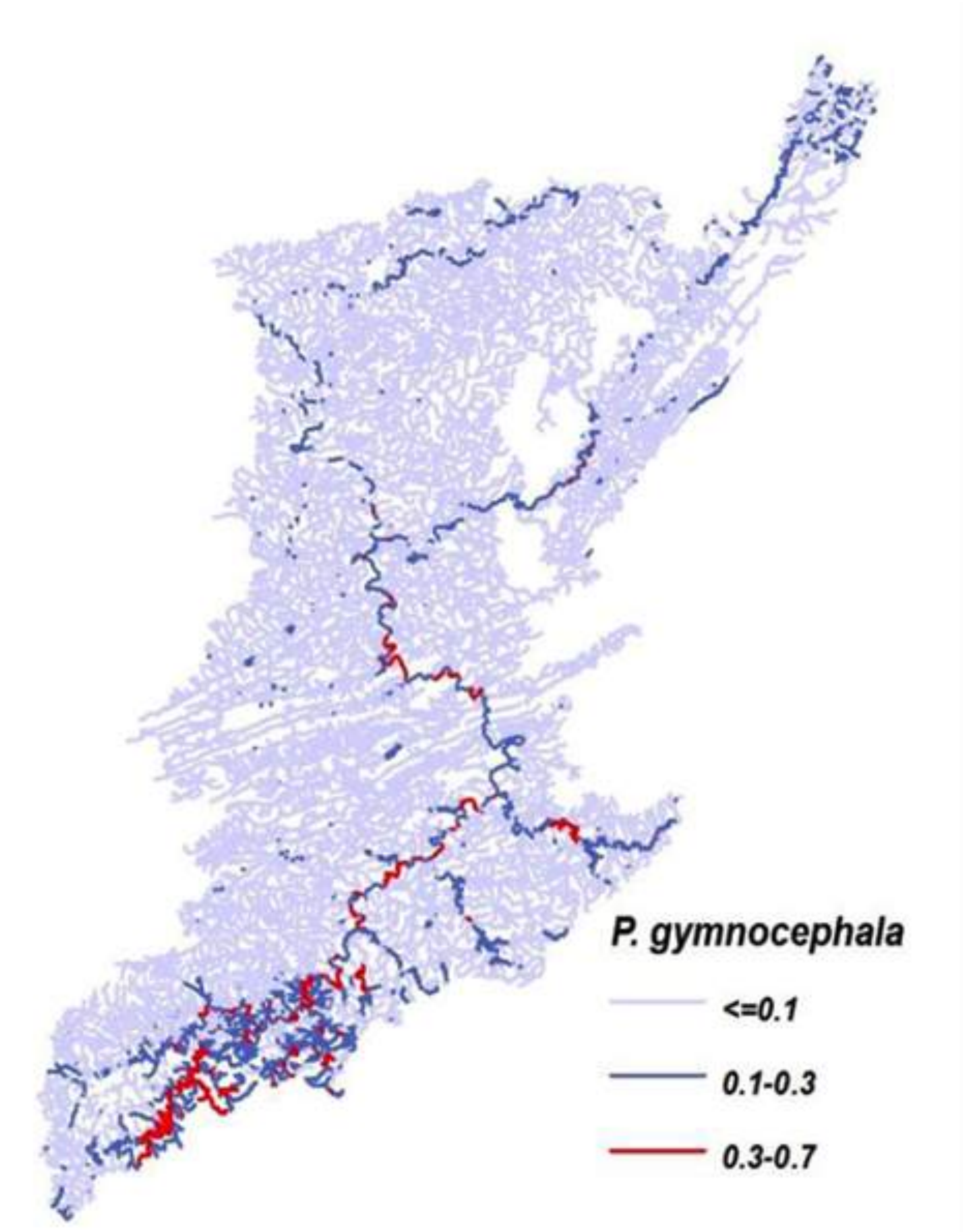
vii. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge; and

Species distribution models provide an approach to develop fine scale maps to predict the spatial distribution of aquatic species in the New River. Frimpong et al. (2014) and Huang et al. (2016) applied these methods to select fishes of the New River with good success. The models predict the probability of occurrence by rivers segment, which can be displayed via maps. See example map for the Appalachia Darter (below)

The methods and data can be applied for Hornleaf riverweed, crayfish, and many other New River fishes and mussels. With treatments such as gravel addition, the bypass reach may be colonized by spawning chubs and other nest associates (McManamay et al. 2010; Peoples et al. 2013).

viii. Describe considerations of the level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

No alternative studies were proposed to address the question in the PAD.



Probability of occurrence of the Appalachia Darter *Percina gymnocephala* (Frimpong et al. 2014).

Enhancement plan for biodiversity and sport fishing in project area

i. Describe the goals and objectives of each study proposal and the information to be obtained;

Adaptive management of the sport fish in the project area and monitor effects of the flow regime and other management interventions.

ii. If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied;

Increase abundance of harvestable size Walleye.

Increase natural reproduction of Walleye below Buck Dam and above Byllesby reservoir.

Enhance biodiversity of unique flora and fauna of the New River.

Increase fishing access and fishing quality in Byllesby and Buck impoundments.

iv. If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study;

Enhance biological diversity, sport fish production, and fishing satisfaction.

v. Describe existing information concerning the subject of the study proposal and the need for additional information;

There are numerous species of concern in the upper New River. Many were once abundant and at critically low levels of abundance. These include three foundational aquatic plants, four species of rare dragonflies, five species of freshwater mussels, an unknown number of crayfish species, Eastern Hellbender (federal and state species of concern), indeterminate number of endemic fishes, and unique New River Walleye. The extent of project impacts on this assemblage has never been studied. Furthermore, it is desired that natural reproduction of Walleye eventually replaces the need for an expensive program of annual stocking by the VDGIF.

vi. Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirement

There is a close interaction between Byllesby-Buck hydroelectric plant operations and loss of habitat for foundational vegetation, crayfish, and a diverse macroinvertebrate fauna that should be mitigated in future license conditions.

vii. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge; and

The complex project conditions warrant continuing, rigorous assessment using adaptive management so that management decisions are constantly monitored, evaluated, and modified or reversed when new information indicates. Therefore, this study request requires formation of a small, dedicated adaptive management team to lead studies during the ILP and continue some level of monitoring after a new license is provided.

viii. Describe considerations of the level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

Survey of rare dragonflies and multi taxa survey.

i. Describe the goals and objectives of each study proposal and the information to be obtained;

Compare the occurrence and abundance of species of crayfish, dragonflies, and small fishes in Project boundary with upstream and downstream reference locations.

ii. If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied;

Biodiversity conservation is a goal of the Virginia Department of Conservation and Restoration and the Department of Game and Inland Fisheries. Dragonflies are sensitive to sediment, water quality, climatic factors, making this group a potential useful indicator of local conditions (Bush et al. 2013).

iv. If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study;

Rare crayfish, dragonflies, and fishes have never been inventoried in the Project area to define project impacts. These unique New River fauna, many endemic, provide many ecosystems services in regulating abundance of aquatic insects and processing dead organic matter.

v. Describe existing information concerning the subject of the study proposal and the need for additional information;

The pygmy snaketail dragonfly (*Ophiogomphus howei*), Allegheny river cruiser (M*acromia alleghanensis*), spine-crowned clubtail (*Gomphus abbreviatus*), and green-faced clubtail (*Gomphus viridifrons*) are rare dragonflies mentioned in Virginia's State Wildlife Action Plan (VDGIF 2015). Carey et al. (2017) recently identified all four species from New River surveys near Fries, Virginia. Crayfish, hellbenders, and some fishes can be surveyed simultaneously for a cost-effective comparison of multi taxa.

vi. Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirement

The project altered habitat for these river-dwelling aquatic organisms via sediment deposition, substrate changes, and flow alteration. There are no previous comparisons of the Project with reference conditions.

vii. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge; and

Species occurrence of dragonflies can be inferred during adult, nymph, and exuviae surveys. Exuviae occupancy probabilities suggested several reliable indicators of species residency, such as (1) finding adults on ≥4 surveys, (2) finding tenerals on ≥2 surveys, and (3) counting >20 adults on ≥1 surveys (Bried et al. 2015). Haag et al. 2013 and Williams et al. 2014 described field methods commonly used for collecting macroinvertebrates and crayfish.

viii. Describe considerations of the level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

Recreational value and access development mitigation

i. Describe the goals and objectives of each study proposal and the information to be obtained;

Determine barriers to access of the New River by recreationists.

Develop plan to improve access.

ii. If applicable, explain the relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied;

The Virginia Department of Game and Inland Fisheries expects an increase in fishing participation with improvement in access in the upper New River. The Virginia Department of Conservation and Recreation manages the New River Trail which can connect to access improvements through the Project Boundary. The U.S. Forest Service owns land that adjoins the Project area and can manage to improve access and campsites.

iv. If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study;

Outdoor recreation is the fastest growing industry in southwest Virginia and can support improvements in the local economy. Access to the river is a principal barrier to participation in water-based recreation in this section of the New River.

v. Describe existing information concerning the subject of the study proposal and the need for additional information;

This information is provided in section 6 of the PAD. "Appalachian plans to conduct a recreational assessment of the Project to assess existing recreational opportunities and potential improvements to facilities. The scope of this study would be limited to within the FERC-approved Project boundary. Recent data regarding usage and capacity of the existing recreation facilities is available through monitoring conducted by Appalachian during the term of the existing license. The most recent monitoring was completed in 2014 (2015 report, see Section 5.8.2). As such, Appalachian does not propose to conduct additional recreational use monitoring for this relicensing, but will incorporate existing monitoring information into the study report and recommendations. "

vi. Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirement.

The Project is currently a major barrier to a float-based water tourism industry due to lack of portage around the Project.

vii. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge; and

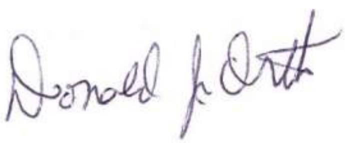
Meetings with stakeholder agencies, VDGIF and VDCR and local outfitters, appear to be appropriate first steps to create an improved access plan.

viii. Describe considerations of the level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

Level of effort and cost is appropriate as it reflects the plans proposed in section 6 of the PAD.

Thanks for the opportunity to review and comment on the Project PAD.

Sincerely,



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Thomas H. Jones Professor

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Arlene f warren, Richmond, VA.

Project Name: NEW SCOPING Byllesby-Buck Hydroelectric Project,
Project #: P-2514-186
UPC #: N/A
Location: Carroll Co.

VDH – Office of Drinking Water has reviewed the above project. Below are our comments as they relate to proximity to public drinking water sources (groundwater wells, springs and surface water intakes). Potential impacts to public water distribution systems or sanitary sewage collection systems must be verified by the local utility.

There are no public groundwater wells within a 1-mile radius of the project site.

The following surface water intakes are located within a 5 mile radius of the project site:

PWS ID Number	System Name	Facility Name
1077240	FRIES_ TOWN OF	EAGLE BOTTOM CREEK
1197435	NEW RIVER REGIONAL WATER AUTHORITY	INTAKE - NEW RIVER

The project is within the watershed of the following public surface water sources (facilities where the project falls within 5 miles of the intake and is within the intake's watershed are formatted in bold):

PWS ID Number	System Name	Facility Name
1197435	NEW RIVER REGIONAL WATER AUTHORITY	INTAKE - NEW RIVER
1750100	RADFORD, CITY OF	INTAKE ON NEW RIVER
1121057	NRV REGIONAL WATER AUTH	NEW RIVER (RAW WATER) PUMP STATION
1155641	PULASKI COUNTY PSA	CLAYTOR LAKE
1121643	RADFORD ARMY AMMUNITION PLANT	NEW RIVER

Best Management Practices should be employed, including Erosion & Sedimentation Controls and Spill Prevention Controls & Countermeasures on the project site.

Materials should be managed while on site and during transport to prevent impacts to nearby surface water.

The Virginia Department of Health – Office of Drinking Water appreciates the opportunity to provide comments. If you have any questions, please let me know.

United States Department of the Interior

NATIONAL PARK SERVICE
NORTHEAST REGION
15 State Street
Boston, Massachusetts 02109-3572

May 7, 2019 Filed Electronically

Kimberly Bose, Secretary ER 19/0090
Federal Energy Regulatory Commission
888 First Street, N. E.
Washington, DC 20426

Re: National Park Service (NPS) Comments on FERC's March 8,, 2019 NOI to File Application, Soliciting Comments on PAD, SD1, and Study Requests for the Byllesby and Buck Hydroelectric Project; FERC No. P-2514-170 – Carroll County, Virginia

Dear Secretary Bose:

General Comments

On May 31, 2002, Department of the Interior Secretary Gale Norton designated the New River Trail as a component of the National Recreation Trail System (NRT). The New River Trail joined a network of more than 900 so designated trails that taken together, encompassing more than 10,000 miles. http://www.americantrails.org/nationalrecreationtrails/06appsnrt.html

This 57-mile rail-trail system offers recreational users a valuable linear park experience and acts as a low-impact recreation corridor, alternative transportation route, community green space, outdoor classroom, and provides links to local and state parks including the New River Trail State Park, public boat launches and the USFS Mt. Rogers National Recreation Area.

Comments on the PAD

Impacts associated with project operations extend beyond the project boundaries, but the applicant proposes to limit any analysis to the limited area within the project boundary. See PAD P. 4.2-1 and Exhibit G drawings. This omits a considerable segment of the river between Buck Dam and Lake & Byllesby Dam, including Buck Falls and numerous island habitats. Any study plans and analysis should include coverage of this area to ensure that FERC has an adequate factual basis upon which to evaluate project impacts and identify adequate mitigation, protection and enhancement measures.

Section 5.8 Recreation and Land Use

5.8.1.1 Byllesby Development

The Byllesby Boat Launch is maintained by the Virginia Department of Game and Inland Fisheries (VDGIF), and as currently configured with gravel, often requires considerable replacement after high water events. A paved surface would provide for additional stability in general and especially after flooding events. According to VDGIF personnel, the parking area is receives more use than can be accommodated.

The Byllesby Canoe Portage parking lot has been relocated from the current portage take-out, with a parking location at the site of the former portage take-out. This displacement of parking facilities necessitates an additional carry, but is not addressed in the PAD description. If this relocation is due to the flashboard replacement project, the applicant should detail when this condition will be addressed, and the final location and conditions to be replaced. The put in below the Byllesby bypass reach is not adequately documented with photographs or a description of the put-in facilities below the bypass.

5.8.1.2 Buck Development

The Buck Dam Canoe Portage take-out and put in at the tailrace are not adequately documented with photographs in the PAD. There is an undeveloped vertical drop of about 3 feet into flowing water, making it difficult to use. The applicant should address how to remedy this situation to provide for safe and convenient access back to the river at this location.

5.8.2 Current Project Recreation Use Levels and Restrictions

A 2015 Form 80 Recreation Report filed in March 2015 (5-84 of the PAD), cites fishing as the most popular activity at the recreation sites on the Byllesby development. However, the PAD does not adequately address fishing access at project locations, nor potential additional or alternative locations where fishing access could be provided at the project. Popular locations include tailrace areas, but no formal angler access is provided at these locations at either project.

Comments on PAD Proposed Studies

Currently available recreational use data is not adequate to assess existing recreational opportunities, user demand, and the possible need for improvements to facilities. The closure of the U.S. Forest Service campground on Buck Reservoir and the development of an improved Byllesby Pool Boat Launch have shifted use, but there has not been any recent evaluation of canoe portage use, particularly as a result of the take-out location relocation at Byllesby Dam.

The need for additional angling access including at the project tailraces, should be evaluated and included in any recreational needs assessment. VDGIF currently manages the Loafer's Rest Access area downstream from the Buck Dam tailrace, however, neither this site nor the associated parking area are close enough to the tailrace or close enough to the river to provide reasonable access and use. There is also no current ADA compliant angler access available at either project. There are also no facilities for riverside camping areas; the former U.S. Forest Service campground area on Buck Reservoir might address this need. Other potential sites should be identified as well.

A more complete assessment of current use and demand is needed as a foundation for a recreational needs assessment. Therefore, the NPS concurs with and supports the Study Requests associated with recreational needs and assessment made by the VDGIF and filed with FERC on May 7, 2019.

Foregoing Studies in Lieu of Protection, Mitigation, and Enhancement Measures

There may be an opportunity to reduce some of these studies in scope, or even forego some of them, if agreements can be reached up front regarding certain Protection, Mitigation, and Enhancement (PM&E) measures. The NPS recommends that the Applicant convene a meeting with the stakeholders after receiving all of the study requests to determine which studies could be reduced or eliminated in return for agreements to proceed with certain PME measures.

The NPS appreciates the opportunity to provide these comments and looks forward to continued assistance to the applicant and other stakeholders in these proceedings. If you have any questions, please feel free to contact Kevin_Mendik@nps.gov NPS Northeast Region Hydro Program Coordinator.

Sincerely,

Kevin Mendik

NPS-NER Hydro Program Manager

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
http://www.fws.gov/chesapeakebay

May 7, 2019

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First St., N.E., Room 1A
Washington, DC 20426

RE: Byllesby-Buck Hydroelectric Project (FERC # 2514 - 186) - Review of Pre-Application Document, Scoping Document 1, and Request for Studies

Dear Secretary Bose:

The U.S. Fish and Wildlife Service (Service) has reviewed the January 7, 2019, Notice of Intent (NOI) to File for a License and Attached Pre-Application Document (PAD), filed by Appalachian Power Company, a unit of American Electric Power (AEP) (Applicant) for the proposed Byllesby-Buck Hydroelectric Project (Project), which would be located at the existing Byllesby and Buck Dams on the upper New River, near the city of Galax, in Carroll County, VA. The Service also participated in the April 10 and 11, 2019 public scoping meetings in Galax, VA, hosted by the Federal Energy Regulatory Commission (FERC), and is providing comment on the Scoping Document 1.

The following comments are provided pursuant to the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended: 16 U.S.C. 1531 *et seq.*), the Migratory Bird Treaty Act (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat.755), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*).

The Byllesby development consists of the following: (1) a 64 foot high, 528 foot long concrete dam and main spillway topped with four sections of 9 foot high flashboards, five sections of 9 foot high inflatable crest gates, and six bays of 10 foot high Tainter gates; (2) an auxillary spillway including six sections of 9 foot high flashboards; (3) a 239-acre reservoir with a gross storage capacity of 2,000 acre-feet; (4) a powerhouse containing four generating units with a total installed capacity of 21.6 megawatts (MW); and (5) appurtenant facilities. The Byllesby development is estimated to produce 41,752 megawatt hours (MWh) on average annually, and could operate down to a low flow of 73 cubic feet per second (cfs) and up to a high flow of 5,868 cfs.

The Buck development consists of the following: (1) a 42 foot high, 353 foot long concrete dam; (2) a 1,005 foot long, 19 foot high spillway section topped with 20 sections of 9 foot high flashboards, 4 sections of 9 foot high inflatable crest gates, and 6 bays of 10 foot high Tainter gates; (3) a 66 acre reservoir with a gross storage capacity of 661 acre-feet; (4) a powerhouse containing 3 generating units with a total capacity of 8.5 MW; and (5) appurtenant facilities. The Buck development is estimated to produce 36,980 MWh on average annually, and could operate down to a low flow of 60 cfs and up to a high flow of 3,540 cfs.

General Comments on the PAD

The PAD outlines a project area delineation that does not include, currently, the affected, impounded area between these two developments operated in synchrony. The impounded reaches of the New River encompassed by the Byllesby-Buck Project have displaced habitat important to a variety of aquatic insects (including rare Odonates), freshwater mussels, crayfish, Eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*), native fishes, and fish spawning areas, including the native New River strain of walleye (*Sander vitreus*). These impoundments block fish migration, disrupting freshwater mussel populations and associated fish host species from dispersing upstream and downstream in the New River. The lack of sand and gravel areas in the bypass reaches, combined with the high levels of sedimentation in the reservoirs, diminish mussel habitat for green floater ((*Lasmigona subviridis*, under Federal review, state listed threatened) and other species. None of these impacts are discussed in the PAD. Promoting and maintaining appropriate natural spawning and rearing conditions for the New River walleye population is also a priority, but is not adequately addressed in the PAD.

Specific Comments on Scoping Document 1

Scoping Document, 3.2.2 Proposed Environmental Measures

Geologic and Soil Resources

The Applicant does not propose any protection, mitigation and enhancement (PM&E) measures yet related to geology and soils. The lack of knowledge of the existing sedimentation processes and results of operations of the dams must be addressed to adequately manage this habitat resource for the aquatic community. The Service supports the Sedimentation Study Request provided by VDGIF in their May 7, 2019 comment letter, and hopes that FERC and the Applicant will give it their full consideration. Only with that full understanding can the Applicant and agencies address needed management measures for riverine sediment.

Aquatic Resources

The Applicant proposes to continue to provide a minimum flow of 360 cfs, or inflow to the project, whichever is less, to the New River downstream of each powerhouse to protect aquatic resources (Article 403). This minimum flow is not designated for the bypassed reaches which are approximately 475 foot (0.1 mile) long at Byllesby and 0.8 mile long at Buck, and which currently receive only leakage flows, not minimum flows, when all flow is through the powerhouses. The bypassed reaches are not provided water flow when all the flow is diverted to the powerhouses, such that there is a lack of habitat and connectivity of the pools. These reaches are sediment starved, lacking suitable spawning habitat or habitat for the endemic Kanawha darter (*Etheostoma kanawhae*) and Kanawha minnow (*Phenacobius teretulus,* both Virginia Species of Greatest Conservation Need, Tier IIIc), odonates and crayfish. Under current and proposed operations, the bypassed reaches are also denied the potential for supporting the Eastern hellbender or federally listed candy darter (*Etheostoma osburni*) and Kanawha darter.

An instream flow study, PHABSIM or other evaluation of each bypassed reach is needed to determine appropriate minimum flows to these reaches to protect aquatic resources. In addition to appropriate fish species (e.g., the endemic Kanawha darter, and Kanawha minnow, walleye, smallmouth bass (*Micropterus dolomieu*), other species to be evaluated should include Eastern hellbender, New River crayfish (*Cambarus chasmodactylus*), green floater, and possibly a species of odonate.

Terrestrial Resources
The Service supports the continued adherence to the Wildlife Management Plan, including inspections of undeveloped land for evidence of human disturbance, consultation with Virginia Department of Game and Inland Fisheries (VDGIF) about any impacts, and monitoring of bank erosion (Article 408).

Threatened and Endangered Species
Any Project-related tree removal (e.g., for maintenance, recreational improvements) should involve consultation with the Service under Section 7 of the ESA, for the protection of the Indiana bat (*Myotis sodalis*) and northern long-eared bat (*Myotis septentrionalis*).

The candy darter was listed as endangered under the Endangered Species Act in November, 2018, and the Service will consider requesting protection, mitigation and enhancement (PM&E) measures to aid in this species' recovery. The species occurs only in the Upper Kanawha River Basin, including the Gauley, Greenbrier, and New River watersheds. This species occurs in Cripple Creek, downstream from the Buck Development. Its habitat use "extends into the large New River" where it occupies runs, riffles, and swift pockets (Jenkins and Burkhead 1993). Such measures are especially appropriate within the New River drainage where the species is endemic, and will also benefit the closely related endemic Kanawha darter. The Upper New River drainage may also be the only drainage within the candy darter's current range where the variegate darter (*Etheostoma variatum*) does not occur, which is important because the most significant threat to the candy darter is hybridization with the variegate darter (USFWS 2018).

We are currently aware of few proposed activities that could affect suitable wetlands, except for the potential one foot winter drawdown of the reservoir. In consultation with FERC and their representative, the Service will determine whether there are concerns related to relicensing with regards to the federally listed threatened bog turtle (*Glyptemys muhlenbergii*), which is dependent on wetland habitat for all of its life stages, and breeding, feeding, and sheltering.

There is a 1992 record of Virginia spiraea (*Spiraea virginiana*), along the western shoreline of the Byllesby impoundment. Based on this record, habitat and presence/absence surveys were conducted in April and July of 2017 for proposed impoundment drawdowns to replace wooden flashboards with inflatable Obermeyer gates. Virginia spiraea was not found. The Service considers the results to be valid for 2 years, and may request a new survey, with particular focus on the suitable habitat identified by the Service, where this species was documented in 1992. This species may be affected by impoundment fluctuations or drawdowns.

Recreation and Land Use

The Service supports the May 7, 2019 comments provided by VDGIF and the National Park Service regarding recommendations for safe outdoor recreation access and opportunities to this important stretch of the New River. Their expertise and recommendations are crucial to one of the Service's national priorities, Connecting People to Nature.

Specific Comments on the PAD

Project Area

The Byllesby-Buck Project area described as necessary for project operations in Figure 4.2.1 of the PAD does not include more than a mile long section of the upper area of Buck Reservoir. The entire river reach between Byllesby and Buck Dams is affected by project operations and is used for project operations. Therefore, it should be included in the project area. There is a direct nexus between project operations and ecological and recreational effects in this reach of the New River.

Project Influence

The Byllesby-Buck Project affects a larger area of the New River upstream and downstream from the project area. New River ecological and geologic processes are influenced by the projects for some distance upstream and downstream from the project area in the following ways: (1) the project reservoirs influence ambient New River water temperature and other water quality parameters, with habitat effects on resident coolwater flora and fauna, including New River endemic fishes; (2) liberation of reservoir sediment deposits during project operations result in increased turbidity in downstream reaches influenced by project flow, disrupting ecological processes, suspending contaminants like PCBs, and thereby negatively affecting angling and recreational use; (3) New River walleye populations are affected by project placement, with the dams likely inundating historic New River walleye spawning areas; (4) project dams block New River walleye migration, requiring substantial VDGIF effort and expense to maintain walleye populations upstream and downstream of the Project via hatchery rearing and stocking programs; and (5) loss of upstream mussel fauna due to Project dams blocking migration of host fishes.

The magnitude and spatial scale of this Project Influence on aquatic species is not adequately addressed in the PAD. Determining the spatial scale of Project Influence will help determine adequate reference conditions for ecological comparisons. Determining the downstream spatial influence will involve consideration of project flow attenuation and downstream turbidity effects of project operations, as well as other downstream water quality and recreational impacts.

4.1 Cumulative Effects

The Service does not agree with the conclusion that continued operation of the Project does not contribute to any cumulative effects on aquatic resources. A case can be made for cumulative effects of this Project, with its two developments, and other dams and hydropower projects on the New and Kanawha Rivers, contributing to effects on fish and freshwater mussel populations (barriers to migration and dispersal, entrainment impacts, reduction in available riffle habitats and an increase in lacustrine habitats where sediments accumulate, fish stranding in bypassed reaches with no or insufficient minimum flows, reduction in transport of spawning gravels, and lack of suitable spawning substrates in bypassed reaches); reduction in suitable hellbender, crayfish, and odonate habitat; reduction in transport of organic materials; increased water temperature; and reduced dissolved oxygen.

Section 4.3.1 Reservoirs

The description of the Project reservoirs lacks recent bathymetric information, including average depth of the reservoirs. The PAD cites surveys done in 1990, but lacks more current information. In the absence of this information, assumptions are made about project sedimentation rates and effects on Project operations, raising questions about effects on reservoir biota and recreational use. Direct observation indicates that the reservoirs have been substantially modified by sediment deposition, raising concerns about what rehabilitation is needed to restore aquatic habitat, with resulting floral and faunal improvements and fisheries benefits.

Section 4.4.1 Current Operations

Ramping rate operations for the Buck Dam bypass reach are described on pages 4-21 but no estimates of resulting downstream flows are included in the description of spillway gate opening sizes.

Section 4.4.2 Proposed Operations

A brief evaluation of lower normal pool operations in winter months (December through March) is discussed in this section, but no consideration is given to potential effects during that period. Lower winter pool elevation could affect potential bog turtle wetland hydrology or inhibit recreational access during winter months. In addition, lower winter pool elevation could result in bank erosion effects within the Project Area in areas with a limited riparian buffer.

Section 5.3 Water Resources

As shown in Table 5.3-1, a subset of flow data is depicted for Byllesby-Buck prorated to the drainage area from the gage data of the USGS gage 03164000, New River near Galax, VA. The period of record chosen by the Applicant to be depicted in the PAD is 1987-2016, with narrative reference to a historic high August 1940 flow of 141,000 cfs. The flow duration curves found in Appendix E are not sufficient nor detailed enough to characterize the seasonality, duration, and magnitude of daily flows the reference reaches of the New River experience, and what would be expected to occur in the bypass channels of Buck Dam (4,100 feet long, unknown width) and Byllesby Dam (475 feet long, unknown width). Currently these channels are dewatered nearly 100 percent of the time during January (Byllesby), February, and April through August in a dry year (2002), as shown in Table 4.4-1.

A longer period of record than 30 years (1986-2016) is likely necessary for determining appropriate representative data, among which the "wet year," a "dry year," and an "average year" and others years could be conveyed. Although those chosen years may be illustrative of important distributions within the precipitation spectrum, they may be the 25th or 75th quartiles or 90 percent exceedance, rather than the lowest and highest maximums we might expect during the period of licensing. The PAD should provide a fuller picture of daily flows potentially experienced within and currently removed from the aquatic habitats of bypass reaches by using a longer period (>30 years) of representative data.

Section 5.4.8.2 Bypass Reach Habitat and Flows

The description of existing environment and resource impacts on the bypass reach does not discuss what flows are provided by spillway gate openings at Buck Dam, nor is there any discussion of the need for minimum flow to the bypass reach, particularly a concern below Buck Dam. The bypass reaches are primarily bedrock, lacking sand, gravel, and cobbles essential for supporting local fauna. This PAD section does not discuss bypass reach habitat adequately to provide a context for understanding flow needs in these channels.

Section 5.6 Wetlands, Riparian, and Littoral Habitat

While this section describes the extent of wetland habitat in the reservoirs, it lacks specifics on littoral habitat, including documentation of emergent and submersed aquatic vegetation. Adjacent New River reaches are known to be inhabited by foundational native aquatic vegetation species such as hornleaf riverweed (*Podostemum ceratophyllum*), water willow (*Justicia americana*), common elodea (*Elodea canadensis*), and eelgrass or water celery (*Vallisneria americana*), creating aquatic habitat and food web benefits for riverine fauna, but this PAD section does not describe the existence or lack of these aquatic vegetation species in the reservoirs or the river reaches in the Project Area. The wetlands information in the PAD is also inadequate in describing how these areas are used recreationally, including for wildlife viewing and waterfowl hunting.

Section 5.7 Rare, Threatened and Endangered Species

As noted in the PAD, the candy darter (*Etheostoma osburni*) was listed as endangered under the Endangered Species Act on November 21, 2018. The Service will consider requesting protection, mitigation, and enhancement (PM&E) measures to aid in this species' recovery, based on anticipated Project impacts.

The species occurs only in the Upper Kanawha River Basin, including the Gauley, Greenbrier, and New River watersheds. Cripple Creek, downstream from the Buck Development, is proposed to be listed as federally designated "critical habitat." (83 FR 59232, November 21, 2018). Candy darter habitat use "extends into the large New River" where it occupies runs, riffles, and swift pockets (Jenkins and Burkhead 1993). Such PM&E measures are especially appropriate within the New River drainage where the species is endemic, and will also benefit the closely related endemic Kanawha darter. The Upper New River drainage may also be the only drainage within the candy darter's current range where the variegate darter does not occur. Significant threats to the candy darter include hybridization with the variegate darter, as well as ongoing contributing threats of excessive sedimentation, warming water temperatures, habitat fragmentation, changes in water quality and flow, catastrophic events, and competition or predation associated with other introduced species. (USFWS Candy Darter Recovery Outline, October 1, 2018).

5.7.2.2 Mussels

The green floater mussel is also currently under Federal review for potential listing under the

Endangered Species Act. A decision is anticipated in 2020. The green floater has been documented in the project vicinity, immediately downstream of the Buck Dam, as well as upstream and downstream of both dams throughout the New River. The PAD does not reference green floater in this section, despite its current status as a state threatened species in Virginia. A full discussion of impacts to listed mussels is warranted.

5.7.2.3 Herpetofauna

Although the Service determined on April 4, 2019, that the Eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*) is not warranted at this time to be listed as an endangered species throughout its entire range under the Endangered Species Act, (84 FR 13223, April 4, 2019, https://www.govinfo.gov/content/pkg/FR-2019-04-04/pdf/2019-06536.pdf), a distinct population segment in Missouri has been proposed for listing. The Eastern hellbender remains a federal Species of Concern for which the Service seeks to protect and enhance populations to prevent its listing under the Endangered Species Act in the future. It is incorrectly noted in the PAD as a Tier II species (Very High Conservation Need) within Virginia's Wildlife Action Plan (VWAP 2015), while it is actually a Tier 1a species in the VWAP Appendix A, Virginia Species of Greatest Conservation Need. The PAD's Table 5.7.2 has the correct Tier 1a designation. The Service is requesting a multi-taxa biological survey study be performed within the Project Area. As a completely aquatic species that prefers clear, fast flowing, well oxygenated stream and river habitats, the Eastern hellbender serves an important role within the aquatic community and ecological heritage of the New River. The Service agrees that the Eastern hellbender should be included within the multi-taxa surveys requested for odonates and crayfishes.

Studies Proposed in the PAD

Shoreline Stability Assessment

This study lacks a sedimentation assessment aspect. Sedimentation is a significant effect on habitat at the Project that needs assessment. Relying on results from the upstream Fries project, a smaller project, is not adequate. Watershed sedimentation modeling from the Claytor Project is mentioned but not adequately explained to provide context for the conclusions drawn. Downstream sediment effects and reservoir rehabilitation needs could potentially be addressed by removal of sediment from the Project Area, but cannot be assessed through a Shoreline Stability Assessment study alone. The Service supports the Sedimentation Study Request provided by VDGIF in their May 7, 2019 comment letter, and hopes that FERC and the Applicant will give it their full consideration.

Water Quality

This study needs a thermal context that considers how the Project affects the thermal regime of the New River due to likely project effects on coolwater endemic fish, including the federally endangered candy darter. In addition, the study needs to examine turbidity effects of project operations. Finally, it needs to include analysis of chlorophyll a levels in the reservoirs and downstream transport.

Bypass Reach Aquatic Habitat and Flow Assessment
Due to changes in New River fish populations since 1997, including increased numbers of New River walleye downstream from Buck Dam, this evaluation needs to look at stranding issues after bypass reach spill events. It should also evaluate how spill gates can be used to limit stranding and create upstream and downstream connectivity in the bypass reaches and how bypass reach habitat is modified relative to reference conditions, particularly as it relates to the lack of sand, gravel, and cobble substrates important to multiple faunal groups. In addition, the study needs a flow modeling component to evaluate how spillway gates can be used to create seasonally appropriate flows. As there is currently no specified plan for which gates are opened in a strategic sequence for optimizing flow within the wide downstream channel (AEP, pers. comm., April 11, 2019 Scoping Meeting), this is an operational measure that needs to be enhanced within the study.

Inflatable Obermeyer Crest Gate Operational Effectiveness Evaluation
This study should be integrated with the Bypass Reach Aquatic Habitat and Flow Assessment study to determine how the crest gates can be used to provide improved bypass reach flows.

Wetland and Riparian Habitat Characterization
This study needs to include documentation of emergent and submersed aquatic vegetation beds in the Project Area. In addition, it should evaluate ways to enhance these areas for wildlife and recreational use, particularly with regard to wildlife viewing and waterfowl hunting opportunities.

Recreational Needs Assessment
From the Service's site visit on February 20, 2019, we believe that currently available recreational use information is not adequate to assess existing recreational opportunities and potential improvements to facilities. During the current license term, closure of the U.S. Forest Service campground area on Buck Reservoir and the development of an improved Byllesby Pool Boat Launch alone have likely shifted use. We are not aware of any recent evaluation of canoe portage use, particularly as a result of the take-out location adjustment at Byllesby Dam. A complete assessment of current use is needed as a foundation for a recreational needs assessment.

There is an unmet need for angling access in desirable fishing locations, including the tailrace areas of both dams. These areas, including the Buck Dam tailrace, need to be examined as potential fishing access areas. VDGIF currently manages the Loafer's Rest access area downstream from the Buck Dam tailrace, but this access site is not reasonably close to the tailrace, nor is the parking area located close enough to the New River to be useful to most anglers. Handicapped angler access is also not available at the Project. In addition, paddlers and anglers on the New River need riverside camping areas. The former U.S. Forest Service campground area on Buck Reservoir is a likely site. Other sites should be identified as well.

Studies Not Proposed in the PAD
In section 6.2.3.2 of the PAD, no broad aquatic surveys are proposed for this relicensing because the Applicant believes such surveys are not necessary for the evaluation of Project effects or

potential PM&E measures. The reasoning for this seems to rely on a combination of distribution results from Fries Project surveys and the lack of proposed operational changes. This reasoning ignores the lack of needed faunal and aquatic vegetation information in the Project Area. Because the Byllesby-Buck Project is located in a more remote area of the New River than the Fries Project, knowledge of the New River fauna in the Byllesby-Buck Project area is limited. The New River supports a unique fauna of coolwater fish, invertebrates, the Eastern hellbender, and ecologically important aquatic vegetation beds. The lack of broad faunal and aquatic plant surveys with corresponding reference sites outside the area of Project Influence leaves a critical informational need unfilled. Reasonable efficiencies could be achieved by performing these surveys in concert with one another. The Service believes this information need should be addressed by relicensing studies.

Study Requests by the Service

The Service requests that the Applicant conduct the following additional studies. We strongly urge the Licensee to undertake these studies or discuss alternatives with the Service and other resource agencies.

Biological and Aquatic Vegetation Surveys within the Project Area

1. Describe the goals and objectives of each study proposal and the information to be obtained.

Goal: Gather current distributional information on multiple fauna and foundational aquatic vegetation beds within the Project Area.

Objective: Conduct biological surveys of fish, crayfishes, Odonates, freshwater mussels, Eastern hellbender and associated habitat within the Project Area with appropriate reference sites for comparison.

Objective: Conduct survey of foundational aquatic vegetation beds within the Project Area with appropriate reference sites for comparison.

2. Relevant resource management goals of the agencies or Indian Tribes with jurisdiction over the resource to be studied.

The mission of the Service is "working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people." Resource management goals include protecting federally listed species, and precluding the need to list at-risk species (species that the state may identify as Species of Greatest Conservation Need, SGCN), and where justified, provide fish passage for aquatic connectivity as well as to ensure protection of species which are known or potential hosts for the glochidia (larva) of at-risk freshwater mussel species.

3. Public interest

The requester is a resource agency.

4. Describe existing information concerning the subject of the study proposal and the need for additional information.

The New River supports a unique fauna of coolwater fish (including the native New River walleye), multiple invertebrates (including four species of rare Odonates listed in Virginia's

Wildlife Action Plan), crayfishes, and freshwater mussels), the Eastern hellbender, and ecologically important aquatic vegetation beds that link invertebrate production with higher trophic levels, including important game fishes. In spite of increased scientific information about these organisms and habitats relative to the previous Project relicensing, a knowledge gap remains regarding these organisms and habitats within the Project Area. Because the Byllesby-Buck Project is located in a remote area of the New River, knowledge of the New River in the Byllesby-Buck Project area is limited. The lack of broad faunal and aquatic plant surveys with corresponding reference sites outside the area of Project Influence leaves a critical informational need unfilled. Reasonable efficiencies could be achieved by performing these surveys in concert with one another.

5. Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied and how the study results would inform the development of license requirement.
The nexus between Project operations and effects on Project Area fauna and foundational aquatic plants result from Project flows, turbidity, sedimentation and maintenance dredging operations, as well as temperature and other water quality effects from the Project. Study results would inform PME measures to benefit aquatic resources within the Project Area.

6. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.
Acceptable study methodology for the biological survey component was employed in the Biological Survey Report for the Fries Project, published in the Fries Project (# 2883-Final License Application). Acceptable study methodology for the aquatic vegetation survey component is available from multiple publications, including a recent survey by Weberg et al. (2015).

7. Describe considerations of the level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.
The level of effort and cost associated with this proposed survey are not cost prohibitive. Reasonable efficiencies could be achieved by performing these surveys in concert with one another as much as possible, given the target species. No alternative studies have been proposed to meet the stated information needs presented by this study request. In fact, the study proposed was determined to be unnecessary by the applicant. The Service believes this study is critical due to the lack of current information on organisms and habitat in the Project Area.

<u>Fish Protection and Downstream Passage Studies</u>
Fish moving downstream are subjected to potential mortality from impingement and entrainment. Many hydroelectric project licenses have incorporated trash racks with 1-inch clear bar spacing to physically exclude most adult fish from the turbines, alternate downstream passage routes, and other features (e.g., reduced approach velocities, adequate plunge pools) to encourage safe downstream fish passage. Both developments have intake screens with 15 degree incline and 2.28-inch clearance between the intake bars. The developments utilize Vertical

Francis turbine units (four at Byllesby, three at Buck), but in the context of multiple, stacked hydropower projects, cumulative entrainment impacts are likely. The Applicant has not proposed additional measures to ensure safe, timely, and effective downstream fish passage. Therefore, we request that downstream passage studies be undertaken.

These studies should include a literature search of available passage designs for the species of concern, as well as information on the relative effectiveness of each design. The Service has a blade strike analysis model which may be useful in this effort. Existing facilities at other dams should be investigated. Careful attention should be paid to attraction flows, guidance mechanisms, and velocities. If the Applicant agrees to provide an alternate downstream bypass, the fish moving downriver must be diverted away from the turbines and guided to the downstream passage facility, and adequate attraction and conveyance flows must be provided. A passage facility should not create a bottleneck that would delay downstream movement or expose the fish to excessive predation. Any passage facilities should be designed to prevent blockage from ice and debris, and should be as maintenance-free as is feasible. They must also be able to operate under all flow conditions experienced in the New River.

In addition to a literature review and on-site investigations of existing facilities, the Applicant should collect site-specific data from the Project to aid in the design of protection and passage facilities. This information should include flows, velocities, water depths, and substrates. The Applicant should also collect information on the passage requirements of the fish species found in the New River. This information should include swimming speeds (including burst speeds), where in the water column these fish are likely to be moving, different forms of attractants or repellents (e.g., sound, light, etc.) that may help guide each species.

1. Goals and Objectives
The goals and objectives of this study are to provide information on potential fish passage and protection structures, or other measures, which could be utilized at this Project. The information obtained will allow the Service's fishway engineers to evaluate the potential effectiveness of various options.

2. Resource Management Goals
Resource management goals include providing safe, timely, and effective passage for fish species that migrate, such as smallmouth bass, walleye, white sucker, northern hogsucker and others. Additional goals include providing passage to fish species which serve as glochidial hosts to freshwater mussels found in the Project Area, in order to prevent negative impacts to fish and mussel populations from the proposed project, and to aid in the continued existence of these populations in the New River. The primary focus is on safe downstream passage measures.

3. Public Interest
The requestor is a resource agency.

4. Existing Information
The PAD provides no information regarding passage alternatives.

5. Nexus to Project Operations and Effects
The project blocks the upstream-downstream migration of fishes and utilization of riverine habitat (e.g., reduced downstream passage over dam crest; downstream diversion through powerhouse; the turbines will entrain fish, resulting in some immediate mortality, as well as latent mortality and cumulative mortality from multiple, stacked hydropower projects).

6. Methodology Consistent with Accepted Practice
The recommended study uses standard literature reviews and site-specific data collection techniques common to most hydro licensing activities.

7. Level of Effort, Cost, and Why Alternative Studies Will Not Suffice
The level of effort would involve moderate literature review, discussions with fishway engineers, and site-specific data collection. The study could be completed in less than one year, but may require more time to design effective facilities. The actual cost is unknown and would depend upon the number of alternatives examined. The existing information in the PAD is inadequate to allow a thorough examination of alternatives; however, most of the information needed should be available in the existing literature.

Hydraulic & Instream Flow (Aquatic Habitat) Study
The proposed project may cause localized changes in the velocity and direction of water flow. These changes could alter aquatic habitat, water quality, and sediment movement and deposition patterns, which in turn may adversely affect freshwater mussels and other aquatic life.

1. Goals and Objectives
The goals and objectives of this study are to determine the impacts of modifying the discharge location and configuration of the flow discharge on the current velocity and direction, sediment transport and deposition patterns, aquatic species and habitats, and recreation in the tailwaters and bypass below the proposed project.

2. Resource Management Goals
The goal of the study is to determine if the proposed discharge from the power plant, or reduced spillage to dam tailwater and bypass habitats, would have an adverse effect on fish communities (e.g., spawning habitat), freshwater mussel communities, or on angling opportunities.

3. Public Interest
The requestor is a resource agency.

4. Existing Information
The Service is unaware of any site-specific studies or information that would address these concerns.

5. Nexus to Project Operations and Effects
Aquatic habitat, including spawning habitat and freshwater mussel beds, can be altered by the modification of flow from a hydropower facility. Changes to minimum flow may reorient the direction of flow as a result of the new discharge locations and reduced spillage over the dam

crest, and could also result in changes in sediment transport and deposition patterns.

6. Methodology Consistent with Accepted Practice
The recommended study uses standard study techniques used in many hydropower licensing activities. The Instream Flow Incremental Methodology developed by the Service incorporates a one-dimensional flow model that could be used for assessing the impact on habitat at various flow discharges. However, a two-dimensional (2-D) model would be preferred for the assessment of the discharge from the proposed power plant. A 2-D hydraulic model coupled with the Physical Habitat Simulation (PHABSIM) software would not only provide information about changes in habitat, but would also provide anticipated flow direction and velocity information over a wide range of flows. Assessments of changes in habitat using the PHABSIM software result in an assessment of pre- and post-project Weighted Use Area (WUA), which requires selection of target species and/or guilds. The Service requests that target species and/or guilds include a shallow-fast species (e.g., greenside darter) or guild, in order to determine how the proposed project may affect tailwater habitats and species.

A 2-D model includes 1-foot or finer contour bathymetry, a detailed digital terrain model (DTM), substrate and cover data to be overlaid on the DTM for modeling hydraulic roughness and aquatic habitat, water surface calibration data, and two-dimensional modeling of flow fields over a range of flows. The use of an Acoustic Doppler Current Profiler (ACDP) is standard for collecting information to be used in the model. The report output would include flow vectors, depth, substrate, shear velocities, boundary shear stress, drag coefficient, Froude numbers, and Reynolds numbers at various flow regimes, pre- and post-project, to identify changes in persistent suitable habitat for freshwater mussels and other aquatic organisms, and model assumptions and information regarding how the model was calibrated.

7. Level of Effort, Cost, and Why Alternative Studies Will Not Suffice
Consulting firms and some universities can perform instream flow studies. The methods for both one- and two-dimensional hydraulic flow studies are well established and the level of effort is reasonable. The Service recognizes that certain training, expertise, and equipment are necessary to conduct instream flow studies. However, numerous studies have been conducted on waters throughout the United States, including previous studies conducted for several other hydroelectric projects in the upper Ohio River basin.

The Service believes that a 2-D study would provide the best information to make a decision about impacts that may be associated with the proposed hydropower development. Alternative studies would not provide adequate information about changes in velocity, direction, and impacts on aquatic habitat for selected species to make informed decisions about resource issues. The Service is unable to determine the cost of the proposed study.

Foregoing Studies in Lieu of Protection, Mitigation, and Enhancement Measures
There may be an opportunity to reduce some of these studies in scope, or even forego some of them, if agreements can be reached up front regarding certain Protection, Mitigation, and Enhancement (PM&E) measures. The Service recommends that the Applicant convene a meeting with the stakeholders after receiving all of the study requests to determine which studies could be

reduced or eliminated in return for agreements to proceed with certain PME measures.

The Draft Study Plan developed by the Licensee should incorporate all of the above-listed studies. The study proposals incorporated into the Draft Study Plan should be as detailed as possible so that all parties know exactly what is being agreed to when the study plan is approved. Thank you for the opportunity to comment on this PAD and the opportunity to provide study requests. If you have any questions regarding this matter, please contact Janet Norman of my staff at 410-573-4533 or Janet_Norman@fws.gov.

Sincerely,

Genevieve LaRouche
Field Supervisor

cc: Lindy Nelson
Stephanie Nash

References:

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

Matthew A. Weberg, Brian R. Murphy, Andrew L. Rypel and John R. Copeland. 2015. A Survey of the New River Aquatic Plant Community in Response to Recent Triploid Grass Carp Introductions into Claytor Lake, Virginia. Southeastern Naturalist, 14(2):308-318.

USFWS. 2018 Candy Darter Recovery Outline. https://ecos.fws.gov/docs/recovery_plan/2018%20CDRecoveryOutline.pdf

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May 7, 2019

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington D.C. 20426

Re: Comments on Scoping Document 1 for the Byllesby-Buck Hydroelectric Project (P-2514-186)

Dear Secretary Bose,

Thank you for the opportunity to comment on the Byllesby-Buck Hydroelectric Project (P-2514-186) Scoping Document (SD1). Virginia Department of Environmental Quality Staff (DEQ) Office of Water Supply staff attended the site visit on April 10, 2019 and the agency scoping meetings on April 10 and April 11, 2019 in Galax, Virginia.

Project Boundaries:

The Pre-Application Document (PAD) indicates two separate project boundaries anchored upstream by Byllesby Dam and downstream by Buck Dam. The separation (gap) in the project boundary was described during the site visit by applicant staff as a portion of the New River where the influences of Byllesby Dam have ended and where the influences of Buck Dam have not begun. However, also during the site visit, it was noted by applicant staff that the operations of Byllesby Dam directly influence the operation of Buck Dam. The site visit explanations by applicant staff were contradictory, and the PAD fails to adequately address the separation of the project boundary. DEQ recommends that the project boundary separation be eliminated and the area in question be included in the defined project boundary in the PAD.

Water Resources:

The PAD notes that sediment accumulation is known to be slowly occurring at locations within and around the reservoirs, in some cases leading to the creation of new wetland areas. The PAD further notes that if such areas interfere with the Project operations, there could be a need in the future to dredge such areas, such as was done in 1997 and 2014. The proposed studies do not include monitoring concentrations of Polychlorinated biphenyls (PCBs) within the sediment that may be dredged or present in the wetlands referenced. Although the Project is not in the New River PCB fish impairment area, PCB concentrations in sediment deposits behind the dams should be investigated. DEQ recommends EPA Method 1668 (PCB congener method has the sensitivity to account for downstream fish impairment.

Minimum Flows:

The PAD notes that during previous relicensing (early 1990's) the potential effects of Project operations on powerhouse tailrace habitat were evaluated with respect to erosional and depositional considerations, spring spawning habitat, and low-flow summer habitat. The previous relicensing findings found that fish likely to spawn in the tailrace would likely do so in spring when water levels would be typically elevated and because the channels below the powerhouses are steep-sided, little spawning surface would be exposed. Based on these previous findings, a minimum flow of 360 cfs was found to be adequate, and the applicant proposes to continue to provide this minimum flow for the new license.

However, standards and information about aquatic resources needs have improved during the previous three decades and we would expect that different flows could be required dependent upon species status and needs. There is significant scientific basis at this point to demonstrate aquatic life impacts from a single minimum flow rate and the Department no longer believes a single instream flow value is protective of aquatic life. Additionally, downstream water withdrawals for public water supplies or other beneficial uses may be affected by flow alterations from the operation of this hydroelectric facility during low flow periods. Any alterations to instream flow caused by the operation of this facility will be assessed during the Virginia Water Protection Permit review.

Virginia Water Protection Permit:

A Virginia Water Protection Permit (VWP permit) issued by the Department will be required for any construction activities in the New River as well as for the alterations to instream flow related to the operation of the hydroelectric plant. As a matter of agency practice, the VWP permit serves as the Clean Water Act § 401 state certification for the Federal Energy Regulatory Commission license. Absent completion of the VWP permit process, DEQ will issue a § 401 certificate conditioned on the receipt of the VWP permit. Please contact the Mr. Joseph Grist at Joseph.Grist@deq.virginia.gov or at DEQ - Office of Water Supply, P.O. box 1105, Richmond, Virginia 23218 about the VWP Permitting Process.

Sincerely,

Joseph Grist
DEQ Office of Water Supply
Water Withdrawal Permitting and Compliance Manager

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May 1, 2019

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Dear Ms. Bose:

This letter details my comments on the Pre-Application Document, and study requests, for the **Byllesby-Buck Project (P-2514-186)**.

Summary of Comments and Study Requests

Comments & Study Requests on the Pre-Application Document

4.2 Project Location

While the project boundary may only encompass lands owned by Appalachian Power Company surrounding Byllesby Dam and Buck Dam, this boundary does not include all areas influenced by project operations; i.e., it does not encompass the footprint of the project. Specifically, the Project Boundary does not cover a ~1.2 RM stretch of the New River between Byllesby Dam and Buck Dam. The natural habitat in this reach has been modified as a result of dam construction and continues to be influenced by current project operations. When evaluating the potential impacts that these dams pose to the environment (e.g., water quality and habitat suitability) and resources (e.g., recreational opportunities), the entire stretch of river between the dams should be assessed.

5.1.2 Major Land and Water Uses

The applicant states that there are no federal lands within the Project Boundary. However, there are several instream islands and shoals along the banks within the Project Boundary that are considered part of the Jefferson National Forest (U.S. Forest Service owned land).

5.2.5 Project Area Soils

Dams disrupt sediment transport processes by serving as sediment and nutrient traps which have created sediment-filled reservoirs above and sediment-starved reaches immediately downstream. The PAD indicates that the rate of sedimentation in the reservoirs has stabilized over recent decades and that sediment loads entering the Project Boundary "is expected to pass through the Project and be deposited downstream (i.e., in Claytor Lake)" [PAD 5.2.5; 5.2.7; 6.2.1.1]. This statement can be misleading as it suggests that the dams are no longer influencing sediment transport. During high flow events these accumulated sediments within the reservoirs can be mobilized and, consequently, result in large deposits of sediments downstream. For aquatic invertebrates, particularly freshwater mussels, these depositions can smoother or cause stress in individuals that results in mortality, reduce growth, or disruption to reproduction (Bogan 1993; Neves et al. 1997; Watters 2000). In addition, while dams and impoundments trap nutrients and accumulate sediments in their reservoirs, they lose their ability to trap nutrients and sediments effectively as they approach capacity over time; subsequently increasing sediment, metals, and nutrient loads into downstream habitats (Stanley and Doyle 2003).

5.3.2 Flows

How are flows at the Project estimated using the upstream USGS gage station 03164000? Are Byllesby and Buck dam operation records/daily generation and forebay elevations considered when estimating discharge capacity of the powerhouse? Does it account for the Fries Project (which has no minimum flow requirements) operations or contributions from upstream tributaries (including those found between the two dams)? Section 4.4.1 of the PAD states that the applicant monitors the upstream U.S. Geological Survey (USGS) gage at Galax and Byllesby and Buck forebay elevations to plan gate openings in the event inflow exceeds powerhouse discharge capacity. If inflows and powerhouse discharge (i.e., outflows) are known for each dam, why aren't these values presented in the PAD? Table 5.3-1 doesn't provide statistics for each individual dam and it is unclear if these values represent estimated inflow discharge or powerhouse discharges.

It would be informative to see daily trends of inflow and outflow discharge from the individual Projects to better understand the modifications to the natural flow regime. Alterations to the flow regime (i.e., the magnitude, frequency, duration, timing, or flashiness of flow releases [Poff et al. 1997]) can have cascading impacts to the ecosystem through changes to habitat and water quality (Williams and Wolman 1984).

5.3.7 Existing Water Quality Data

The maximum water temperature and minimum D.O. requirements in the New River associated with Project waters is 29°C and 4.0 mg/L, respectfully (noted in PAD Table 5.3-3). The PAD does not address the fact that water quality monitoring data collected for Appalachian Power in 2017 shows that temperatures exceeded the 29°C threshold (PAD Figure 5.3-6) and D.O. measurements fell below the 4.0 mg/L threshold approximately 1 mile downstream of Buck Dam. This area falls within the Project Boundary and readings are likely influenced to some degree by dam operations. If these water quality parameters ~1 mile below Buck Dam violated criteria set for the New River, it stands to reason that temperature and D.O. immediately below the dam or bypass reach, or in the impoundment, would have been similar—if not more extreme—given the proximity to the dam and habitat characteristics. Additional water quality monitoring is warranted throughout the Project Footprint (e.g., collection of long-term, continuous data by deploying loggers or Sondes).

5.4.1 Fish and Aquatic Resources

The applicant lists sportfish species found in the vicinity of the Project Boundaries based on a VaFWIS database search (VDGIF 2017a citation). Why were non-game fishes from the database search not presented? Although the Appalachian 1990 fish study results (that include non-game species) are presented, are there not more recent records on non-game fish distributions within the Project Boundaries? If not, additional studies are needed to assess their distributions across Project influenced waters. It has been nearly three decades since the last comprehensive fish survey was conducted within the Project Boundaries. Additionally, the Project Boundary encompasses the lower reaches of several tributaries yet there is no data presented on the aquatic community assemblage within these tributaries. The 1990 fish study did not sample these tributaries which could be supporting a different diversity of aquatic fauna that prefer cooler tributary habitats (e.g., New River endemic sculpins; Jenkins and Burkhead 1994).

Other than the 1990 fish study, have any other fish surveys been completed between the two dams? Note that sampling efforts by the Virginia Department of Game and Inland Fisheries (VDGIF), as described in PAD Section 5.4.1.2, did not cover the stretch of the New River between Byllesby Dam and Buck Dam. In addition, these surveys conducted by the VDGIF (as cited in the PAD, VDGIF 2015) report only statistics on gamefish species. This report describes surveys conducted by electroshocking and assesses trends in catch-rate overtime for gamefish populations (i.e., does not provide data on non-game fishes). Lack of information on non-game species within the influence of the Project dams is a gap in knowledge that needs to be addressed.

PAD page 5-33: "A decline in Walleye was reflected in spring electrofishing catch rates, and the collection of limited numbers of naturally-reproducing Walleye indicated the necessity of continued stocking to maintain a viable recreational fishery."

The stocking of the native strain of New River Walleye has met one of the criteria of a successful reintroduction—post-release survival of stocked individuals. However, there is evidence indicating the native Walleye population has not reached self-sustaining levels of natural recruitment to maintain a long-term viable population without intervention which suggests there may be factors limiting successful recruitment. These factors may include lack of suitable spawning or juvenile habitat. Studies on factors that limit recruitment in river spawning walleye suggest that temperature and flow may drive recruitment success (Mion et al. 1998; Gillenwater et al. 2006; Rutherford et al. 2016). Hence, modification to natural pH, thermal, and flow regimes caused by the Byllesby-Buck dams may be disrupting Walleye reproduction or limiting successful recruitment.

5.4.2 Essential Fish Habitat

While there are no obligate migratory fish species or federal managed fishery in the vicinity of the Project dams that would fall under NOAA regulation, it can be argued that the Project Boundary contains essential habitat for native Walleye unique to the upper New River under the Magnuson-Stevens Act definition of "Essential Fish Habitat":

"Pursuant to the Magnuson-Stevens Act, each fishery management plan (FMP) must identify and describe Essential Fish Habitat (EFH) for the managed fishery, and the statute defines EFH as "*those waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity*." 16 U.S.C. § 1853(a)(7) and § 1802(10)."

Additionally, the Upper New River serves as essential fish habitat for 8 endemic fish species (i.e., species which exist only in the New River). Was the VDGIF database (VaFWIS) or State Wildlife Action Plan reviewed to see if this section of the Project Boundary overlaps with essential habitat identified for state protected species or Species of Greatest Conservation Need (SGCN)?

5.4.4.5 Walleye

"Walleye in the New River are known to migrate upstream to spawn, but are inhibited by the Byllesby and Buck dams. However, they will also spawn in lakes over rocky or gravel shoals or clean, low-growing emergent vegetation."

The non-native Walleye strain will spawn in lakes, such as Claytor Lake. The native, unique New River Walleye strain (the one VDGIF is working to reestablish through genetic marker assistance and stocking efforts) is a river-spawner.

5.4.5 Benthic Macroinvertebrates Habitat and Life-History Information

5.4.5.1 Crustaceans

- Jones et al. (1998) and the VaFWIS database should be consulted for a review of crayfishes and snails in the vicinity of the two Project dams. The diversity of crayfishes appears to be declining in the Upper New River and there are many gaps in knowledge on species distributions and the impacts non-native crayfishes are having on native species. An excerpt on the endemic New River crayfish (*Cambarus chasmodactylus*) taken from Russ et al. (2017):

"It is clear that monitoring and surveys are needed for this species especially in West Virginia where it is limited to the Greenbrier River sub-basin and in Virginia where the least is known about the current range. Future work in all three states should focus on monitoring the introduction of nonnative crayfish and devoting resources into the prevention of the spread of all aquatic nuisance species."

- Correction to results described in third paragraph (page 5-39). It should state that crayfish *were* collected in the Fries Project bypass reach.

"Over 800 live Spiny Stream Crayfish were collected within the study reaches upstream and downstream of the Fries Project (Reaches 1, 3, 4, and 5), but not within the Fries Project reservoir or bypass reach (Reaches 2 and 3)."

5.4.6 Freshwater Mussels

- The taxonomic name for pistolgrip is *Tritogonia verrucosa.*
- Correction on Page 5-43. Dive searches were also completed in the impoundment, Reach 2
- The Project Boundary includes Chestnut Creek however this tributary was not assessed for mussels during surveys for the Byllesby water drawdown (Stantec 2018a).
- Habitat below both Project dams was not surveyed for mussels during recent surveys conduct for water drawdowns (Stantec 2018a, 2018b).
- The last mussel survey conducted below Byllesby Dam was in 1997 (Jones et al. 1998; Pinder et al. 2002) in which 1 purple wartyback mussel was collected. The last mussel survey conducted below Buck Dam was in 2008 (Alderman 2008) where notably >100 State Threatened pistolgrip (among other species) were collected. Both of these areas need updated status assessments.
- The furthest upstream section of the New River within the Project Boundary (above Byllesby Dam) was not searched for freshwater mussels during recent surveys (Stantec 2018a; Appendix B, Figure 1)
- It is unclear how far upstream into Brush Creek and Crooked Creek that mussel searches were conducted (Stantec 2018a). Did it cover the entire ~0.2 RM reach of Brush Creek and ~1.5 RM reach of Crooked Creek found within the Project Boundary? Both of these creeks have been identified as "Habitat Predicted for Aquatic WAP Tier I & II Species" by the VDGIF (VaFWIS).
- Additional mussel surveys are needed to cover the entire habitat within the Project Boundary.

5.4.8.2 Bypass Reach Habitat and Flows (& 5.7.3)

"During the previous licensing, FERC noted that that the Buck bypass reach is characterized by exposed bedrock and that the Commission had no evidence that this reach provided any unique or outstanding characteristics of fish habitat relative to nearby reaches." -PAD 5.4.8.2

"Additionally, Appalachian notes that due to existing topographic and substrate conditions, the existing bypass reaches are not expected to provide habitat for the aquatic species described in the section above." -PAD 5.7.3

- The reason the bypasses don't contain unique or species-specific suitable habitat was undoubtedly caused by the Project dams which diverted and essentially eliminated flows in the reach. "The bypasses don't contain suitable habitat" is not a justification for not mandating a minimum flow requirement in the bypasses and implementing efforts to restore riverine habitat in the bypasses. The photographs below (Byllesby top, Buck bottom) depict the extensive loss of river habitat caused by the Project dams. The Project dams have left these reaches scoured and sediment starved. Habitat restoration to these reaches should be considered as a requirement of the new license.

6.2.3.3 Proposed Studies

Bypass Reach Aquatic Habitat and Flow Assessment: "Appalachian proposes, therefore, to perform a desktop aquatic habitat assessment of each Project bypass reach."

- These assessments should not be limited to a desktop. Field surveys should be conducted.
- Habitat restoration should be considered (e.g., restoring flows, aquatic vegetation plantings).

Water level loggers

- These should be installed at several locations in the Project Boundary for continuous monitoring (along with water quality parameters) over a minimum 1 year study period. Water level loggers should be permanently be installed above and below the powerhouses and in the bypasses reaches.

Virginia spiraea surveys

- Field surveys were last conducted in July 2017. "Appalachian requested that the negative results remain valid for 2 years, based on the guidelines established by the USFWS Virginia Field Office" (Stantec 2018a). These results will soon be outdated and updated surveys will be needed to assess the presence/absence of Virginia spiraea within the Project Boundaries. Given the dispersal and life-history of the species, and the presence of suitable habitat within the Project

Boundary, Virginia spiraea may be present. In addition, while the previous surveys were within the time window (May-early July when it is blooming) established suitable for conducting field assessments, the 2017 survey was conducted right at the tail-end of this window (early July). Future surveys should start earlier in the season and be conducted at several intervals within the time window.

Other

- There is no mention in the PAD on the status of native aquatic plants within the Project vicinity. Several species found in the New River are considered foundation species that can significantly influence aquatic community structure and composition. The hornleaf riverweed (*Podostemum ceratophyllum*), American water-willow (*Justicia americana*), and American water celery (or eel-grass; *Vallisneria americana*) are three ecologically important species (Hill 1981; Fritz et al. 2004; Strayer et al. 2013; Wood and Freeman 2017) found in the New River whose distribution is impacted by the Project dams and operations. The loss of these species can negatively impact other aquatic biota through declining habitat and water quality, disruptions to the trophic web, and loss of ecosystem services. Wood and Freeman (2017) note that hornleaf riverweed is in decline throughout much of its range and that "Information on responses of the plant to environmental changes throughout its range is essential to understanding how to conserve or restore populations. Conservation efforts would also benefit from better documentation of *Podostemum* populations, a long recognized deficiency in our understanding of the plant (….). As pressures on freshwater resources increase, conserving *Podostemum* appears crucial for preserving and improving the health and vitality of many eastern North American Rivers."

- Aquatic biota assessments should be extended across the entire reach between the Project dams and in an up- and downstream reference site.

- There is a need to assess native and non-native crayfish distributions across the Project Boundary. The endemic New River crayfish is a species of special interest.

- Freshwater mussel population restoration efforts (e.g., laboratory propagation) should be considered, particularly for state threatened pistolgrip and green floater. If an updated survey below Buck dam determines pistolgrip have significantly declined or been extirpated, then mussel population restoration efforts should be a mandatory requirement of the Project license.

Sincerely,

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Research Associate
Conservation Management Institute,
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Virginia Tech

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Molly Joseph Ward
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May 7, 2019

Kimberly Bose
Federal Energy Regulatory Commission
888 First Street NE, Room 1A
Washington DC 20426

Re: P-2514-186, Byllesby-Buck Hydroelectric Project

Dear Ms. Bose:

The Department of Conservation and Recreation's Division of Natural Heritage (DCR) has searched its Biotics Data System for occurrences of natural heritage resources from the area outlined on the submitted map. Natural heritage resources are defined as the habitat of rare, threatened, or endangered plant and animal species, unique or exemplary natural communities, and significant geologic formations.

According to the information currently in our files, the New River – Big Branch Stream Conservation Unit (SCU) is located within the project site. SCUs identify stream reaches that contain aquatic natural heritage resources, including 2 miles upstream and 1 mile downstream of documented occurrences, and all tributaries within this reach. SCUs are also given a biodiversity significance ranking based on the rarity, quality, and number of element occurrences they contain. The New River – Big Branch SCU has been given a biodiversity ranking of B4, which represents a site of moderate significance. Natural heritage resources associated with this site are:

Gomphus adelphus	Moustached clubtail	G4G5/S1/NL/NL
Ophiogomphus howei	Pygmy snaketail	G3/S1S2/NL/NL

The Moustached Clubtail is a gray-green and black dragonfly which inhabits mostly rapid clear rocky streams and rivers and occasionally the exposed shorelines of lakes (Dunkle, 2000). The Moustached Clubtail occurs in the northeastern United States and southeastern Canada, extending its range southward along the Appalachian Mountains rarely reaching into North Carolina and Georgia (Lasley accessed 25 February 2010). In Virginia, *G. adelphus* is known from areas of the New River (Grayson, Carroll, and Wythe counties) and has historical occurrences in Augusta and Bath counties. As with all dragonflies, its larvae are aquatic and adults emerge from the water to forage and mate (Dunkle, 2000). Because of their aquatic lifestyle and limited mobility, the larvae are particularly vulnerable to shoreline disturbances that cause the loss of shoreline vegetation and siltation. They are also sensitive to alterations that result in poor water quality, aquatic substrate changes, and thermal fluctuations.

The Pygmy snaketail is a very small sized, stocky dragonfly with amber basal field hindwings, ranging from northeast Maine west to Wisconsin, and south to Virginia and Kentucky. This species requires big, clear rivers with high water quality and stable flow over coarse cobbles and periodic rapids. The larva of this species is unique due to the small size and lack of a dorsal abdominal spine. These larvae overwinter and take flight late April to early June. The major threat to this species is habitat degradation by the impoundment of running waters from poorly drained roads, damming, and channelization (NatureServ, 2009).

Adult Odonata (dragonflies and damselflies), commonly seen flitting and hovering along the shores of most freshwater habitats, are accomplished predators. Adults typically forage in clearings with scattered trees and shrubs near the parent river. They feed on mosquitoes and other smaller flying insects, and are thus considered highly beneficial. Odonates lay their eggs on emergent vegetation or debris at the water's edge. Unlike the adults, the larvae are aquatic and typically inhabit the sand and gravel substrates. Wingless and possessing gills, the larvae crawl about the submerged leaf litter and debris stalking their insect prey. The larvae seize unsuspecting prey with a long, hinged "grasper" that folds neatly under their chin. When larval development is complete, the aquatic larvae crawl from the water to the bank, climb up the stalk of the shoreline vegetation, and the winged adult emerges (Hoffman 1991; Thorpe and Covich 1991).

Because of their aquatic lifestyle and limited mobility, the larvae are particularly vulnerable to shoreline disturbances that cause the loss of shoreline vegetation and siltation. They are also sensitive to alterations that result in poor water quality, aquatic substrate changes, and thermal fluctuations.

In addition, the New River has been designated by the VDGIF as a "Threatened and Endangered Species Water" for the Pistolgrip.

Due to the legal status of the Pistolgrip, DCR recommends coordination with the VDGIF, Virginia's regulatory authority for the management and protection of this species to ensure compliance with the Virginia Endangered Species Act **(**VA ST §§ 29.1-563 – 570).

DCR reiterates the presence of Virginia spiraea (*Spiraea virginiana*,G2/S1/LT/LE) in the New River and additional suitable habitat for this rare plant as indicated in the 2017 survey report. Any change of water levels and/or drastic flow alterations could have potential negative impacts on this species. Therefore, DCR supports updated surveys during the relicensing process to inform any protection, mitigation and enhancement measures related to threatened and endangered species for the Byllesby-Buck Project and recommends coordination with VDGIF and USFWS to ensure compliance with protected species legislation.

Under a Memorandum of Agreement established between the Virginia Department of Agriculture and Consumer Services (VDACS) and the DCR, DCR represents VDACS in comments regarding potential impacts on state-listed threatened and endangered plant and insect species. Survey results should be coordinated with DCR-DNH and USFWS. If it is determined the species is present, and there is a likelihood of a negative impact on the species, DCR-DNH will recommend coordination with VDACS to ensure compliance with Virginia's Endangered Plant and Insect Species Act.

There are no State Natural Area Preserves under DCR's jurisdiction in the project vicinity.

New and updated information is continually added to Biotics. Please re-submit a completed order form and project map for an update on this natural heritage information if the scope of the project changes and/or six months has passed before it is utilized.

The VDGIF maintains a database of wildlife locations, including threatened and endangered species, trout streams, and anadromous fish waters that may contain information not documented in this letter. Their database may be accessed from http://vafwis.org/fwis/ or contact Ernie Aschenbach at 804-367-2733 or Ernie.Aschenbach@dgif.virginia.gov.

Should you have any questions or concerns, feel free to contact me at 804-371-2708. Thank you for the opportunity to comment on this project.

Sincerely,

S. René Hypes
Natural Heritage Project Review Coordinator

CC: Ernie Aschenbach, VDGIF
Troy Andersen, USFWS
Keith Tignor, VDACS
Valerie Fulcher, EIR-DEQ

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Secretary Kimberly D. Bose
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Byllesby-Buck Project (P-2514-186) Comments on Pre-Application Document, Scoping Document 1, and Study Requests

Dear Secretary Bose:

New River Conservancy (NRC) appreciates the opportunity to comment on the Byllesby-Buck Hydroelectric Project (Number 2514-186) Pre-Application Document (PAD), Scoping Document 1 (SD1), and the opportunity to provide Study Requests for this relicensing project. We attended the Scoping Site Visit and the public meeting on April 10, 2019 in Galax, Virginia, and reviewed the PAD and SD1. We offer the following comments on the PAD and SD1 and then provide Study Requests.

General Comments on PAD

The impounded reaches of the New River encompassed by the Byllesby-Buck Project have displaced habitat important to a variety of aquatic insects, freshwater mussels, crayfish, Eastern Hellbender, native fishes, and fish spawning areas, including the native New River walleye. By blocking fish migration, disrupting freshwater mussel populations and associated fish host species from dispersing upstream and downstream in the New River. Lack of sand and gravel areas in bypass reaches, combined with high levels of sedimentation in the reservoirs, diminish habitat for freshwater mussels and other aquatic life. None of these impacts are discussed in the PAD

Specific Comments on PAD

1. **Project Area:** The Byllesby-Buck Project area necessary for project operations in Figure 4.2.1 of the PAD ignores more than a mile-long section of the upper area of Buck Reservoir. The entire river reach between Byllesby and Buck Dams is affected and used by project operations, thus should be included in the project area. There is a direct nexus between project operations and ecological and recreational effects in this reach of the New River. AEP may not own the upland forest area but certainly owns and manages the river that runs between the dams.

2. **Project Influence:** The Byllesby-Buck Project affects a large area of the New River up and downstream from the project area. New River ecological and geologic processes are influenced by the projects for some distance upstream and downstream from the project area. Examples include: (1). The project reservoirs influence on ambient New River water temperature and other water quality parameters, with habitat effects on resident coolwater flora and fauna, including New River endemic fishes; (2) Liberation of reservoir sediment deposits during operations result in increased turbidity in downstream reaches influenced by project flow, disrupting ecological processes, suspending contaminants like PCB's, and negatively affecting angling and recreational use; (3) New

River walleye populations are affected by project placement, with the dams likely inundating historic New River walleye spawning areas; (4) Project dams block New River walleye migration, and, (5) Loss of upstream mussel fauna due to Project dams blocking migration of host fishes.

The magnitude and spatial scale of this Project Influence is not adequately addressed in the PAD. Determining the spatial scale of Project Influence will help determine adequate reference conditions for ecological comparisons during multiple study efforts. Determining downstream spatial influence will involve consideration of project flow attenuation and downstream turbidity effects of project operations, as well as other downstream water quality and recreational impacts.

3. **Section 4.3.1 Reservoirs:** The description of the project reservoirs lacks recent bathymetric information, including average depth of the reservoirs, citing surveys done in 1990. Current information is needed to determine sedimentation rates and effects on project operations, effects on reservoir biota and recreational use. Direct observation indicates that the reservoirs have been substantially modified by sediment deposition, raising concerns about what rehabilitation is needed to restore aquatic habitat, with resulting floral and faunal improvements and fisheries benefits.

4. **Section 4.4.1 Current Operations:** Ramping rate operations for the Buck Dam bypass reach are described on page 4-21 but no estimates of resulting downstream flows are included in the description of spillway gate opening sizes.

5. **Section 4.4.2 Proposed Operations:** A brief evaluation of lower normal pool operations in winter months (December through March) is discussed, but no consideration given to potential effects during that period. Lower winter pool elevation may inhibit recreational access during winter resulting in bank erosion effects within the Project Area with limited riparian buffer.

6. **Section 5.3 Water Resources:** PAD section 5.3.2 titled Flows does not characterize the range of flows typical for the Project Area, which inhibits analysis of needed bypass reach flows. More information should be provided over a longer period of record than 30 years, providing likely dry, wet, and average year conditions that should be replicated in bypass reach flow management.

7. **Section 5.4.6 Freshwater Mussels**
   Section 5.4.6.1 Mussel Surveys from 2002 to 2017
   This PAD review of recent mussel surveys in the New River failed to include the following: (1) VDGIF and Appalachian Power Company Claytor Lake drawdown assessments starting in 2006, and subsequent mussel salvages during alternating year Claytor Lake drawdowns, that included collection of Eastern Elliptio (*Elliptio complanata*); and, (2) A 2017 mussel relocation conducted by Environmental Solutions & Innovations, Inc. at the I-81 bridge downstream from Claytor Dam, where upwards of 8 species were collected, including the state threatened Pistolgrip (*Tritogonia verrucosa*) and where Eastern Elliptio was documented in the mainstem river for the first time. In

addition, an assessment of this area by Stantec in 2017 turned up 1 state threatened Green Floater (*Lasmigona subviridis*).

8. **Section 5.4.8**
   5.4.8.1 Fish and Aquatic Resources: *Entrainment*: There is no mention of potential entrainment of larval mussels. Information on and potential for bivalve entrainment should be included in the PAD.

   5.4.8.2 Bypass Reach Habitat and Flows: The description of existing environmental and resource impacts on the bypass reach does not discuss what flows are provided by spillway gate openings at Buck Dam, nor is there discussion of the need for minimum flow to the bypass reach, particularly a concern below Buck Dam. The bypass reaches are primarily bedrock, lacking sand, gravel, and cobbles essential for supporting local fauna. This PAD section does not discuss bypass reach habitat adequately to provide a context for understanding flow needs in these channels.

9. **Section 5.6 Wetlands, Riparian, and Littoral Habitat:** This section lacks specifics on littoral habitat, including documentation of emergent and submersed aquatic vegetation. Adjacent New River reaches are known to be inhabited by foundational native aquatic vegetation species such as *Podostemum ceratophyllum* (hornleaf riverweed) *Justicia americana* (water willow), *Elodea canadensis* (common elodea), and *Vallisneria americana* (eelgrass or water celery) that create aquatic habitat and food web benefits for riverine fauna, but this PAD section lacks description of aquatic vegetation species in the reservoirs or river reaches in the Project Area and there is no description of recreational use, including for wildlife viewing and waterfowl hunting.

10. **Section 5.7 Rare, Threatened, and Endangered Species:**
    5.7.1.1 Candy Darter
    As noted in the PAD, the Candy Darter (*Etheostoma osburni*) was listed as endangered under the federal Endangered Species Act on November 21, 2018. New River Conservancy supports VDGIF's request for protection, mitigation, and enhancement (PME) measures to aid in this species' recovery. Such PME measures are especially appropriate within the New River drainage where the species is endemic, and will also benefit the closely related endemic Kanawha darter.

    5.7.2.2 Mussels
    NRC also supports including the Green Floater in its references to species with state legal status as a state threatened species which is known from the project vicinity. This species is also being reviewed for federal listing, which should also be discussed in the PAD.

    5.7.2.3 Herpetofauna
    NRC strongly supports VDGIF in requesting a multi-taxa biological survey study be performed within the Project Area which should include searches for Eastern Hellbender and its habitat due to its status federally and Tier I a status in Virginia's Wildlife Action Plan.

11. Section 5.8 Recreation and Land Use
NRC supports VDGIF's requests for upgrades of boat launches and canoe portages at both Byllesby and Buck Dams.

Studies Proposed in the PAD

NRC supports VDGIF comments below:

1. *Shoreline Stability Assessment*: This study lacks a sedimentation assessment aspect. Sedimentation has a significant effect on habitat that needs assessment. Downstream sediment effects and reservoir rehabilitation needs could potentially be addressed by removal of sediment from the Project Area, but cannot be assessed through a Shoreline Stability Assessment study alone. NRC requests a comprehensive shoreline stability and sediment study resulting in development of a sediment management plan.

2. *Water Quality*: This study needs a thermal context to consider project effects on coolwater endemic fish, including the federally endangered Candy Darter. In addition, the study needs to examine turbidity effects of project operations. Finally, it needs to include analysis of chlorophyll a levels in the reservoirs and downstream transport.

3. *Bypass Reach Aquatic Habitat and Flow Assessment*: Due to changes in New River fish populations since 1997, including increased numbers of New River walleye downstream from Buck Dam, this evaluation needs to look at stranding issues after bypass reach spill events, with field data collection. It should also evaluate how spill gates can be used to limit stranding and create upstream and downstream connectivity in the bypass reaches and how bypass reach habitat is modified relative to reference conditions, particularly as it relates to the lack of sand, gravel, and cobble substrates important to multiple faunal groups. In addition, the study needs a flow modeling component to evaluate how spillway gates can be used to create seasonally appropriate flows.

4. *Inflatable Obermeyer Crest Gate Operational Effectiveness Evaluation*: This study should be integrated with the Bypass Reach Aquatic Habitat and Flow Assessment study to determine how the crest gates can be used to provide improved bypass reach flows.

5. *Wetland and Riparian Habitat Characterization*: This study needs to include documentation of emergent and submersed aquatic vegetation beds in the Project Area and should evaluate ways to enhance these areas for wildlife and recreational use, particularly wildlife viewing and waterfowl hunting opportunities.

6. *Recreational Needs Assessment*: Currently available recreational use information is not adequate to assess existing recreational opportunities and potential improvements to facilities. During the current license term, closure of the U.S. Forest Service campground area on Buck Reservoir and the development of an improved Byllesby Pool Boat Launch alone have likely shifted use. A more complete assessment of current use is needed as a foundation for a recreational needs assessment.

   We state elsewhere in our comments the need for angling access in desirable fishing locations, including the tailrace areas of both dams. These areas, including the Buck

Dam tailrace, need to be examined as potential fishing access areas. VDGIF currently manages the Loafer's Rest Access area downstream from the Buck Dam tailrace, but this access site is not reasonably close to the tailrace, nor is the parking area located close enough to the New River to be useful to most anglers. Handicapped angler access is also not available at the Project. In addition, paddlers and anglers on the New River need riverside camping areas. The former U.S. Forest Service campground area on Buck Reservoir is a likely site. Other sites should be identified as well.

Studies Not Proposed in the PAD

Because the Byllesby-Buck Project is located in a more remote area of the New River than the Fries Project, knowledge of the New River fauna in the Byllesby-Buck Project area is limited. The New River supports a unique fauna of coolwater fish, invertebrates (including, but not limited to freshwater mussels), and the Eastern Hellbender, and ecologically important aquatic vegetation beds. The lack of broad faunal and aquatic plant surveys with corresponding reference sites outside the area of Project Influence leaves a critical informational need unfilled. Reasonable efficiencies could be achieved by performing these surveys in concert with one another. This information need should be addressed by relicensing studies.

Comments on SD1

General Comments

The New River supports a unique fauna of coolwater fish, invertebrates, the Eastern Hellbender, and ecologically important aquatic vegetation beds. The lack of focus by Appalachian Power on broad faunal and aquatic plant surveys with corresponding reference sites outside the area of Project Influence leaves a critical informational need unfilled. This information need should be considered in the EA.

Specific Comments

Section 3.2.1 Proposed Project Facilities and Operation**:** Lower winter pool elevation could inhibit recreational access during winter months. In addition, lower winter pool elevation could result in bank erosion effects within the Project Area in areas with a limited riparian buffer.

Section 4.1.1 Resources that could be Cumulatively Affected**:** NRC supports VDGIF's recommendation of examining the following list of cumulatively affected resources: (1) Sedimentation impacts to reservoir habitat; (2) Downstream sediment transport due to project operations with multiple ecological and recreational effects; (3) Temperature and other water quality parameters affected by the existence of the Project; and, (4) Riverine habitat and biota altered by the Project reservoirs and in the bypass reaches.

Section 4.2 Resource Issues**:** VDGIF agrees that the preliminary list of resource issues to be addressed in the EA is as complete as possible at this time with the following suggestions for additional considerations under each resource section.

4.2.1 Geologic and Soils Resources: Sedimentation is a significant effect on habitat in the Project that needs assessment. A shoreline erosion assessment needs to include examination of sedimentation sources and habitat impacts, including how the current state of sedimentation contributes to downstream sediment transport and related impacts downstream on riverine biota and recreational and angling use.

4.2.2 Aquatic Resources:
Bullet 1 (Water Quality): Water quality issues need to include a consideration of turbidity effects of project operations on downstream resources as well as examining chlorophyll a levels in the reservoirs and downstream transport.

Bullet 2 (Adequacy of 360-cfs minimum flow): Analysis of the existing 360-cfs minimum flow for aquatic resources needs to include an examination of how power generation flow fluctuations affect aquatic resources in terms of turbidity and flow fluctuation effects on fish and mussel spawning. In addition, this analysis needs to include an examination of flow fluctuation impacts on recreational use.

Bullets 3 and 7 (Minimum flow and Ramping Rates in the Buck Bypass Reach): Due to changes in New River fish populations since 1997, including increased numbers of New River walleye downstream from Buck Dam, analysis needs to include: (1) Examination of stranding issues after bypass reach spill events; (2) Effective utilization of spill gates to limit stranding and create upstream/downstream connectivity in the bypass reach; and, (3) How bypass reach habitat is modified relative to reference conditions, particularly as it relates to the lack of sand, gravel, and cobble substrates important to multiple faunal groups. In addition, this analysis needs to evaluate how spillway gates can be used to create seasonally appropriate flows.

4.2.3 Terrestrial Resources: Analysis of continued project operation and maintenance on riparian and wetland habitat needs to include consideration of emergent and submersed aquatic vegetation beds as well as the importance of these beds to terrestrial and aquatic species.

4.2.4 Threatened and Endangered Species: Both the Candy Darter and the Eastern Hellbender need to be considered in this analysis. The Green Floater mussel is also a species being reviewed for federal listing, so it should be included as well.

Candy Darter
Note our earlier comments on the inadequacy of the information on this species in the PAD. VDGIF will consider requesting PME measures to aid in this species' recovery. Such PME measures are especially appropriate within the New River drainage where the species is endemic, and will also benefit the closely related endemic Kanawha darter.

Eastern Hellbender
Note our earlier comments on the PAD with regard to specifics on this species importance. VDGIF is requesting a multi-taxa biological survey study be performed within the Project Area. This survey effort should include searches for Eastern Hellbender and its habitat due to its federal Species of Concern status and its Tier I a status (Species of Critical Conservation Need) in Virginia's Wildlife Action Plan.

***Section 5.0 Proposed Studies*:**

During the Scoping meeting, VDGIF noted that the Wetland and Riparian Habitat Characterization study is not included in the proposed list of studies in SD1. It needs to be included under the Terrestrial Resources Section of SD1. Our comments relative to this proposed study under the specific PAD comments section of this letter should also be noted here.

Shoreline Stability Assessment: This study lacks a sedimentation assessment aspect. Sedimentation is a significant effect on habitat at the Project that needs assessment. Downstream sediment effects and reservoir rehabilitation needs could potentially be addressed by removal of sediment from the Project Area, but cannot be assessed through a Shoreline Stability Assessment study alone.

Water Quality Study: This study needs a thermal context that considers how the project affects the thermal regime of the New River due to likely project effects on coolwater endemic fish, including the federally endangered Candy Darter. In addition, the study needs to examine turbidity effects of project operations. Finally, it needs to include analysis of chlorophyll a levels in the reservoirs and downstream transport.

Bypass Reach Aquatic Habitat and Flow Assessment and Inflatable Obermeyer Crest Gate Operational Effectiveness Evaluation: These separate studies need to be integrated as much as possible due to the need to include gate operation considerations in bypass reach habitat and flow assessment. Due to changes in New River fish populations since 1997, including increased numbers of New River walleye downstream from Buck Dam, this evaluation needs to examine: (1) Stranding issues after bypass reach spill events, (2) How spill gates can be used to limit stranding and create upstream and downstream connectivity in the bypass reaches; and, (3) How bypass reach habitat is modified relative to reference conditions, particularly as it relates to the lack of sand, gravel, and cobble substrates important to multiple faunal groups. In addition, the study needs to evaluate how spillway gates can be used to create seasonally appropriate flows.

Recreational Needs Assessment A more complete assessment of current use is needed as a foundation for a recreational needs assessment due to changes in use patterns over time associated with changing availability of river access. Analysis of recreational needs should include consideration of most desirable fishing locations, handicapped accessible facilities, and riverside camping opportunities.

NRC supports both of VDGIF's study requests as follows:

<u>Biological and Aquatic Vegetation Surveys within the Project Area</u>

Goals and Objectives:

- **Goal:** Gather current distributional information on multiple fauna and foundational aquatic vegetation beds within the Project Area.
    - **Objective:** Conduct biological surveys of fish, crayfishes, Odonates, freshwater mussels, Eastern hellbender and associated habitat within the Project Area with appropriate reference sites for comparison.
    - **Objective:** Conduct survey of foundational aquatic vegetation beds within the Project Area with appropriate reference sites for comparison.

<u>Comprehensive Sediment Study to Develop a Sediment Management Plan</u>

Goals and Objectives:

- Determine volume of sediment deposited in the impounded reaches to-date.
- Determine average annual rate of deposition in the impounded reaches.
- Determine the projected remaining lifespan of the impoundments at current sedimentation rates.
- Assess the magnitude and spatial extent of the coarse-substrate deficit in the bypass reaches and mainstem channels downstream of the dams and powerhouses relative to the historic rate of transport and sediment-size distribution prior to construction of the dams and the resultant disruption to sediment transport processes.
- Analyze ecological, recreational, and economic impacts resulting from sediment accumulation upstream of the dams and sediment deficit downstream of the dams.
- Evaluate potential sediment-budget impact mitigation opportunities including removal of accumulated sediment in the impounded reaches and augmentation of gravel/coarse sediment downstream of the dams and powerhouses.

In closing, if the decision is made by controlling authorities that the Byllesby-Buck Project will be decommissioned or removed, we respectfully request the opportunity to propose additional studies addressing information needs germane to that decision.

If you have questions regarding our comments and study requests, please contact me at the address and phone number listed below.

Sincerely,

Laura W Walters
New River Conservancy
Claytorlakegirl@gmail.com
540 230-6272

COMMONWEALTH of VIRGINIA

Matthew J. Strickler
Secretary of Natural Resources

Department of Game and Inland Fisheries

Gary F. Martel
Acting Executive Director

May 7, 2019

Secretary Kimberly D. Bose
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Byllesby-Buck Project (P-2514-186) Comments on Pre-Application Document, Scoping Document 1, and Study Requests

Dear Secretary Bose:

We appreciate the opportunity to comment on the Byllesby-Buck Hydroelectric Project (Number 2514-186) Pre-Application Document (PAD), Scoping Document 1 (SD1), and the opportunity to provide Study Requests for this relicensing project. Virginia Department of Game and Inland Fisheries (VDGIF) Aquatic Wildlife Resources staff attended the Scoping Site Visit and the public meeting on April 10, 2019 and the agency meeting on April 11, 2019 in Galax, Virginia, and reviewed the PAD and SD1. We offer the following comments on the PAD and SD1 and then provide Study Requests. We also offer comments on the proposed studies as written in the PAD and summarized in the SD1, including important points about improvements or additions to those proposed studies.

General Comments on PAD

The impounded reaches of the New River encompassed by the Byllesby-Buck Project have displaced habitat important to a variety of aquatic insects (including rare odonates), freshwater mussels, crayfish, Eastern Hellbender, native fishes, and fish spawning areas, including the presumptive native New River walleye. These impoundments block fish migration, disrupting freshwater mussel populations and associated fish host species from dispersing upstream and downstream in the New River. The lack of sand and gravel areas in the bypass reaches, combined with the high levels of sedimentation in the reservoirs, diminish habitat for freshwater mussels and other aquatic life. None of these impacts are discussed in the PAD. Promoting and maintaining appropriate natural spawning and rearing conditions for the New River walleye population is a high priority for VDGIF, but is not adequately addressed in the PAD.

Specific Comments on PAD

1. **Project Area:** The Byllesby-Buck Project boundary displayed in Figure 4.2-1 of the PAD ignores more than a mile long section of the upper area of Buck Reservoir. The entire river reach between Byllesby and Buck Dams is affected by project operations and is used for project operations. Therefore, it should be included in the project boundary. There is a direct nexus between project operations and ecological and recreational effects in this reach of the New River.

2. **Project Influence:** The Byllesby-Buck Project affects a larger area of the New River upstream and downstream from the project area. New River ecological and geologic

processes are influenced by the projects for some distance upstream and downstream from the project area. Examples include: (1). The project reservoirs influence ambient New River water temperature and other water quality parameters, with habitat effects on resident coolwater flora and fauna, including New River endemic fishes; (2) Liberation of reservoir sediment deposits during project operations result in increased turbidity in downstream reaches influenced by project flow, disrupting ecological processes, suspending contaminants like PCB's, and negatively affecting angling and recreational use; (3) New River walleye populations are affected by project placement, with the dams likely inundating historic New River walleye spawning areas; (4) Project dams block New River walleye migration, requiring substantial VDGIF effort and expense to maintain walleye populations upstream and downstream of the Project via hatchery rearing and stocking programs; and, (5) Loss of upstream mussel fauna due to Project dams blocking migration of host fishes.

The magnitude and spatial scale of this Project Influence is not adequately addressed in the PAD. Determining the spatial scale of Project Influence will help determine adequate reference conditions for ecological comparisons during multiple study efforts. Determining the downstream spatial influence will involve consideration of project flow attenuation and downstream turbidity effects of project operations, as well as other downstream water quality and recreational impacts.

3. **Section 4.3.1 Reservoirs:** The description of the project reservoirs lacks recent bathymetric information, including average depth of the reservoirs. The PAD cites surveys done in 1990, but lacks more current information. In the absence of this information, assumptions are made about project sedimentation rates and effects on project operations, raising questions about effects on reservoir biota and recreational use. Direct observation indicates that the reservoirs have been substantially modified by sediment deposition, raising concerns about what rehabilitation is needed to restore aquatic habitat, with resulting floral and faunal improvements and fisheries benefits.

4. **Section 4.4.1 Current Project Operations:** Ramping rate operations for the Buck Dam bypass reach are described on page 4-21 but no estimates of resulting downstream flows are included in the description of spillway gate opening sizes.

5. **Section 4.4.2 Proposed Operations:** A brief evaluation of lower normal pool operations in winter months (December through March) is discussed in this section, but no consideration is given to potential effects during that period. Lower winter pool elevation could inhibit recreational access during winter months. In addition, lower winter pool elevation could result in bank erosion effects within the Project Area in areas with a limited riparian buffer.

6. **Section 5.3 Water Resources:** PAD section 5.3.2 titled "Flows" does not provide enough information to characterize the range of flows typical for the Project Area, which inhibits analysis of needed bypass reach flows. More information should be provided over a longer period of record than 30 years, providing likely dry, wet, and average year conditions that should be replicated in bypass reach flow management.

7. **Section 5.4.6 Freshwater Mussels**
   Section 5.4.6.1 Mussel Surveys from 2002 to 2017

This PAD review of recent mussel surveys in the New River failed to include the following: (1) VDGIF and Appalachian Power Company Claytor Lake drawdown assessments starting in 2006, and subsequent mussel salvages during alternating year Claytor Lake drawdowns, that included collection of Eastern Elliptio (*Elliptio complanata*); and, (2) A 2017 mussel relocation conducted by Environmental Solutions & Innovations, Inc. at the I-81 bridge downstream from Claytor Dam, where upwards of 8 species were collected, including the state threatened Pistolgrip (*Tritogonia verrucosa*) and where Eastern Elliptio was documented in the mainstem river for the first time. In addition, an assessment of this area by Stantec in 2017 turned up 1 state threatened Green Floater (*Lasmigona subviridis*).

8. **Section 5.4.8**

5.4.8.1 Fish and Aquatic Resources:
Entrainment: There is no mention of potential entrainment of larval mussels in this PAD review. In the report titled " Impingement Mortality and Entrainment Characterization Report Chesterfield Power Station June 2005-May 2006": by EA Engineering, Science, and Technology, Inc., bivalve young were entrained annually at 363.8 x 10^6 and were the largest number of invertebrates noted. Some information on and potential for bivalve entrainment should be included in the PAD.

5.4.8.2 Bypass Reach Habitat and Flows: The description of existing environmental and resource impacts on the bypass reach does not discuss what flows are provided by spillway gate openings at Buck Dam, nor is there any discussion of the need for minimum flow to the bypass reach, particularly a concern below Buck Dam. The bypass reaches are primarily bedrock, lacking sand, gravel, and cobbles essential for supporting local fauna. This PAD section does not discuss bypass reach habitat adequately to provide a context for understanding flow needs in these channels.

9. **Section 5.6 Wetlands, Riparian, and Littoral Habitat:** While this section describes the extent of the wetlands habitat in the reservoirs, it lacks specifics on littoral habitat, including documentation of emergent and submersed aquatic vegetation. Adjacent New River reaches are known to be inhabited by foundational native aquatic vegetation species such as *Podostemum ceratophyllum* (hornleaf riverweed) *Justicia americana* (water willow), *Elodea canadensis* (common elodea), and *Vallisneria americana* (eelgrass or water celery), creating aquatic habitat and food web benefits for riverine fauna, but this PAD section does not describe the existence or lack of these aquatic vegetation species in the reservoirs or river reaches in the Project Area. The wetlands information in the PAD is also inadequate in describing how these areas are used recreationally, including for wildlife viewing and waterfowl hunting.

10. **Section 5.7 Rare, Threatened, and Endangered Species:**

5.7.1.1 Candy Darter
As noted in the PAD, the Candy Darter (*Etheostoma osburni*) was listed as endangered under the federal Endangered Species Act on November 21, 2018. Since the PAD lacks sufficient detail on this species, we provide additional information below.

Candy Darter occurs only in the Upper Kanawha River Basin, including the Gauley, Greenbrier and New River watersheds. In the Virginia portion of the New River, it is only known from the Ridge and Valley Province. Cripple Creek, downstream from the

Buck Development, is proposed to be listed as federally designated "critical habitat." Current Virginia Tech research by Katie McBaine, under the direction of Dr. Paul Angermeier at Virginia Tech, demonstrates that the Cripple Creek Candy Darter population inhabits the lowest reaches of the creek near its confluence with the New River. According to Jenkins and Burkhead's species account in Freshwater Fishes of Virginia, Candy Darter habitat use "extends into the large New River" where it occupies runs, riffles, and swift pockets (Jenkins and Burkhead 1993). Suitable Candy Darter habitat is available downstream from Cripple Creek in the Ridge and Valley Province. The Upper New River drainage may be the only drainage within the Candy Darter's current range where the Variegate Darter (*Etheostoma variatum*) does not occur. Significant threats to the candy darter include hybridization with the Variegate Darter, as well as ongoing contributing threats of excessive sedimentation, warming water temperatures, habitat fragmentation, changes in water quality and flow, catastrophic events, and competition or predation associated with other introduced species. (USFWS Candy Darter Recovery Outline, October 1, 2018).

VDGIF will consider requesting protection, mitigation, and enhancement (PME) measures to aid in this species' recovery. Such PME measures are especially appropriate within the New River drainage where the species is endemic, and will also benefit the closely related endemic Kanawha darter.

5.7.2.2 Mussels

This section of the PAD fails to mention the Green Floater in its references to species with state legal status as a state threatened species which is known from the project vicinity. This species is also being reviewed for federal listing, which should also be discussed in the PAD.

5.7.2.3 Herpetofauna

The U.S. Fish and Wildlife Service determined on April 4, 2019 that the Eastern Hellbender (*Cryptobranchus allieganiensis allieganiensis*) is not warranted to be listed as an endangered species across its range, but remains a federal Species of Concern. The text section in the PAD relative to Eastern Hellbender lists this species as a Tier II species in Virginia's Wildlife Action Plan, which is erroneous. Eastern Hellbender is actually a Tier I a species (Species of Critical Conservation Need). The correct information on this species is found in Table 5.7-2, which should also be reflected in this text section of the PAD. VDGIF is requesting a multi-taxa biological survey study be performed within the Project Area. This survey effort should include searches for Eastern Hellbender and its habitat due to its status federally and Tier I a status in Virginia's Wildlife Action Plan.

11. Section 5.8 Recreation and Land Use

5.8.1.1 Byllesby Development

- *Byllesby VDCR Boat Launch*: This launch site on the Byllesby pool is incorrectly identified as a VDCR Boat Launch site. The site is maintained by VDGIF. It has a number of inadequacies that create maintenance problems, including the gravel surface, which requires extensive replacement after flooding events. A hard surface parking lot would require much less improvement work after flooding events. According to VDGIF personnel familiar with use patterns, the parking area is undersized for the use it receives.

- *Byllesby Canoe Portage*: The canoe portage parking lot at the Byllesby pool is displaced from the current portage take-out, with a parking location at the site of the former portage take-out. This displacement of parking facilities requires extra carry by users of the portage, and is not addressed in the PAD description. In addition, re-entry below the Byllesby bypass reach is not adequately documented with photographs or a description of the put-in facilities below the bypass.

5.8.1.2 Buck Development

- *Buck Dam Canoe Portage*: The portage take-out at Buck Dam and return location in the Buck tailrace are not adequately documented in the PAD, with a lack of pictures accompanying the description. The return location involves an undeveloped vertical drop of about 3 feet into flowing water, making it difficult to use, but no pictures accompany this section to allow adequate evaluation of this condition.

5.8.2 Current Project Recreation Use Levels and Restrictions

- In a 2015 Recreation Report filed in March 2015 (mentioned on page 5-84 of the PAD), fishing is cited as the most popular activity at the recreation sites on the Byllesby development. However, the PAD does not adequately discuss how fishing access is provided at project locations, nor does it address other locations where fishing access could be provided at the project. For example, popular locations include tailrace areas where fish activity is enhanced by flow and aeration. Creating and maintaining angler access areas where fish activity is enhanced are high priorities for VDGIF. The PAD does not adequately address access issues related to the tailrace areas of either project dam.

Studies Proposed in the PAD

1. *Shoreline Stability Assessment*: This study lacks a sedimentation assessment aspect. Sedimentation is a significant effect on habitat at the Project that needs assessment. Relying on results from the upstream Fries project, a smaller project, is not adequate. Watershed sedimentation modeling from the Claytor Project is mentioned but not adequately explained to provide context for the conclusions drawn. Downstream sediment effects and reservoir rehabilitation needs could potentially be addressed by removal of sediment from the Project Area, but cannot be assessed through a Shoreline Stability Assessment study alone. A significant outcome from a comprehensive shoreline stability and sediment study could be development of a sediment management plan.

2. *Water Quality*: This study needs a thermal context that considers how the project affects the thermal regime of the New River due to likely project effects on coolwater endemic fish, including the federally endangered Candy Darter. In addition, the study needs to examine turbidity effects of project operations. Finally, it needs to include analysis of chlorophyll a levels in the reservoirs and downstream transport.

3. *Bypass Reach Aquatic Habitat and Flow Assessment*: Due to changes in New River fish populations since 1997, including increased numbers of New River walleye downstream from Buck Dam, this evaluation needs to look at stranding issues after bypass reach spill events, with field data collection. It should also evaluate how spill gates can be used to limit stranding and create upstream and downstream connectivity in the bypass reaches and how bypass reach habitat is modified relative to reference conditions, particularly as

it relates to the lack of sand, gravel, and cobble substrates important to multiple faunal groups. In addition, the study needs a flow modeling component to evaluate how spillway gates can be used to create seasonally appropriate flows.

4. *Inflatable Obermeyer Crest Gate Operational Effectiveness Evaluation*: This study should be integrated with the Bypass Reach Aquatic Habitat and Flow Assessment study to determine how the crest gates can be used to provide improved bypass reach flows.

5. *Wetland and Riparian Habitat Characterization*: This study needs to include documentation of emergent and submersed aquatic vegetation beds in the Project Area. In addition, it should evaluate ways to enhance these areas for wildlife and recreational use, particularly with regard to wildlife viewing and waterfowl hunting opportunities.

6. *Recreational Needs Assessment*: VDGIF is not convinced that currently available recreational use information is adequate to assess existing recreational opportunities and potential improvements to facilities. During the current license term, closure of the U.S. Forest Service campground area on Buck Reservoir and the development of an improved Byllesby Pool Boat Launch alone have likely shifted use. VDGIF is not aware of any recent evaluation of canoe portage use, particularly as a result of the take-out location adjustment at Byllesby Dam. A more complete assessment of current use is needed as a foundation for a recreational needs assessment.

   We state elsewhere in our comments the need for angling access in desirable fishing locations, including the tailrace areas of both dams. These areas, including the Buck Dam tailrace, need to be examined as potential fishing access areas. VDGIF currently manages the Loafer's Rest Access area downstream from the Buck Dam tailrace, but this access site is not reasonably close to the tailrace, nor is the parking area located close enough to the New River to be useful to most anglers. Handicapped angler access is also not available at the Project. In addition, paddlers and anglers on the New River need riverside camping areas. The former U.S. Forest Service campground area on Buck Reservoir is a likely site. Other sites should be identified as well.

Studies Not Proposed in the PAD

In section 6.2.3.2 of the PAD, no broad aquatic surveys are proposed for this relicensing because the applicant believes such surveys are not necessary for the evaluation of Project effects or potential PM&E measures. Reasoning in this section relies on a combination of distribution results from Fries Project surveys and the lack of proposed operational changes. However, this reasoning ignores the lack of needed faunal and aquatic vegetation information in the Project Area. Because the Byllesby-Buck Project is located in a more remote area of the New River than the Fries Project, knowledge of the New River fauna in the Byllesby-Buck Project area is limited. The New River supports a unique fauna of coolwater fish, invertebrates (including, but not limited to freshwater mussels), and the Eastern Hellbender, and ecologically important aquatic vegetation beds. The lack of broad faunal and aquatic plant surveys with corresponding reference sites outside the area of Project Influence leaves a critical informational need unfilled. Reasonable efficiencies could be achieved by performing these surveys in concert with one another. VDGIF believes this information need should be addressed by relicensing studies.

Comments on SD1

General Comments

The New River supports a unique fauna of coolwater fish, invertebrates, and the Eastern Hellbender, and ecologically important aquatic vegetation beds. The lack of focus by Appalachian Power on broad faunal and aquatic plant surveys with corresponding reference sites outside the area of Project Influence leaves a critical informational need unfilled. VDGIF believes this information need should be considered in the EA.

Specific Comments

***Section 3.2.1 Proposed Project Facilities and Operation*:** Lower winter pool elevation could inhibit recreational access during winter months. In addition, lower winter pool elevation could result in bank erosion effects within the Project Area in areas with a limited riparian buffer.

***Section 4.1.1 Resources that could be Cumulatively Affected*:** VDGIF recommends examining the following list of cumulatively affected resources: (1) Sedimentation impacts to reservoir habitat; (2) Downstream sediment transport due to project operations with multiple ecological and recreational effects; (3) Temperature and other water quality parameters affected by the existence of the Project; and, (4) Riverine habitat and biota altered by the Project reservoirs and in the bypass reaches.

***Section 4.2 Resource Issues*:** VDGIF agrees that the preliminary list of resource issues to be addressed in the EA is as complete as possible at this time with the following suggestions for additional considerations under each resource section.

4.2.1 Geologic and Soils Resources: Sedimentation is a significant effect on habitat at the Project that needs assessment. A shoreline erosion assessment needs to include an examination of sedimentation sources and habitat impacts, including how the current state of sedimentation contributes to downstream sediment transport and related impacts downstream on riverine biota and recreational and angling use.

4.2.2 Aquatic Resources:

Bullet 1 (Water Quality): Water quality issues need to include a consideration of turbidity effects of project operations on downstream resources as well as examining chlorophyll a levels in the reservoirs and downstream transport.

Bullet 2 (Adequacy of 360-cfs minimum flow): Analysis of the existing 360-cfs minimum flow for aquatic resources needs to include an examination of how power generation flow fluctuations affect aquatic resources in terms of turbidity and flow fluctuation effects on fish and mussel spawning. In addition, this analysis needs to include an examination of flow fluctuation impacts on recreational use.

Bullets 3 and 7 (Minimum flow and Ramping Rates in the Buck Bypass Reach): Due to changes in New River fish populations since 1997, including increased numbers of New River walleye downstream from Buck Dam, this analysis needs to include: (1) An examination of stranding issues after bypass reach spill events; (2) How spill gates can be used to limit stranding and create upstream and downstream connectivity in the bypass reach; and, (3) How bypass reach habitat is modified relative to reference conditions, particularly as it relates to the lack of sand, gravel, and cobble substrates important to multiple faunal groups. In addition, this analysis needs to evaluate how spillway gates can be used to create seasonally appropriate flows.

4.2.3 Terrestrial Resources: Analysis of continued project operation and maintenance on riparian and wetland habitat needs to include consideration of emergent and submersed aquatic vegetation beds as well as the importance of these beds to terrestrial and aquatic species.

4.2.4 Threatened and Endangered Species: Both the Candy Darter and the Eastern Hellbender need to be considered in this analysis. The Green Floater mussel is also a species being reviewed for federal listing, so it should be included as well.

Candy Darter

Note our earlier comments on the inadequacy of the information on this species in the PAD. VDGIF will consider requesting PME measures to aid in this species' recovery. Such PME measures are especially appropriate within the New River drainage where the species is endemic, and will also benefit the closely related endemic Kanawha darter.

Eastern Hellbender

Note our earlier comments on the PAD with regard to specifics on this species importance. VDGIF is requesting a multi-taxa biological survey study be performed within the Project Area. This survey effort should include searches for Eastern Hellbender and its habitat due to its federal Species of Concern status and its Tier I a status (Species of Critical Conservation Need) in Virginia's Wildlife Action Plan.

***Section 5.0 Proposed Studies*:**

During the Scoping meeting, VDGIF noted that the Wetland and Riparian Habitat Characterization study is not included in the proposed list of studies in SD1. It needs to be included under the Terrestrial Resources Section of SD1. Our comments relative to this proposed study under the specific PAD comments section of this letter should also be noted here.

Shoreline Stability Assessment: This study lacks a sedimentation assessment aspect. Sedimentation is a significant effect on habitat at the Project that needs assessment. Downstream sediment effects and reservoir rehabilitation needs could potentially be addressed by removal of sediment from the Project Area, but cannot be assessed through a Shoreline Stability Assessment study alone.

Water Quality Study: This study needs a thermal context that considers how the project affects the thermal regime of the New River due to likely project effects on coolwater endemic fish, including the federally endangered Candy Darter. In addition, the study needs to examine turbidity effects of project operations. Finally, it needs to include analysis of chlorophyll a levels in the reservoirs and downstream transport.

Bypass Reach Aquatic Habitat and Flow Assessment and Inflatable Obermeyer Crest Gate Operational Effectiveness Evaluation: These separate studies need to be integrated as much as possible due to the need to include gate operation considerations in bypass reach habitat and flow assessment. Due to changes in New River fish populations since 1997, including increased numbers of New River walleye downstream from Buck Dam, this evaluation needs to examine: (1) Stranding issues after bypass reach spill events, (2) How spill gates can be used to limit stranding and create upstream and downstream connectivity in the bypass reaches; and, (3) How bypass reach habitat is modified relative to reference conditions, particularly as it relates to the lack of sand, gravel, and cobble substrates important to multiple faunal groups. In addition, the study needs to evaluate how spillway gates can be used to create seasonally appropriate flows.

Recreational Needs Assessment: VDGIF is not convinced that currently available recreational use information is adequate to assess existing recreational opportunities and potential improvements to facilities. A more complete assessment of current use is needed as a foundation for a recreational needs assessment due to changes in use patterns over time associated with changing availability of river access. Analysis of recreational needs should include consideration of most desirable fishing locations, handicapped accessible facilities, and riverside camping opportunities.

Study Requests

Biological and Aquatic Vegetation Surveys within the Project Area

Goals and Objectives:

- **Goal:** Gather current distributional information on multiple fauna and foundational aquatic vegetation beds within the Project Area.
  - **Objective:** Conduct biological surveys of fish, crayfishes, Odonates, freshwater mussels, Eastern hellbender and associated habitat within the Project Area with appropriate reference sites for comparison.
  - **Objective:** Conduct survey of foundational aquatic vegetation beds within the Project Area with appropriate reference sites for comparison.

Relevant Resource Management Goals:
The mission of the Virginia Department of Game and Inland Fisheries includes the conservation of wildlife resources and their habitats for the benefit of present and future generations.

Background and Existing Information:
The New River supports a unique fauna of coolwater fish (including the native New River walleye), multiple invertebrates (including 4 species of rare Odonates listed in Virginia's Wildlife Action Plan), crayfishes, freshwater mussels, the Eastern hellbender, and ecologically important aquatic vegetation beds that link invertebrate production with higher trophic levels, including important game fishes. In spite of increased scientific information about these organisms and habitats relative to the previous Project relicensing, a knowledge gap remains regarding these organisms and habitats within the Project Area. Because the Byllesby-Buck Project is located in a remote area of the New River, knowledge of the New River in the Byllesby-Buck Project area is limited. The lack of broad faunal and aquatic plant surveys with corresponding reference sites outside the area of Project Influence leaves a critical informational need unfilled. Reasonable efficiencies could be achieved by performing these surveys in concert with one another.

Project Nexus:
The nexus between Project operations and effects on Project Area fauna and foundational aquatic plants result from Project flows, turbidity, sedimentation and maintenance dredging operations, as well as temperature and other water quality effects from the Project. Study results would inform PM&E measures to benefit aquatic resources within the Project Area.

Proposed Methodology:
Acceptable study methodology for the biological survey component was employed in the Biological Survey Report for the Fries Project, published in the Fries Project (Number 2883-Final License Application. Acceptable study methodology for the aquatic vegetation survey component is available from multiple publications, including a recent survey by Weberg et. al. 2015, referenced below.

Matthew A. Weberg, Brian R. Murphy, Andrew L. Rypel and John R. Copeland. 2015. A Survey of the New River Aquatic Plant Community in Response to Recent Triploid Grass Carp Introductions into Claytor Lake, Virginia. Southeastern Naturalist, 14(2):308-318.

Level of Effort and Cost:
The level of effort and cost associated with this proposed survey are not cost prohibitive. Reasonable efficiencies could be achieved by performing these surveys in concert with one another as much as possible, given the target species. No alternative studies have been proposed to meet the stated information needs presented by this study request. In fact, the study proposed was determined to be unnecessary by the applicant. VDGIF contends that this need for this study is critical due to the lack of current information on organisms and habitat in the Project Area.

Comprehensive Sediment Study to Develop a Sediment Management Plan

Goals and Objectives:
- Determine volume of sediment deposited in the impounded reaches to-date.
- Determine average annual rate of deposition in the impounded reaches.
- Determine the projected remaining lifespan of the impoundments at current sedimentation rates.
- Assess the magnitude and spatial extent of the coarse-substrate deficit in the bypass reaches and mainstem channels downstream of the dams and powerhouses relative to the historic rate of transport and sediment-size distribution prior to construction of the dams and the resultant disruption to sediment transport processes.
- Analyze ecological, recreational, and economic impacts resulting from sediment accumulation upstream of the dams and sediment deficit downstream of the dams.
- Evaluate potential sediment-budget impact mitigation opportunities including removal of accumulated sediment in the impounded reaches and augmentation of gravel/coarse sediment downstream of the dams and powerhouses.

Relevant Resource Management Goals:
VDGIF is tasked with managing Virginia's aquatic populations and promoting their long-term vitality. Sediment supply, whether excess fine sediment or deficit of coarse sediment, in aquatic systems is a critical factor in the health of all macroinvertebrate, mussel, and fish populations (Merz and Chan, 2005; McManamay et al., 2010).

The impoundment of the New River by Byllesby and Buck Dams in 1912 disrupted the natural sediment transport mechanisms of the river, trapping almost all coarse sediment (often defined as greater than 8 mm in diameter) supplied by the upstream watershed, resulting in aggradation of the bed along the impounded reaches and imposing a coarse-sediment deficit in the river channel downstream of the dams and powerhouses in the bypass reaches and mainstem river. The Pre-Application Document (PAD) contains very little analytical information on sedimentation in these reservoirs in spite of the fact that dredging operations have occurred twice in the past 30 years. In addition, the applicant proposes a Shoreline Stability Assessment in the PAD, but fails to include any assessment of sedimentation impacts, requiring a study request for addressing our agency concerns about the need for a sediment management plan for the Project.

As with most dammed river reaches, extensive geomorphic and ecologic impacts occur upstream and downstream of the dams (Bunte, 2004; Kondolf, 1997; Merz and Chan, 2005; McManamay et al., 2010). A comprehensive sediment study of the impacted reaches would 1) determine the extent of aggradation/sedimentation of the upstream channel and the extent of downstream bed-material deficit, and 2) provide an estimate of volume and size distribution of material that would be needed to removed from or augmented to the channel to mitigate for these impacts. Such mitigation efforts would benefit many of the aquatic populations that VDGIF is charged with managing, which in turn would drive increased recreational fishing opportunities and resultant economic benefits to the community.

Background and Existing Information:
The PAD provides no data on the sedimentation of the impounded reaches other than reviewing recent dredging operations and discussing Claytor Lake as the likely long-term sediment storage location for the Upper New River. However, due to years of siltation, substrates, particularly in the Byllesby impoundment, are dominated by silt, sand and other fine sediments, and several islands have been created from this accumulated sediment. The PAD contains no mention of a sediment management plan or any information on the magnitude and extent of coarse-sediment deficit downstream of the dams.

Existing information that could aid in characterizing these conditions includes topographic maps, geologic maps, and aerial photographs, but additional data need to be collected to assess the full impacts to sediment transport in the river due to the impoundments. There are numerous, peer-reviewed, commonly used methods for sediment yield analysis which have been used for similar studies including other FERC-relicensing projects (McBain and Trush, 2002; Snyder et al., 2004; McPherson and Harmon, 2000). Extensive data exists in the literature that can be used as a guide to developing a protocol to assess the current sediment-transport condition and for formulating a mitigation plan that could include upstream dredging and downstream coarse material augmentation (Bunte, 2004; Merz and Chan, 2005; McManamay et al., 2010; Kondolf, 1997).

Project Nexus:
The construction of Byllesby and Buck Dams and the lack of a sediment management plan for over 100 years has had obvious impacts on the sediment regime of the New River, with channel aggradation upstream and channel degradation downstream, resulting in impacts on fisheries and other aquatic life. Mitigating the ecological and geomorphic impacts of this impact requires gathering sediment data upstream and downstream of the dams to develop a sediment management plan incorporating both upstream and downstream components.

Proposed Methodology:

- Estimating sediment volume accumulated in impounded reaches upstream from Byllesby and Buck Dams:
    - Sediment deposition could be estimated using topographic differencing techniques comparing pre-dam topography (estimated based on channel geomorphology outside of the impacted reach) to contemporary bathymetry (Snyder et al., 2004; McPherson and Harmon, 2000) of the Project Area.

Mapping will be performed by boat-based bathymetry (e.g., Real Time Kinematic GPS). Sediment coring in the depositional material could be conducted to confirm estimates of historic bed elevations.

- Topographic differencing could be analyzed using either GIS or cross-section overlays, depending on the type and format of the data. A representative mass conversion could be applied once the volumetric difference has been estimated.
- From these data, total sediment yield to the impounded reaches to-date could be estimated, as well as a projection of the predicted lifespan of the impoundments at current sedimentation rates. Based on these calculations, a sediment-management plan could be developed that incorporates a cost-benefit analysis for 1) scheduled, significant dredging and 2) coarse sediment augmentation.

- Estimating extent and magnitude of coarse-sediment deficit below Byllesby and Buck Dams:
  - Sediment size distribution could be estimated by collecting pebble count data in a reference reach of New River located more than 1.5 miles upstream so as to be outside of the impact area of the dam.
  - Similar data could be collected within the area immediately downstream of the dams and powerhouses and continuing downstream to a point at which the bedload has adjusted to the reference condition by the tributary and bank erosion contributions of sediment in the intervening river reaches.
  - These sediment size distribution data could be compared to determine the magnitude and downstream extent of the sediment deficit downstream of the dams and be used to guide a cost-benefit analysis and proposal for coarse-substrate augmentation quantities and size distribution in order to mitigate for downstream ecological impacts to the sediment regime from the impoundments. One approach to accomplishing this would be periodic (e.g., semi-annually) augmentation of the channel below the dams with the average bed material (appropriate sediment-size distribution and volume) trapped by the impoundment in that given period of time. This augmentation could be done within the bypass reaches as well as the mainstem reaches to restore appropriate habitat conditions.

Level of Effort and Cost (estimate dependent on methods and models):

Office-based and field-based data collection	$100,000
Analysis of Data	$50,000
Development of sediment management/gravel augmentation plan	$25,000
Total	$175,000

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Thank you for the opportunity to provide comments on the PAD and SD1 and to submit requests for studies for the Byllesby-Buck Hydroelectric Project.

In closing, if the decision is made by controlling authorities that the Byllesby-Buck Project will be decommissioned or removed, we respectfully request the opportunity to propose additional studies addressing information needs germane to that decision.

If you have questions regarding our comments and study requests, please contact me at the address and phone number listed below.

Sincerely,

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Dynamics of Lotic Ecosystems

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13. AQUATIC MACROPHYTE CONTRIBUTION TO THE NEW RIVER ORGANIC MATTER BUDGET

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ABSTRACT

The contribution of aquatic macrophytes to the energy budget of a 135-km reach of the New River was estimated. Production rates were measured by the harvest method and extrapolated to the entire reach on the basis of measurements of cover made by aerial photography. The estimated macrophyte contribution was compared with measurements of periphyton production and model estimated allochthonous inputs. Macrophytes contributed 13.1% of the total input and 28% of the input generated within the reach. Macrophyte input to the New River trophic dynamics occurs as an autumnal pulse of rapidly decomposed detritus. This pulse forms an important link between spring–summer periphyton production and fall–winter allochthonous-based production.

INTRODUCTION

Recent studies of energy flow in lotic ecosystems indicate that streams are strongly dependent on watershed-derived organic matter (Cummins, 1974; Hynes, 1975; Vannote et al., 1980). However, appreciable in situ production of organic matter can occur under favorable conditions of insolation and nutrient availability (Minshall, 1978). Such conditions are

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likely to be met in higher order streams where shading by riparian vegetation is minimal and nutrient levels are generally high (Vannote et al., 1980). In such streams the ratio of photosynthesis to respiration may be greater than one (Minshall, 1978).

Generally the first producers to appear along the length of a stream system are attached periphyton. As stream size increases, autotrophic production by attached benthic algae often decreases in proportion to contributions by other primary producers. Assuming that planktonic forms are rare in swift-flowing, medium-sized rivers (Hynes, 1970; Wetzel, 1975a), the other important primary producers are aquatic macrophytes. Hynes and Wetzel stated that macrophytes (which include bryophytes, macroalgae, and angiosperms) are, as a whole, poorly adapted to lotic conditions. In spite of this, macrophytes can contribute significantly to energy budgets of some streams. Previous studies have shown that aquatic macrophytes contribute between 1.2 and 30% of stream primary production (Odum, 1957; King and Ball, 1967; Mann et al., 1972; Westlake et al., 1972; Fisher and Carpenter, 1976).

Since aquatic macrophytes are not extensively grazed in most aquatic systems (Westlake, 1965; Fisher and Carpenter, 1976), the only avenues for macrophyte input into stream trophic dynamics are excretion of dissolved organic matter (DOM) by living macrophytes and decay of senescent macrophyte tissue. The excretion of DOM by aquatic macrophytes has been extensively studied in lake ecosystems (e.g., Wetzel, 1975b), but little is known of this phenomenon in lotic ecosysems. Apparently, the major contribution by aquatic macrophytes to stream ecosystems comes via death and decay. Aquatic vegetation has been found to decay considerably faster than terrestrial vegetation (Fisher and Carpenter, 1976; Godshalk and Wetzel, 1978; Hill, 1979). Thus, although autumn-shed tree leaves may be an organic energy supply for many months (e.g., Petersen and Cummins, 1974), macrophytic detritus occurs as an autumn pulse in the energy budget.

The purpose of this study was to estimate the relative contribution of aquatic macrophytes to the organic matter budget of the New River. We hypothesized that aquatic macrophytes, although perhaps only secondary as an annual energy source to streams, may contribute a significant organic matter pulse in late summer and autumn and can provide a readily usable carbon source between high summer production by periphyton and the breakdown of autumn-shed allochthonous litter.

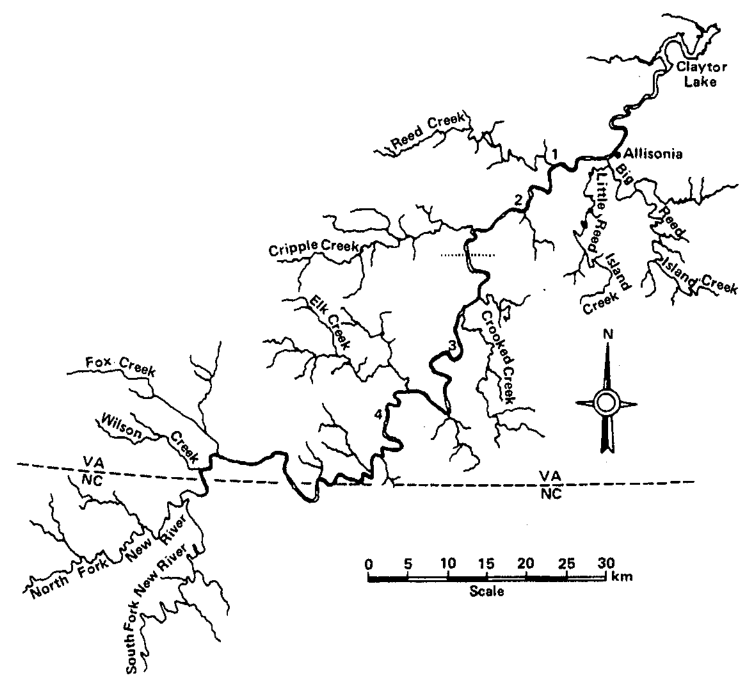

Figure 1. Map of the New River study area. Numbers refer to the sampling locations. The dotted line at the center of the figure separates hardwater (downstream) and softwater (upstream) sections of the river.

METHODS

Site Description

The New River originates in the Appalachian highlands of North Carolina and flows north through Virginia and West Virginia to the Ohio River. It is characterized by a narrow floodplain, steep gradient (2.33 m/km), average), and high velocity (Kanawha River Basin Coordinating Committee, 1971). The river passes through two distinct geologic formations, gneiss and limestone/dolomite, which divide it into soft and hardwater regions. The section of the New River considered in this study extends from the confluence of the North and South Forks of the New River (forming a sixth-order stream) downstream 135 km to Allisonia, VA, at the upper end of Claytor Lake (Figure 1). Average river width in this reach is 167 m, and depths are often less than 1 m. Riparian vegetation covers about 47% of the river bank.

Distribution and Production of Aquatic Macrophytes

The distribution and extent of aquatic macrophyte cover in the study area was determined by aerial photography. The Montana method of 35-mm aerial photography (Meyer and Grumstrup, 1978) was used with Ektachrome daylight color transparency film. The film was exposed on October 16, 1979, at an altitude of 305 m above the river surface. After processing, the slides were projected onto a gridded screen for estimation of percent cover by presence or absence of aquatic macrophytes within the squares of the grid. Total area of macrophyte beds and total river area were determined by measuring these areas on the slides with calibration from U. S. Geological Survey 7.5-minute topographic maps.

Production of *Podostemum ceratophyllum* L., *Justicia americana* (L.) Vahl, and *Potamogeton crispus* L. was determined by harvesting aboveground and belowground biomass at monthly intervals throughout the 1979 growing season. Biomass in 0.25 m^2 plots (0.10 m^2 for *P. ceratophyllum*) was collected (three to five replicates) from four sites (Figure 1), washed, air-dried, weighed, ashed (525° C for 30 min), and reweighed to determine ash-free dry weight (AFDW). Production rates at these sites were determined by differences in biomass on subsequent sampling dates. Losses of biomass caused by physical and biological processes were assumed to be negligible. Data from all four sites were combined to give a single production value for each species to facilitate extrapolation to the whole river.

Periphyton Contributions

Estimates of New River periphyton production were obtained by extrapolating in-stream measurements of ^{14}C uptake by periphyton in the New River at Glen Lyn, VA, 128 km downstream from Allisonia (Figure 1) (Rodgers, 1977). In estimating production from this source, we assumed that periphyton cover was 100% in all areas where aquatic macrophytes were absent and that there were no site differences in periphyton production between Glen Lyn and our study reach. Because of the assumption of 100% coverage, our estimate of the periphyton contribution is undoubtably an overestimate.

Allochthonous Input

Allochthonous particulate organic matter (POM) input as litter fall was estimated by using the New River model developed by Webster et al. (1979). Litter fall was 201.8 g m^{-2} $year^{-1}$ on the stream bank (Hill, 1981), and it decreased linearly to zero at 10 m from the stream bank (Gasith and Hasler, 1976). By solving numerically a partial differential equation relating litter fall to river distance and time, we estimated the upstream and tributary inputs to the study reach and the allochthonous input along the study reach. This estimate of upstream inputs ignores upstream macrophyte and periphyton production. From our observation, ignorance of upstream macrophyte production is probably justified; we have observed few macrophytes in the river upstream from our study reach. We have no information to help us with upstream periphyton production. The model estimate also assumes that allochthonous leaf material is not processed upstream and is, therefore, an overestimate of upstream input. Newbern et al. (1981) estimated that total organic matter transport at a point about halfway through our study reach was 67,400 T/year, of which 24,322 T/year was particulate. This latter value is more than twice the model estimate, 10,962 T/year (see Table 3), which we are using.

Table 1. Mean Monthly Aquatic Macrophyte Biomass in the New River*

Species	June	July	August
Justicia americana			
Aboveground	255.5 ± 111.9	341.5 ± 78.5	447.8 ± 123.4
Belowground	886.9 ± 398.8	1568.6 ± 550.1	2076.7 ± 460.0
Combined	1313.8 ± 328.7	1910.1 ± 615.5	2524.5 ± 515.0
Podostemum ceratophyllum	157.0 ± 50.4	251.8 ± 58.4	318.6 ± 156.5
Potamogeton crispus	350.3 ± 87.9	300.3 ± 94.1	269.2 ± 38.0

*Biomass given in g AFDW/m^2 ± SE.

Table 2. Aquatic Macrophyte Contribution to the New River Study Area

Species	Input, T/AFDW/yr
Podostemum ceratophyllum	1154
Justicia americana	179
Typha latifolia	97
Potamogeton crispus	3
Elodea canadensis	2
Total macrophyte contribution	1435

Table 3. Particulate Organic Matter Inputs to a 135 km Reach of the New River

Source	Input, (T AFDW/yr)	Percent of total input
Allochthonous		
Upstream and tributary	5,893	53.8
Within study area	64	0.5
Autochthonous		
Periphyton	3,570	32.6
Aquatic macrophytes	1,435	13.1
Total POM input	10,962	

Table 4. Breakdown Rates, Sample Size (n), and Coefficient of Determination (r^2) for Five Species of Aquatic Macrophytes in the New River

Species	n	Breakdown rate*	r^2
Podostemum ceratophyllum	26	0.037 ± 0.009	0.74
Elodea canadensis	28	0.026 ± 0.004	0.84
Potamogeton crispus	28	0.021 ± 0.007	0.59
Justicia americana	28	0.016 ± 0.003	0.79
Typha latifolia	28	0.007 ± 0.002	0.64

*Values are rate/d ± SE.

Breakdown of Aquatic Macrophytes

The rate at which aquatic macrophyte organic matter was broken down was measured by the loss of weight from litter bags. Two to five g (air-dried weight) of five species of aquatic macrophytes (*P. ceratophyllum, J. americana, Typha latifolia* L., *P. crispus,* and *Elodea canadensis* Michx.) were placed in nylon mesh bags (15 by 15 cm, with 3-mm octagonal openings). Five bags of each species were placed between two layers of wire mesh to hold the samples to the river bed. Six sets of samples were anchored at each of four sites, and one set was returned immediately to the laboratory to determine handling loss. The others were removed after 2 days and 1, 2, 4, 6, and 8 weeks. Retrieved samples were air-dried, weighed, ashed, and reweighed to determine loss of AFDW. Breakdown rate coefficients were calculated by using linear regression of log-transformed data (Jenny et al., 1949; Olson, 1963). Analysis of covariance (Sokal and Rohlf, 1969) was used to compare breakdown rates.

RESULTS

Aerial photography indicated that aquatic macrophytes covered about 27% (590 ha) of the New River study area. *Podostemum ceratophyllum*, the dominant aquatic macrophyte in the New River, accounted for 25% of the macrophyte cover. Other species measured were *T. latifolia* (1.4%), *J. americana* (0.9%), *P. crispus* (0.03%), and *E. canadensis* (0.03%). Of these species, only *P. ceratophyllum* and *E. canadensis* occurred throughout the study area. *Justicia* and *P. crispus* were restricted to the hardwater section of the river, and *T. latifolia* occurred mostly in two small impounded areas.

Aquatic macrophyte biomass increased rapidly from late spring to midsummer and then appeared to level off (Table 1). Average production rates were: *J. americana,* 23.3 g AFDW m^{-2} day^{-1} (4.7 g AFDW m^{-2} day^{-1} for aboveground biomass only); *P. ceratophyllum*, 3.4 g AFDW m^{-2} day^{-1}; and *P. crispus*, 2.9 g AFDW m^{-2} day^{-1}. Maximum standing crops of these three species were 2500 (450 aboveground), 320, and 300 g AFDW/m^2, respectively. Standing crops for *T. latifolia* and *E. canadensis* were estimated from reported values (McNaughton, 1966; Sculthorpe, 1967; Klopatek and Stearns, 1978) as 2800 (500 aboveground) and 300 g AFDW/m^2, respectively.

The contribution of each macrophyte species to the New River study area was estimated by multiplying the area of coverage by growing season aboveground production or maximum standing crop (*T. latifolia* and *E. canadensis*) (Table 2). Belowground production of *J. americana* and *T. latifolia* was estimated by assuming a belowground biomass turnover of 4.5 years, a rate midway between the values suggested by Westlake (1965) and Sculthorpe (1967). The values in Table 2 can only be considered approximate, especially those for *J. americana* and *T. latifolia*, because of our lack of knowledge concerning belowground dynamics. Because of its wide distribution in the New River, *P. ceratophyllum* was the greatest source of aquatic macrophyte POM, contributing 80% of the macrophyte input. This was followed by *J. americana* (12%), *T. latifolia* (7.7%), *P. crispus* (< 1%), and *E. canadensis* (< 1%) (from Table 2).

Annual periphyton production averaged 0.60 g AFDW m^{-2} day^{-1} (Rodgers, 1977). Extrapolating this value to our study area yielded an estimated organic matter input from this source of 3570 T/year, or roughly twice that of aquatic macrophytes. Upstream and tributary litter-fall inputs were estimated to be 5893 T/year, and in situ allochthonous input contributed 64 T/year to our study area (Table 3).

Breakdown of aquatic macrophytes proceeded rapidly at all sites. Weight loss from litter bags was greatest for *P. ceratophyllum.* Since there were no overall site effects ($p < 0.05$), all sites were combined to give an average breakdown rate for each species (Table 4).

DISCUSSION

From our estimates, aquatic macrophytes account for at least 13.1% of the total input of particulate organic matter to our study area on the New River (Table 2). They are responsible for nearly one-third (28%) of the POM generated within the study reach, however (autochthonous production plus direct riparian inputs). We feel that the latter number is more significant for two reasons. First, our estimate of upstream and tributary inputs is an overestimate because it assumes no instream utilization. A large portion of the POM entering the New River upstream of our study area is, in fact, used before it enteres the study area. Second, the material entering from upstream is low quality, partly because of upstream processing but also because terrestrial leaves generally have lower quality than aquatic macrophyte tissue. Because aquatic macrophytes consist mostly of cellulose and other easily degraded compounds, with little lignin (Sculthorpe, 1967), they break down rapidly (Table 4) in comparison with terrestrial leaves (e.g., Petersen and Cummins, 1974).

The timing of the availability of aquatic macrophytes to aquatic food chains is the key to their importance in the energy dynamics of mid-sized streams. Since aquatic macrophytes are not generally used while living, biomass accumulates through the growing season. In autumn, when the plants die, this material is released as a pulse that is rapidly used by aquatic detritivores. Periphyton production occurs throughout spring, summer, and early fall and probably is the most important trophic base during this period. Allochthonous leaf input occurs in fall and is used by detritivores after a period of conditioning (e.g., Barlocher and Kendrick, 1975). Because some leaves condition and breakdown rapidly and others condition and breakdown slowly, there is a continuum of leaf availability lasting through winter and spring (Petersen and Cummins, 1974).

Vannote et al. (1980) speculated that natural stream ecosystems should tend toward a temporal uniformity of energy flow. In this regard Fisher and Carpenter (1976) and Hill (1979) suggested that the autumn pulse of aquatic macrophyte detritus may be the major energy source during the period when periphyton production is decreasing with decreasing insolation and before allochthonous litter input has become important.

Therefore the role of aquatic macrophytes in rivers should be viewed not only with respect to their organic matter pool or annual production but also with respect to the temporal aspects of stream energy budgets.

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Periphyton production in an Appalachian river

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Keywords: periphyton production, ^{14}C uptake, stream production, HCO_3^- utilization, organic matter budgets

Abstract

Periphyton primary production was measured by ^{14}C uptake on natural substrates in two sections of the New River, Virginia, U.S.A. Production ranged from 6.71 ± 0.43 mg C g^{-1} h^{-1} in summer to 1.47 ± 0.22 mg C g^{-1} h^{-1} in late autumn in the hardwater reach and from 1.90 ± 0.10 mg C g^{-1} h^{-1} to 0.12 ± 0.08 mg C g^{-1} h^{-1} in the softwater reach. Production in the hardwater reach was 3–5 times greater than in the softwater reach and significantly correlated with dissolved inorganic carbon (DIC) concentration ($r^2 = 0.506$). No significant correlation was found between periphyton production and photosynthetically active radiation (PhAR). Extrapolation of periphyton production to a 135 km reach of the New River yielded an estimated annual input of 2 252 T AFDW from this source. Estimates of allochthonous (excluding upstream contributions) and aquatic macrophyte inputs to this same reach were 64 T AFDW and 2 001 T AFDW, respectively. While periphyton is not a large source of organic matter, its high food quality and digestibility make it an important component of the New River energy dynamics.

Introduction

While it is widely accepted that most stream ecosystems are heterotrophic, considerable autotrophic production can occur in some streams (e.g., Minshall 1978). Periphyton, generally the most abundant primary producer in stream ecosystems, is often ignored by stream ecologists studying organic matter dynamics. Wetzel (1975a) pointed out the error in this judgement and stated that studies of detritus based ecosystems must also include autochthonous production, as well as allochthonous production, to accurately reflect stream energy budgets.

Rivers of the Appalachian region are usually wide, shallow streams flowing over stable bedrock. Such conditions support high periphyton production. There have been few periphyton production studies of mid-order (4–6 order) streams (e.g., McConnell & Sigler 1959; Duffer & Dorris 1966; King & Ball 1966; Thomas & O'Connell 1966; Flemer 1974), and all have used either biomass accumulation on artificial substrates or gas exchange methods to determine production. Both methods have considerable limitations (Wetzel 1975a). Measurement of ^{14}C uptake by periphyton enclosed in recirculating chambers has greatly improved primary production studies, particularly in systems of low productivity (Hornick *et al.* 1981).

The present study was undertaken to estimate periphyton production in softwater and relatively hardwater reaches of a mid-sized river ecosystem and to extrapolate production data to yield an annual estimate of periphyton inputs to this ecosystem.

Methods

The New River originates in the Appalachian

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highlands of northwestern North Carolina, U.S.A., and flows northward through southwestern Virginia and West Virginia to join the Ohio River. The river is characterized by a steep gradient, swift flow, a wide, shallow, bedrock channel, and a narrow floodplain. The river flows over two geologic formations, gneiss and limestone/dolomite, which divide the river into softwater and relatively hardwater (14.8 and 44.2 mg $CaCO_3$ l^{-1}, respectively, Klarberg 1977) reaches. The section of the New River considered in this study extends from the confluence of the North and South Forks of the New River in North Carolina, where the river becomes sixth-order, downstream 135 km to the head of Claytor Lake, Virginia (Fig. 1).

Four sites were located within the overall study area, two each in the soft and hardwater reaches. Site 1, located near the downstream edge of the study area, is characterized by hardwater, sand and bedrock substrate, 175 m wide channel, and average depth of about 1.5 m during non-storm flows. Most periphyton at this site was located in a bedrock riffle with depths less than 0.5 m. Site 2, also located in the hardwater reach, has a bedrock and sand substrate, 200 m wide channel, and water depth less than 0.5 m. This site is dominated by a

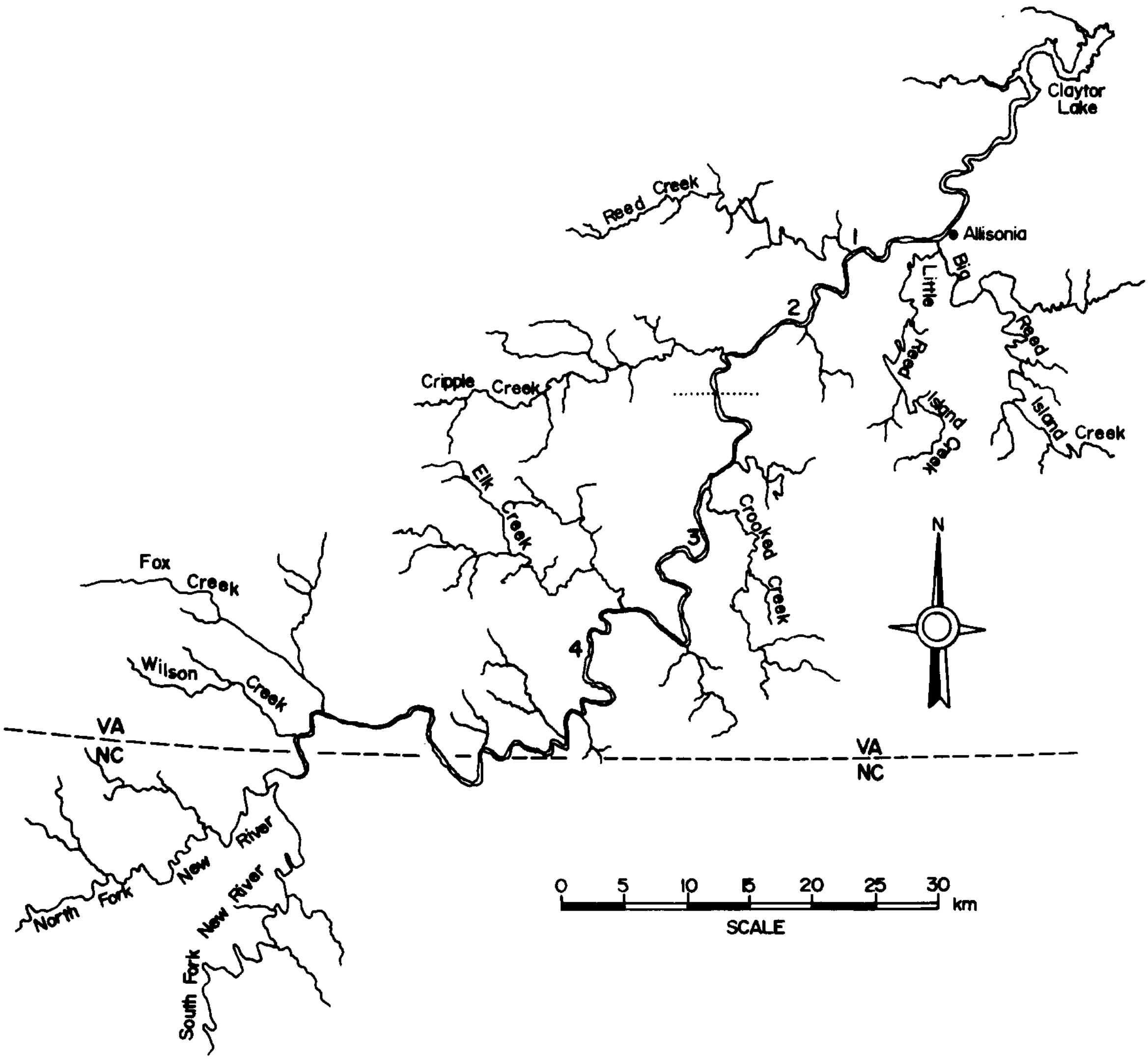

Fig. 1. Map of the New River showing sampling sites and change from softwater to hardwater reaches (dotted line in center of figure).

large bedrock riffle. Site 3, located in the softwater reach, is characterized by bedrock substrate, channel width of 100 m, and an average depth of 0.5 m. Site 4, also located in the softwater reach, has a sand/cobble substrate and an average depth of 0.5 m. Average channel width for the New River study area is 167 m. Water depth averages about 0.5 m.

Periphyton (used here to mean epilithic algae) production at the four sites was measured as ^{14}C uptake by enclosed natural substrates. Measurements were taken twice monthly from June through early November 1980. Randomly selected rock substrates, with periphyton attached, were placed in 1.9 liter, recirculating (battery powered submersible pumps, 300 ml min^{-1}), polystyrene chambers (Hornick *et al.* 1981). The chambers were filled with river water, sealed, and placed in the river at the approximate depth from which the rocks were taken (usually 0.25–0.50 m). Ninety minute, midday incubations were initiated by injecting 5 μCi ^{14}C-sodium bicarbonate into the chambers. Following the incubations, substrates were removed from the chambers, placed in plastic bags, packed on ice, and returned to the laboratory for processing. Depletion of ^{14}C within the chambers was checked by withdrawal of 1 ml samples of chamber water which were transferred to scintillation cocktail. In no instance was ^{14}C depleted within the chambers.

In the laboratory, three 7 cm^2 periphyton subsamples were scraped from each substrate from an area contained by a foam-bottomed cylinder (Hornick *et al.* 1981). Loosened material from two of the scrapings was washed into 7 ml shell vials and fumed with concentrated HCl in a 100 °C water bath to eliminate residual labelled inorganic carbon (Wetzel 1965). Samples were wet oxidized with cold potassium dichromate (Shimshi 1969), and evolved $^{14}CO_2$ was trapped in 0.25 N NaOH and transferred to Aquasol scintillation cocktail. Oxidation efficiency, checked by oxidation of benzoic acid of known activity, was 85%. Counting efficiency, measured by the external channels ratio method and by internal standards, was 96%. Production rate of the samples was calculated using the formula of Vollenweider (1974). Loosened material from the third scraping was dried, weighed, ashed (525 °C, 30 min), and reweighed to determine ash free dry weight (AFDW) of the samples.

Temperature, pH, and alkalinity (titration with 0.2 N H_2SO_4, methyl purple endpoint, 4.5 pH) of river water were determined on each sampling date to estimate dissolved inorganic carbon (DIC). Photosynthetically active radiation (PhAR, 390–710 nm) was measured on eight dates during the study period using a PhAR quantum sensor.

Results

Periphyton production in the New River increased at most sites until late August or early September before declining sharply in the November samples (Fig. 2 and Table 1). Average summer production (±SE) was: Site 1, 4.17 ± 0.95 mg C g^{-1} h^{-1} Site 2, 6.35 ± 0.97 mg C g^{-1} h^{-1} Site 3, 1.22 ± 0.20 mg C g^{-1} h^{-1} Site 4, 1.16 ± 0.17 mg C g^{-1} h^{-1}. Production was generally 3–5 times greater in the hardwater reach of the New River.

Abiotic variables potentially affecting New River periphyton production are given in Table 2. Temperature, PhAR, and pH were similar in both the softwater and hardwater reaches of the New River. Alkalinity, and thus DIC, showed marked differences between the two reaches, with values in the hardwater reach averaging 5 times those of the softwater reach. Average nitrogen and phosphorus concentrations were 1.22 mg NO_3-N l^{-1} and 0.071 mg PO_4-P l^{-1}, respectively (Wright 1976). While Wright (1976) showed that New River periphyton was nutrient limited in static, 6-hour incubations, the constant replenishment of waters containing these concentrations of nitrogen and phosphorus precludes the possibility of limitation

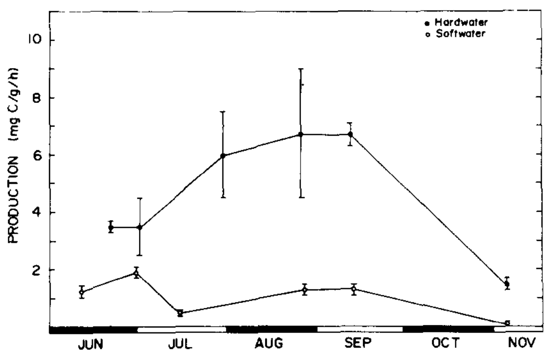

Fig. 2. Periphyton production, as ^{14}C uptake, in the River during 1980. Sites 1 and 2, and 3 and 4 were combined to yield hardwater and softwater estimates, respectively.

Table 1. Periphyton production in the New River during the 1980 sampling season (mg C/g/h) (±SE).

Date	Site 1	Site 2	Site 3	Site 4
11, 21 June	1.41 ± 0.10	5.54 ± 3.56	0.92 ± 0.28	1.54 ± 0.17
1, 2 July	1.73 ± 0.28	5.27 ± 0.05	1.90 ± 0.10	
17 July			0.51 ± 0.15	0.60 ± 0.02
30 July	8.60 ± 0.59	3.31 ± 0.40		
26, 27 Aug.	10.51 ± 0.55	2.83 ± 0.22	1.52 ± 0.42	1.08 ± 0.28
12, 13 Sept.	7.12 ± 0.65	6.31 ± 0.60	1.64 ± 0.41	0.99 ± 0.28
5, 6 Nov.	1.85 ± 0.02	1.10 ± 0.13	0.12 ± 0.01	0.13 ± 0.01

Table 2. Abiotic variables affecting periphyton production in the New River (June–September 1980).

Variable	Mean ± SE	Range	n
pH			
softwater	7.5 ± 0.2	7.0–7.8	11
hardwater	7.7 ± 0.4	7.2–8.2	13
Alkalinity (mg $CaCO_3$/l)			
softwater	7.5 ± 0.8	6.0–0.8	11
hardwater	37.3 ± 2.8	34.0–42.0	13
Dissolved inorganic carbon (mg/l)			
softwater	2.0 ± 0.2	1.5–2.3	11
hardwater	9.5 ± 0.9	8.2–11.3	13
Temperature (°C)	24.8 ± 2.0	20.0–30.0	24
PhAR (μEin/m^2/s)	1830.2 ± 334.5	1078.1–2222.5	24

of periphyton production due to macronutrient deficiencies.

Product moment correlations (Sokal & Rohlf 1974) were significant (t-test, $p < 0.05$) for comparisons of production and DIC (Fig. 3), alkalinity, and temperature. No significant correlations (t-test, $p > 0.05$) were found for comparisons of pH and PhAR with productivity.

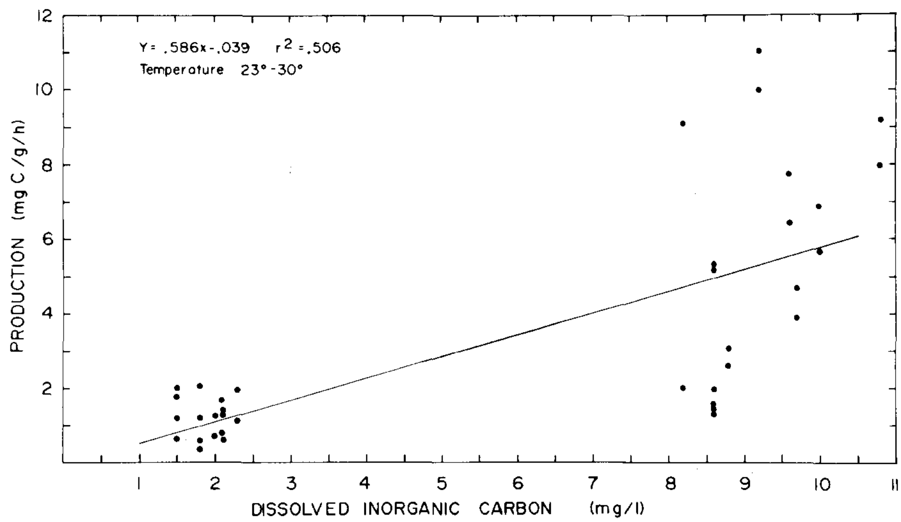

Fig. 3. Periphyton production in response to available dissolved inorganic carbon in the New River during 1980.

Discussion

Periphyton production in the New River is divided into two distinct productivity classes which correlate significantly with DIC. The relationship between DIC and primary production in lakes has long been recognized (e.g., Birge & Juday 1911), but has received little attention from stream ecologists. Wright & Mills (1967) found increased net photosynthesis with increased free CO_2 in a stream community dominated by aquatic macrophytes. The phenomenon of increased secondary production in hardwater streams is well documented (e.g., Hynes 1970). Availability of DIC in the New River is related to the geology of the underlying bedrock. In the upstream, softwater reach of the river, DIC is about 5 times less than in the hardwater reach and this is reflected by production which is about 5 times less than concomitant rates in the hardwater reach. Since labelled bicarbonate was not depleted within the production chambers, the limited production of the softwater periphyton suggest that New River periphyton may be unable to use HCO_3^-, and use only dissolved CO_2, as a carbon source in photosynthesis. Limitation due to CO_2 depletion appears to be the result of photosynthetic uptake of CO_2 occurring faster than dehydroxylation of HCO_3^- to CO_2 (Gavis & Ferguson 1975; Burris *et al.* 1981). This is particularly a problem at higher pH where the chemical equilibrium of inorganic carbon species is shifted towards HCO_3^- (Wetzel 1975). At the near neutral to slightly alkaline pH of the New River, dissolved CO_2 appears to be dependent on the size of the HCO_3^- pool, as well as the rate of dehydroxylation of HCO_3^- to CO_2, and explains the greater periphyton production in the hardwater reach.

Use of ^{14}C to measure primary production is widely accepted, though the argument over whether the method measures gross or net primary production is unresolved. Most investigators (e.g., Wetzel 1975a; Petersen 1980) agree that ^{14}C uptake is close to net primary production in incubations less than several hours. Use of the ^{14}C method for periphyton production in the New River (9.3–1,059.0 mg C m^{-2} d^{-1}) gave rates similar to those reported for some stream ecosystems (Wetzel 1975a; Fisher & Carpenter 1976; Hornick *et al.* 1981) though somewhat lower than rates reported for most rivers (King & Ball 1966; Flemer 1974; Duffer & Dorris 1966; Berrie 1972; Thomas & O'Connell 1966; McConnell & Sigler 1959; Cushing 1967). The lower periphyton production in New River, compared to the rivers sited above, may be due to differences in levels of nutrient enrichment, for example the Red Cedar River (King & Ball 1966) is highly enriched, or to differences in site conditions or methods.

Average annual periphyton production in the New River was determined from production measurements for June through November 1980. Periphyton production from December through May was estimated by extrapolating between November and June values. Extrapolation of average annual periphyton production, weighted for production in the softwater (70% of the study area) and hardwater reaches, was based on an average width of 167 m throughout the 135 km study area. Estimated periphyton net primary production input to the New River was 2251.9 T AFDW (825.5 T from the softwater reach, 1423.4 T from the hardwater reach) to the New River. This estimate assumes 100% periphyton cover in all areas not inhabited by aquatic macrophytes (Hill & Webster 1982), an assumption that is reasonable in light of the shallow mean depth of the New River. However, the occurrence of large sandy areas would decrease annual input from periphyton because of reduced substrate available for periphyton colonization.

We can compare this estimate of periphyton input to the 135 km reach of the New River with estimates for other sources. Hill (1981) estimated aquatic macrophyte production by the harvest method for emergent macrophytes and by ^{14}C uptake for submerged macrophytes. Allochthonous input was estimated by measuring leaffall from riparian vegetation (Hill 1981) and includes only input directly to the study reach, not transport from tributaries or upstream. Periphyton input to the New River was 19.5% of total inputs, aquatic macrophyte and allochthonous input represented 20.5% and 60.4%, respectively (Hill 1981). It has been suggested that, while periphyton POM input and production is small in stream ecosystems, it is higher in food quality and digestibility than allochthonous POM (McCollough *et al.* 1979a, 1979b; Naiman & Sedell 1979; Ward & Cummins 1979; Benke & Wallace 1980; Hornick *et al.* 1981). While this input of organic matter is smaller than estimated allochthonous organic matter inputs, its high food quality and digestibility make it an important component of the New River organic matter dynamics.

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PRODUCTIVITY OF PODOSTEMUM CERATOPHYLLUM IN THE NEW RIVER, VIRGINIA[1]

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ABSTRACT

Productivity of *Podostemum ceratophyllum*, the dominant aquatic macrophyte in the New River, was measured at four sites representing soft- and hardwater reaches of the river. Available dissolved inorganic carbon (DIC) was 4–5 times greater in the hardwater reach. The difference in available DIC was reflected in standing crop and productivity of *P. ceratophyllum*. Maximum standing crops of *P. ceratophyllum* at the two hardwater sites (Sites 1 and 2) were 244.8 ± 30.7 g ash-free dry wt (AFDW) m^{-2} and 193.8 ± 18.7 g AFDW m^{-2} compared to 128.5 ± 14.9 g AFDW m^{-2} and 101.3 ± 6.9 g AFDW m^{-2} for the softwater sites (Sites 3 and 4). Productivity, based on differences in standing crops, was: Site 1, 1.08 ± 0.12 g C m^{-2} d^{-1}; Site 2, 0.86 ± 0.08 g C m^{-2} d^{-1}; Site 3, 0.58 ± 0.06 g C m^{-2} d^{-1}; Site 4, 0.45 ± 0.03 g C m^{-2} d^{-1}. Corresponding values for productivity as ^{14}C uptake were: 2.77 ± 0.44 g C m^{-2} d^{-1}; 2.10 ± 0.45 g C m^{-2} d^{-1}; 0.34 ± 0.04 g C m^{-2} d^{-1}; 0.28 ± 0.03 g C m^{-2} d^{-1}. Productivity/biomass (P/B) based on ^{14}C uptake and standing crop revealed that *P. ceratophyllum* productivity was inhibited at the softwater sites perhaps due to carbon limitation. Because of its abundance and its high productivity, *P. ceratophyllum* is hypothesized to contribute significantly to the New River organic matter budget.

LIKE MANY RIVERS of the Appalachian region, the New River supports a large, productive aquatic macrophyte community. The dominant aquatic macrophyte in the New River is *Podostemum ceratophyllum,* a species well suited to the swift-flowing, shallow, bedrock riffles common to rivers of this region. Because of its abundance, productivity of *P. ceratophyllum* dominates the primary productivity and particulate organic matter (POM) input from aquatic macrophytes to the New River. (Hill and Webster, 1983).

Standing crop and ^{14}C uptake studies of aquatic macrophyte productivity are well documented for lake ecosystems (e.g., Wetzel, 1964a, b; Wetzel and Hough, 1973; Adams and McCracken, 1974; McCracken et al., 1975; Adams, Guilizzoni and Adams, 1978; Adams, Titus, and McCracken, 1974). Aquatic macrophyte productivity, especially as ^{14}C uptake, in lotic ecosystems has received far less attention.

Use of chambers for aquatic macrophyte productivity studies is not meant to mimic field conditions but rather to allow the investigator controlled conditions in the field. However, there are some problems associated with the use of chambers that may obscure the actual productivity of aquatic macrophytes (Wetzel, 1974; Moeller, 1978). Such problems as oxygen accumulation, dissolved inorganic carbon (DIC) depletion, and other environmental changes within the chambers may inhibit photosynthesis of enclosed aquatic macrophytes.

This study was undertaken to compare productivity estimates for *P. ceratophyllum* based on differences in standing crop and ^{14}C uptake and to determine potential POM contribution from *P. ceratophyllum* to the New River. *Podostemum ceratophyllum* Michx. (Podostemaceae: Angiospermae) is a small aquatic plant characteristic of riffles in tropical and subtropical rivers and extending into temperate regions of North America as far north as New Brunswick and Ontario. This plant lacks roots, but attaches itself to substrate with holdfasts, an adaptation which allows the plant to attach to large cobbles, boulders, and bedrock in swift riffles.

The New River originates in the Appalachian highlands of western North Carolina and flows northward through Virginia and West Virginia. The river is characterized by a narrow floodplain, swift flow, and steep gradient. It flows in the channel of the ancient River Teays, reported to be the second oldest river in the world (Janssen, 1953). This ancient channel of exposed bedrock remains relatively free of silt because of the swift flow and is quite shallow for its width. The river passes through two geologic provinces, gneiss and limestone/do-

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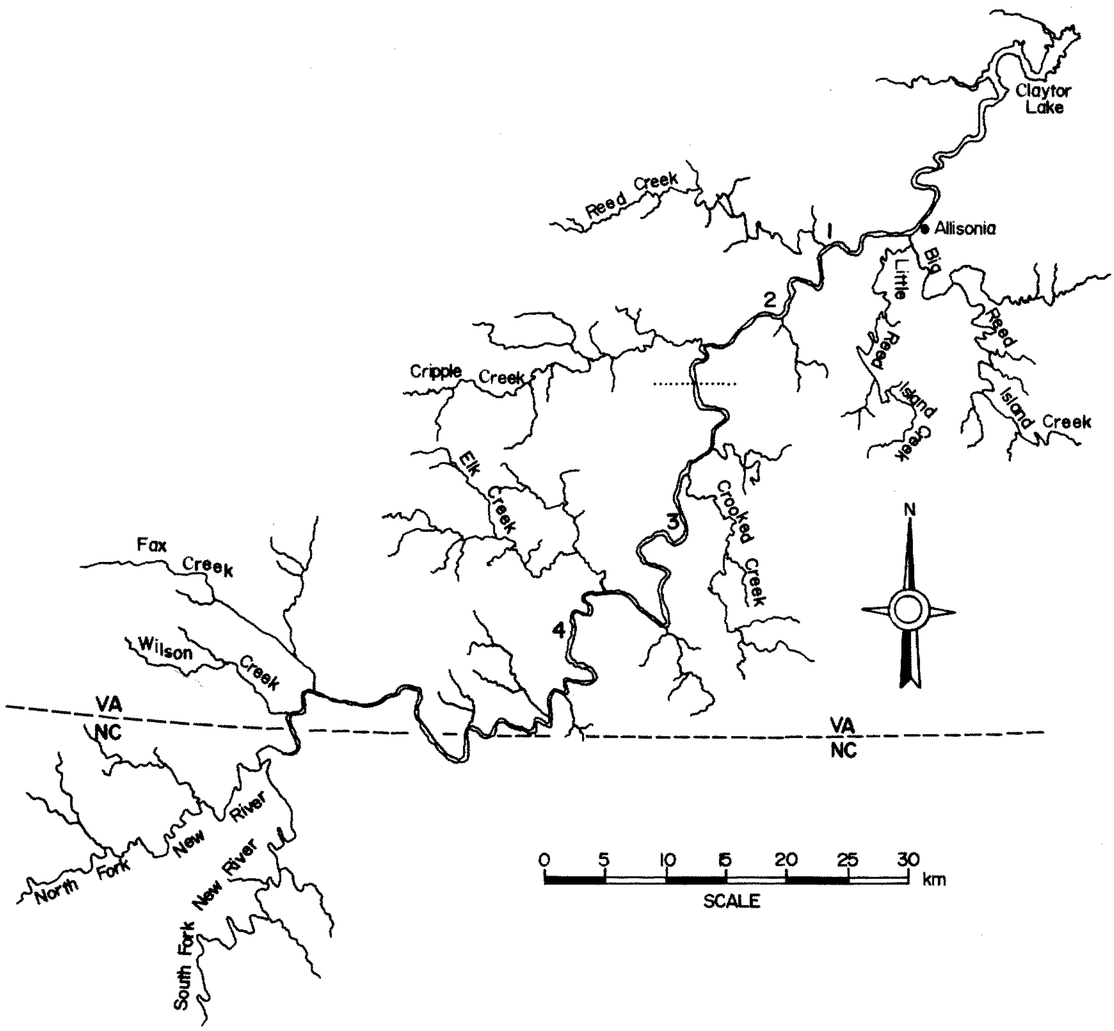

Fig. 1. Map of the New River showing sampling sites and the change from the softwater to hardwater (dotted line in center of figure) regions.

lomite, which divide the river into distinct softwater (upstream) and relatively hardwater (downstream) reaches. The softwater and hardwater reaches represent 66% and 34% of the study area, respectively. The section of the New River considered in this study extends from the confluence of the North and South Forks of the New River in North Carolina, forming a sixth-order stream, downstream 135 km to Allisonia, Virginia, at the head of Claytor Lake (Fig. 1).

Four sites were located within the overall study area, two each in the soft and hardwater reaches of the New River (Fig. 1). Site 1, located near the downstream end of the study area, is characterized by hardwater, sand and bedrock substrate, a 175-m-wide channel, and an average depth of 1.5 m. Most *Podostemum* growth at this site occurred in a bedrock riffle with depths less than 0.5 m. Site 2, also located in the hardwater reach, has a bedrock and sand substrate, 200-m channel width, and water depth less than 0.5 m. This site is dominated by a large bedrock riffle. Site 3, located in the softwater reach, was characterized by bedrock substrate, channel width of 100 m, and an average depth of 0.5 m. Site 4, also located in the softwater reach, has a sand/cobble substrate and an average depth of 0.5 m. Channel width at this site was 100 m. Average channel width and water depth for the New River study area are 167 m and about 0.5 m, respectively.

METHODS—Harvests of *P. ceratophyllum* biomass at the four sites were undertaken at monthly intervals from May through early November 1980. Sampling sites were selected randomly from areas in which the plants occurred. The plant samples were collected by scraping the plant from the rock substrate contained by a 0.10 m^2 box sampler. Replicate samples (n = 5) from each site were returned to the laboratory, air dried (22 C, 5 days), weighed, and subsampled. Subsamples were weighed, ashed (525 C, 30 min), and reweighed to determine ash free dry weight (AFDW).

Carbon-14 uptake by *P. ceratophyllum* was measured at the four sites during the 1980 growing season. Uptake of ^{14}C was measured during replicate (n = 5) 90 minute incubations in recirculating (battery powered submersible pumps, 300 ml min^{-1}), 1.9-l polystyrene chambers (Hornick, Webster and Benfield, 1981). Rock substrates with healthy *P. ceratophyllum* were placed in the chambers, filled with river water, sealed, and placed on the river bed at approximately the depth from which they were removed (about 0.25–0.5 m). Incubations were initiated by injecting 5 μCi $NaH^{14}CO_3$ into each chamber. Following each incubation, but before opening the chambers, 1-ml samples of the water within the chambers were removed with a syringe and transferred to scintillation cocktail to test for inorganic carbon depletion. The chambers were then opened and *P. ceratophyllum* was removed, placed in plastic bags, and packed on ice until returned to the laboratory. In the laboratory, samples were either frozen or processed immediately. Sample processing included removal of three equal subsamples of *P. ceratophyllum* from each rock substrate. One subsample was placed in an aluminum drying pan, air dried, weighed, and ashed to determine AFDW. The two remaining subsamples were placed in shell vials and fumed with concentrated HCl for 1 hour to remove any residual inorganic ^{14}C (Wetzel, 1965). After fuming, samples were frozen then wet oxidized with cold potassium dichromate (Shimshi, 1969), and evolved $^{14}CO_2$ was trapped in 0.25 N NaOH and transferred to the scintillation cocktail for counting. Oxidation efficiency, checked by oxidation of benzoic acid of known activity, was 85%. Counting efficiency, measured by the external channels ratio method and by internal standards, was 96%. Productivity of the samples was calculated using the formula of Vollenweider (1974).

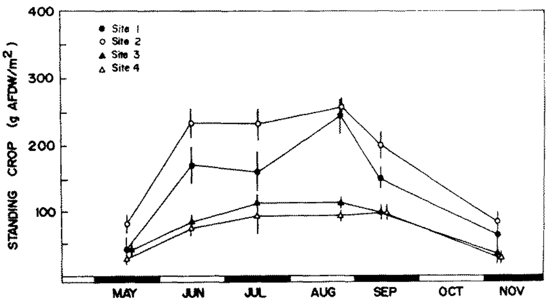

Fig. 2. Standing crop of *Podostemum ceratophyllum* in the New River during 1980. Vertical bars indicate ±SE.

A diurnal productivity curve for *P. ceratophyllum* was determined using a series of 90-min incubations, as above, from before sunrise to after sunset on 12 August 1980, at Site 2.

Temperature, pH, and alkalinity (titration with 0.2 N H_2SO_4, methyl purple endpoint, pH 4.5) of the river water were determined for each site on each sampling date to estimate dissolved inorganic carbon (DIC). Photosynthetically active radiation (PAR 390–710 nm) was measured on site on eight dates during the study period as a check against the PAR data collected on the VPI & SU campus 50 km north of Site 1.

RESULTS—Standing crop of *P. ceratophyllum* increased from mid-May until late August before starting to decline (Fig. 2). Maximum standing crops and productivity of *P. ceratophyllum* are given in Table 1. Productivity of

TABLE 1. *Standing crop and productivity of* Podostemum ceratophyllum *in the New River (±SE). Vertical bars after productivity values indicate no significant differences (*P *> 0.05) between sites*

Site (Date)	Maximum productivity: Standing crop (g AFDW m^{-2})	(g C m^{-2} d^{-1})	^{14}C uptake (g C m^{-2} d^{-1})
1 (27 Aug)	244.8 ± 30.7	1.08 ± 0.12 |	2.77 ± 0.44 |
2 (27 Aug)	193.8 ± 18.7	0.86 ± 0.08 |	2.10 ± 0.45 |
3 (26 Aug)	128.5 ± 14.9	0.58 ± 0.06 |	0.34 ± 0.04 |
4 (26 Aug)	101.3 ± 6.9	0.45 ± 0.03 |	0.28 ± 0.03 |

TABLE 2. *Abiotic variables effecting* Podostemum ceratophyllum *productivity in the New River (June–September 1980)*

Variable	Mean ± SE	Range	*n*
pH			
Softwater	7.5 ± 0.2	7.0–8.0	11
Hardwater	7.7 ± 0.4	7.2–8.2	13
ALKALINITY (mg $CaCO_3$/l)			
Softwater	7.5 ± 0.8	6.0–8.0	11
Hardwater	37.3 ± 2.8	34.0–42.0	13
DISSOLVED INORGANIC CARBON (mg/l)			
Softwater	2.0 ± 0.2	1.5–2.3	11
Hardwater	9.5 ± 0.9	8.2–11.3	13
TEMPERATURE			
(C)	24.8 ± 2.0	20.0–30.0	24
PAR			
(μEin/m²/s)	1830.2 ± 334.5	1078.1–2222.5	24

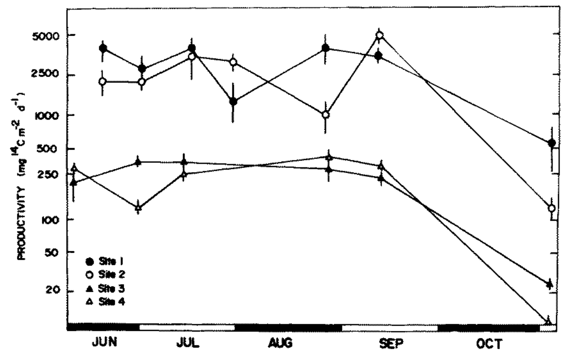

Fig. 3. Production (as ^{14}C uptake) by *Podostemum ceratophyllum* in the New River during 1980. Vertical bars indicate ±SE.

P. ceratophyllum based on ^{14}C uptake was fairly constant from mid-June to early September, but dropped off markedly by early November (Fig. 3). Productivity during August at the four sites is given in Table 1.

Productivity of *P. ceratophyllum* through the course of a day followed typical diurnal productivity patterns closely associated with PAR (Fig. 4), however, there was an absence of an afternoon depression often reported for other aquatic macrophyte species (Wetzel, 1975). Maximum productivity in this study actually occurred in the afternoon. Production followed PAR closely but lagged in response by about 4 hours.

Extrapolation of ^{14}C uptake data to daily values, adjusted for daylength and the diurnal productivity curve, were compared to measured standing crop on four dates between 15 June and 12 September 1980. Ratios of productivity to standing crop biomass (P/B) from the harvest studies ranged from 2.38:1 to 7.88:1 in the hardwater reach and from 0.46:1 to 1.14:1 in the softwater reach. The low values in the softwater samples suggest that some chamber effect, perhaps DIC limitation, caused low estimates of carbon assimilation. Highest P/B were measured in the September samples and reflect the active photosynthesis of healthy tissue and the sloughing of senescent tissue, causing net biomass loss in spite of high productivity. Differences between ^{14}C productivity and biomass productivity estimates make comparison of studies using these methods difficult. The higher productivity estimated by ^{14}C uptake suggests that this method does not measure net primary productivity, but measures rates closer to gross primary productivity. However, productivity based on biomass change appears to underestimate net primary productivity by losses of plant tissue to consumption by grazers and by fragmentation and sloughing.

Average values for pH, alkalinity, DIC, temperature, and PAR are given in Table 2. No differences between softwater and hardwater reaches were found for pH, temperature, or PAR. Significant differences (t-test, $P < 0.05$) were found for DIC and alkalinity between the softwater and hardwater reaches, with values in the hardwater reach 4–5 times greater than in the softwater reach.

Production of *P. ceratophyllum* was tested for significant correlation with the abiotic variables. At the hardwater sites (1 and 2) productivity was significantly correlated (t-test,

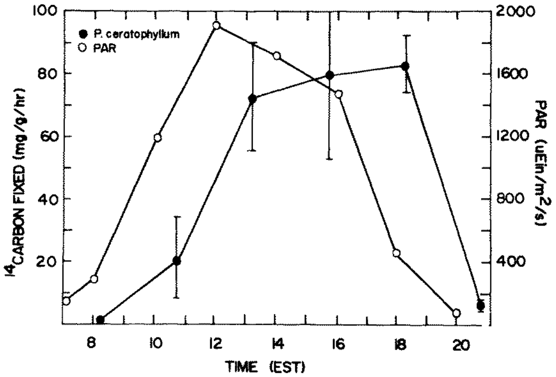

Fig. 4. Diurnal production of *Podostemum ceratophyllum,* and photosynthetically active radiation (PAR) on 28 August 1980 (measured at Site 2) (each point plotted as the mid-point of 90 minute incubations). Vertical bars indicate ±SE.

$P < 0.05$) with alkalinity. Correlations in the softwater reach were significant for PAR. Linear regression of productivity along a DIC gradient showed only a poor response ($r^2 = 0.33$) of *P. ceratophyllum* to increasing DIC availability.

DISCUSSION—Data on *P. ceratophyllum* productivity are found only for studies from the Appalachian region (Nelson and Scott, 1962; Rodgers et al., 1983). Based on differences in standing crops between May and August, productivity of *P. ceratophyllum* in our study ($0.45 \pm 0.03 - 1.8 \pm 0.12$ g C m^{-2} d^{-1}) was 1.9 to 4.6 times greater than estimates of *P. ceratophyllum* productivity (0.235 g C m^{-2} d^{-1}) for the Middle Oconee River, Georgia (Nelson and Scott, 1962). Rodgers et al. (1983) reported changes in *P. ceratophyllum* standing crops for the Watauga River, Tennessee and for the New River, Virginia, at a site 128 km downstream from our study area. Using their data for standing crops in June and September (a period of about 91 days) *P. ceratophyllum* productivity is estimated as 0.40 g C m^{-2} d^{-1} for the Watauga River and 0.05 g C m^{-2} d^{-1} for the New River. These values are 1.1 to 21.6 times lower than the productivity values we are reporting for our study. The extremely low *Podostemum* productivity reported by Rodgers et al. (1983) for the New River is probably due to increased scouring caused by daily pulses of discharge from an upstream hydroelectric dam.

Podostemum productivity is comparable to productivity by other submerged aquatic macrophytes in streams and lakes. Owens and Edwards (1961, 1962) reported productivity of 0.04–2.30 g C m^{-2} d^{-1} for *Ranunculus fluitans, Callitriche* sp., *Potamogeton lucens,* and *P. densus.* Adams and McCracken (1974) reported *Myriophyllum spicatum* productivity as 1.77 g C m^{-2} d^{-1}; Fisher and Carpenter (1976) reported productivity at 0.36 g C m^{-2} d^{-1} for *Potamogeton crispus*; and Hannan and Dorris (1970) reported a productivity of 1.24 g C m^{-2} d^{-1} for a stream community composed of 15 species of submerged macrophytes.

The differential productivity of *P. ceratophyllum* in the soft and hardwater reaches of our study area appears to be in response to water hardness and available DIC. This is not uncommon among aquatic plants (Raven, 1976; Hutchinson, 1975; Adams et al., 1978) and is either attributable to higher concentrations of bicarbonate or greater availability of free CO_2, because of the chemical equilibrium of the different carbon species. At the mean pH of 7.6, the percent of DIC as CO_2 and HCO_3^- is 9.8 and 90.2, respectively (Wetzel, 1975). Thus the difference in DIC, especially to a plant that uses only CO_2 in photosynthesis becomes critical. Since *P. ceratophyllum* uses only free CO_2 (Hill, 1981; Hill, Webster and Linkins, in press), the availability of DIC to the species is reduced from 2.0 to 0.20 mg l^{-1} and 9.5 to 0.93 mg l^{-1} of total inorganic carbon, respectively for the soft and hardwater reaches. Productivity is almost 3 times greater in the hardwater reach, comparable to the differences in DIC. Because of the limiting free CO_2 availability at the softwater sites correlation of *P. ceratophyllum* productivity to free CO_2 was not significant ($r = 0.397$).

Measurement of *P. ceratophyllum* productivity in the New River is complicated by two factors. First, the plant grows in swift-flowing riffles where losses of biomass due to fragmentation and scouring may be considerable. This is reflected by the high P/B ratios in the hardwater reach of the river. Second, the plant appears to use only free CO_2 (Hill, 1981; Hill et al., in press) in photosynthesis, and thus may be carbon limited in the chamber studies of productivity in the softwater reach, as indicated by P/B less than 1.

Estimation of productivity based on biomass changes over time has the inherent weakness of underestimating productivity because of loss of plant tissue due to sloughing, grazing, fragmentation, and/or scouring between sampling times. Underestimation of net productivity because of this error may be considerable if times between sampling are lengthy (Fisher and Carpenter, 1976). P/B ratios are generally near 2 for aquatic macrophytes (Nelson and Scott, 1962; Adams and McCracken, 1974), but were nearer to 4 for *P. ceratophyllum* in the hardwater reach, suggesting that losses of plant tissue from this species, due to scouring and fragmentation, may be considerable.

The inability of *P. ceratophyllum* to use HCO_3^- as an inorganic carbon source (Hill, 1981; Hill et al., in press) is unusual among submerged aquatic angiosperms, but not unexpected of plants growing in riffles (Gessner, 1959; Raven, 1970). While no previous reports of DIC use in *Podostemum* are available, another member of the Podostemaceae, *Apinagia,* has been shown to use only free CO_2 (Gessner, 1959). The inability to use HCO_3^- has been viewed as a competitive disadvantage in hardwater lakes (Moeller, 1978), however, this does not appear to be the case in swift-flowing, turbulent rivers which are well mixed and saturated with CO_2. Aquatic mosses, the typical primary producers in swift-flowing waters, use only free CO_2 (Bain and Proctor, 1980).

Podostemum productivity was, on a per gram basis, lower than similar productivity estimates for periphyton (Hill and Webster, 1982, 1983) and reflects the greater metabolic and turnover rate of periphyton. On an areal basis, production of *P. ceratophyllum,* because of its growth out from the substrate, is as much as 10 times higher than periphyton productivity. Aquatic macrophyte and periphyton contributions to the New River organic matter budget are nearly equal (Hill and Webster, 1983).

It is generally assumed by stream ecologists that aquatic macrophytes play only a minor role in the middle reaches (4–6 orders) of streams, and overall are rarely significant to the entire stream ecosystem (Cummins, 1974; Vannote et al., 1980). Since aquatic macrophytes are not extensively grazed in most ecosystems (Westlake, 1965; Sculthorpe, 1967; Fisher and Carpenter, 1976; Rodgers et al., 1983) biomass accumulates throughout the growing season. Thus maximum aquatic macrophyte standing crop may be an adequate estimate of POM contributions from these plants to stream ecosystems. While the contribution of aquatic macrophytes to stream energy budgets may be small, it has been hypothesized that the timing of this POM input may make them an important link in the organic matter dynamics of stream ecosystems in which they occur (Hill and Webster, 1983). Such may be the case with *P. ceratophyllum* in the New River.

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EFFECTS OF FLOW ALTERATION ON

THE AQUATIC MACROPHYTE *PODOSTEMUM CERATOPHYLLUM* (RIVERWEED);

LOCAL RECOVERY POTENTIAL AND REGIONAL MONITORING STRATEGY

by

JENNIFER P. PAHL

(Under the Direction of C. Ronald Carroll)

ABSTRACT

A survey of *Podostemum ceratophyllum* Michx. biomass and recovery rates was conducted in the Middle Oconee River, Athens, GA over a one-year time period under altered hydrology and severe drought. Biomass was found to be an order of magnitude lower than reported by previous studies conducted in non-drought years. An information-theoretic (AIC) modeling approach found variation in biomass within the study site to be related in part to variation in duration of low flow events. Recovery rates in the Middle Oconee River as well as Hunnicutt Creek, a tributary, were similar among sites and under varying hydrologic regimes. Re-colonization from vegetative growth seemed most prominent, and little support was found for seed dispersal as a major mechanism or recovery. Regionally, *P. ceratophyllum* range is likely expansive, and the impact of hydrologic alteration may be equally as widespread. Future monitoring could be accomplished through existing programs, focusing in basins where *P. ceratophyllum* is present and flow modification is prevalent.

INDEX WORDS: *Podostemum ceratophyllum*, hydrologic alteration, drought, Middle Oconee River, re-colonization, monitoring

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by

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CHAPTER 1

INTRODUCTION

The natural flow regime paradigm (Poff et al. 1997) has been a foundation for understanding stream ecology since the 1990s. It implies that natural variations in flows are required for the life histories of organisms that have evolved to tolerate those conditions. Over the last 50 years however, a significant rise in the number of impoundments (McCully 2001) and surface water withdrawals have profoundly changed the patterns of flow across North American rivers (Rosenberg et al. 2000). Shifting flow regimes can alter the transport of important nutrients, sediment and biota across all planes laterally, longitudinally and vertically within the channel (Silk and Ciruna 2005) and at varying time scales (Poff et al. 1997).

Compounding these hydrologic changes, precipitation patterns in the southeastern United States have drastically reduced the amount of rain over Georgia, North and South Carolina over the last decade. This extreme drought (2007 to present) has resulted in fewer high flow events and prolonged durations of very low flows. Climate change models predict higher winter rainfall in the southeast, accompanied by increased evapotranspiration rates, which will likely yield less summer and fall runoff to streams and rivers (Mulholland et al. 1997). Population projections for the southeast, particularly Georgia indicate continued rapid growth (USCB 2008), which may further increase demand for water resources, resulting in lower base-flows (Mulholland et al. 1997). While these conditions alone may influence the productivity of aquatic organisms within a stream reach, perhaps the most challenging conditions for aquatic biota may occur as anthropogenic perturbations interact with climatically-induced low flows.

In streams that support low-head hydropower dams for example, consistent daily fluctuations in flow resulting from normal dam operations may result in minor discharge changes under normal flow conditions, however, under extreme drought, these fluctuations may affect a larger portion of the streambed over the course of 24 hours. The frequency and duration of these drying events and the duration may influence the productive capacity of stream biota. Short-duration drying events could lead to stress on macrophytes resulting in reduced growth, while long duration may result in mortality. Long-duration drying events that occur frequently will likely result in larger population declines, while infrequent long-duration events may result in initial mortality or extreme stress, but allow for macrophyte re-colonization.

The Middle Oconee River, near Athens, GA provides an example of how climate in combination with water management can alter natural flow regimes. The extreme drought conditions that have persisted since early 2007 through the present have resulted in lower than normal stream flow. Upstream of our study shoals, the Tallassee Shoals Hydropower dam operates as a low-head dam, producing power for the Jackson EMC which supplies the surrounding counties (Davis 2007). A pump-storage facility called Bear Creek Reservoir is operated by the Upper Oconee Basin Water Authority and supplies water to Athens-Clarke County, as well as three other counties (Williams 2007). An additional water withdrawal station downstream of these shoals is operated for municipal water supply by Athens-Clarke County (Knight 2007).

While the three features may influence the hydrology of this reach, the pump storage facility has had a great effect on flows during the drought. Neither the hydroelectric dam (Davis 2007) nor the Athens-Clarke County municipal withdrawal station (Knight 2007), were able to operate during the drought flows experienced over the course of our study. The remaining feature, Bear Creek Reservoir, resulted in daily changes on the order of 5 to 10 cubic feet per second (cfs), but up to 90 cfs under normal conditions. The reservoir was issued a special permit by the Georgia Environmental Division to withdrawal 7 to 15 Million Gallons per Day (13 – 28 cfs) under drought conditions (Williams, 2007). This created areas of the shoal that were continually wetted, continually exposed, and those that experienced fluctuations in flow that may result in short term drying events. The drought conditions increased the extent of the substrate that was fully exposed and possibly the areas experiencing daily changes in flow.

One of the major primary producers and habitat providers in this study shoal is the submerged aquatic macrophyte *Podostemum ceratophyllum* Michx. (*Podostemaceae*) *P. ceratophyllum* thrives in swift water on rocky substrate, and resists flows by attaching to bedrock and boulders with holdfast disks (raphes) rather than roots (Hammond 1937). *P. ceratophyllum* is the dominant macrophyte in riverine shoal habitats in Georgia and is ecologically significant for a number of reasons. *P. ceratophyllum* is an important habitat for many macroinvertebrate and fish species in this region. It is highly productive (Hill and Webster 1984) and has been linked with the highest secondary production of filter feeders (Grubaugh and Wallace 1995, Grubaugh et al. 1997) ever recorded in streams (Huyrn and Wallace 2000).

Hutchens et al. (2004) documented the importance of *P. ceratophyllum* for macroinvertebrate communities, finding that removal of this species resulted in a much lower total macroinvertebrate abundance and biomass. The authors also indicated that the recovery of such communities was extremely slow (Hutchens et al. 2004). *P. ceratophyllum* has also been correlated with increased presence of fish (Argentina 2006, Connelly et al. 1999, Hagler 2006, Marcinek 2003). *P. ceratophyllum* may provide fish, especially small ones, with refuge from predation, and food in the form of macroinvertebrates (Argentina 2006).

Over the past few decades, *P. ceratophyllum* has been in decline in many of the northeastern states due to various impacts such as reduced water quality, siltation or hydrologic alterations (NYSNHP 2008). In Georgia, *P. ceratophyllum* is not listed as endangered or threatened, as it is in the northeastern U.S.; however, recent climatic events may have caused significant stress.

Historically, *P. ceratophyllum* formed lush mats across shoal in the Middle Oconee River, Athens, GA during the growing season and persisted throughout the winter in a more dormant stage (Grubaugh and Wallace 1995). Due to the recent extreme drought of 2007-2009, much of the area that previously supported *P. ceratophyllum* has been exposed and the plant has died. Many of the remaining refuge areas for the plant are subject to fluctuating hydrology on a daily basis due to the upstream water withdrawals. Future human population growth in Georgia may demand more of our water resources, exacerbating the problem of water extraction resulting in low, variable flows.

To understand how the hydrology in the Middle Oconee River is affecting the productive capacity of *Podostemum ceratophyllum* and its ability to recover, the following research questions were addressed: (1) Does *P. ceratophyllum* biomass change seasonally over one year? (2) How has the biomass of *P. ceratophyllum* in this study shoal changed over the past 50 years? (3) How does hydrology influence *P. ceratophyllum* biomass within the shoal habitat? (4) What is the rate of *P. ceratophyllum* re-colonization through seed dispersal and vegetative growth within the shoal? (5) Are other areas of Georgia where *P. ceratophyllum* occurs that are also experiencing hydrologic changes?

To understand these questions, I collaborated with others (R. Katz and M. Freeman) to develop a number of methodologies and analytical strategies: First, we investigated effects of hydrologic stress on *P. ceratophyllum* in conjunction with a number of habitat covariates on standing stock biomass of *P. ceratophyllum.* We used an information theoretic approach to compare models predicting *P. ceratophyllum* biomass and to determine relative support for including the effects of hydrologic variables. We found that the best supported model included a hydrologic stress variable, and indicated that one or more hours of hydrologic stress resulted in loss of *P. ceratophyllum* biomass.

Second, I analyzed the rate at which *P. ceratophyllum* may recover from hydrologic stress or other forms of disturbance such as scour or grazing. To do this, a fixed-plot repeated-measures approach was taken to assess vegetative re-colonization rates as well as seed accrual over time in two locations under varying hydrologic conditions. An independent study looking at seed dispersal was problematic, but did provide insight into the potential resiliency of this species.

Third, we analyzed observed occurrences across north Georgia to establish a preliminary range for *P. ceratophyllum* above the fall line in Georgia. The basins in which these observations occurred were cross-referenced with U.S. Geological Survey stream gages to determine the possible extent of hydrologic alteration by basin (USGS 2008). Basins with *P. ceratophyllum* and high percentages of gages indicating hydrologic alterations such as water withdrawals or hydroelectric impoundments were determined to be priority areas for future monitoring work. These locations will also likely experience high rates of population growth in the future, which may lead to increased stress on water resources (Seager et al. 2007). Monitoring of *P. ceratophyllum* might be facilitated through the Georgia Natural Heritage Program.

CHAPTER 2

HIGH RESOLUTION ASSESSMENT OF ENVIRONMENTAL FACTORS THAT INFLUENCE BIOMASS OF *PODOSTEMUM CERATOPHYLLUM* (RIVERWEED) IN A SIXTH-ORDER PIEDMONT RIVER

ABSTRACT

Hydrologic alteration by impoundment structures and water extraction has significantly impacted aquatic systems for over a century. Some of the most vulnerable habitats are shoals which often occur at areas of high elevation gradients and are ideal sites for energy producing hydropower dams. Shoals in free-flowing rivers are often influenced by upstream alteration to hydrology such as frequent draw-downs or hydro-peaks. These hydrologic changes are amplified during drought conditions, such as those experienced in the Georgia Piedmont during 2007 - 2008. Our study in the Middle Oconee River, Athens, GA, investigated effects of hydrologic alteration at a fine scale with respect to the aquatic macrophyte *Podostemum ceratophyllum* Michx. (*Podostemaceae*). Through information-theoretic analysis (AIC), we found higher support for predictive models of *P. ceratophyllum* biomass that included hydrology factors such as the number of hours in the past 30 days with less than a water depth of 5cm. The relationship between *P. ceratophyllum* biomass and duration of low water depth was negative. We projected that about 2% of our transect may experience these stressed conditions at or above 45 cubic feet per second (cfs), which is the 7Q10. We modeled biomass loss to be close to 8% in 30 days under the average number of hours under 5 cm of water that our samples experienced. We found that *P. ceratophyllum* biomass in 2007-2008 was less than half as large compared to 1956-1957 and 1991-1992 studies, and investigated variations in annual hydrology to help explain this difference.

INTRODUCTION

Over the past fifty years, humans have modified aquatic habitats in significant ways. Surface water withdrawals have increased 20-fold over this time (Revenga et al. 1998 in Silk and Ciruna 2005), and impoundments have influenced 60% of large river systems (McCully 2001). These dams and water extractions alter the natural flow regime (Rosenberg et al. 2000) and change transport of nutrients, sediment and biota within the system (Silk and Ciruna 2005). Not only can hydrologic alteration reduce the overall flow (i.e. via water extractions), it can also change the magnitude, duration, timing and seasonality of biologically important flows (Poff et al. 1997). These alterations can occur at varying time scales, such as hourly, daily, monthly, annually and inter-annually (Gehrke and Harris 2001).

The historic pattern of flow variations in a specific riverine system influences composition of the resident biota. The life-histories of many aquatic organisms rely directly on flow characteristics to signal the onset of certain life stages. Many studies have examined how even small variations in the natural flow regime may have large impacts on fishes (Anderson et al. 2006, Dutterer and Allen 2008, Freeman and Marcinek 2006, Propst et al. 2008, Roy et al. 2005), macroinvertebrates (Dewson et al. 2007, Malmqvist and Englund 1999, McIntosh et al. 2002, Rader and Belish 1999, Suren et al. 2003a), byrophytes (Englund et al. 1997) and even periphyton (Suren et al. 2003b). Few studies exist however, that investigate aquatic macrophyte changes as a result of hydrologic modifications. A limited amount of research has looked at long-term consequences of hydrologic alteration for plant communities within the floodplain (Pettit et al. 2001), and emergent macrophyte growth and recession in rivers (Ham et al. 1981), though almost no reported effort has been devoted to effects of hydrologic alteration on submerged macrophytes. Given the limited range of movement for sessile aquatic plants, and the increasing frequency with which we are altering the natural flow regime of most rivers, it is important to understand how flow alterations may influence these important primary producers.

We chose to investigate the effects of hydrologic alteration on the aquatic macrophyte *Podostemum ceratophyllum* Michx. (Riverweed), as it is a key foundational species (Ellison et al. 2005) for shoal habitats, which support a large number of imperiled fishes and federally endangered fishes (Freeman and Freeman, 1994). *P.ceratophyllum* thrives in swift water on rocky substrates (Hammond, 1937), and provides a complex habitat structure for the benthic community (Argentina 2006, Grubaugh and Wallace 1995, Hutchens et al. 2004). It has been associated with increased abundances of macroinvertebrates (Hutchens et al. 2004, Grubaugh and Wallace 1995, Voshell and Parker 1985) as well as increased presence of fish species (Argentina 2006, Connelly et al. 1999, Hagler 2006, Marcinek 2003). *P.ceratophyllum* has been noted to have lower abundances in areas of scouring or daily pulses from upstream hydroelectric dams (Hill and Webster1984), and may dry, break and flow downstream after experiencing low flow events (Nelson and Scott 1962, personal observations 2007- 2008).

Often hydrologic alteration is quantified by modeling changes in hydrologic data at a daily timescale, assessing for deviations from historical norms (Richter et al. 1996). A commonly used program, Indicators of Hydrologic Alteration was developed through The Nature Conservancy to analyze hydrologic changes, but presents problems of redundancy (Olden and Poff 2003) with respect to parameters and a bias towards longer time frames. Many current hydrologic alteration studies are not focused on fine-scale hydrologic modeling. Our goal was to estimate the effects of low flows and exposure events at an hourly timescale on *P. ceratophyllum* biomass at specific sample localities within our study site. We used an Information Theoretic approach (Burnham and Anderson, 2004) to evaluate alternative models of factors affecting *P. ceratophyllum* biomass, because we believe it to be more biologically meaningful to determine the relative effect of parameters rather than to accept or reject them completely with traditional null hypothesis testing.

We expected lower *P. ceratophyllum* biomass today than the two previous studies (Grubaugh and Wallace 1995, and Nelson and Scott, 1962), which were conducted during non-drought periods (USGS 2008). We anticipated that variation in *P. ceratophyllum* biomass within this shoal would be related in part to low flow hydrology factors. We wondered, however, whether we would be able to quantify a linear effect of increasing frequency or duration of low flows on *P. ceratophyllum* biomass by examining patterns across a topographically varied shoal environment (where some areas were more subject to becoming shallow or dry than others).

METHODS

Study site

This study was conducted at the shoals of the Middle Oconee River at Ben Burton Park, Athens, Georgia. The Middle Oconee River is a sixth-order river in the upper Altamaha watershed. It has a number of tributaries and eventually joins with the North Oconee River in Athens to form the Oconee River, and ultimately the Altamaha River.

The headwaters of the Middle Oconee River are in the Piedmont physiographic province at an elevation of approximately 1,000 feet above the mean sea level (GA DNR, 1998). The headwater streams are entrenched, have small floodplains and steep longitudinal gradients ranging from 4.5-7.4 feet per mile (GA DNR, 1998). The steeper portions are often reflected by shoal habitats within the channel.

This study site on the Middle Oconee has a drainage area of about 641 km^2 (USGS, 2008). Over half of the land in this basin is forested (~55%), however approximately 20% is pasture and row crop, about 9.5% is low and high impact urban development, and 6.6% is clear cut (NARSAL, 2008). In the 1950's, approximately 40% of the basin was used as farmland and 10% of this was in cotton, and by the 1990's, less than 20% of the basin was in cropland (Grubaugh 1994).

Within the Oconee River Basin, there are 14 withdrawal points for drinking water supply, 5,467 instream impoundments that cover 147 square kilometers, and three major surface water reservoirs (GRN 2008). The Oconee River is part of the larger Altamaha River basin, and in 2002, the Altamaha River was listed as the 7th most endangered river in the country due to the loss of water flow from reservoirs and power plants (GRN 2008).

The study shoal is located within Ben Burton Park, Athens, GA and is characterized as a bedrock outcrop. The hydrology of the shoal study area is highly influenced by two upstream facilities. The first is Bear Creek Reservoir, which is privately owned by the Upper Oconee Basin Water Authority and supplies water to Athens-Clarke County Public Utilities and three other surrounding counties. Bear Creek

Reservoir, constructed in 2002, is a pump-storage facility that is located outside of the river channel (on the former location of the stream named Bear Creek) spanning 505 acres. The intake point used to fill the reservoir from the Middle Oconee River is located approximately 2 miles upstream of the study shoal. The reservoir pumps operate from 8AM to 4PM and may withdrawal between 7 and 15 million gallons per day (MGD) under drought conditions, and 20 and 60 MGD during non-drought conditions (Williams 2007).

The second facility above the shoal is the Tallassee Shoals Hydroelectric Dam, which is operated by FLHC, Inc., and is located about 800 meters downstream of the intake for Bear Creek. This dam maintains a federal permit and has been named a "green" dam based on its perceived low impact to the hydrology of the river. The dam operates by directing water through a chute which intersects a turbine and produces energy. Any water that enters the chute is released approximately 3000 meters downstream through the headrace. If there is more water in the river than the capacity of the chute, water flows over the dam. When the discharge is $<100ft^3/sec$ or $>900ft^3/sec$ the dam cannot operate, so the chute is closed allowing water to flow over the dam itself. Under these conditions, when the small reservoir behind the dam is full, the upstream discharge equals the downstream discharge over this structure. According to the dam operator, it has not been used since the summer of 2007 due to low flow conditions that made it inoperable; in this situation, the dam and did not affect the hydrograph and hydrology downstream (Davis 2007).

In the past, the combined effect of the dam and pumping water to fill the reservoir has significantly changed the natural hydrology of the shoals just downstream. In recent months, with no dam operation, the water withdrawals alone have caused changes in the hydrology. This alteration is evident by the differences between U.S. Geological Survey (USGS) gages upstream (Arcade, GA), and downstream (Athens, GA) of our study shoal (Figure 2.1). It is clear that these facilities between the gages have resulted in extreme alteration of the hydrograph on a daily basis over the one month period (October 1 – 31, 2007) illustrated in Figure 2.1.

An additional factor within this reach of the river is an Athens-Clarke County Public Utilities intake located at the intersection of the Middle Oconee River and Mitchell Bridge, just down-stream from Ben Burton Park, which withdrawals water for the city. This pump takes water directly out of the river to a larger treatment facility located on the north side of Athens. The facility had not been in operation since from mid-summer through autumn 2007, thus, is not likely a source of any of the variability illustrated in the hydrograph (Knight 2007).

The study shoal itself consists mainly of bedrock, large boulders, and small areas of sand and gravel. *P. ceratophyllum* is widespread throughout the shoals, covering large bedrock areas, boulders of various sizes, and in some cases gravel. Historically, *P. ceratophyllum* has formed lush mats across this shoal during the growing season and has persisted throughout the winter in a more dormant stage (Grubaugh and Wallace, 1994). Red algae (*Rhodophyta*) are also common.

Due to the recent extreme drought of 2007-2008, much of the area that previously supported *P. ceratophyllum* has been exposed and the plant has died (Image 2.1). Many of the remaining refuge areas however are subject to fluctuating hydrology on a daily basis due to the upstream water withdrawals, which is compounded by the already low flows from persistent drought conditions.

Data Collection

Samples

We sampled *P. ceratophyllum* along a 100-meter long transect that defined a cross-section of the channel from one bank to the other. We used a nylon cord on a spool as a transect line which was affixed to trees on either bank. The cord was labeled at approximately 1 meter intervals with a permanent marker and every 2 meters with flagging tape. We defined five distinct sections along this transect based on substrate and topographical differences (Table 2.1).

P. ceratophyllum was sampled monthly by collecting two samples per section for a total of 10 samples. Sample locations were randomly produced and never re-sampled. If a sample point was dry, we chose the next random location. At each sampling location, we used a 103.87 cm^2 t-sampler with a 250µm mesh sleeve to collect all materials from the substrate. The sampler was pressed firmly to the substrate to prevent loss of materials. We used a metal putty knife and our hands to scrape *P. ceratophyllum* and its associated macroinvertebrates and algae. These materials were then placed into a plastic zip-lock bag and stored on ice until we returned to the lab within 2 hours of collection.

We then used an Earl Dudley Associates Inc. (Birmingham, AL) TC600 Total Station to record the distance along the transect and relative elevation of the sample location. Velocity measurements were recorded at 60% depth for each sample using a Marsh-McBirney Flo-Mate™ Model # 2000. A DataSonde 4a Water Quality Multiprobe (Hydrolab Corporation, Austin, TX) and a 2100P HACH Turbidmeter were used once in the same location at each sampling time to record water quality parameters including pH, turbidity, temperature, dissolved oxygen and specific conductivity.

After returning to the lab, the ten samples were stored in a refrigerator for no more than 48 hours (and usually less than 4 hours) before sorting. Macroinvertebrates, algae and remaining detritus were removed from the *P. ceratophyllum* under 0.8x and 5x magnification.

P. ceratophyllum separated from the samples was then placed onto pre-weighed aluminum trays and dried at 60°C for at 5 to 7 days before weighing. The samples were then ashed in a muffle furnace at 500°C for 5 hours and then cooled for 24 hours in a desiccator. The dry weight was subtracted from the final weight to determine the ash free dry mass (AFDM) of the samples.

Hydrology

In order to understand the hydrological changes experienced by each sample location, we developed a fine-scale hydrologic assessment. A USGS gage located downstream of our study shoal recorded discharge and stage at 15 minute intervals. An Athens-Clarke County (ACC) Public Utilities intake was located between our study site and this gage, so we added back discharges withdrawn from this facility to the discharge recorded at the USGS gage. This provided us with an estimate of the gage reading if this uptake did not exist. (The ACC data were only available in hourly format, so we used hourly USGS data for this study).

An Onset HOBO (model # U20-001-04) pressure transducer (HOBO 1) was installed in December 2008, at the deepest portion of our cross-section (which was adjacent to the bank on river-left) to allow for more detailed hydrologic analysis. To secure it, we drilled four holes in a large boulder using a DeWalt pneumatic drill, and attached four eye bolts using epoxy glue. Zip ties were then used to attach a PVC chamber to the boulder to house HOBO 1. A plastic-coated steel wire was affixed to HOBO 1cap and secured to shore and the boulder. The boulder was then placed in the deepest location accessible and wedged between other rocks. While rare extreme high flows could potentially move the boulder, the steel wire would prevent a total loss of the HOBO.

HOBO 1 recorded changes in pressure at 15 minute intervals at this location, and in April, 2008, we installed a second pressure transducer (HOBO 2) above the water and to a tree, to adjust the pressure readings of our submerged HOBO (HOBO 1) for changes in atmospheric pressure. Data from both pressure transducers were downloaded and formatted using the Onset HOBOware Pro for Windows software package. We used a linear regression correlation to relate the water depths at HOBO 1 with the USGS stage readings. This relationship resulted in an equation for estimating changes at HOBO 1 location before it was in place (September to December 2008). We used this correlation to estimate hourly water depths for the 30 days prior to collecting each sample over the course of our sampling year.

In order to estimate how changes at the HOBO 1 location related to changes in depths across the cross-section for every sample, we conducted a number of surface water elevation assessments at approximately 2 meter intervals identified by pre-measured flagging tape (Figure 2.2). We also recorded the elevation of the substrate underneath each flag, and thus were able to generate water depth at those points. A regression between the water depth at each flagged point along the cross-section over time and the HOBO 1 water depth at the same time intervals resulted in individual equations relating HOBO 1 depth to depth at each flag over time. In most cases, a third order polynomial fit the data best due to an apparent inflection point at the middle discharge levels. However, changes in depth over a range of low flows appeared approximately linear in relation to depth at the transducer, and so we fit and used linear regressions to predict temporal sequences of depths at low flows along this cross-section. We accept that this may have resulted in a larger error at the higher water elevations, however, we were interested in the lower water elevations and how those changes impacted biomass during drought. At this scale, we were able to estimate the hydrologic history at one hour intervals for each 2 meter interval along the transect.

We determined each flag to be the center point of a 2 meter section to which this history was applied. Water depths over time were then calculated for all samples falling within each 2 meter section. To do this, we determined the difference in elevation between the flag location and the sample location. If the elevation at the sample was lower, we added this difference to the simulated water depth history. If the elevation at the sample was higher, the difference was subtracted, as we assumed the water to be shallower.

We did not conduct regressions between HOBO 1 and the first 21 meters (flags 2 – 10) because we determined the surface water elevation to be relatively flat in that section, meaning that changes at HOBO 1 were similar if not the same across that section. We related all samples collected within the first 21 meters of the transect directly to the HOBO 1, by calculating the difference in elevation between HOBO 1 and the bed elevation at each sample. This difference was either added for deeper samples or subtracted for shallower samples to generate a depth history for each sample location.

To determine frequencies and durations of exposure or stress events experienced at each point along the transect prior to being sampled, we used a binary system to label depths equal to or less than zero (dry) as a "1" and those greater than zero as "0." Additionally, in a separate analysis, we labeled depths less than five centimeters (stressed conditions) as "1" and those above five centimeters as "0." This system allowed us to sum exposure or stress events in terms of hours of duration to determine the frequency with which these events occurred at various time intervals. We used five centimeters to represent a "stressed" condition because depths that low may result in a partial exposure due to the vertical structure of the plant.

Statistical analysis

An information-theoretic approach (Anderson et al. 2001) was used for statistical analysis to allow investigation into the effect of several hydrologic and habitat variables on *P. ceratophyllum* biomass. We hypothesized that a combination of hydrology variables as well as substrate type, velocity, day and location within the channel would influence the *P. ceratophyllum* biomass (the response variable). Biomass was log-transformed because it was not normally distributed (Box and Cox 1964).

We determined that "day" may have a significant effect on the biomass collected from a given sample because concurrent work on *P. ceratophyllum* re-colonization rates found that season was a significant driver of the rate of asexual colonization (Chapter 3, Pahl 2009). If drying events occurred within a specific season, biomass collected may have been influenced by the time of year. Day was recorded as Julian day, and due to the season effect, a quadratic relationship between Julian day and biomass was determined to be the most appropriate. Thus, we use day and day^2 to account for this.

Substrate is also an important factor, as *P. ceratophyllum* grows predominantly on bedrock and boulders, but occasionally gravel. We hypothesized that *P. ceratophyllum* biomass would reflect the substrate, where bedrock and boulders may allow more *P. ceratophyllum* biomass to accumulate than gravel and cobble. This variable was categorized as discrete with a "1" representing bedrock/boulder, and a "0" representing gravel/cobble.

Velocity was included in the analysis and was reported as the velocity on the day the sample was taken, and reflects the general velocity of that site over time. While changes in velocity may occur seasonally, thus we took our samples at base flow, and hypothesized that if they were reflective of the prevailing base flow velocities, then our measured velocities should relate positively to *P. ceratophyllum* biomass. Based on previous work (Hammond 1937), we hypothesize that faster velocities will generally positively influence *P. ceratophyllum* biomass.

The location factor is an indication of the location of the sample within the channel. It is a binary variable with a "1" representing samples taken within the 12 meters of either edge of the channel (representing 25% of the transect) where shading occurs for the longest period of time, and a "0" representing samples taken on the center 75% of the channel. We hypothesize that location in the center of the channel with full sun for the longest period of time will positively influence *P. ceratophyllum* biomass (Argentina 2005).

For hydrology factors, we determined, through basic growth simulation models, that the single longest exposure event within the last 30 days, and the total number of hours of exposure during the last 30 days may be the largest drivers of change in biomass. We also hypothesized that water depths less than 5 cm might "stress" *P. ceratophyllum*, and therefore we identified total hours of water depths less than 5 cm as well as the longest time under 5 cm. These two variables represent "stressed" hydrologic conditions.

To understand how all of these variables related to *P. ceratophyllum* biomass, we first analyzed the effects of the five non-hydrologic covariates (day, day^2, substrate, velocity and location) using multivariate linear regression in SAS v 9.1 (SAS Institute, Inc., Cary, NC, USA). There were no strong correlations among the covariates (except of course day and day^2, all $r^2 < 0.52$). Our 32 covariate models included combinations of all five variables as well as the interaction between location and day/day^2, as we believed that the location effect was influenced by the time of year, as more riparian foliage was present for shading during spring and summer. We did not test other interactions because we did not believe they were scientifically relevant (Anderson and Burnham 2002). We used Akaiki's Information Criterion (AIC), adjusted for a small sample size (AICc) to evaluate the relative support for each of these models (Anderson and Burnham 2002) using Proc GLM. We then chose the most supported models (those with AICc values within two of the best supported model) to analyze with our four hydrology variables. We did not include models with more than one hydrology variable or interactions because they were highly correlated.

Our final model set included the best supported habitat covariate models and each of these models with one of the four hydrology variables included for a total of 30 models evaluating 92 samples. This design resulted in a balanced representation of all variables within the models (Anderson and Burnham 2004), thus we were able to test the relative support for each hydrology parameter and the habitat covariate models independently. To do this, we used the total weights for each model that contained each variable and added them for a total parameter weight (Anderson et al. 2001, Anderson and Burnham 2004).

RESULTS

Biomass comparisons

A comparison between our study, Grubaugh and Wallace 1995, and Nelson and Scott 1962, indicates a significant decline in *P. ceratophyllum* in recent years (Figure 2.3). Biomass values are significantly lower on average than those reported by Grubaugh and Wallace (n=24, Fcrit=4.30, P < 0.0001) and Nelson and Scott (n=24, Fcrit=4.28, P < 0.0001). Mean annual standing crops for our 2007-2008 study was 54.04 ± 7.14 gAFDM/m^2. Compared with mean monthly standing crop from Nelson and Scott's 1956-1957 study (350.2 ± 33.8 gAFDM/m^2) and Grubaugh and Wallace's 1991-1992 study (514.0 ± 53.2 gAFDM/m^2), our results were an order of magnitude lower (Table 2.2).

Covariate Analysis

Comparison of relative support among the models using habitat and time of year variables to predict *P. ceratophyllum* biomass resulted in six models with AICc values within 2 of the top model (Table 2.3). The most supported model included the substrate, location, day and day^2 covariates, and was 1.35 times more likely to be the true model than the second model. The top six models had about 68% of the total model weight, and location in the channel was included in all six models along with time of year (day and day^2).

Hydrologic Analysis

We ran the six best-supported covariate models with each of the four hydrology variables added, giving 24 models, and combined these with the six habitat-covariate only models to yield a final set of 30 models. Of these 36 models, there were 8 models within 2 delta AICc values of the top supported model (Table 2.4). The top model with an AIC Weight of 0.11, was 1.55 times more likely to be true than the second most supported model, and 1.72 times more likely to be true than then most supported null model. The top model consisted of substrate, location, velocity, day and day^2 and total number of hours under "stressed" conditions (< 5cm). We summed total AIC weights across all models containing each hydrologic variable. We found the most support for the hydrology variable describing of the total time under 5 centimeters (Total AIC weight: 0.37), which was 1.57 times more likely to be true than total AIC weight of null covariate models (Table 2.5). We also calculated the parameter estimates for the most supported model (Table 2.6).

Parameter estimates from the top model were used to estimate percent log biomass loss at a range of total hours spent with less than 5 cm of water (Table 2.7. Samples experiencing the minimum time under low water (2 hours) may lose approximately 0.06% biomass in 30 days, while those experiencing the longest duration (687 hours) may lose up to 21% biomass in 30 days. The average of percent loss expected under average low water conditions is approximately 8% in 30 days.

Effect on the cross-section

In order to determine the effect of low flows as described by the hydrology factor (total hours below 5 centimeters) in the best-supported model on *P. ceratophyllum* standing crop along the cross-section, we first estimated the discharge at which the cross-section would theoretically become stressed. Using the water depth regression equations for each two-meter interval, we determined the depth at HOBO 1 at which the interval would go dry (depth = 0 cm) and become stressed (depth = 5 cm). We used a regression equation between HOBO 1 and the USGS stage downstream to determine discharge in cubic feet per second (cfs) at the cross-section. Flows at 55 cfs resulted in 2% of the transect experiencing stressed conditions (depth = 5cm), while discharges of 10 cfs resulted in 85% of the cross-section stressed with 51% completely exposed (Figure 2.4).

To understand how much of this biomass reduction may be due to water withdrawals vs. drought induced low flows, we calculated the difference between drainage areas at the upstream gage in Arcade, GA and Athens, GA. This difference was used to adjust the Arcade gage discharges to what we might expect at Athens with no withdrawals (Figure 2.8). Adjusted flows for the Middle Oconee River did not fall below 20 cfs, which indicates that flows less than 20 cfs may be the result of withdrawals from the upstream pump storage reservoir. Flow at our study site was below 20 cfs for 460 hours over the last year.

DISCUSSION

The results of our study indicate some substantial changes in *P. ceratophyllum* biomass within the shoal of the Middle Oconee River at Ben Burton Park, Athens, GA. Inter-annual declines in biomass appear to be significant, and hydrologic stress may be a factor in this reduction.

One possible reason for the difference in *P. ceratophyllum* biomass reported in our study and Grubaugh and Wallace's 1995 study was the sampling protocol. We sampled randomly, and only avoided locations that were dry or sandy depositional areas. Grubaugh and Wallace (1995) report avoiding locations where shallow conditions occurred and exposure events were possible. Although this might have influenced the overall averages, only 2 out of 104 samples taken in the present study were above 296.8 g-AFDM/m^2 which was Grubaugh and Wallace's lowest recorded biomass (no samples were as large as Grubaugh and Wallace's average of 514g-AFDM/m^2; Figure 2.6). Whereas our sampling protocol may have been expected to result in lower average *P. ceratophyllum* biomass estimates compared to the earlier studies, the overall lack of samples approaching those previously reported averages strongly supports the notion that *P. ceratophyllum* was considerably reduced.

Additionally, Grubaugh and Wallace (1995) report a decline in cropland coverage, specifically cotton and corn, as a possible reason for water quality conditions that supported slightly higher *P. ceratophyllum* biomass results in their study compared with an earlier study by Nelson and Scott (1962). Today, cropland coverage in the same three counties, Barrow, Clarke, and Jackson, remain at similar acreages with 27% in 1991, and 28% in 2005 (NARSAL 2008). The only county in which cropland and pasture acreage increased since 1991 is in Jackson County, but only by approximately 6500 acres (NARSAL, 2008). The lack of change in cropland indicates that this may not be the driver of decreased biomass in this study compared with the last two studies, given that Grubaugh and Wallace (1995) predicted that increasing cropland would negatively affect water quality and consequently *P. ceratophyllum* biomass.

Changes in impervious surface however have been quite significant, as the three counties experienced an increase from 9% low and high impact urban land cover in 1991 to 17% in 2005 (NARSAL 2008). As our study site is located upstream of much of Clarke County, we also looked at this change with respect to Barrow and Jackson county alone (upstream counties). In these two counties, low and high intensity urban land cover went from 5% in 1991 to 10% in 2005: a change of only 5% (NARSAL 2008). While the increase in urban land cover is undoubtedly bound to change water chemistry, data are not available for this comparison. Roy et al. (2005) report that impervious surfaces can change hydrologic regimes, including increased flashiness and possible reductions in base-flow due to declines in infiltration. Reduced base-flow from impervious surfaces may further exacerbate the effect of daily hydrologic changes from water withdrawals or hydroelectric operation. Increasing urban land use is also linked to rising populations, which require more extractive water use.

Subsequent to the studies conducted in the 1950's and 1990's, a pump storage facility (Bear Creek Reservoir) was constructed in 2002. No water return structure exists between Bear Creek Reservoir and our study shoal, thus less water is reaching the shoal today than before 2002. Figure 2.5 illustrates the differences in hourly discharges across this site over each study year. Flows were higher during Grubaugh and Wallace's 1991-1992 study, so despite hydrologic alteration likely due to dam operations (Figure 2.1), low flow conditions did not occur to the extent that they do today. Comparisons between hydrographs in Athens, GA and upstream of these facilities in Arcade, GA, indicated that over the year of our study, 175 withdrawal events occurred, spanning 47.9% of the year, where average withdrawals were 35.6 cfs.

Another source of declining biomass between study years could be herbivory by geese and crayfish (Parker, 2005). As water levels declined during the drought of 2007-2008, low flows resulted in easier access to *P. ceratophyllum* through shallower depths and lower velocities. Parker (2005) notes that deeper faster water was problematic for geese as they tended to be washed downstream and as a result are unable to graze.

Although our results indicated a negative effect of the number of hours *P. ceratophyllum* experienced water depths less than 5 cm, the standard error spanned zero (-0.0013 ± 0.0014 log g-AFDM/m^2/hr), indicating the possibility of a positive effect of such flows. This may relate to heavy periphyton coverage during the summer months, which could die during short exposure events and move downstream during subsequent storm flows. This would remove periphyton from its location on top of *P. ceratophyllum* where it competes for sunlight.

The estimated loss of *P. ceratophyllum* biomass over 30 days varies quite widely based on the number of hours spend under low water conditions, however the average of all samples experiencing low water depths indicates over an 8% loss. Based on predicted base flows using an upstream gage, we think that up to 83% of the low flows may be due to drought; however the remaining 17% may be due to water extraction to fill Bear Creek Reservoir. These results indicated that water withdrawals for consumptive use may have repercussions for benthic macrophytes under drought conditions.

While information-theoretic approaches may not illicit causality for different variables in relation to the *P. ceratophyllum* biomass, we feel it provides insight into the nature of the relationships and reasonable support for the inclusion of certain variables when thinking about *P. ceratophyllum* work. Our study indicates that indeed, hydrology does influence *P. ceratophyllum* biomass to some degree, as a hydrology variable was included in the most supported model. While the estimated effect of this hydrology parameter has an error that spans zero, it is likely that future work to increase the precision of this estimate will result in a negative association between low flows and *P. ceratophyllum* biomass.

As we look towards the future, it is becoming more evident that the southeastern United States may experience increases in winter precipitation as well as increased evapotranspiration in many climate change scenarios (Mulholland et al. 1997). The combination of these two factors may result in declines in summer and fall runoff which influences stream flow (Mulholland et al. 1997). To compound this problem, population growth rates in this region remain some of the highest in the country, and will likely require more surface water extraction. Dewatering of rivers for consumption will likely increase the severity of future droughts and low flows (Seager et al. 2007).

Through this research, we have indicated that hydrologic changes, as a result of droughts and water extractions, may have negative implications for aquatic macrophytes that are key foundational species in shoal habitats. While the effects of hydrologic alteration are difficult to separate from all environmental factors which shape species persistence and productivity (Rosenberg et al. 1997), this type of analysis has allowed us to investigate the relative likelihood that hydrology, particularly very low flows, plays a role in shaping *P. ceratophyllum* biomass.

In order to better estimate the effects of variable hydrologic regimes, we recommend a more spatially expansive approach, investigating hydrology effects at the shoal-wide scale, and ultimately reach and basin scale. This type of work may provide more precise estimates of low flow effects on *P. ceratophyllum* biomass that are meaningful for management. We also recognize the possible contributions of field or mesocosm experiments looking at *P. ceratophyllum* productivity changes during various hydrologic regimes through the use of ^{14}C uptake chambers (Hill and Webster 1984) to measure use of dissolved inorganic carbon, which is a common method to quantify aquatic plant productivity. This type of analysis may provide more evidence of causality.

CHAPTER 3

RECOVERY AND RE-COLONIZATION POTENTIAL FOR *PODOSTEMUM CERATOPHYLLUM* (RIVERWEED) IN A SOUTHEASTERN PIEDMONT RIVER

ABSTRACT

Shoal habitats in southern Piedmont streams provide a unique environment for a multitude of aquatic organisms. Hydrologic alterations through reservoir and dam installation, as well as surface water withdrawal for municipal, industrial and agricultural uses, have impacted the natural flow regimes of riverine shoals. Pronounced drought, as has been documented in northern Georgia in 2007 and 2008, exacerbates these impacts. The aquatic macrophyte *Podostemum ceratophyllum* Michx. (*Podostemaceae*), is a major primary producer in these shoal habitats that generally support a diversity of macroinvertebrates and fishes. As a result of the current drought, large areas of *P. ceratophyllum* have become desiccated or stressed in the Middle Oconee River, which may have implications for species at higher trophic levels. My study in the Middle Oconee River shoals, Athens, GA investigated local rates and mechanisms of re-colonization after disturbances such as those experienced over the last two years. *P.ceratophyllum* was able to recover rapidly (within a month), primarily through vegetative growth, during the growing season (May-October), but experienced very little colonization during the winter and early spring. It appears as though recovery through seed dispersal is limited; however more in depth studies could clarify this. Ultimately, this research can be utilized to aid in the development of more comprehensive in-stream flow recommendations in order to sustain macrophyte abundances and their associated biota.

INTRODUCTION

Throughout the past century humans have greatly modified natural riverine flow regimes. Today, over 5,500 dams higher than 15 m tall exist in the United States alone and over 7,000 in North America (Pringle et al. 2000). These impoundments have considerably changed flow regimes and altered ecosystems along river continua (Freeman et al. 2007, Bunn and Arthington 2002, Naiman et al. 1995, Sparks 1995, Ward et al. 1999)

There has been a substantial response by the scientific community resulting in a large body of work illustrating upstream and downstream effects of stream diversions and impoundments on macroinvertebrates (Dewson et al. 2007, Malmqvist and Englund 1999, McIntosh et al. 2002, Rader and Belish 1999, Suren et al. 2003a), fishes (Anderson et al. 2006, Dutterer and Allen 2008, Freeman and Marcinek 2006, Propst et al. 2008, Roy et al. 2005) as well as bryophytes (Englund et al. 1997) and periphyton (Suren et al. 2003b). In some cases, the removal of impoundments has allowed for studies of fish and invertebrate re-colonization (Catalano and Bozek 2007, and Kanehl et al. 1997). While some of these systems have experienced restorative management, there has been little support for long- term monitoring of the recovery of the benthic community after such efforts (Bernhardt et al. 2007).

Though there have been a number of studies investigating long-term changes from hydrologic alteration in plant communities within the floodplain (Pettit et al. 2001), and emergent macrophyte growth and recession in rivers (Ham et al. 1981), this study offers one of the first investigations into the potential for recovery of a submerged macrophyte, *Podostemum ceratophyllum*.

The flowering aquatic plant *P. ceratophyllum* thrives in the swift, bedrock- and boulder-dominated streams and rivers of eastern North America (Hammond 1937). *P. ceratophyllum* is the most dominant macrophyte in riverine shoal habitat in Georgia and is ecologically significant for a number of reasons. *P. ceratophyllum* is highly productive (Hill and Webster 1984) and has been linked with the highest secondary production of filter feeders (Grubaugh and Wallace 1995, Grubaugh et al. 1997) ever recorded in streams (Huyrn and Wallace 2000). *P. ceratophyllum* on bedrock appears to be particularly important for secondary filter-feeders when compared with cobble habitats (Rosi-Marshall and Meyer, 2004).

Hutchens et al. (2004) documented the importance of *P. ceratophyllum* for macroinvertebrate communities, finding that removal of this species resulted in a much lower total macroinvertebrate abundance and biomass. They also indicated that the recovery of such communities were extremely slow. *P. ceratophyllum* presence has also been correlated with the presence of a number of fish species through the southeast (Argentina 2006, Connelly et al. 1999, Hagler 2006, Marcinek 2003). *P. ceratophyllum* may provide fish, especially small ones, with refuge from predation, and food in the form of macroinvertebrates (Argentina 2006).

Over the past few decades, *P. ceratophyllum* has been in decline in many of the north-eastern states presumably due to various impacts such as poor water quality or hydrologic alterations. In Georgia, *P. ceratophyllum* is not listed as endangered or threatened, as it is in the northeastern U.S., however recent climatic events have caused significant negative impacts.

The drought of 2007-2009 has sent river water levels to record lows causing a widespread desiccation of *P. ceratophyllum.* The areas of remaining *P. ceratophyllum* are under additional stressors in some regions where hydrologic alteration, in the form of extreme fluctuations in discharge, increases the severity of daily trauma to the plants. Increasing human populations in Georgia may demand more of our water resources, exacerbating this problem in the future.

This study is designed to investigate how *P. ceratophyllum* recovers from removal disturbances such as short term desiccation under a variable hydrology due to anthropogenic alteration of the natural flow or scarification from debris flow. It is imperative to understand recovery potential and growth of *P. ceratophyllum* given that it is an important base to the biological structure within southern Piedmont Rivers.

To assess the rate of re-colonization of *P. ceratophyllum* under the current conditions, I conducted a removal study. Most studies to date collect *P. ceratophyllum* samples at discrete locations and compare these over time. In these cases, the sampling occurs in random locations so there is no temporal aspect to the individual sample itself, beyond the season. To understand how a specific location may change in terms of *P. ceratophyllum* biomass over time, I utilized a repeated measures experimental design to examine re-colonization.

METHODS

Study Sites

This study was conducted at two different sites; the Middle Oconee River and Hunnicutt Creek, a tributary to the Middle Oconee. The two sites allow comparison of *P. ceratophyllum* re-colonization in contrasting hydrologic regimes.

<u>Middle Oconee River (MOR):</u>

The Middle Oconee River at Ben Burton Park, Athens, Georgia is a sixth order river within the upper Altamaha watershed. It has a number of tributaries and eventually joins with the North Oconee River in Athens to form the Oconee River, and ultimately the Altamaha River. The study site is located in the north-west corner of Athens-Clarke County, and is north of a USGS gauging station.

The study site is characterized by bedrock a bedrock outcropping and scattered boulders, gravel and sandy pools. The hydrology of this site is heavily altered by upstream water extraction (see Chapter 2 for more details) as well as prevailing drought which has impacted this region beginning in 2007. Due to the extreme drought conditions, much of the area that previously supported *P. ceratophyllum* has been exposed, resulting in mortality of the Riverweed. Many of the remaining refuge areas however, are influenced by the upstream water extraction which causes daily fluctuations in discharge on the order of 13 to 28 cfs (7-15 MGD) which is permitted under drought conditions.

While current conditions do not allow for widespread re-colonization within this shoal due to low base flow and continuing fluctuations, a manipulative study has allowed us to assess the rates of *P. ceratophyllum* recovery from two different mechanisms. We intend to use these data to inform management plans regarding current water withdrawals and future extractions. As the local rates may be influenced partially by the recurring withdrawals, a comparison was made with an adjacent tributary population that was not subjected to major daily fluctuations in hydrology.

Hunnicutt Creek (HCC):

Hunnicutt Creek is a tributary to the Middle Oconee River and enters at Ben Burton Park. Hunnicutt Creek is spring fed with a generally unaltered hydrology, except for the possibility of runoff from localized impervious surfaces. The lowest 100 meters of the stream before its confluence with the Middle Oconee is predominantly bedrock and supports one main patch of *P. ceratophyllum* as well as a number of very small patches approximately 30m upstream. Within the study area of Hunnicutt Creek, *P. ceratophyllum* is only found on bedrock.

Hunnicutt Creek was subjected to an oil spill in October of 2003 (Shearer, 2003). The Upper Oconee Watershed Network has been monitoring this creek since then. It appears as though the stream has recovered however, and *P. ceratophyllum* coverage is near 100% where wetted bedrock occurs in the lower portion (the upper portion contains bedrock as well, but heavy shading likely excludes *P. ceratophyllum* from these locations).

Experimental Design

P. ceratophyllum populations may be affected by small-scale disturbances, such as scouring during a storm event or when a change in hydrology temporarily desiccates a patch. It is important to understand how much re-colonization occurs from local processes such as from vegetative in-growth versus seeds or cloning propagules from distant sources. This information will be especially important if climate change and modified hydrology continue to impact the quantity of remaining viable habitat.

In order to assess re-colonization of disturbed areas of *P. ceratophyllum*, it is important to consider the two major pathways of dispersal: seed germination and vegetative cloning (Hammond 1937). *P. ceratophyllum* can undergo sexual reproduction; however it predominantly undergoes pre-anthesis cleistogamy, a form of self-pollination (Philbrick et al. 2006). Philbrick (1984) also reports that *P. ceratophyllum* can form seeds above or below the water level, and that the seeds then flow downstream until the outer mucilaginous coat allows them to attach to a surface (usually a bare hard substrate). Philbrick (1984) also found that these seeds were often dislodged by rising water levels. Low flow conditions could either enhance germination through increased area of bare lodging sites, or decrease it through drying stress on new seedlings. Philbrick (1984) found that only one of his three study populations produced viable seeds, indicating that this mechanism may not be the most important.

In the field, these differing types of common colonization, seed dispersal and vegetative growth, can be studied through two experimental designs. First, small scale disturbances could result in patches of destroyed *P. ceratophyllum* surrounded by a larger colony. If the patch within the larger colony has the same substrate, bedrock in this case, the mechanisms for re-colonization could include vegetative spread through cloning, seed accrual, or the acquisition of a dislodged piece of *P. ceratophyllum* from upstream that contains growth meristems, which can reestablish. In an alternative situation, where a boulder is isolated by a substrate type that is not suitable for the vegetative spread of *P. ceratophyllum*, such as sand or silt, the only theoretical source for re-colonization would be seed accrual or plants dislodged upstream.

To determine what types of substrate are not suitable for *P. ceratophyllum* growth, I conducted a preliminary study in September of 2007, in which I assessed forty 30 cm transects from the center of boulder and bedrock substrate perpendicular to the flow. At each transect I characterized the substrate and *P. ceratophyllum* coverage at 5 cm intervals. I found sand and silt to be unsuitable as *P. ceratophyllum* substrate, while bedrock, boulders, and some cobble were acceptable.

Compounding factors influencing re-colonization post-disturbance could include the following: 1. the altered hydrology, including presence or absence of strong daily fluctuations beyond the natural variation, 2. percent of the area wetted at the time re-colonization was examined, 3. season, which influenced temperature and sunlight, 4. quality of the surrounding source patch, for example, in the case where the disturbance was within a patch of *P. ceratophyllum.*

I investigated colonization of disturbance sites through two different experiments, taking into account the applicable compounding factors described above. A repeated measures approach was taken to assess *P. ceratophyllum* re-colonization both within an existing patch and when isolated from remaining patches.

The following research questions were addressed: 1. What are the different mechanisms by which *P. ceratophyllum* re-colonized areas? 2. What is the rate of *P. ceratophyllum* productivity in terms of re-colonization rates within the shoal? 3. How do different local site conditions influence *P. ceratophyllum* productivity as affected by water depth and velocity? To understand these questions, two different methodologies and analytical strategies were utilized.

Patch Study:

I conducted a split-plot repeated measures study of re-colonization within an existing patch of *P. ceratophyllum* (Patch Study). The experiment consisted of two blocks of four 20cm x 20cm plots in the Middle Oconee River (MOR) as well as in one of its tributaries, Hunnicutt Creek for a total of 16 plots. In the MOR, two large patches (blocks) of *P. ceratophyllum* were identified, both near the center of the channel. Patches selected were predominantly bedrock, and appeared to maintain some flow at all times (100% area wetted) despite low discharge conditions during the drought of 2007-2008. These patches also maintained similar quality *P. ceratophyllum*, in color, average length and density of cover. The purpose of the two location blocks within the MOR was to allow for analysis of any additional spatial factors in the river that may have influenced re-colonization. As Hunnicutt Creek maintains just one major patch of *P. ceratophyllum*, only one location (block) of eight 20cm x 20cm plots was assessed there.

Four or eight 20 x 20cm plots were located within each patch by identifying areas that were relatively flat and uniform in coverage. These areas were then assessed for depth and velocity and assigned a treatment label that reflected its combination of depth and velocity (shallow: slow or deep: fast).

A comparison of velocities among plots at the beginning of this study using a student's t-test in the Middle Oconee River (MOR) and Hunnicutt Creek (HCC), found ambient velocities of the shallow plots within each site to be significantly different ($P<0.013$, $P=0.0003$ respectively) from deep plots, and no significant difference between the two sites in shallow plot velocities ($P=0.99$), or deep plot velocities ($P=0.08$).

Ambient depths of the "shallow" and "deep" plots within each site were found to be significantly different ($P<0.013$ MOR, $P=0.022$ HCC), however "shallow" plots were not significantly different between MOR and HCC ($P=0.57$), nor were the "deep" plots ($P=0.07$).

Water depth and velocity measurements were recorded during the monthly base flow when no apparent hydrological changes were occurring (early morning before upstream pumping began). The two different velocity and depth ranges found in the preliminary work are labeled "Deep" treatment, and "Shallow" treatment. The Deep treatment consists of the faster, deeper water, while the Shallow treatment is the slower, shallower water. (A factorial analysis was not conducted with the remaining two possible combinations of velocity and depth (deep: slow and fast: shallow) because they either did not exist or did not contain any *P. ceratophyllum* patches).

Each plot was scraped of any existing *P. ceratophyllum* on October 22, 2007 using a metal putty knife. A sub-sample 5cm^2 was collected during the scraping process, dried at 50^{o}C for at least 7 days, weighed, ashed at 500^{o}C for 5 hours in a muffle furnace, and the re-weighed to find the ash free dry mass (AFDM) for later comparison. The scraped plots were then marked with stakes in the two upstream corners. Holes were drilled into the bedrock using a DeWalt pneumatic drill and cement drill bits. The holes were ¼" to ½" deep. One corner was marked with a 2" metal tension rod painted orange, and the other was marked with a 1" wooden pin also painted orange. This set-up was to reduce the number of permanent objects but ensure at least one marker did not decay and was able to withstand the high flows in the river.

Each plot was observed monthly using a 20cm x 20cm x 10cm wooden box with a woven wire grid providing 400 1cm x 1cm squares. The bottom of the box was lined with upholstery foam to help create a seal on the bottom of the rock and prevent flow-through during observation at lower flows. At flows exceeding visual assessment with the box, a viewing bucket with the same grid drawn on plexi-glass bottom with a permanent marker was used. A high powered flashlight was used to illuminate the plots for easier assessment.

At each observation day, the number of 1cm x 1cm squares intersected by spreading *P. ceratophyllum* was recorded as well as the number of cells with new propagules that did not appear to be attached to spread from the surrounding patch. Water depth, velocity, and time were also recorded. The results of each observation were recorded as the number of 1 cm^2 squares intersected by *P. ceratophyllum* and the number of squares with new propagules per 20cm x 20 cm plot.

Three hypotheses were tested: 1. Recovery rates will be faster in the deep: fast plots in terms of vegetative spread because of the superior quality of the *P. ceratophyllum* in those patches (longer and greener), and the general understanding that this species grows best in fast flowing water. 2. Recovery rates from new propagules will be faster in the shallower plots as they might have the opportunity to temporarily dry down allowing for seed deposition and germination. 3. Recovery rates will be faster in Hunnicutt Creek than the Middle Oconee River despite depth: velocity treatment due to the possibility of fluctuating flow stress on plots in the Middle Oconee.

This study was conducted for 11 months. The complete methodology was repeated on May 30, 2008 to separately assess the growing season re-colonization rates and mechanisms (figure 3.4). I hypothesized that the growing season would have a higher occurrence of new propagules due to the life-history characteristics of *P. ceratophyllum*. Many of the annual plots reached 100% coverage by May, thus a growing season assessment allowed for continued re-colonization rate calculations.

Throughout the early time period of the study, it became evident that perhaps some of the "new propagule" recordings were the result of incomplete scraping that left part of the plant in the plot. To account for this, I added dry flat rocks with no initial *P. ceratophyllum,* that were approximately the same size as the plots to the patches, so they were also within a patch. I recorded percent coverage on these over time as well to better understand the rates of propagule recruitment.

<u>Boulder Study:</u>

To understand how *P. ceratophyllum* may re-colonize an area with no local source for vegetative spread, I evaluated boulders that were isolated by sandy substrate (Boulder Study) within the Middle Oconee River (similar conditions did not exist in Hunnicutt Creek). In October 2007, I identified three blocks across the shoal that contained a number of boulders greater than 30cm in diameter that were surrounded by sandy substrate (Figure 2.5). Within each block, the six closest boulders to the center point that were not connected to any other bedrock or boulder substrate were selected. All boulders contained remnant *P. ceratophyllum* holdfast markings, indicating that they had previously served as a suitable substrate for the plant (Image 3.1). Some boulders contained a small fringe of live *P.*

ceratophyllum where the water levels covered a small portion of the boulder. To ensure that re-colonization rates could be determined with no local spread, these fringe areas were scraped with a putty knife and wire brush to remove all remnant *P. ceratophyllum.* As a control, each block contained one boulder that was completely dry at the start with no fringe *P. ceratophyllum* population to scrape.

Each boulder was observed monthly to quantify the number of new propagules landing on the boulder, as well as the amount of spread expressed in cm^2. The rocks were observed using the underwater viewer described in the first experiment. I hypothesized that there would be no vegetative spread due to the isolation of the boulders from other substrates containing *P. ceratophyllum*, and that the rate of re-colonization would be slower than on the plots surrounded by *P. ceratophyllum* because of the lack of vegetative spread and distance from neighboring propagule or seed sources.

Originally I planned to measure the surface area of the boulder as well as water depths over time to model the area wetted. The wetted area would be the possible re-colonization area to be compared with the *P. ceratophyllum* growth in cm^2. Unforeseen changes in the substrate, due to seasonal storm flows that caused shifting sand and silt, made this comparison ultimately impossible. Thus, this study does not afford comparisons between boulders, only on a given boulder over time.

Data Analysis

Patch Study:

The Patch Study was developed as an a priori split-plot repeated measure design with a block effect. Each patch of *P. ceratophyllum* is a whole-unit, subjected to two levels of depth treatment. The sub-unit factors are the time levels applied to each whole unit. The experimental units within these treatments are the *P. ceratophyllum* plots. A repeated measures split-plot design allows for analysis of the sub-units (time) within the whole-units (treatments).

The response variable in this study is the percent of the plot occupied by *P. ceratophyllum* over time. This number was calculated by taking the number of 1 cm x 1 cm squares crossed by spread as well as those occupied by a new propagule and dividing that by the total number of 1 cm x 1 cm squares in the plot. This number was then converted into a percentage. Initially an independent assessment of the new propagules and vegetative spread was intended, however due to the control rocks indicating that there were no actual new propagules, these data were pooled to form the percent cover values.

A split-plot repeated measures design was analyzed in SAS v 9.1 (SAS Institute, Inc., Cary, NC, USA) to determine sources of variance between the rates of re-colonization among the blocks over time. All comparisons regarding time were made with a univariate procedure adjusted for Huynh-Feldt epsilon due to insufficient degrees of freedom. The only exception is the comparison between the Middle Oconee River and Hunnicutt Creek during the growing season, as degrees of freedom allowed for a multivariate comparison between time factors. A profile analysis was used to illustrate the sources of any significant interactions between time and treatment, time and block or time, treatment and block.

<u>Boulder Study:</u>

No statistical analysis was possible with the data, given that I was unable to calculate boulder wetted area over time. It is however, valuable as a descriptive study.

RESULTS

<u>Patch Study (Biomass accumulation):</u>

P. ceratophyllum biomass at the start of this study was not significantly different among depth treatments within each site (P = 0.24, MOR; P = 0.63, HCC), nor was there a difference between blocks in the Middle Oconee River (P = 0.29) or between the Middle Oconee River and Hunnicutt Creek (P = 0.79).

Annual accumulation of biomass (over 352 days) was different between depth treatments within Hunnicutt Creek (P=0.04) with more accumulation in deep plots, but not in the Middle Oconee River (P=0.75) (Figure 3.5). Overall average biomass accumulation was greater between the Middle Oconee River than Hunnicutt Creek (P=0.029) (Figure 3.5 A) but there was no significant difference between blocks in the Middle Oconee River (P=0.85). Growing season (May 30, 2008 – September 17, 2008) average biomass accumulation did not differ significantly among treatments within each site (MOR, P=0.13; HCC, P=0.08). Growing season average biomass was not significantly different between the Middle Oconee River and Hunnicutt Creek (P=0.10), nor was it different between blocks in the Middle

Oconee River (P=0.31). A general trend in biomass suggests that there is lower biomass accumulation in shallower plots versus deeper plots, despite the lack of significance among all comparisons (Figure 3.5 A & B).

Growth rates varied among months, and between the two study systems. Based on the biomass data, growth rates over the annual study were approximately 0.15 ± 0.03 g-AFDM/cm^2/day in the Middle Oconee River, and slightly slower at 0.04 ± 0.01 g-AFDM/cm^2/day in Hunnicutt Creek. During the growing season the rates both the Middle Oconee River (0.07 ± 0.04 g-AFDM/cm^2/day) and Hunnicutt Creek (0.27 ± 0.11 g-AFDM/cm^2/day) had slightly faster growth rates than the annual average, although the rate was much higher in Hunnicutt Creek.

Patch Study (Percent-cover):

The null hypotheses investigated in this study were that there is no difference in *P. ceratophyllum* percent cover over time, among treatments over time, among blocks over time, or among an interaction between treatment and block over time. First, a repeated measures analysis of the two blocks within the MOR over an annual time frame resulted in a significant time effect (F=6.25, df=12, P<0.0001), but no significant effects of treatment, block, block*treatment interactions, or time*treatment, time*block, time*treatment*block interactions when $\alpha = 0.05$ (Table 3.1). Figure 3.6 illustrates how block # 2 in the MOR lagged behind block # 1 with respect to average percent cover from May 2008 until September 2008, when it surpassed percent cover in block #1.

Interestingly, the depth and velocity treatments were not significant over time in general or within specific locations when analyzing average *P. ceratophyllum* percent cover between the MOR and HCC (Table 3.2). Time, however, was a significant variable with respect to average *P. ceratophyllum* percent cover in both the MOR (blocks combined) and HCC (F=26.88, df=12, P<0.0001) (Table 3.2). The time*block interaction was also significant (F=3.01, df=12, P=0.0355) when $\alpha = 0.05$ (Table 3.2). A profile analysis of this interaction indicated that the average percent cover of *P. ceratophyllum* was similar between the MOR and HCC from October 2007 through February 2008, but became significantly greater in the MOR from March to May (Figure 3.7). In June, average percent cover in HCC surpassed the MOR and remained higher until October, 2008 when the two sites became very similar (Figure 3.7).

The growing season plots were analyzed similarly to the yearly data, first comparing the two plots within the MOR, and then comparing the MOR with HCC. Within the MOR, there was a significant effect on the average percent cover of *P. ceratophyllum* from the treatment (F=80.06, df=1, P=0.0009), block (F=37.87, df=1, P=0.0035), and block*treatment interaction (F=29.56, df=1, P=0.0056) reported in Table 3.3. There was also a significant among-subject effect of time (F=5.05, df=5, P=0.0104) which indicates that average percent cover changed significantly over time (Table 3.3). Average percent cover was significantly different among the two blocks in the first month of the growing season (May-June) as well as later from August to September (Table 3.3). These differences are the result of a treatment effect in block # 2, which likely caused the shallow/slow plots to become drier during low flows, which might reduce average percent cover of *P. ceratophyllum* (Figure 3.8).

A comparison between the combined blocks in the MOR and the block in HCC during the growing season indicates that time was significant (F=15.96, df=5, P=0.0006) as well as the time*block interaction (F=8.52, df=5, P=0.0046) reported in Table 3.4. It appears as though while HCC had smaller average percent values than the MOR, they changed over time in similar ways; both declining in August and October during low flow conditions with no significant difference between plots that were in deeper/faster water than those in shallower/slower water.

While average *P. ceratophyllum* percent cover varied among months and between the MOR and HCC, the variance followed similar patterns. The only major difference between the growing season study and the year-long analysis is that treatment became significant within the MOR in one month where the shallow plots became much drier than the deeper plots. The growing season analysis was integral to quantifying *P. ceratophyllum* growth over time, as it allowed for continued surveillance after plots reached 100% cover.

The rate of *P. ceratophyllum* spread in percent cover was fastest from April to May during the annual study in both locations (MOR: 0.0186 ± 0.0037 m^2/day; HCC: 0.0140 ± 0.0009 m^2/day), but the growing season plots indicate that this rate may continue to increase through June and July (MOR: 0.0267 ± 0.0023 m^2/day; HCC: 0.0255 ± 0.0019 m^2/day)

Boulder Study:

Monthly observations found that no boulders acquired any *P. ceratophyllum* for the first four months (November – February). March marked the beginning of *P. ceratophyllum* colonization with 39% of the boulders containing from 2 to 300 cm^2 of *P. ceratophyllum*. The average coverage was 24.4cm^2. Coverage persisted throughout September (Figure 3.11) but did appear to peak in May and June. The predominant pattern of re-colonization was through spread on the upstream side of the boulder. In many cases, shifting sand and silt uncovered unknown patches of *P. ceratophyllum* in close proximity to the boulders. In other cases, sand and silt covered boulders completely.

DISCUSSION

Initial biomass pooled from both sites was not significantly different from biomass 352 days later, suggesting that there were no extenuating environmental circumstances throughout this year beyond recognized hydrological changes. Plots in the Middle Oconee River gained less biomass during the growing season than those in Hunnicutt Creek, perhaps due to the influence of the treatment effect on shallow plots between May –June and August-September which negatively impacted average percent cover.

The results of the patch study indicate that there was no significant difference in average *P. ceratophyllum* percent cover among plots in the MOR and between MOR and HCC with regard to the two treatment levels, or location. The percent cover was significantly different however during the growing season comparisons within the MOR. This may be due to occurrence of a drying event in block 1 (Figure 2.7) which desiccated and removed all *P. ceratophyllum* during that time interval. By mid summer, this difference had disappeared, indicating recovery.

Expectedly, time was a significant factor in *P. ceratophyllum* percent cover at some point in each of the four comparisons (MOR blocks annual, MOR and HCC annual, MOR blocks growing season, and MOR and HCC growing season). In the annual comparisons between MOR and HCC, time was a significant factor in average percent cover during March, April, May and June, indicating that *P. ceratophyllum* spread occurred at the fastest rates during this time. Before March, there was not a significant difference in cover between sampling times because of the slow growth that resulted in values close to zero. After June, time is not significant, indicating that the plots have reached 100% cover in most cases; however density and length may have continued to increase.

The growing season comparisons within the MOR blocks provide insight into the growth rates during the later summer and early fall months. The MOR growing season plots had significant increases in average *P. ceratophyllum* cover within each time interval, indicating a continued spreading pattern, likely due to the physiological response to acceptable temperature, available light and substrate in a neighboring location. The block effect, and interactions between time and block were also significant, but I think this is mainly driven by the drying event, which impacted block 2 (Figure 2.7). The drying event resulted in a significant treatment and time*treatment effect, as the two shallow: slow plots were the ones that dried. These results indicate that within one month, drying can decimate a patch of *P. ceratophyllum*, but if it occurs within the growing season, that area may recover within a very quickly if surrounding *P. ceratophyllum* remains intact as a source of vegetative re-colonization.

These results are important because they provide a time-line for recovery. If water levels were to return to historic base-flow conditions, a large area would be submerged providing expansive opportunities for re-colonization. If these areas remained wetted, it is possible that *P. ceratophyllum* could grow as much as 0.0267 ± 0.0023 g-AFDM/m^2/day during the growing season in the Middle Oconee River, and 0.0255 ± 0.0019 g-AFDM/m^2/day in Hunnicutt Creek. This would depend on the size and position of the neighboring patch, as this study looked at *P. ceratophyllum* spread inward from a completely surrounding patch.

The results of the boulder study were the most surprising. I hypothesized that re-colonization would be slower and driven by new propagules rather than vegetative spread given the isolation from surrounding patches. Monthly observations found however, that re-colonization appeared to come from remnant *P. ceratophyllum* patches under the sand and silt that were exposed through winter high flow events. *P. ceratophyllum* spread upward from these refuges onto the boulders in many cases. In other instances, it appeared as though re-colonizing *P. ceratophyllum* was predominantly on the upstream side, which may relate to the increased velocities at that location, or perhaps some propagule recruitment. Given the coarse scale of observation techniques, I do not believe that I was able to accurately determine propagule presence, and often, what I determined to be local spread, may have actually been propagule recruitment that spread downward. A more in-depth study using magnification would be appropriate in the future for understanding the impact of seed dispersal on re-colonization potential in this shoal.

Future work should focus on comparing recovery rates in a multitude of larger river systems as well as tributaries. This will be important for understanding *P. ceratophyllum* growth dynamics more broadly. While we know that macroinvertebrate abundance is correlated with *P. ceratophyllum* presence (Hutchens et al. 2004), as well as presence of fishes (Argentina 2006, Hagler 2006, Marcinek, 2003, Connelly et al. 1999), further study regarding how and at what rate those communities recover would be useful in developing restoration predictions and goals. While *P. ceratophyllum* does possess the capacity to recover quickly under certain conditions (i.e. sufficient water, substrate, and season), it will be important to continue to monitor this important foundation species as well as the rest of the benthic community in this region (Kominoski et al. 2007) in order to detect declines and implement management strategies in a timely manner.

CHAPTER 4

MONITORING PRIORITY FOR *PODOSTEMUM CERATOPHYLLUM,* (RIVERWEED), IN MAJOR BASINS ABOVE THE FALL LINE IN GEORGIA, USA

ABSTRACT

Anthropogenic sources of stream flow alteration have increased in magnitude over the last 50 years. These changes may be stressors to populations of aquatic plants, including *Podostemum ceratophyllum*, a common fixture in southeastern shoals. *P. ceratophyllum* is ecologically important as it provides habitat for the benthic community, including imperiled species. While this plant ranges from Georgia north through Canada, it has declined in the northeastern portion of its range. Current work has indicated that hydrologic changes as a result of upstream water withdrawals and drought may result in biomass loss through stress. As Georgia continues to grow in population and demand for water resources, and as climate change may result in less runoff to feed river systems, it may be necessary to monitor this species. Other states such as New York and Massachusetts have employed their Natural Heritage Programs to monitor *P. ceratophyllum*, which may also be an option in Georgia. An analysis of the likely range of *P. ceratophyllum* in Georgia with respect to indicators of hydrologic alteration within this range provides some focal watersheds to begin a monitoring process, including the Conasauga, Upper Oconee, Upper Chattahoochee and Etowah basins.

INTRODUCTION

Aquatic macrophytes are experiencing significant changes within their habitat as our larger river systems continue to be altered by dams (Dynesius and Nilsson,1994), and water extractions. Changes to the natural flow regime can influence plants by changing the timing of critical flows (Poff et al. 1997) that may be necessary for seed dispersal, or by creating more pronounced low flow events, which can cause direct stress on or loss of aquatic species.

Often aquatic macrophytes occur in mid-order rivers where an open canopy allows for necessary sunlight (Argentina, 2006). These regions also tend to be most impacted by hydrologic alterations, as headwater streams are dewatered for development and mid and downstream portions are often impounded (Freeman et al. 2007).

An important foundational macrophyte along the east coast of the United States is *Podostemum ceratophyllum.* It thrives in high velocity conditions on rocky substrates typical of shoal habitat (Hammond 1937). It is a root-less species that attaches to rocks with a disk-like appendage called a raphe (Hammond 1937).

P. ceratophyllum plays an important ecological role as it provides a complex habitat matrix for other benthic organisms (Argentina 2006, Grubaugh and Wallace 1995, Hutchens et al. 2004). Its abundance has been correlated with increasing abundances of macroinvertebrates (Hutchens et al. 2004, Grubaugh and Wallace 1995, Voshell and Parker 1985) and presence of fish species (Connelly et al. 1999, Argentina 2006, Hagler 2006, Marcinek 2003), including a number of imperiled fishes (Freeman and Freeman 1994, Hagler 2006).

While *P. ceratophyllum* plays a key role as a major primary producer in middle order streams, it has been in decline across its range, particularly in the northeastern U.S. (USDA 2008). According to the U.S. Department of Agriculture (USDA) (2008), it is listed as a species of concern in Connecticut, Maine, Massachusetts and Tennessee. *P. ceratophyllum* is threatened in New York, endangered in Ohio and considered "historic" in Rhode Island (USDA 2008) (Figure 4.1). A "Historic" classification in this state implies that no specimens have been observed since 1982 (USDA 2008).

Although *P. ceratophyllum* is not listed as of special concern in any southeastern U.S. states, researchers have noted declines or population changes. Hill and Webster (1985) note that *P. ceratophyllum* productivity found in their study in the New River, VA was higher than that of Rogers et al (1983), whose site was just 128 km downstream and experienced strong daily fluctuations in flow from an upstream hydroelectric dam. Nelson and Scott (1962) also note that *P. ceratophyllum* was vulnerable to low flow events in a middle order Georgia Piedmont River, where short drying events caused the plant to dry, break off and flow downstream as detritus.

A study in a middle order Georgia Piedmont River by J. Pahl, R. Katz and M. Freeman (2008) (Chapter 2) found that hydrologic events such as low flows at an hourly scale may have a negative effect on *P. ceratophyllum* biomass. Often short low flow events are the result of upstream water extraction or hydropower generation, and longer duration events may be caused by drought conditions.

The goal of this chapter is to assess the likely range of *P. ceratophyllum* above the Fall Line in Georgia, and the possible extent of hydrologic alteration which may be affecting populations. Areas with the highest percentage of habitats impacted are cross-referenced with projected population growth to better understand the possible threats to *P. ceratophyllum* in the future through increased water extraction (Seager et al. 2007) and impoundment construction (SB 346 2008).

METHODS

In order to determine the possible range of *Podostemum ceratophyllum* within the Piedmont, Valley and Ridge, Appalachian, and Cumberland Plateau regions of Georgia (above the Fall Line), we used a subset of the Georgia Museum of Natural History database of fish collections in Georgia containing records from 1995-2007. The presence of *P. ceratophyllum* was recorded at shoal sites, as it is an indicator of good fish habitat (Argentina 2006, Hagler 2006, and Marcinek 2003). The sampling locations where *P. ceratophyllum* was present are shoal habitats and were characterized in terms of stream order, link magnitude and downstream link for a descriptive analysis of *P. ceratophyllum* general range requirements.

Strahler stream order is a process for defining stream size based on a hierarchy of tributaries (Strahler 1952). Link magnitude is a surrogate for upstream watershed size, as it is a count of all first order streams and is correlated with drainage area. Downstream link refers to the number of first order streams draining into the closest downstream segment to the site. This may be important, as tributaries close to larger order segments may be more likely to be colonized from larger patches of *P. ceratophyllum* located in large shoals.

We chose to use Geographic Information Systems (GIS) to view this data on the USGS National Hydrography Data Set 1999, 1:100,000 scale stream cover, because this is available to the public (http://nhd.usgs.gov/data/html) and most commonly used for similar research. The stream coverage was underlain by the USGS 1946 Physical Divisions of the United States, automated from Fenneman's 1:7,000,000 scale, physiographic provinces map. County designations were delineated using the USGS 1994 1:100,000 scale County Boundary-DLG map and watersheds were identified using a modification of the USGS HUC 8 watershed boundaries map. USGS gage locations were mapped using the USGS stream flow gage coverage available at (http://water.usgs.gov/waterwatch/?m=real&r=ga).

Due to the lack of a non-random sample of *P. ceratophyllum* locations and of specific non-presence data, a model to predict *P. ceratophyllum* presence was not possible at this time; however my descriptive approach may provides information on where *P. ceratophyllum* is known to occur on a larger scale. Based on this non-random sampling of *P. ceratophyllum* sites, we accept that there are likely locations outside of this range that are also suitable for *P. ceratophyllum* habitat.

In order to assess the possibility of hydrologic alteration near these *P. ceratophyllum* observations, I identified U.S. Geological Survey (USGS) gages within watersheds that contained *P. ceratophyllum* (Figure 4.2) and assessed the 15 minute interval hydrograph for signs of hydrologic alteration over the previous 60 days for each gage. Daily patterns in fluctuating discharge were determined to be the likely result of upstream water withdrawals or hydropower dam releases (Figure

4.3). While many of the hydrographs for each gage had easily distinguished patterns of alteration, others were more difficult and possibly the result of natural daily variations, particularly where the flow was extremely low (<1 cfs). In these cases, if there was a pattern of reductions or rises in flow with each day, and if daily fluctuations were 10% or more of the daily base flow, the gages were identified as altered.

To better understand the extent of hydrologic alteration, we determined the percent of USGS gages within each major watershed that showed signs of alteration. We believe this is the most informative approach given the lack of knowledge regarding locations of the source of alteration with respect to each gage (exact municipal and industrial surface withdrawal locations are not public information due to Homeland Security regulations).

Ideally, the use of a hydrology model such as the Indicators of Hydrologic Alteration (IHA) may be useful to quantify specific changes in hydrology that may be biologically meaningful to *P. ceratophyllum* such as low flow durations (Richter et al. 2007), however adequate before/after data were not available within the time frame of this project. Models such as IHA also typically work with daily data, so development of a model that works with more fine-scale hydrology measurements at the 15 minute or hourly time interval would be necessary to detect some of the short-term changes in hydrology which may negatively affect *P. ceratophyllum* biomass.

RESULTS

The results of this analysis indicate that a conservative estimate of the range of *P. ceratophyllum* above the Fall Line in Georgia spans almost all HUC 8 watersheds; exceptions are the Tugaloo, Hiawassee and Middle Tennessee-Chickamauga, although no sampling occurred there, so it is possible the range extends into these basins also.

Most of the *P. ceratophyllum* observations occur in middle order streams (Figure 4.4), and there seems to be some patterns involved with link magnitude and downstream link. For all data, link magnitude and downstream link are highly, positively correlated (R^2 = 0.88; Figure 4.5), but are less so for the samples under a value of 100 in link magnitude (R^2 = 0.14; Figure 4.5). The correlation between downstream link and link magnitude is actually negative for the samples with link magnitudes equal to or less than 10 (R = -0.19) (Figure 4.5), indicating that sites where *P. ceratophyllum* occurs may have a slight tendency to have higher downstream links when link magnitudes are very small. This type of pattern results when patches are in smaller streams but closely connected to larger systems, which may provide a better source for colonization.

Within this range, there are 159 USGS gages, 83 of which that indicate some form of hydrologic disturbance. The most altered basins (>50%) are the Oostanaula, Conasauga, Middle Savannah, Upper Chattahoochee, Etowah and the Upper Oconee (Figure 4.6, Table 4.1). The Ocoee Basin contains *P. ceratophyllum*, however no USGS gages were present in this basin for analysis.

DISCUSSION

Based on previous work by J. Pahl, R. Katz and M. Freeman (2009) (Chapter 1), it appears that shoals within waters upstream and downstream of USGS gage locations indicating hydrologic alteration may be areas to focus future monitoring of *P. ceratophyllum*. As *P. ceratophyllum* observations in other states indicate upstream water withdrawals or impoundments may be responsible for changes in *P. ceratophyllum* population sizes over time (NYSNHP 2008), these locations and drainages may be important focal points for a monitoring approach.

As we come to understand the critical role *P. ceratophyllum* plays in providing good habitat for a number of fish (Argentina 2006, Hagler 2006, Marcinek 2003) and macroinvertebrate species (Hutchens et al. 2004, Grubaugh and Wallace 1995, Voshell and Parker 1985), including imperiled species (Freeman and Freeman 1994, Hagler 2006), the need for monitoring of this species in Georgia is becoming more apparent. The results of this exercise highlight areas where attentive monitoring of this species could occur, as they may represent the most challenging places for *P. ceratophyllum* to maintain populations.

Podostemum ceratophyllum is typically found in large drainage areas (> 400 km^2, Etowah River: Hagler, 2006 and > 2000km^2, Flint River: Marcinek 2003) which may be related to increased sunlight availability (Argentina 2006), however one notable exception may be the Conasauga River where percent cover declines in relation to drainage area (Argentina 2006). J.E. Argentina and B.J. Freeman note in unpublished data that *P. ceratophyllum* has declined approximately 50% at some sites in the Conasauga

River over the last 20 years (2005). While there may be a number of causes for this decline, one possibility could be the higher percentage of altered flows experienced in that basin as a result of water extractions or impoundments (Table 4.1) relative to the Etowah or Upper Flint. (The possibility of this effect would depend however on the relative location of these site experiencing declines to sources of flow alteration).

Monitoring of aquatic species in Georgia such as *P. ceratophyllum* may be increasingly important as human population projections indicate a 46.8% increase between 2000 and 2030 (USCB 2008). More people will undoubtedly increase stress on our aquatic resources. Population projections by county in Georgia show that 88% of the counties expected to grow by more than 50% between 2000 and 2015 were above the Fall Line, with the highest growth rates occurring in counties in the following basins: Upper Chattahoochee, Etowah, Upper Oconee and the Upper Flint (GAOPB 2005). Table 4.2 highlights the top 12 counties and their projected growths in percent.

Particularly disturbing is the projection that by 2015, Gwinnett county (located in the headwaters of the Upper Oconee), will house one out of every eleven people in Georgia (GAOPB 2005), and already has a high proportion of hydrologic alteration. By 2015 the 28 county Atlanta-metro area is expected to house about 57% of the state's population, and require potable water for this growth. Most of the projected population growth is for the region above the Fall Line, where there is a large area of headwater streams and middle order rivers, and the majority of *P. ceratophyllum* populations likely exist.

In conjunction with increasing populations, climate change projections for the north Georgia region include increased precipitation along with increased evapotranspiration rates, likely resulting in decreased runoff to fuel river systems (Mulholland et al. 1997). Low flows on top of increased water extraction may result in perilous conditions for *P. ceratophyllum* in the future.

To meet some of the future demand as well as to mitigate some of the problems due to the recent drought in the southeast, Georgia's Legislature has passed the Georgia Water Conservation and Drought Relief Act (SB342 2008) which encourages and provides funding for reservoir construction. Impoundment structures alter flows, and during droughts, may be sources of debate regarding outflows, as was experienced during the drought of 2007-2009 when Lake Lanier outflows became a legal warfare between the states of Georgia and Florida. It may be critical to assemble baseline data on *P. ceratophyllum* now to better understand its population dynamics and stressors; this may help us mitigate the effects of future impoundments and manage impoundment outflows to benefit people and the benthic community.

Monitoring approaches for *P. ceratophyllum* in other states where it is listed as of special concern or threatened (NY and MA) are based in the Natural Heritage Program. The New York Natural Heritage Program, a contract unit housed in the New York State Department of Environmental Conservation's Division of Fish, Wildlife and Marine Resources, was established in 1985 and is a partnership with The Nature Conservancy (NYSNHP 2008). The mission of this organization is to "facilitate conservation of New York's biodiversity by providing comprehensive information and scientific expertise on rare species and natural ecosystems to resource managers and other conservation partners (NYSNHP 2008)." *Podostemum ceratophyllum* is currently monitored by this program in cooperation with Cornell University, at an un-specified time interval. Records show monitoring to occur fairly randomly but closer to a decadal time scale. A number of field observation records indicated a decline in *P. ceratophyllum* within locations among years, and potentially attribute this to upstream impoundments or water diversions (NYSNHP 2008).

The Massachusetts Natural Heritage and Endangered Species Program was founded in 1978 and serves as the State's branch of the National Natural Heritage program in cooperation with The Nature Conservancy. This organization's primary goal is to protect the State's range of native biological diversity (MANHESP 2008) It is responsible for conservation and protection of the State's non-game non-commercial species and has over 176 invertebrate and vertebrates and 259 plant species listed as of special concern, threatened or endangered (MANHESP 2008). Unfortunately state funding for this project was discontinued in 2004, and it now relies solely on grant money for specific projects, private donations, and over 20,000 residents who contribute via their state income tax forms (MANHESP 2008). The program currently monitors *P. ceratophyllum* as it is listed of special concern, occurring in only eight locations across the state. Monitoring occurs at five year intervals for species of this listing to document any changes in population vigor and to identify any possible sources of decline.

The NY and MA Natural Heritage Programs are comparable to the Georgia Department of Natural Resources (GADNR) Wildlife Resources Division Natural Heritage Program, now referred to as the Nongame Conservation Section. The GADNR program was established in 1986, and focuses on rare, threatened or endangered species and communities (GADNR 2008). Like the NY and MA Programs, it is geared towards providing an objective source of information regarding plant and animal communities for conservation purposes and land use decision making. Both NY and MA include an expansive data base regarding rare, threatened and endangered organisms; however *P. ceratophyllum* has not yet made the Georgia list. The resource base afforded to such programs, and the general use of data for management decisions, may make the Natural Heritage Program a key universal monitoring entity in Georgia.

In addition to monitoring, further research by the scientific community may enhance our understanding of the biological response of *P. ceratophyllum* to hydrologic stress and other anthropogenic sources of decline. Ideally this information along with patterns in *P. ceratophyllum* population abundance and quality will help inform management of Georgia's water resources.

CHAPTER 5

CONCLUSIONS

Hydrologic alterations in the form of extreme drought, water impoundments and extraction have profoundly shaped riverine systems in the southeastern United States. Low annual rainfall, in conjunction with special permits for continued water use, has come close to dewatering some major rivers. While many aquatic organisms may be impacted by these conditions, some of the most affected are sessile aquatic macrophytes.

In Georgia, and many southeastern states, the predominant aquatic macrophyte is the riverweed, *Podostemum ceratophyllum*, an important foundational species. This plant has been in decline in northeastern states, and the results of this research show that there is the potential for local declines due to hydrologic stress. Reductions in flow and continued daily disturbances from upstream dams or extractions result in extremely low water depths (< 5 cm), which were found to have a negative effect on *P. ceratophyllum* biomass. It is likely that a low flow threshold exists below which *P. ceratophyllum* biomass is significantly affected on a larger scale.

While this study also indicated that *P. ceratophyllum* may be able to re-colonize previously disturbed areas through asexual spread, seed dispersal ability may be limited and should be investigated further. Local recovery will depend on remnant populations that manage to exist in wetted refuge areas.

This work found substantially lower *P. ceratophyllum* biomass in the Middle Oconee River compared to studies conducted 16 and 50 years ago; an issue which may extend beyond the Upper Oconee watershed. Hydrologic alteration seems to be prevalent across Georgia above the Fall Line, where the range of *P. ceratophyllum* is extensive. Projected population growth in the region threatens to compound the problem and further reduce biomass of this important species.

State-wide programs, such as the Georgia Natural Heritage Program, may be employed to conduct base-line monitoring of this species to better understand how we may mitigate the effects of future water consumption and impoundments. Scientific research should continue and focus on determining shoal-wide effects of varying hydrology as well as estimating the quality and quantity of *P. ceratophyllum* across its range.

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Table 2.1: Characteristic sections of the cross-sectional transect. Each section is described in terms of substrate and surface water slope.

Section	**Meters**	**Substrate**	**Surface Water Elevation**
1	2 – 22	Sand/silt with random boulders	Fairly uniform (flat)
2	22 – 38	Varied (boulders, gravel, sand)	Sloping towards section 1
3	38 – 61	Gravel and Cobble, some boulders	Fairly uniform (flat) and relatively shallow
4	61 – 85	Mostly Bedrock	Fairly uniform (flat) and relatively shallow
5	85 – 94	Mostly Bedrock	Sloping towards the bank

Table 2.2: Comparison of annual mean P. ceratophyllum biomass between three decades. Our data is compared with that of Nelson and Scott, 1962 and Grubaugh and Wallace, 1995. The range of biomass values recorded during our study was 0 – 371.3 g-AFDM/m^2, however we reported the next lowest biomass value for comparison (only one sample had a biomass value of 0 g-AFDM/m^2).

Year of Study	**Mean *P. ceratophyllum* ± SE**	**Range**
Nelson & Scott 1956-1957	350.2 ± 33.8	136.8 - 635.0
Grubaugh & Wallace 1991-1992	514.0 ± 53.2	296.8 - 1044.8
Pahl 2009	54.0 ± 7.1	0.11 – 371.3

Table 2.3: Best-supported models of *P. ceratophyllum* standing stock biomass using habitat and time of year variables. Results are number of model parameters (K) and AIC values for the five (of 32 total covariate models) within two of the lowest AIC value. Model parameters include substrate (Bedrock/boulder or gobble/gravel), location (center 75% of channel or edges), velocity (cm/s; measured when sample was taken), time of year (represented by day and day^2 terms), and an interaction between location and time of year.

Covariates in Model	K	AICc	delta AICc	AIC Weights
Substrate, Location, Day, Day^2	6	41.97	0	0.19
Substrate, Location, Velocity, Day, Day^2	7	42.57	0.59	0.14
Location, Day, Day^2, Day*Location, Day^2*Location	8	43.36	1.39	0.09
Location, Day, Day^2	5	43.37	1.40	0.09
Substrate, Location, Velocity, Location*Day, Location*Day^2, Day, Day^2	9	43.39	1.42	0.09
Location, Velocity, Day, Day^2	96	43.90	1.94	0.07

Table 2.4: Best-supported models of *P. ceratophyllum* standing stock biomass using habitat, time of year and hydrology variables. Results are number of model parameters (K) and AIC values for the three (of 25 total models) within two of the lowest AIC value. Model parameters include substrate (Bedrock/boulder or gobble/gravel), location (center 75% of channel or edges), velocity (cm/s; measured when sample was taken), time of year (represented by day and day^2 terms), the total number of hours water depth was less than 5 cm during 30 days prior to sampling (T5), and the longest single duration in hours of water depth less than 5 cm during 30 days prior to sampling (L5).

Variables in Model	**K**	**AICc**	**Delta AICc**	**AIC Weights**
Substrate, Location, Day, Day^2, T5	7	40.88	0	0.11
Substrate, Location, Velocity, Day, Day^2, T5	8	41.76	0.87	0.07
Substrate, Location, Day, Day^2	6	41.97	1.09	0.07
Location, Day, Day^2, T5	6	42.07	1.19	0.06
Substrate, Location, Day, Day^2, L5	7	42.14	1.26	0.06
Substrate, Location, Velocity, Day, Day^2	7	42.57	1.68	0.05
Substrate, Location, Day, Day^2, Day*Location, Day^2*Location, T5	9	42.71	1.82	0.05
Substrate, Location, Velocity, Day, Day^2, L5	8	42.83	1.94	0.04

Table 2.5: A comparison of the total weight of relative support for each variable. The AIC weights of each model containing each hydrology model were summed, and all models containing only covariates were summed to represent null (no hydrology) models. The most supported variable is the total number of hours with less than 5 cm of water depth of the last 30 days. This parameter is 1.57 times more likely to describe *P. ceratophyllum* biomass than the next highest variable (null variable with no hydrology).

Variable	**Relative AIC Weight (sums)**
Total Hours <5cm	0.37
Null (no hydrology)	0.23
Longest Hour <5cm	0.21
Longest Hour <0cm	0.09
Total Hours <0cm	0.09

Table 2.6: Top AIC model variable estimates. The estimated effect on the response variable (*P. ceratophyllum* log g-AFDM/m^2) for each factor within the top model (n=92) and standard error are displayed below. The intercept is the model intercept. T5 refers to the total number of hours 30 days prior to collection that the sample experienced water depths less than 5 cm.

	Intercept	**Substrate**	**Location**	**Day**	**Day2**	**T5**
Estimates	1.4447	0.6012	-1.1364	0.0232	-0.00006	-0.0013
Standard error	0.6005	0.3301	0.2629	0.0062	0.00002	0.0007

Table 2.7: Hydrology effect on *P. ceratophyllum* biomass. Based on the variable estimates from the top model, the following biomass loss (in percent) are estimated for a range of total hours spent with less than 5 cm of water during the last 30 days. The shortest total duration was the smallest recorded number of hours greater than zero. The average values refer to hours spent in less than 5 cm of water among samples that experienced at least some shallow water (n=40). The longest duration was the greatest number of hours recorded within 30 days of sample collection, spent with less than 5 cm of water.

	Hours < 5 cm	**Log Biomass loss (%)**
Shortest	2	0.06
Average (all >0 hours)	256.40	7.83
Longest	687	21.12

Table 3.1: Middle Oconee River block annual comparisons. A split-plot repeated measures analysis was conducted. Time is the only significant factor. A univariate approach adjusted for the Huynh-Feldt epsilon was used to calculate p-values for parameter involving Time due to insufficient degrees of freedom for a multivariate test.

Variable	**Degrees of Freedom**	**F value**	**P value**
Time	12	6.25	<0.0001*
Time*Treatment	12	0.70	0.6973
Time*Block	12	1.42	0.2203
Time*Treat*Block	12	0.48	0.8705
Treatment	1	1.65	0.5562
Block	1	0.03	0.2688
Block*Treatment	1	1.40	0.3022

Table 3.2: Middle Oconee River and Hunnicutt Creek comparisons. A split-plot repeated measures analysis with only two blocks (MOR all plots equal one block, HCC has one block). Time is significant as well as the Time*Block interaction. Due to this interaction, a profile analysis was conducted to determine at which time interval the significant interaction occurred. The significant time intervals and parameters are displayed in this table. A univariate approach adjusted for the Huynh-Feldt epsilon was used to calculate p-values for parameters involving Time due to insufficient degrees of freedom for a multivariate test.

Parameter	**Degrees of Freedom**	**F value**	**P value**
Time	12	26.88	<0.0001*
Time*Treatment	12	0.94	0.4459
Time*Block	12	3.01	0.0355*
Time*Treat*Block	12	0.72	0.5662
Treatment	1	0.03	0.8632
Block	1	1.08	0.3228
Block*Treatment	1	0.00	0.9659
Time Intervals/Parameter			
5:6 Time	1	16.22	0.0024*
5:6 Block	1	9.44	0.0118*
6:7 Time	1	5.65	0.0387*
7:8 Time	1	9.25	0.0124*
8:9 Block	1	7.17	0.0232*
12:13 Block	1	5.72	0.0379*

Table 3.3: Middle Oconee River growing season block comparisons. A split-plot repeated measures analysis was used. Time, treatment, block and block*treatment interaction factors were significant at α = 0.05. Due to this interaction, a profile analysis was conducted to determine at which time interval the significant interaction occurred. The significant time intervals and parameters are displayed in this table. A univariate approach adjusted for the Huynh-Feldt epsilon was used to calculate p-values for parameters involving Time due to insufficient degrees of freedom for a multivariate test.

Parameter	**Degrees of Freedom**	**F value**	**P value**
Time	5	5.05	0.0104*
Time*Treatment	5	3.14	0.0501
Time*Block	5	3.00	0.0573
Time*Treat*Block	5	2.60	0.0834
Treatment	1	80.06	0.0009*
Block	1	37.87	0.0035*
Block*Treatment	1	29.56	0.0056*
Time Intervals/Parameter			
1:2 Treatment	1	19.68	0.0114*
1:2 Block*Treatment	1	15.40	0.0172*
4:5 Time	1	109.45	0.0005*
4:5 Treatment	1	85.05	0.0008*
4:5 Block	1	67.23	0.0012*
4:5 Block*Treatment	1	52.46	0.0019*

Table 3.4: Middle Oconee River and Hunnicutt Creek growing season comparisons. A split-plot repeated measures analysis was applied to the growing season re-colonization rates with only two blocks (MOR all plots equal one block, HCC has one block). Block is significant at time interval 1:2, and time is significant between time intervals 2 and 3. A Wilks' Lambda multivariate test was used for Time and its interactions, and a univariate approach was used to assess Treatment, Block, and their interaction.

Parameter	**Degrees of Freedom**	**F value**	**P value**
Time	5	15.96	0.0006*
Time*Treatment	5	0.40	0.8364
Time*Block	5	8.52	0.0046*
Time*Treat*Block	5	0.48	0.7820
Treatment	1	0.14	0.7150
Block	1	2.19	0.1648
Block*Treatment	1	0.44	0.5176
Time Intervals/Parameter			
1:2 Block	1	11.22	0.0058*
2:3 Time	1	24.13	0.0004*

Table 4.1: Hydrologic alteration by major Georgia river basin. Percent of U.S. Geological Survey gages showing signs of hydrologic alteration within each major river basin above the fall line where *Podostemum ceratophyllum* has been observed. The Middle Tennessee and Upper Coosa basins indicate 100% alteration, however they have very few (1 and 3 respectively) gages within GA, so it is likely that analysis of gages in Alabama and Tennessee would change this percentage. The most impaired basins according to this analysis include the Oostanaula, Conasauga, Middle Savannah, Upper Chattahoochee, Etowah and the Upper Oconee. The Little, Broad and Upper Savannah Rivers indicate no hydrologic alteration, possibly due to the small number of gages, and only partial overlap with the state of Georgia.

River Basin	% USGS gages Altered	Number of gages
Middle Tennessee	100	1
Upper Coosa	100	3
Oostanaula	71	7
Conasauga	71	7
Middle Savannah	67	3
Upper Chattahoochee	63	31
Etowah	60	21
Upper Oconee	56	9
Coosawattee	50	6
Middle Chattahoochee	50	20
Tugaloo	50	2
Upper Ocmulgee	45	22
Upper Flint	43	11
Upper Tallapoosa	33	3
Little	0	2
Broad	0	2
Upper Savannah	0	1

Table 4.2: Projected population growth in north Georgia. Population growth projected to occur from 2000 to 2015 in percent change for the top 12 fastest growing counties in Georgia. The watershed in which they occur is also noted. Data is from the Georgia 2015 Population Projections Report from the Georgia Office of Planning and Budget: Policy, Planning and Technical Support. 2005. A single asterisk (*) represents one of the top 12 counties in terms of population, in which half of the state of Georgia will live by 2015. A double asterisk (**) represents where 1/11th of Georgia's population will live by 2015, more than the population of Georgia's 79 smallest counties.

County	Growth (%)	Watershed	
Forsyth	137	Upper Chattahoochee	*
Henry	135	Upper Flint/Upper Ocmulgee	*
Newton	121	Upper Ocmulgee	*
Paulding	117	Etowah	
Cherokee	91	Etowah	*
Lee	91	Ichawaynachaway, Lower Flint, Kinchafoonee-Muckalee (below fall-line)	
Pickens	90	Etowah / Coosawattee	
Butts	88	Upper Oconee	
Dawson	87	Etowah/Upper Chattahoochee	
Barrow	84	Upper Oconee	
Walton	75	Upper Oconee	
Gwinnett	75	Upper Oconee	**

Figure 2.1: Hydrographs from the USGS gages in Athens, GA and Arcade, GA. These hydrographs illustrate the changes in natural flow regime as a result of upstream hydroelectric dam operations and municipal water withdrawals. The Arcade, GA gage is upstream of our study site, and the Athens, GA gage is downstream. The source of the alterations during the 1990's is likely the Tallassee Shoals Hydropower Dam, located approximately two miles upstream from Ben Burton Park. The source of hydrologic alteration during our study in 2007-2008, is Bear Creek Reservoir, a pump-storage facility constructed in 2002. The hydroelectric dam was not in operation throughout the course of our study due to historic drought conditions that did not enable the dam to produce electricity.

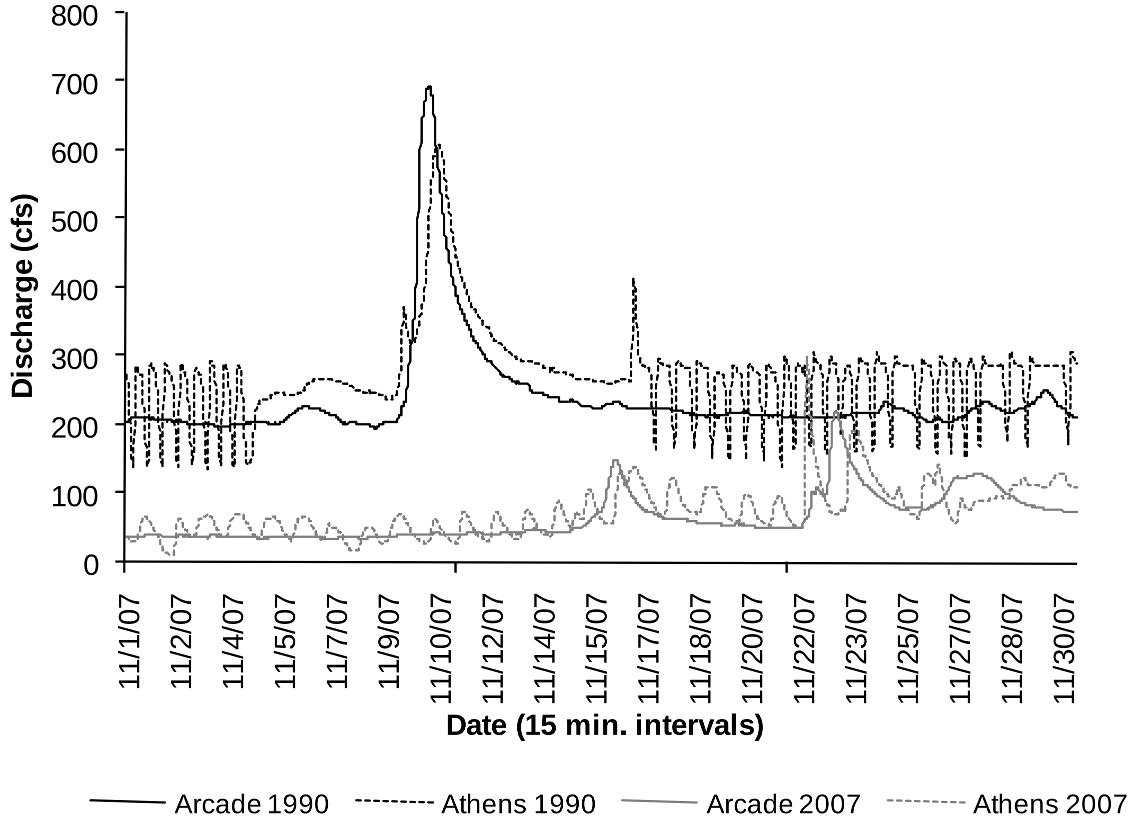

Discharge (cfs)
800
700
600
500
400
300
200
100
0
11/1/07
11/2/07
11/4/07
11/5/07
11/7/07
11/9/07
11/10/07
11/12/07
11/14/07
11/15/07
11/17/07
11/18/07
11/20/07
11/22/07
11/23/07
11/25/07
11/27/07
11/28/07
11/30/07
Date (15 min. intervals)
Arcade 1990
Athens 1990
Arcade 2007
Athens 2007

Figure 2.2: Water surface elevation changes across our study shoal. Changes along a cross-sectional transect in the Middle Oconee River, Ben Burton Park, Athens, GA. This figure illustrates the variability in flows across the channel. The legend refers to a subset of varying discharge levels in cfs (cubic feet per second). The substrate and water surface elevations are displayed using data collected at the 2 meter interval.

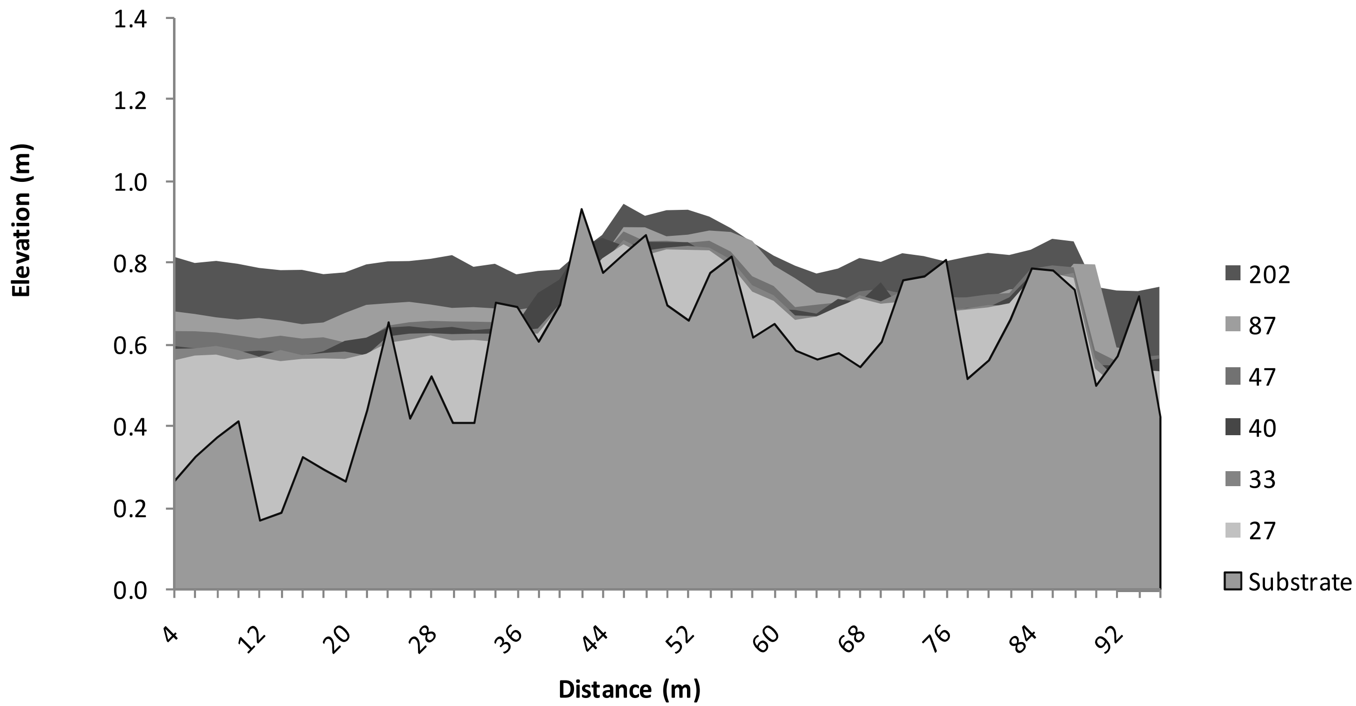

Elevation (m)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
4
12
20
28
36
44
52
60
68
76
84
92
Distance (m)
202
87
47
40
33
27
Substrate

Figure 2.3: Monthly average P. ceratophyllum biomass comparisons between three studies. Our study 2007-2008 is compared with Grubaugh and Wallace (1995), who examined *P. ceratophyllum* biomass between 1991 and 1992, and Nelson and Scott (1962), whose study spanned 1956-1957. Error bars were not available from the two previous studies because they were not reported in their papers, however our error bars indicate that our monthly average biomass valued did not come close to the other studies. The lowest biomass reported by both authors was 136.8 g-AFDM/m^2 (Nelson and Scott, 1962), which is still higher than our highest monthly average.

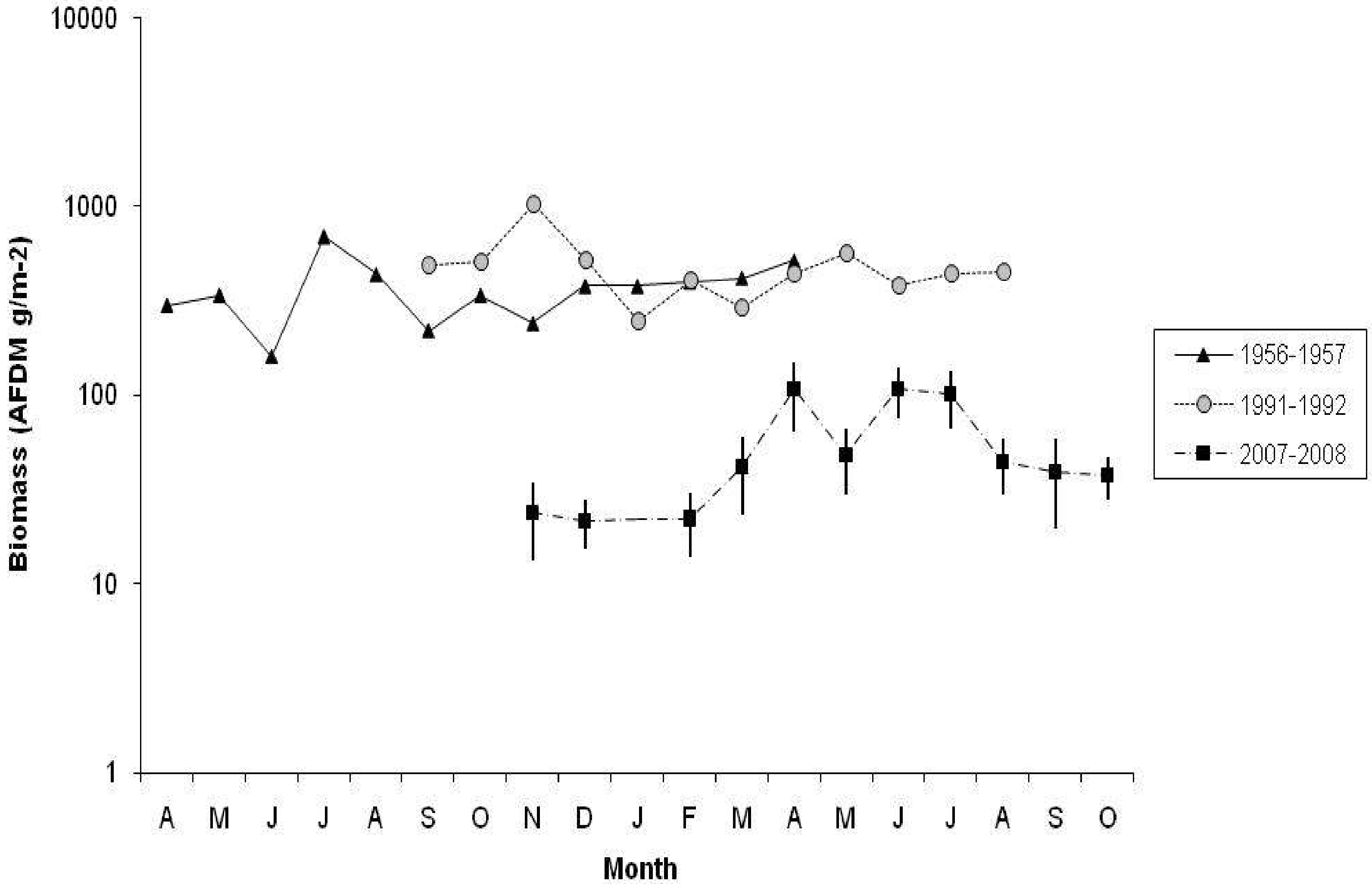

10000
1000
100
10
1
Biomass (AFDM g/m-2)
A M J J A S O N D J F M A M J J A S O
Month
1956-1957
1991-1992
2007-2008

Figure 2.4: Frequency of low flows across transect. Frequency analysis of flows across the cross-sectional transect at which areas will become stressed (< 5cm) or exposed (<0cm). The discharge at which a percentage of our transect would be stressed or exposed was calculated by using the regression equation between water depth at each interval and our pressure transducer to determine the depth reading on the pressure transducer when the flag location would be dry (0 cm) or stressed (5cm). These values were then converted to discharges using the relationship between our pressure transducer and the USGS gage downstream. Stressed conditions (<5 cm) begin to occur across our transect at a discharge of 55 cubic feet per second (cfs), and exposures begin at discharges of 40 cfs.

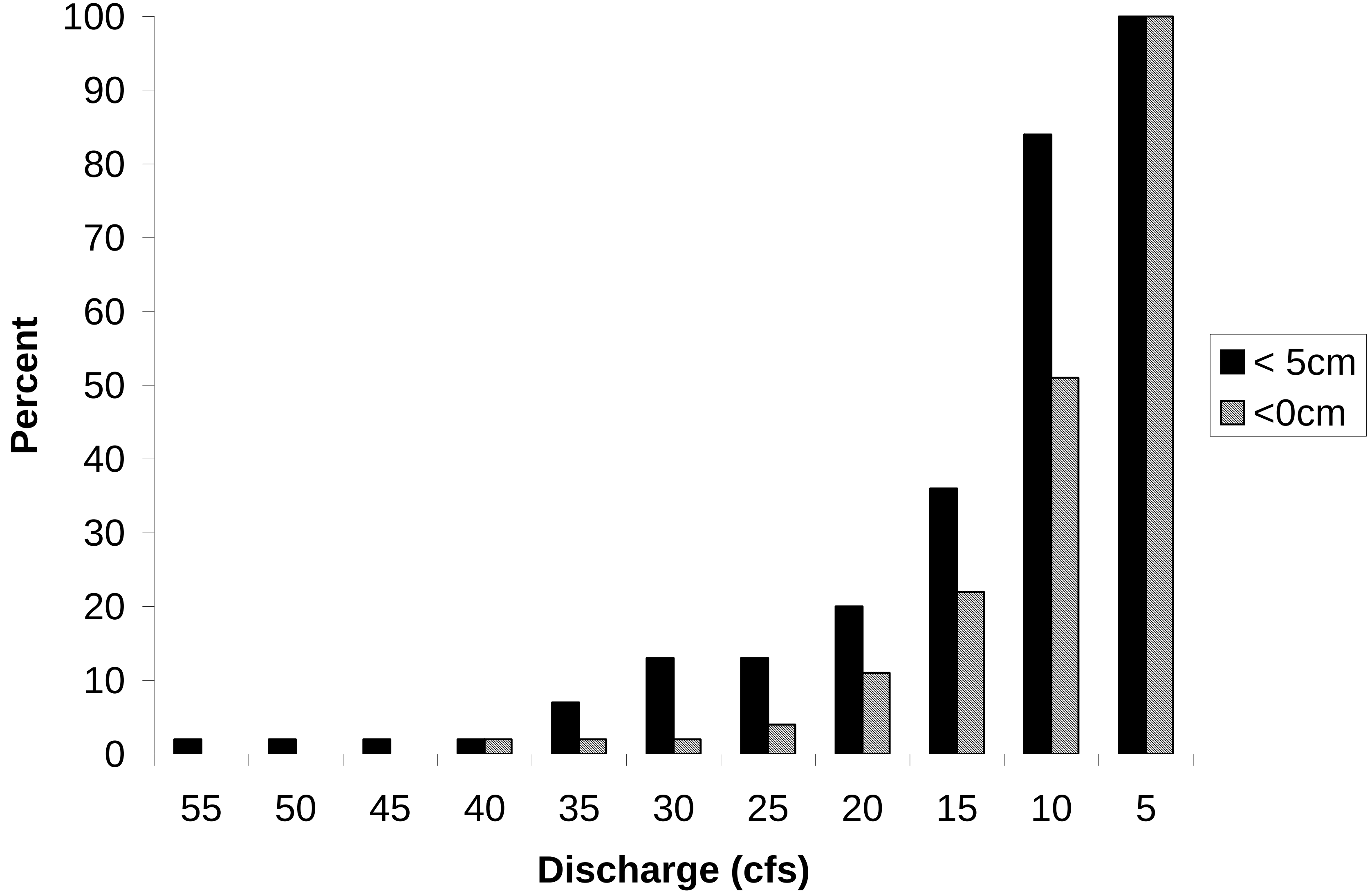

100
90
80
70
60
50
40
30
20
10
0
Percent
55
50
45
40
35
30
25
20
15
10
5
Discharge (cfs)
< 5cm
<0cm

Figure 2.5: Frequency analysis of annual flows in the Middle Oconee River, Athens, GA. Hourly intervals for a year during Grubaugh and Wallace's study (8/27/1991 -8/28/1992) and one year during our study (8/27/2007-8/27/2008) are represented. The red dotted vertical line represents 55 cubic feet per second (cfs), the discharge at which our cross-section began to experience stressed conditions, and the blue dotted vertical line represents the 7Q10 for this site (45 cfs). There were approximately 2700 hours spent under 55 cfs during our study, but none during Grubaugh and Wallace's study. We were not able to make comparisons between our study and that conducted by Nelson and Scott (1962) due to the lack of hourly data available from that time period.

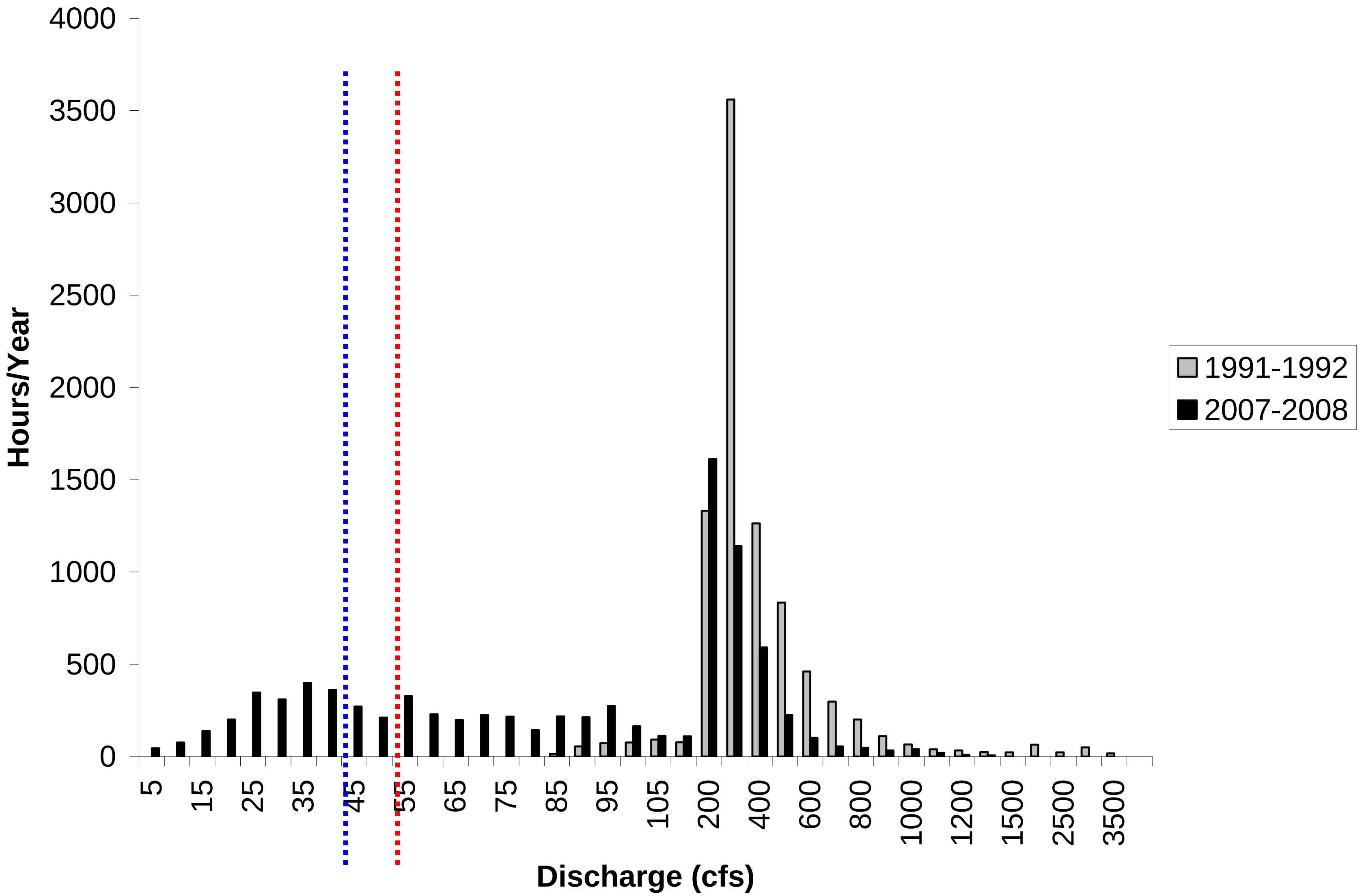

Hours/Year
4000
3500
3000
2500
2000
1500
1000
500
0
5
15
25
35
45
55
65
75
85
95
105
200
400
600
800
1000
1200
1500
2500
3500
Discharge (cfs)
1991-1992
2007-2008

Figure 2.6: Frequency analysis of *P. ceratophyllum* biomass. Only 14 out of 104 samples or 13.3% of the total samples exceeded 136 g-AFDM/m^2, which was the lowest recorded biomass in the Nelson and Scott (1962) study. Only 2 out of 104 samples or 1.9% were as large as or larger than Grubaugh and Wallace's (1995) lowest biomass value (296.8 g-AFDM/m^2).

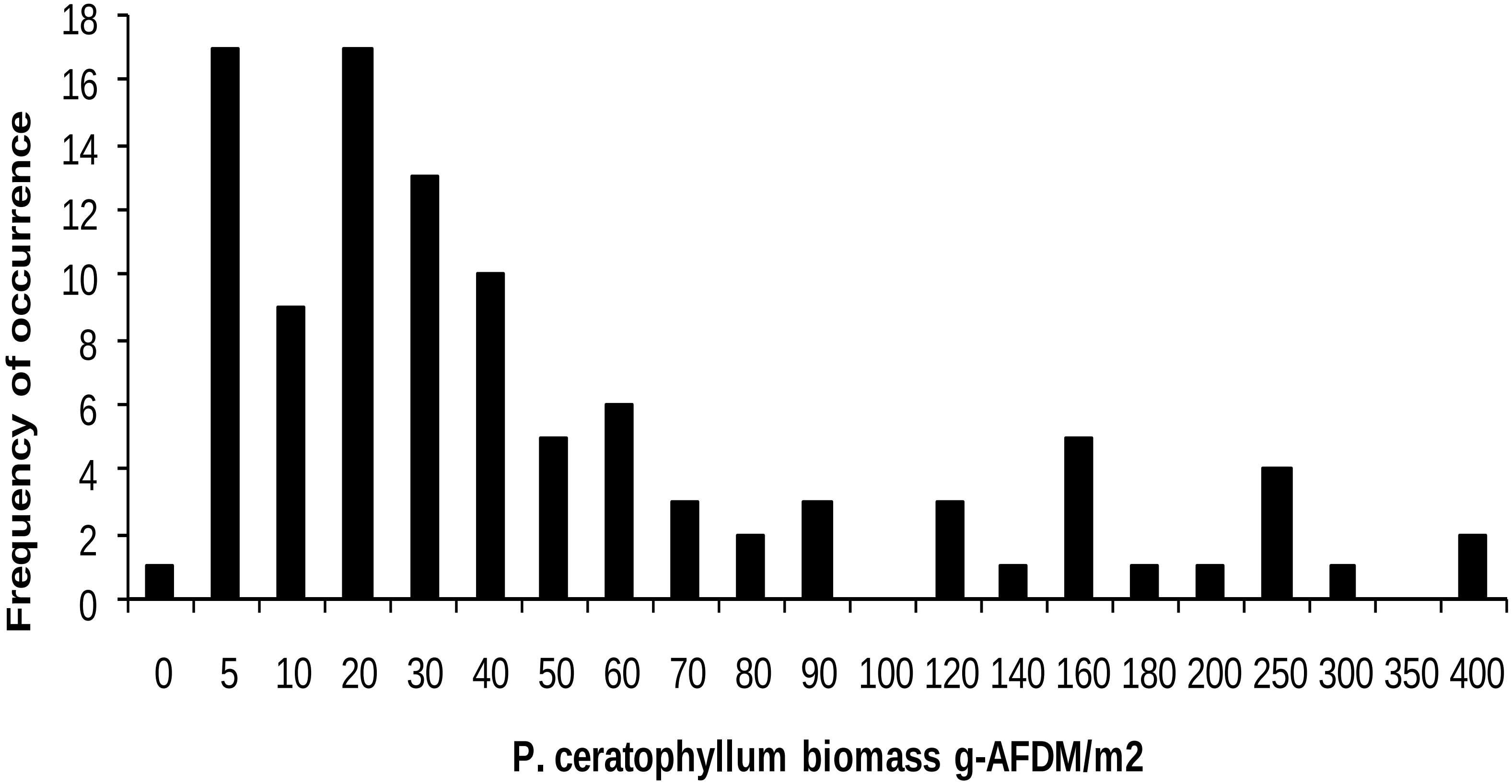

Frequency of occurrence
0
2
4
6
8
10
12
14
16
18
0 5 10 20 30 40 50 60 70 80 90 100 120 140 160 180 200 250 300 350 400
P. ceratophyllum biomass g-AFDM/m2

Figure 2.8: Yearly flows in the Middle Oconee River; drought vs. water extraction. Watershed adjusted estimated flows at Middle Oconee River (based on the upstream USGS gage in Arcade, GA) illustrating likely flows without Bear Creek Reservoir, in contrast to recorded flows at the USGS gage in Athens, GA. The difference between these may be the result of pump storage activities at Bear Creek Reservoir.

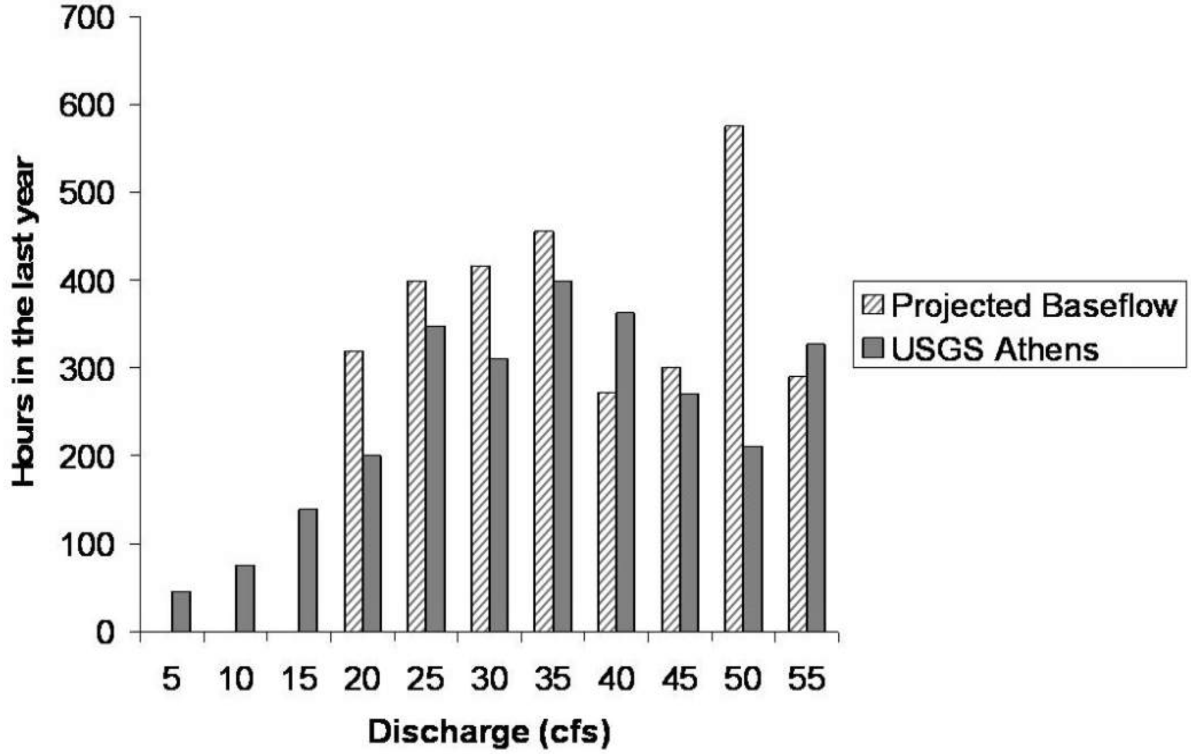

700
600
500
400
300
200
100
0
Hours in the last year
5
10
15
20
25
30
35
40
45
50
55
Discharge (cfs)
Projected Baseflow
USGS Athens

Figure 3.1: Hydrographs from the USGS gages in Athens, GA and Arcade, GA. These hydrographs illustrate the changes in natural flow regime as a result of upstream hydroelectric dam operations and municipal water withdrawals. The Arcade, GA gage is upstream of our study site, and the Athens, GA gage is downstream. The source of the alterations during the 1990's is likely the Tallassee Shoals Hydropower Dam, located approximately two miles upstream from Ben Burton Park. The source of hydrologic alteration during our study in 2007-2008, is Bear Creek Reservoir, a pump-storage facility constructed in 2002. The hydroelectric dam was not in operation throughout the course of our study due to historic drought conditions that did not enable the dam to produce electricity.

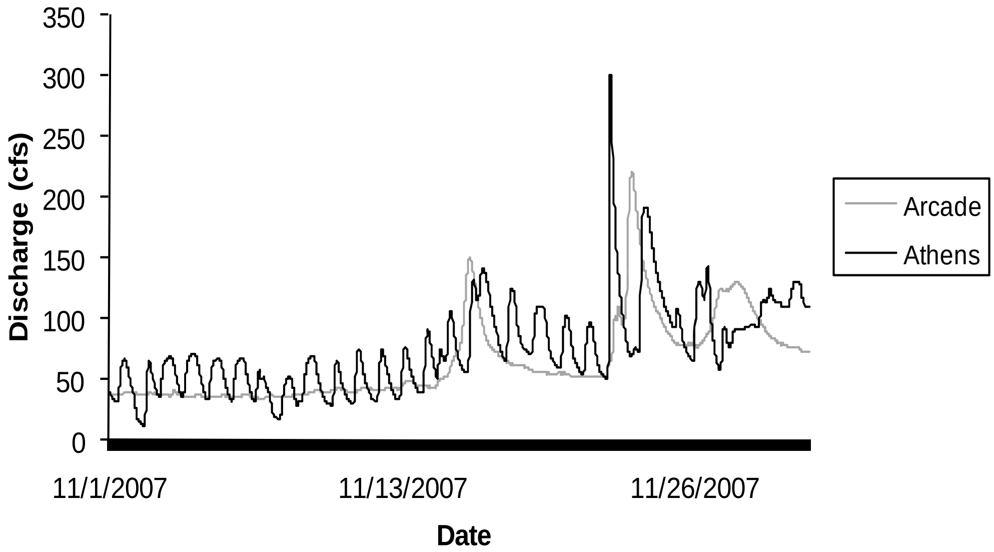

Discharge (cfs)
350
300
250
200
150
100
50
0
11/1/2007
11/13/2007
11/26/2007
Date
Arcade
Athens

Figure 3.2: Experimental Design of Middle Oconee River Plot Study. Solid block represent those under a shallow treatment, and striped blocks represent the deep treatment. White blocks are those analyzed throughout the entire year, and gray blocks represent the growing season.

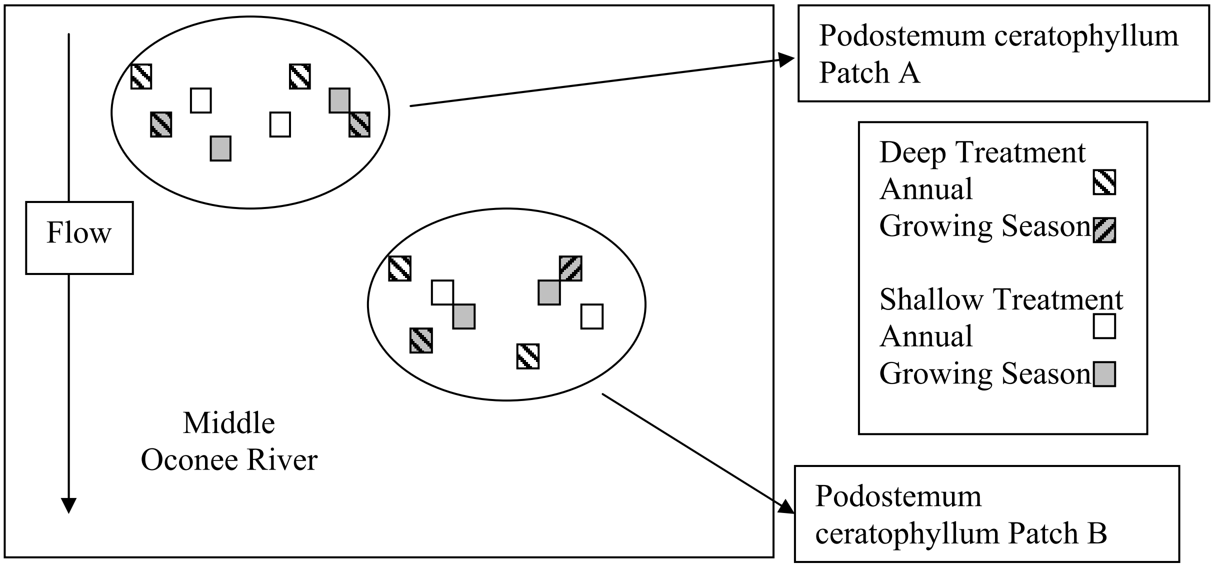

Podostemum ceratophyllum Patch A
Deep Treatment
Annual
Growing Season
Shallow Treatment
Annual
Growing Season
Flow
Middle Oconee River
Podostemum ceratophyllum Patch B

Figure 3.3: Experimental Design of Hunnicutt Creek Plot Study. Solid block represent those under a shallow treatment, and striped blocks represent the deep treatment. White blocks are those analyzed throughout the entire year, and gray blocks represent the growing season.

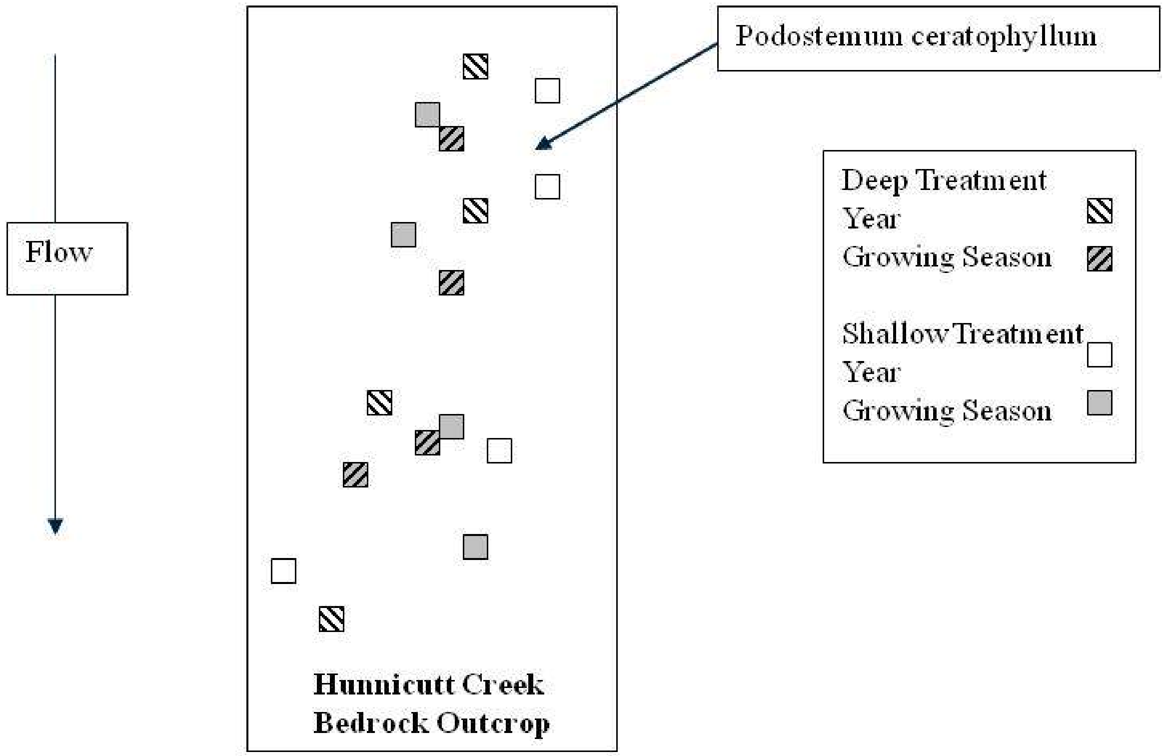

Podostemum ceratophyllum
Flow
Deep Treatment
Year
Growing Season
Shallow Treatment
Year
Growing Season
Hunnicutt Creek
Bedrock Outcrop

Figure 3.4: Experimental Design of Middle Oconee River Boulder Study. The white circles represent boulders within one of three blocks, and the gray circles represent the control boulder within each block. The control boulders were fully exposed at the beginning of the study, thus had no possibility for missed *Podostemum ceratophyllum* in the scraping process.

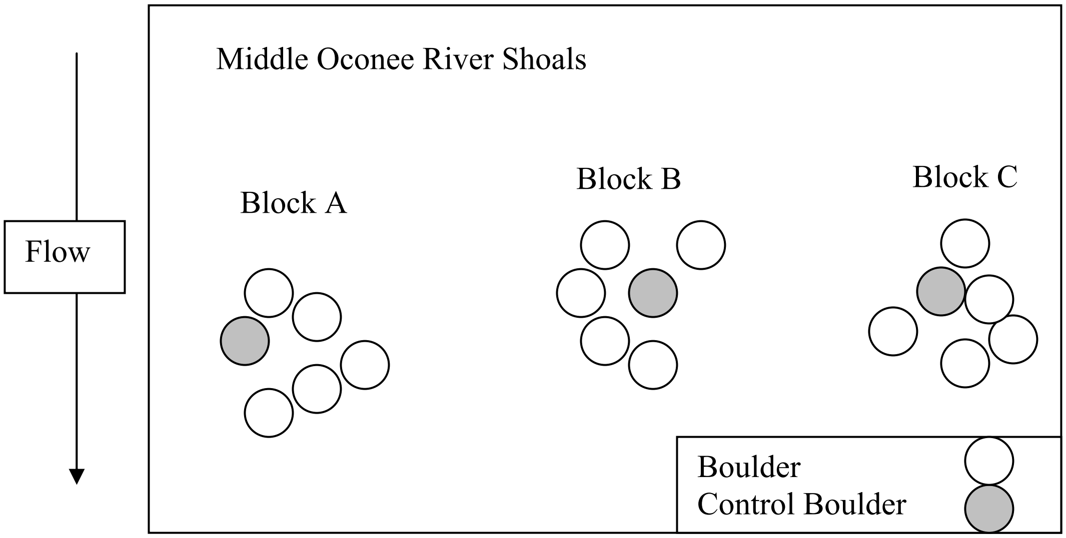
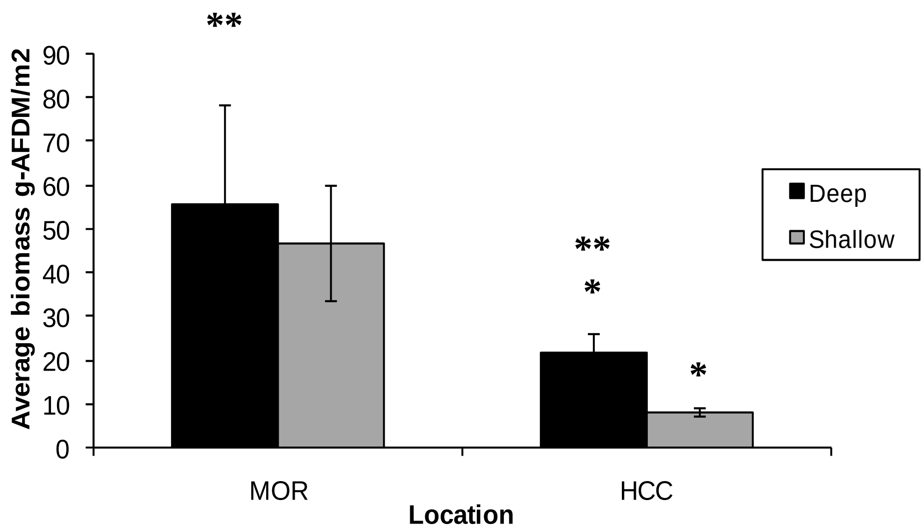

Middle Oconee River Shoals
Flow
Block A
Block B
Block C
Boulder
Control Boulder

Figure 3.5: Biomass comparisons between sites and seasons. **A.** Year-long average *P. ceratophyllum* biomass comparisons between MOR and HCC by treatment and location. **B.** Growing season average *P. ceratophyllum* biomass comparisons between MOR and HCC by treatment and location.

A.


**
**
*
*
Average biomass g-AFDM/m2
90
80
70
60
50
40
30
20
10
0
MOR
HCC
Location
Deep
Shallow

B.

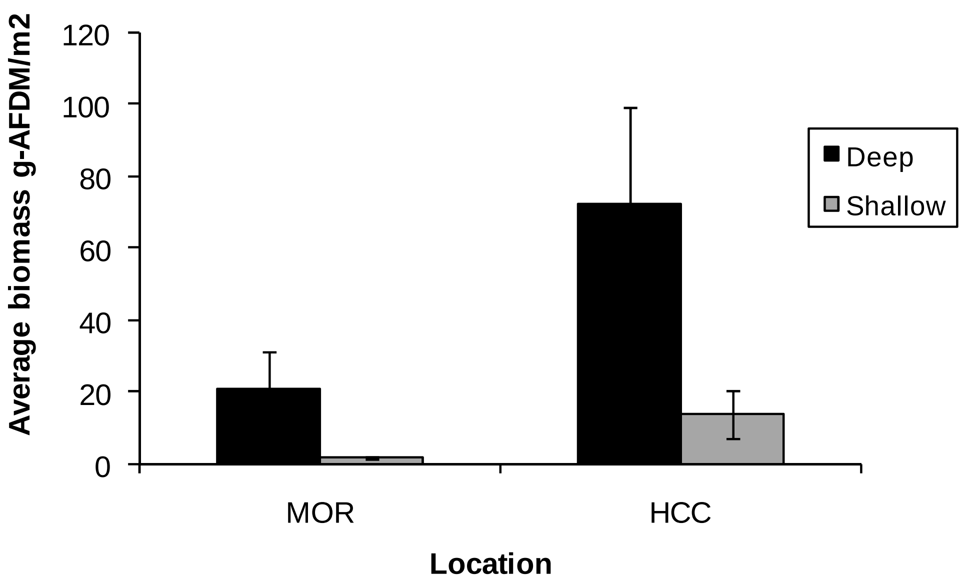
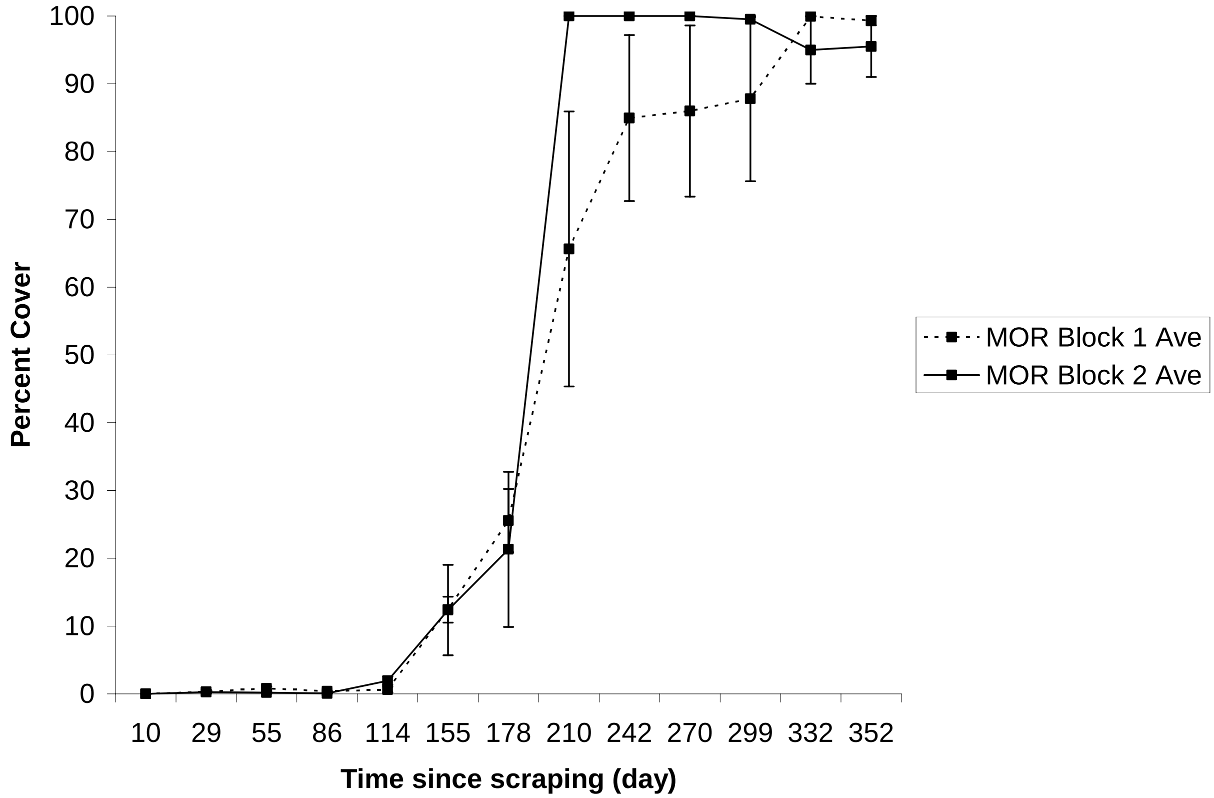
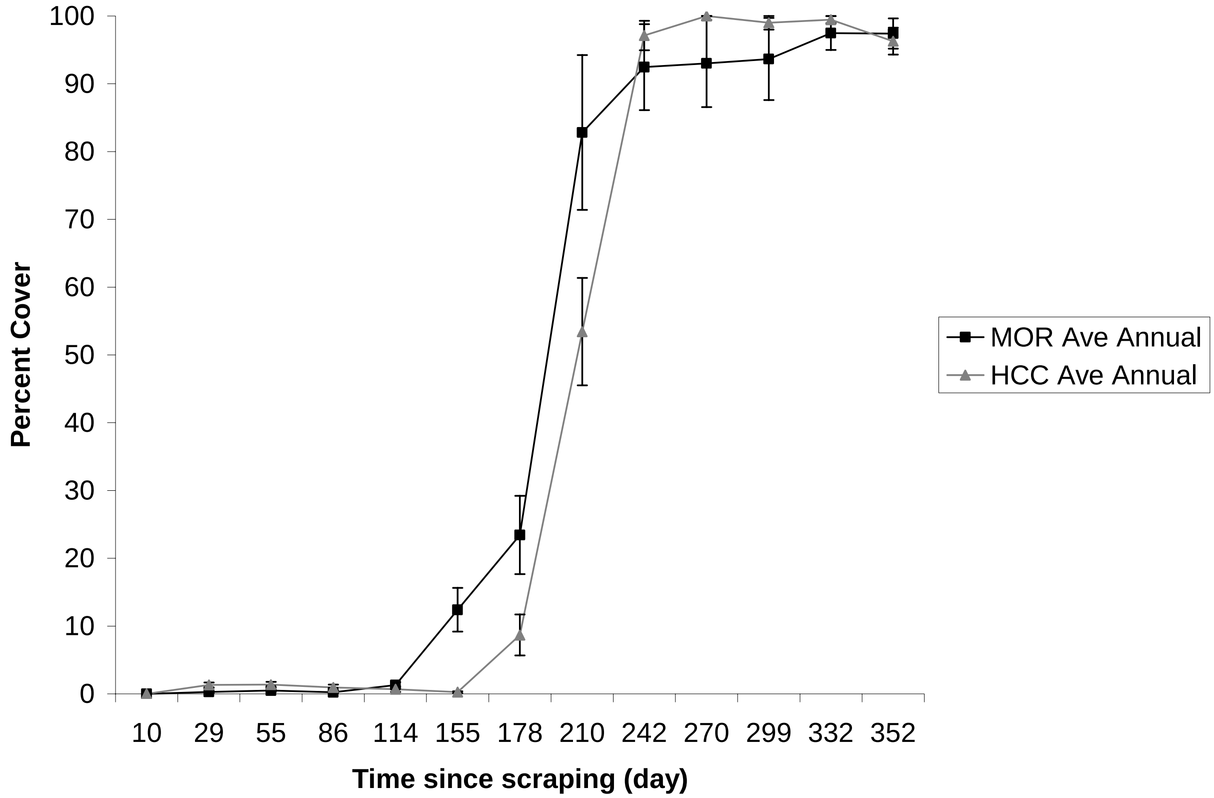

Average biomass g-AFDM/m2
120
100
80
60
40
20
0
MOR
HCC
Location
Deep
Shallow

Figure 3.6: Middle Oconee River blocks: annual average percent cover. Block 1 appeared to lag behind Block 2 in re-colonization rates, with Block 2 reaching 100% cover by day 210. Block 1 reached 100% cover 122 days later.



Percent Cover
100
90
80
70
60
50
40
30
20
10
0
10 29 55 86 114 155 178 210 242 270 299 332 352
Time since scraping (day)
MOR Block 1 Ave
MOR Block 2 Ave

Figure 3.7: Annual average percent cover comparison between sites. While re-colonization rates in plots in Hunnicutt Creek appeared to be initially slower (as signified by the lagging percent cover line), it eventually surpassed the Middle Oconee plots. Both sites neared 100% cover after around 320 days.



Percent Cover
100
90
80
70
60
50
40
30
20
10
0
10
29
55
86
114
155
178
210
242
270
299
332
352
Time since scraping (day)
MOR Ave Annual
HCC Ave Annual

Figure 3.8: Middle Oconee River blocks: growing season average percent cover. On day 79, two of the plots in Block 1 dried and no *P. ceratophyllum* survived. Flows remained relatively low in the following days, likely explaining the fluctuating and ultimately declining percent cover.

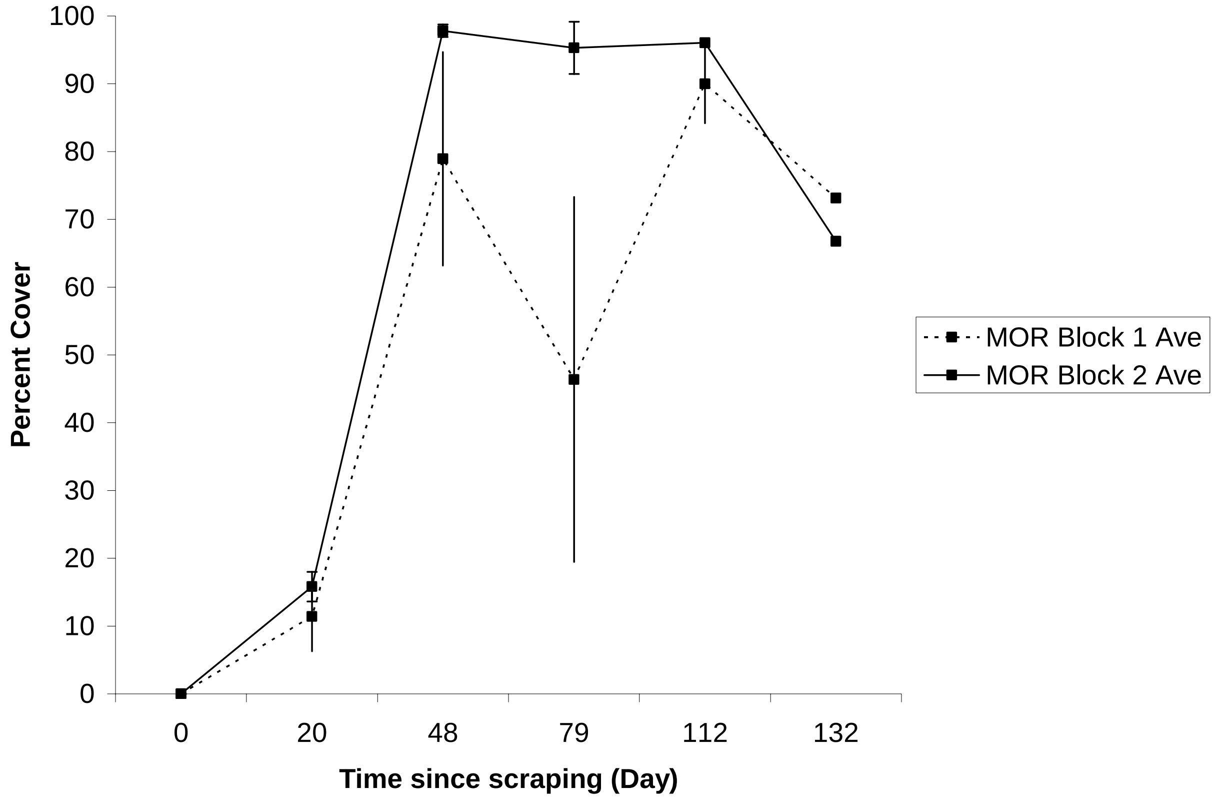
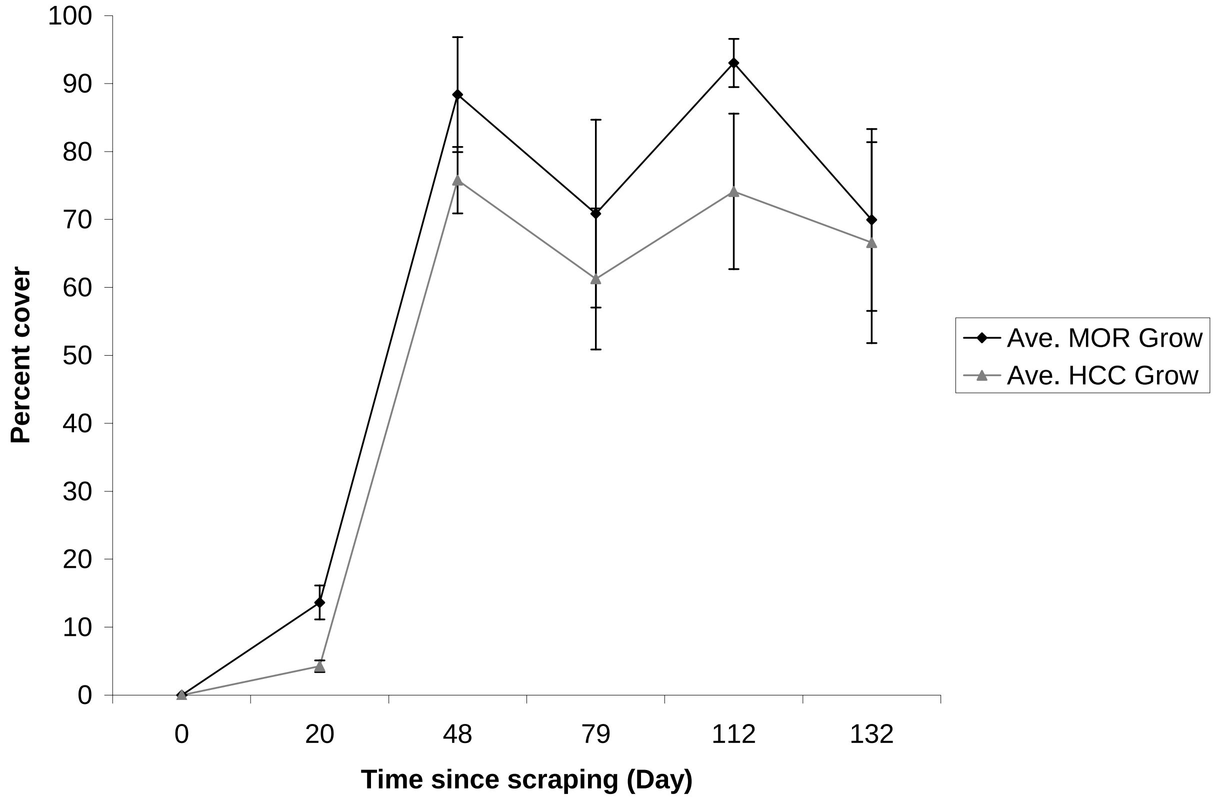
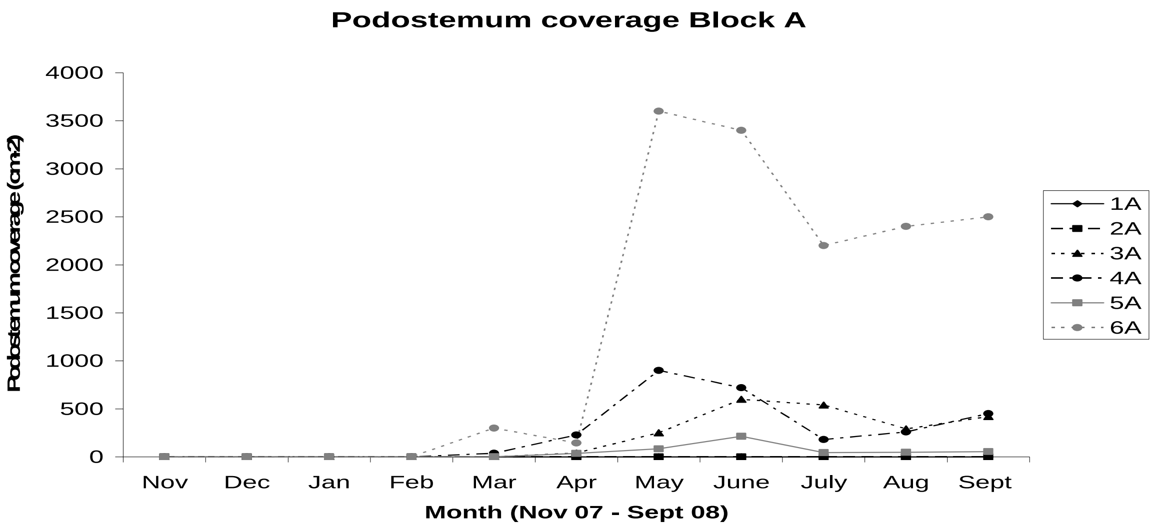

100
90
80
70
60
50
40
30
20
10
0
Percent Cover
0
20
48
79
112
132
Time since scraping (Day)
MOR Block 1 Ave
MOR Block 2 Ave

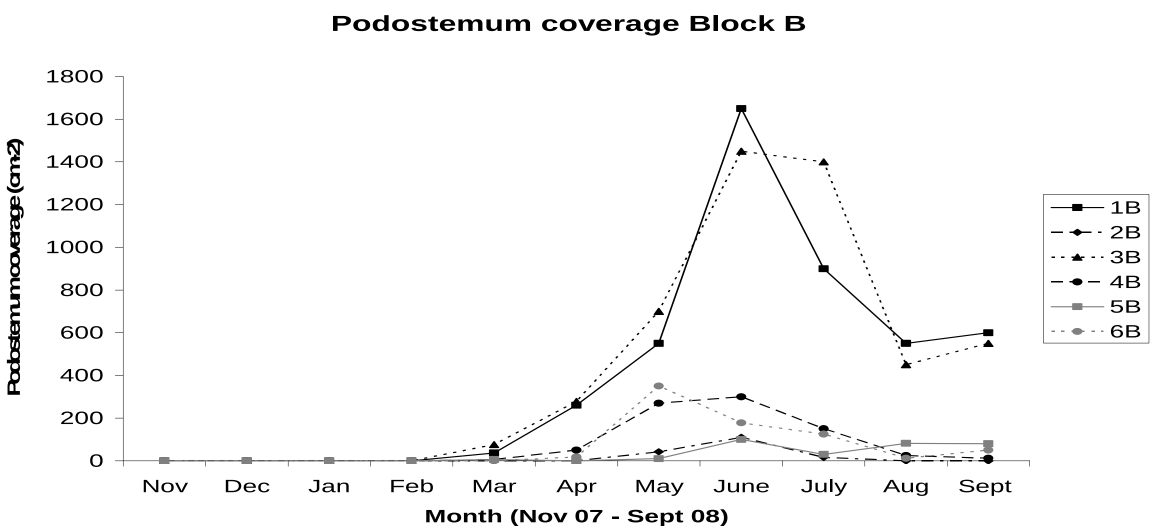
Figure 3.9: Growing season average percent cover comparison between sites. On day 79, a drying event left many plots with little or no water, resulting in some mortality. This may be responsible for the lower average percent cover on that day. Flows remained relatively low in the following days, likely explaining the lack recovery to 100% cover.



100
90
80
70
60
50
40
30
20
10
0
Percent cover
0
20
48
79
112
132
Time since scraping (Day)
Ave. MOR Grow
Ave. HCC Grow

Figure 3.10: Boulder *P. ceratophyllum* coverage comparisons. *P. ceratophyllum* coverage (cm^2) by boulder in 3 Blocks in the Middle Oconee River.


Podostemum coverage Block A
Podostemum coverage (cm2)
4000
3500
3000
2500
2000
1500
1000
500
0
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Month (Nov 07 - Sept 08)
1A
2A
3A
4A
5A
6A


Podostemum coverage Block B
Podostemum coverage (cm2)
1800
1600
1400
1200
1000
800
600
400
200
0
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Month (Nov 07 - Sept 08)
1B
2B
3B
4B
5B
6B

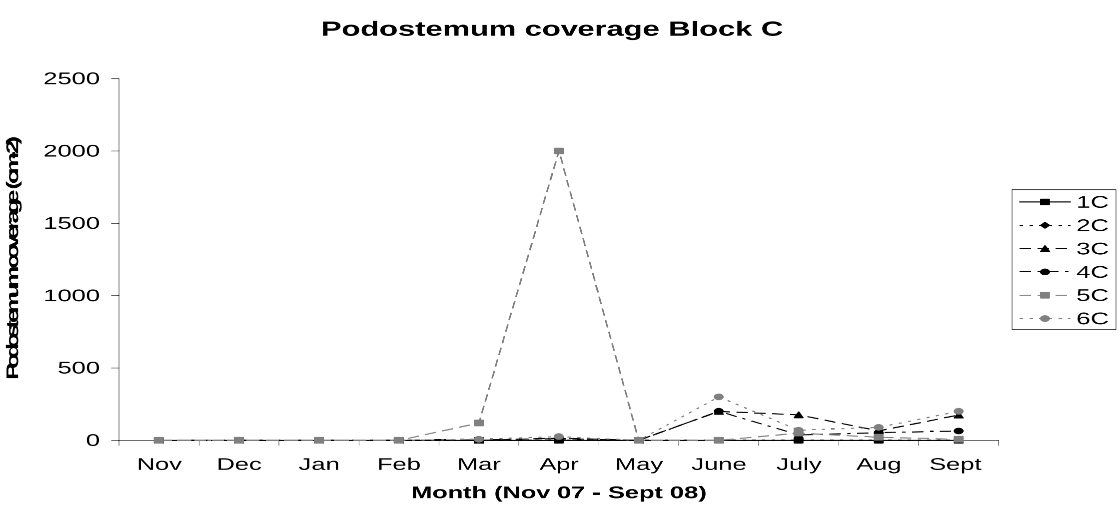

Podostemum coverage Block C
Podostemum coverage (cm2)
2500
2000
1500
1000
500
0
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Month (Nov 07 - Sept 08)
1C
2C
3C
4C
5C
6C

Figure 4.1: *P. ceratophyllum* distribution. Distribution of *Podostemum ceratophyllum* (USDA Plant Database) ranging from Georgia north along the east coast through northern Canada. States where *P. ceratophyllum* is state listed as a species of special concern, threatened, endangered or historic are highlighted accordingly.

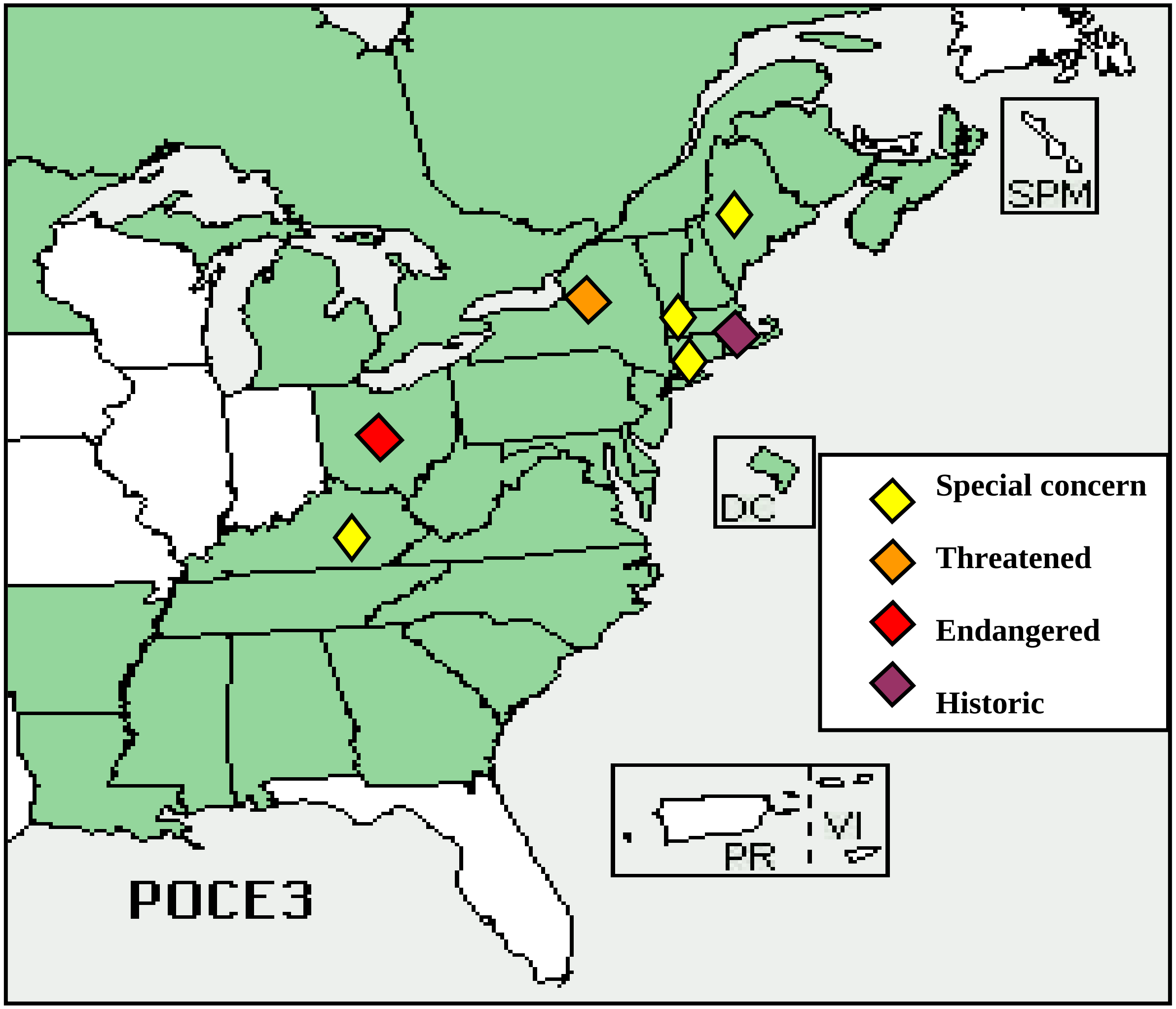

SPM
DC
Special concern
Threatened
Endangered
Historic
PR
VI
POCE3

Figure 4.2: *P. ceratophyllum* survey distribution in Georgia. 1:100,000 meter scale stream coverage map of Georgia highlighting physiographic province, *Podostemum ceratophyllum* observation locations (plus signs), and U.S. Geological Survey gages (circles). *P. ceratophyllum* observations were collected through fish surveys by B.J. Freeman and M.C. Freeman over the past 20 years, and are not random observations. This map represents an initial *P. ceratophyllum* range identification.

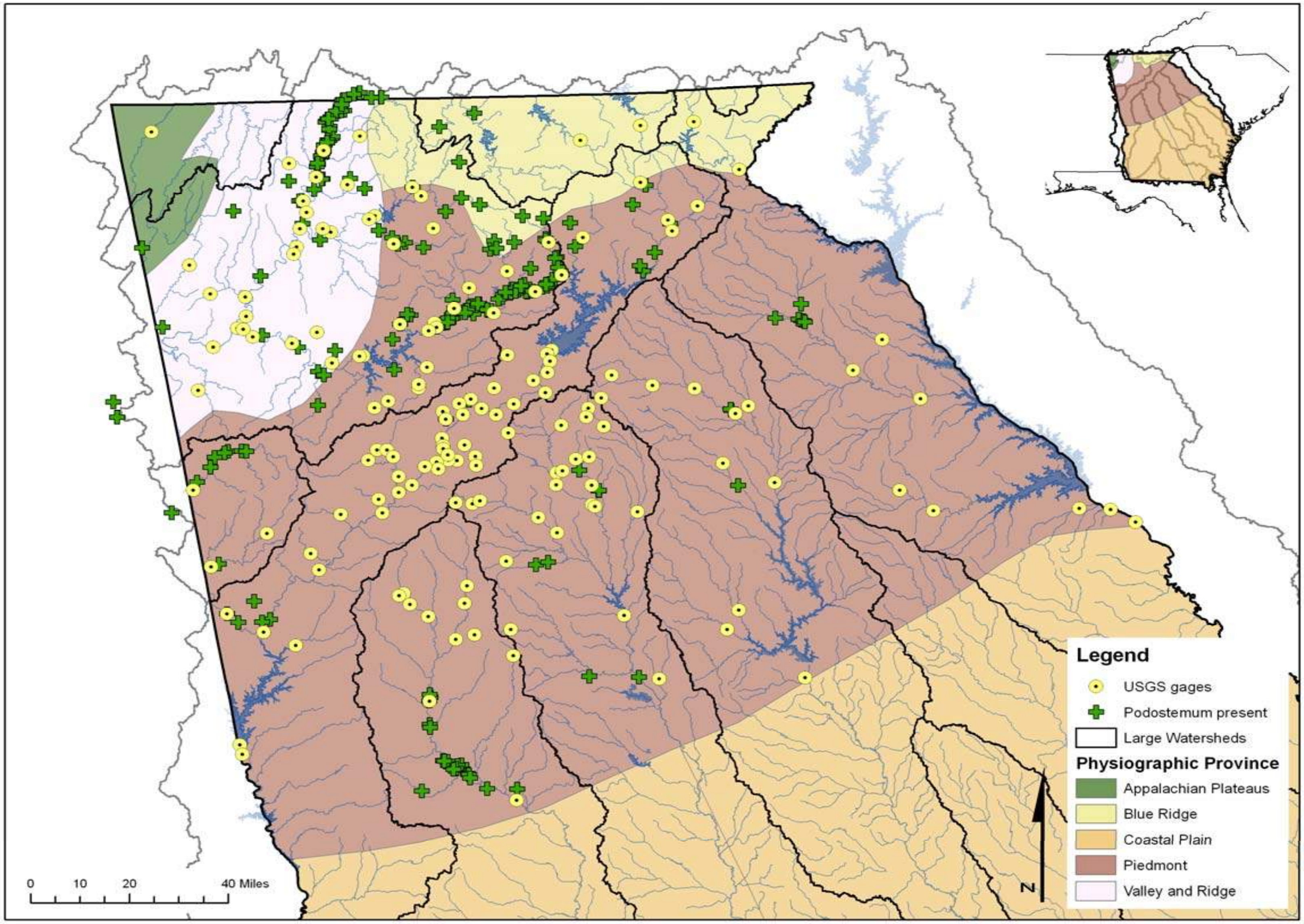

Legend
USGS gages
Podostemum present
Large Watersheds
Physiographic Province
Appalachian Plateaus
Blue Ridge
Coastal Plain
Piedmont
Valley and Ridge
0 10 20 40 Miles
N

Figure 4.3: Examples of altered and unaltered hydrology. Hydrographs of three U.S. Geological Survey gages at the 15 minute time scale to illustrate gages that had hydrologic alteration present and those that were classified as not altered. USGS gage number 02392950 is from Noonday Creek at Hawkins Store Rd, near Woodstock, GA, and represents a normal hydrograph. USGS gage number 02389150 is from the Etowah River at GA 9, near Dawsonville, GA, and indicates upstream water extraction. USGS gage number 0239400 is from the Etowah River at Allatoona Dam, above Cartersville, GA and reflects the presence of the upstream dam operation.

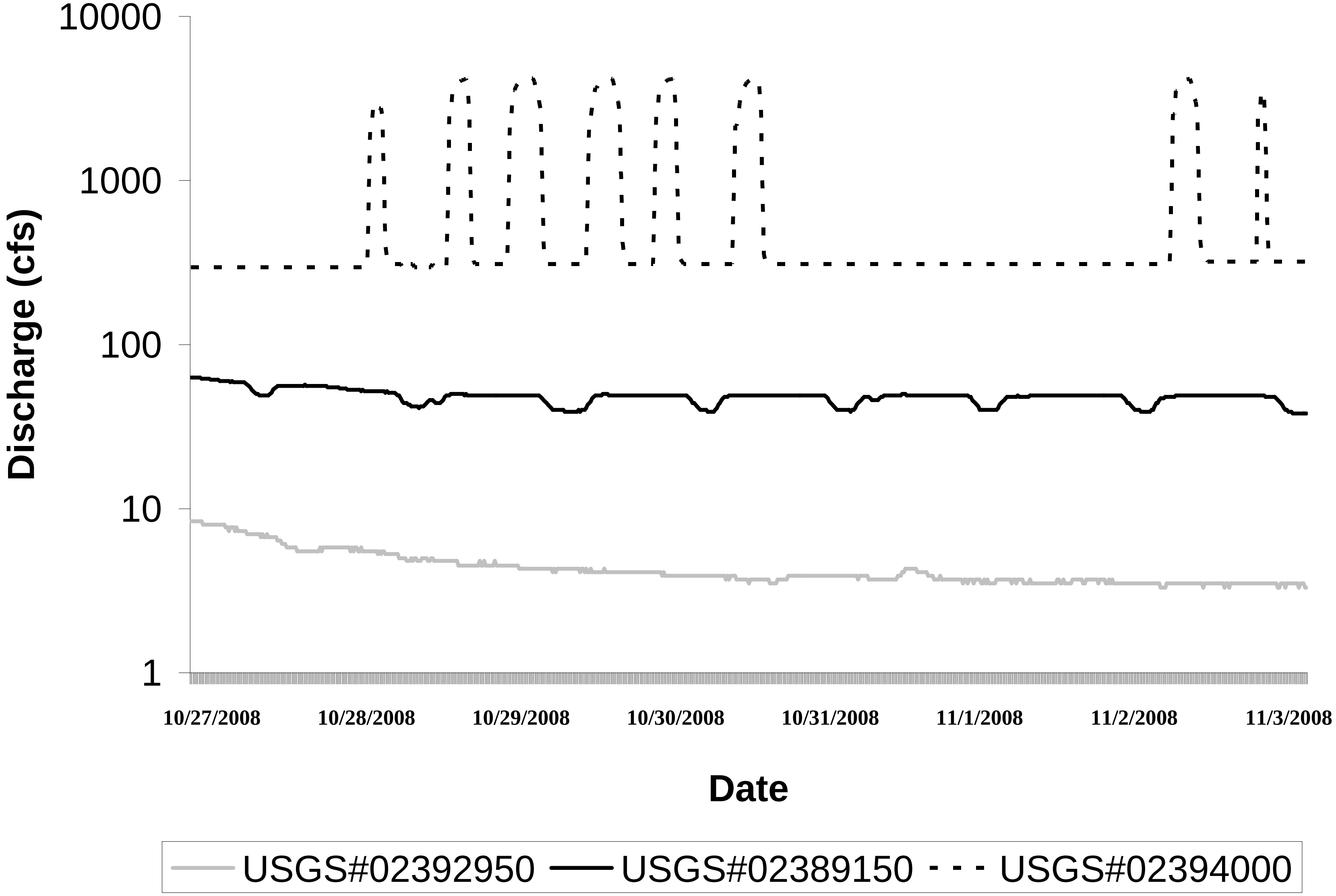

Discharge (cfs)
10000
1000
100
10
1
10/27/2008
10/28/2008
10/29/2008
10/30/2008
10/31/2008
11/1/2008
11/2/2008
11/3/2008
Date
USGS#02392950
USGS#02389150
USGS#02394000

Figure 4.4: Histogram of *Podostemum ceratophyllum* observations classified by stream order.

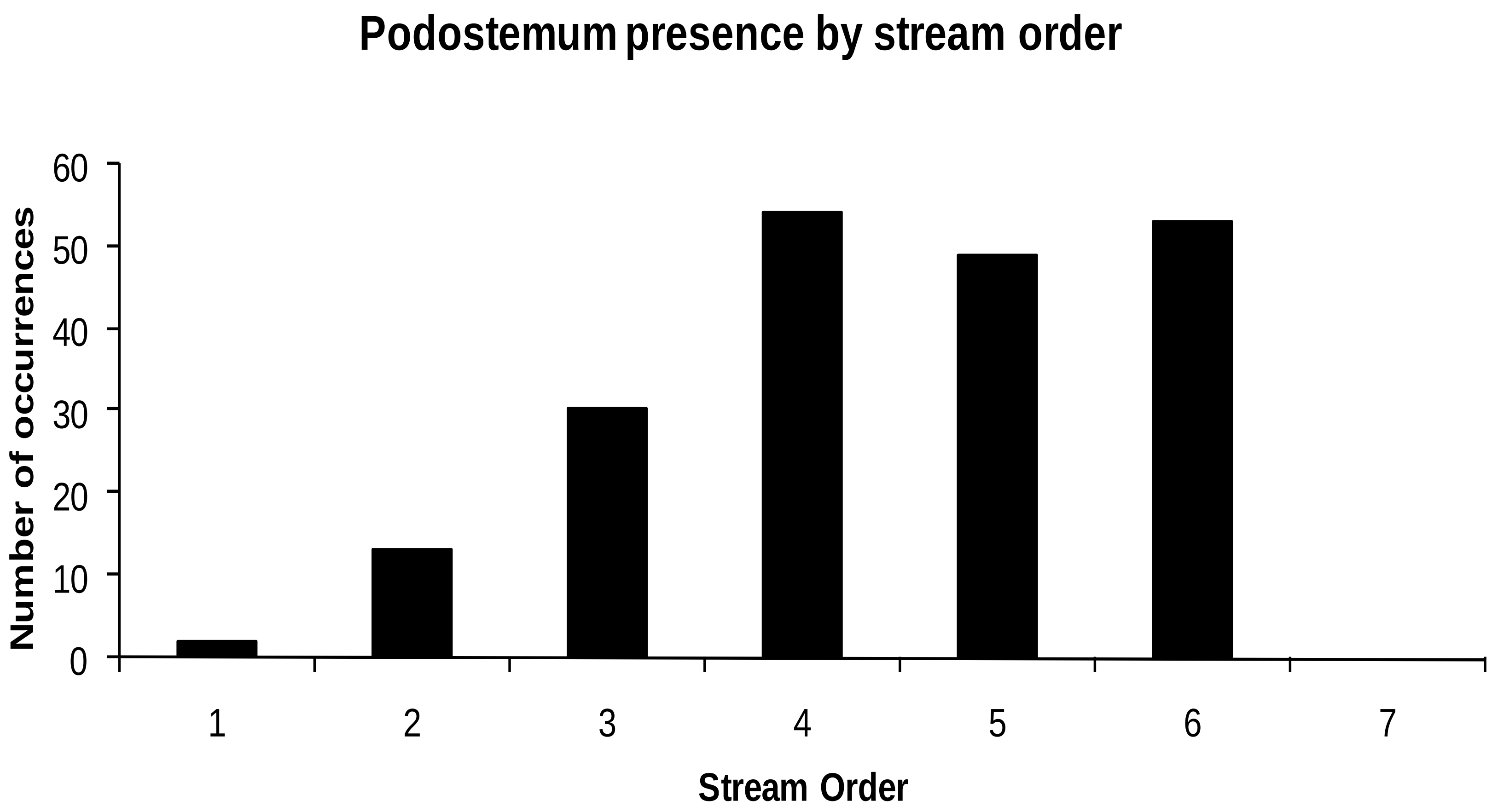
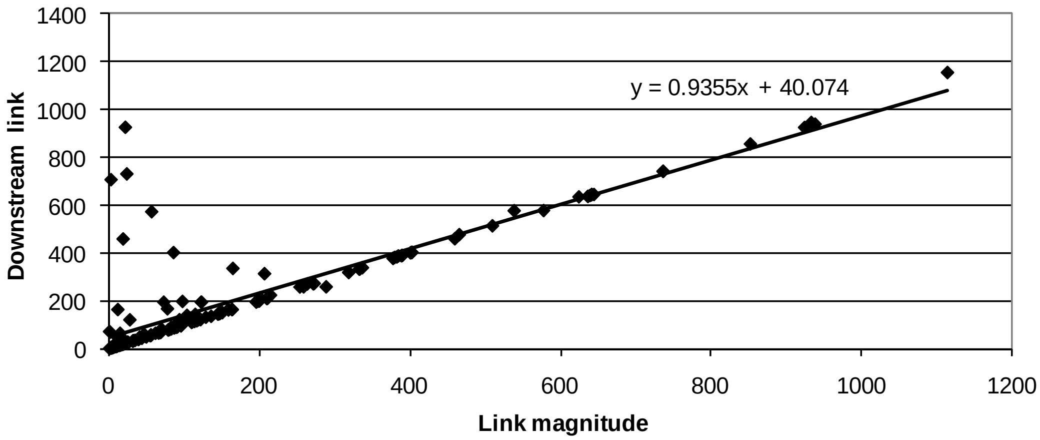
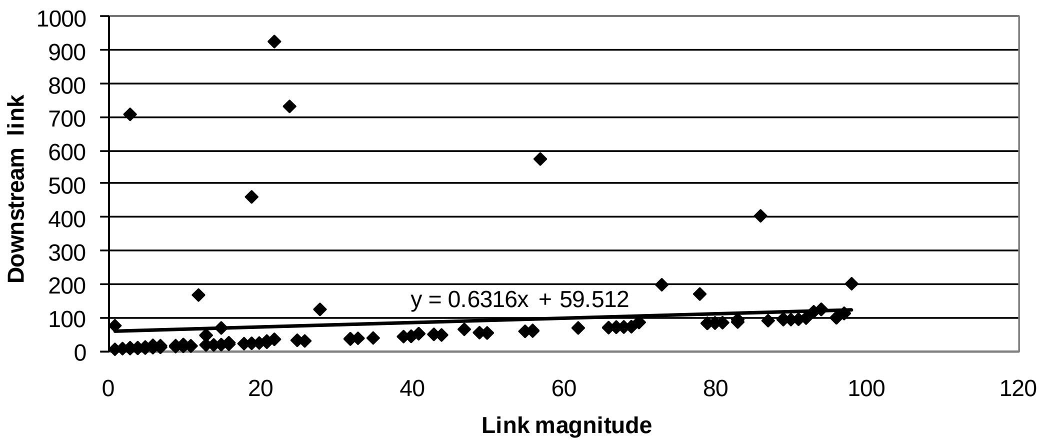

Podostemum presence by stream order
Number of occurrences
60
50
40
30
20
10
0
1
2
3
4
5
6
7
Stream Order

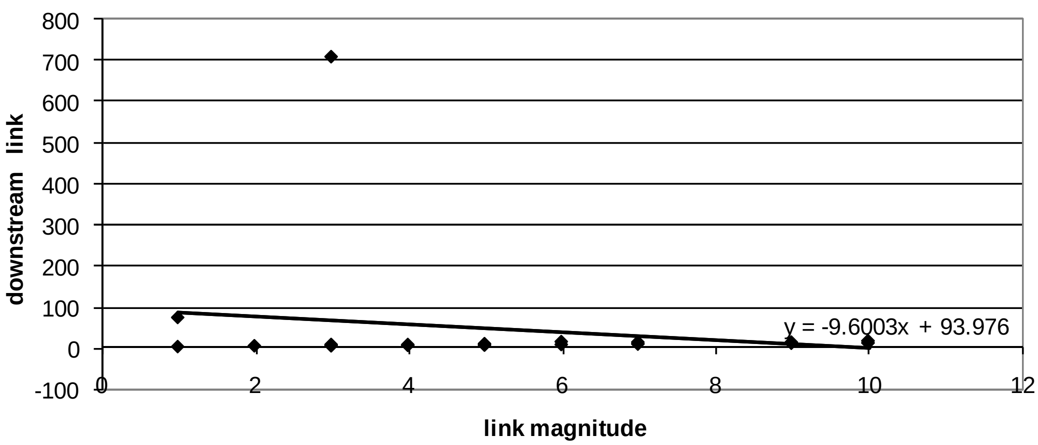
Figure 4.5: Link magnitude and downstream link associations. Regressions between link magnitude and downstream link for all observation sites, those with link magnitudes under 100, and those equal to or less than 10. These figures indicate that link magnitude and downstream link are well correlated for link magnitudes greater than 200, but are less correlated below this value. At extremely low link magnitudes, there is not a very strong correlation, and downstream links can range from close to the link magnitude to much larger.



y = 0.9355x + 40.074
Downstream link
Link magnitude
0
200
400
600
800
1000
1200
1400



y = 0.6316x + 59.512
Downstream link
Link magnitude



y = -9.6003x + 93.976
downstream link
link magnitude

Figure 4.6: Hydrologic alteration by major basin. 1:100,000 scale stream cover map of Georgia above the fall line with major drainages outlined. Each basin is color coded with respect to its percentage of USGS gages that indicated altered hydrology from water extractions or impoundments.

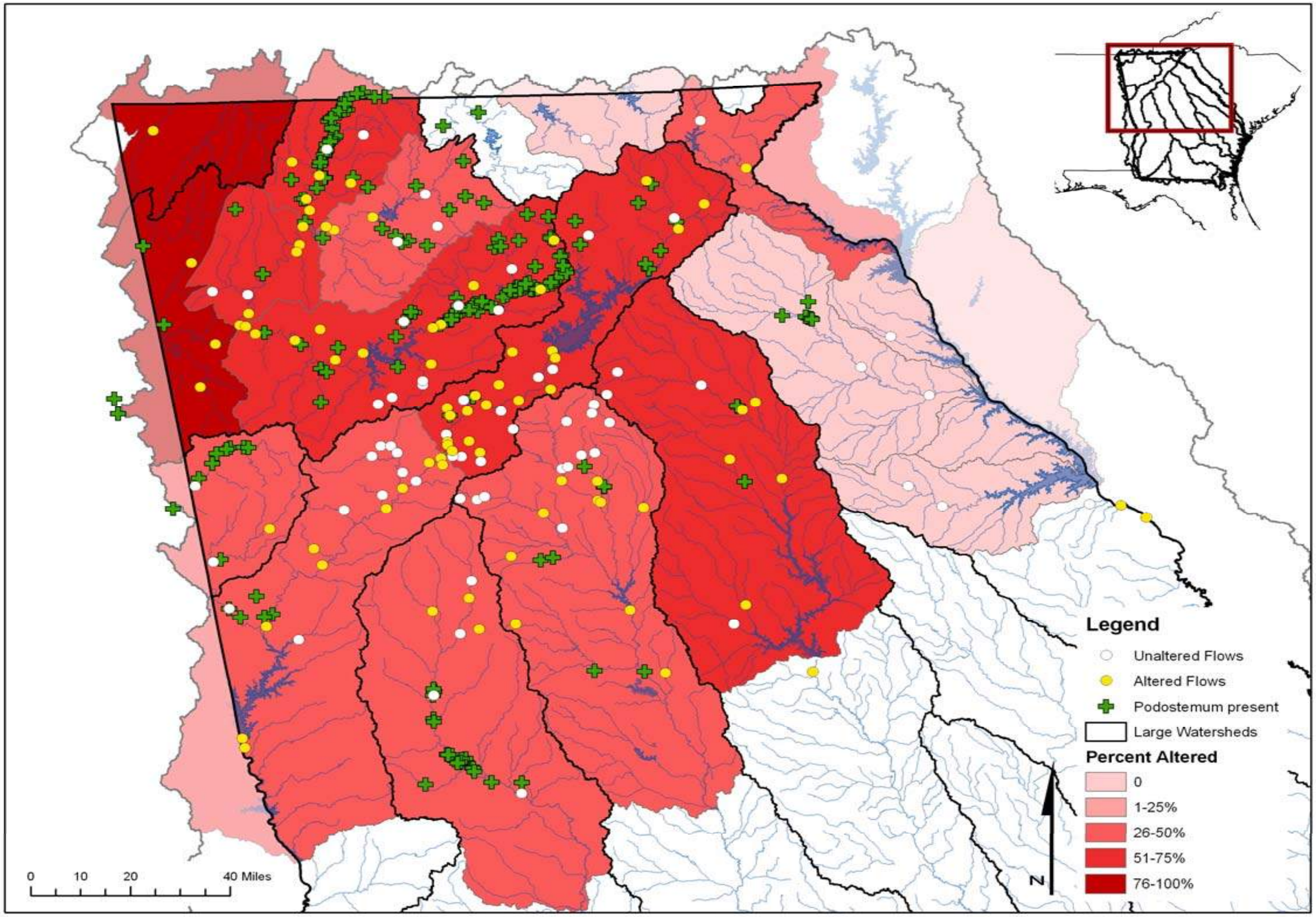

Legend
Unaltered Flows
Altered Flows
Podostemum present
Large Watersheds
Percent Altered
0
1-25%
26-50%
51-75%
76-100%
0 10 20 40 Miles
N

Image 3.1: Study shoal in the Middle Oconee River, at Ben Burton Park, Athens, GA. This image highlights the variability in substrate elevation and the large area of exposed sediments under drought conditions.

Image 3.2: Photograph of *P. ceratophyllum* holdfast (raphe) markings on a boulder. This type of marking was used as evidence of past colonization for boulders that were used in the isolated substrate study.

APPENDIX A

RAW DATA: RIVERWEED BIOMASS AND OTHER VARIABLES

P. ceratophyllum (Riverweed) biomass is expressed in g-AFDM/m^2, velocity is in m/s, substrate code 1 = bedrock/boulder, 0 = gravel/cobble, Location code 1 = edge, 0 = center.

Date	Riverweed	Substrate	Location	Velocity
12/13/2007	24.9254	1	1	0.11
12/13/2007	61.1149	1	1	0.04
12/13/2007	4.8137	0	0	0.08
12/13/2007	38.9237	1	0	0.34
12/13/2007	32.1267	0	0	0.04
12/13/2007	32.8006	1	0	0.59
12/13/2007	19.9576	0	0	0.75
12/13/2007	1.0494	0	0	-0.04
12/13/2007	1.2131	0	1	-0.06
12/13/2007	0.2696	1	1	0.15
2/11/2008	12.1979	1	0	0.51
2/11/2008	6.8066	0	0	0.52
2/11/2008	58.0630	1	0	0.51
2/11/2008	35.2941	1	0	0.59
2/11/2008	7.0184	1	1	0.85
2/11/2008	55.2999	1	0	0.79
2/11/2008	1.2516	1	1	0.42
2/11/2008	2.0892	1	1	0.41
3/25/2008	69.3174	1	0	0.66
3/25/2008	0.1059	1	0	0.75
3/25/2008	0.5776	1	0	0.25
3/25/2008	120.4776	1	0	0.23
3/25/2008	116.2126	1	0	0.29
3/25/2008	21.5751	0	0	0.61
3/25/2008	0.0000	1	1	0.29
3/25/2008	6.1423	1	1	0.37
4/21/2008	69.3848	1	0	0.71
4/21/2008	11.2545	1	0	0.82
4/21/2008	371.2815	1	0	0.52
4/21/2008	155.1459	1	0	0.48
4/21/2008	27.0145	1	1	-0.01
4/21/2008	161.5193	0	0	0.40
4/21/2008	41.8023	1	1	0.73
4/21/2008	23.0192	1	1	0.49
5/27/2008	16.7132	1	1	1.17
5/27/2008	5.6513	1	1	0.43

5/27/2008	81.7849	1	1	0.38
5/27/2008	18.5232	1	0	-0.02
5/27/2008	48.0697	0	0	0.37
5/27/2008	11.6203	0	0	0.24
5/27/2008	197.4199	1	0	0.67
5/27/2008	31.2987	0	0	0.52
5/27/2008	4.7752	1	1	0.27
5/27/2008	70.5209	1	1	0.53
6/19/2008	1.8100	1	1	0.65
6/19/2008	9.7911	0	1	0.14
6/19/2008	25.9266	1	0	0.20
6/19/2008	215.7987	1	0	0.49
6/19/2008	276.3936	1	0	0.42
6/19/2008	146.7700	1	0	0.25
6/19/2008	141.9371	1	0	0.03
6/19/2008	208.5492	1	0	0.47
6/19/2008	20.5545	1	1	0.52
6/19/2008	29.2000	1	1	0.47
7/14/2008	9.0209	1	1	0.18
7/14/2008	13.2184	1	1	0.06
7/14/2008	75.8737	1	0	0.12
7/14/2008	156.0316	1	0	0.02
7/14/2008	36.1606	1	0	0.08
7/14/2008	355.7525	0	0	0.19
7/14/2008	207.6442	1	0	0.13
7/14/2008	44.9408	1	0	0.09
7/14/2008	27.5441	1	1	0.05
7/14/2008	84.0378	1	1	0.07
8/18/2008	54.0676	1	0	0.01
8/18/2008	87.5999	0	0	0.10
8/18/2008	154.3372	1	0	0.34
8/18/2008	1.8388	0	0	0.24
8/18/2008	28.8726	1	0	-0.04
8/18/2008	19.3126	1	0	0.11
8/18/2008	4.0050	1	1	0.09
8/18/2008	15.1632	1	1	0.07
9/19/2008	36.0836	1	1	0.28
9/19/2008	14.6433	1	1	0.00
9/19/2008	11.2545	1	0	0.16
9/19/2008	28.8052	1	0	0.02
9/19/2008	212.6794	1	0	0.34
9/19/2008	4.2264	0	0	0.25
9/19/2008	27.8714	1	0	0.10
9/19/2008	19.1586	1	0	0.00
9/19/2008	18.8890	1	1	0.19
9/19/2008	17.8877	1	1	0.16
10/15/2008	7.5960	1	1	0.04
10/15/2008	39.8960	0	1	0.09
10/15/2008	15.6349	1	0	0.16
10/15/2008	54.2409	1	0	0.22
10/15/2008	23.5198	0	0	0.41

10/15/2008	110.2532	1	0	0.36
10/15/2008	7.8945	1	0	0.18
10/15/2008	42.6880	1	0	0.11
10/15/2008	39.9923	1	1	0.37
10/15/2008	35.3808	1	1	0.23

A Survey of the New River Aquatic Plant Community in Response to Recent Triploid Grass Carp Introductions into Claytor Lake, Virginia

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URL: http://www.bioone.org/doi/full/10.1656/058.014.0211

A Survey of the New River Aquatic Plant Community in Response to Recent Triploid Grass Carp Introductions into Claytor Lake, Virginia

Matthew A. Weberg[1,*], Brian R. Murphy[1], Andrew L. Rypel[1, 2], and John R. Copeland[3]

Abstract - Aquatic plant communities play critical roles in the form and function of stream ecosystems. In this study, we surveyed the aquatic-plant community along a 39-km reach of the New River, VA, in response to triploid *Ctenopharyngodon idella* (Grass Carp) stockings to control *Hydrilla verticillata* (Hydrilla) in Claytor Lake. We utilized drift-net sampling methods and visual observations to document the current plant community in this reach. Nine of 12 aquatic plant species identified in our survey have been documented as preferred forage for Grass Carp. These findings may indicate that migrating Grass Carp could alter the plant community in this reach. We recommend continued monitoring of this system to characterize any future effects of Grass Carp herbivory.

Introduction

Aquatic plants are vital to the overall structure and function of lotic ecosystems (Minshall 1978). In mid-sized rivers, aquatic plants often comprise a significant fraction of primary production (Hill and Webster 1983, Minshall 1978, Rodgers et al. 1983, Vannote et al. 1980), and are thus especially important in these environments. For example, diverse aquatic-plant communities provide complex and heterogeneous habitat for a large variety of aquatic species, as well as refuge from predators (Allen and Castillo 2007, Grenouillet et al. 2002). Furthermore, aquatic plants in lotic habitats are known to play important roles in nutrient dynamics and sediment transport (Clarke and Wharton 2001, Madsen et al. 2001). Therefore, changes to the diversity and abundance of aquatic plants have the capacity to severely alter river ecosystems (Holmes et al. 1998), including the recreational and industrial benefits these environments provide to humans (Strange et al. 1999).

Invasive species are one of the foremost threats to the integrity of aquatic ecosystems at multiple scales. Pimentel et al. (2005) estimated the monetary cost of invasive species management for 6 developed nations at >$US335 billion per year and growing. Additionally, the economic effects of invasive species can be highly localized and severe. For example, property values in Wisconsin lakes invaded by *Myriophyllum spicatum* L. (Eurasian Water Milfoil) on average experienced a 13% decline following invasion (Horsch and Lewis 2009). Similarly, *Hydrilla*

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verticillata (L.f.) Royle (Hydrilla) infestations can block irrigation canals, hasten sedimentation in reservoirs, interfere with water supplies, impede boat navigation, and reduce fisheries productivity (Langeland 1996).

Hydrilla was first documented in 2003 in Claytor Lake, Pulaski County, VA, by Virginia Department of Game and Inland Fisheries (VDGIF) biologists (J.R. Copeland, VDGIF, Blacksburg, VA, pers. comm.). Claytor Lake is an impoundment of the upper New River located in the Valley and Ridge physiographic province. In 2011, triploid (reproductively sterile) *Ctenopharyngodon idella* (Valenciennes in Cuvier and Valenciennes) (Grass Carp) were stocked into the reservoir to manage the expanding Hydrilla infestation using an incremental stocking approach. This strategy aimed to gradually reduce Hydrilla abundance over several years through periodic low-level Grass Carp stockings (Bain 1993, Chilton and Magnelia 2008). However, relatively long migrations (up to 500 km) by Grass Carp have been observed in large-river environments in both their native range and the US (Gorbach and Krykhtin 1988). Such occurrences could bring stocked Grass Carp into contact with macrophyte communities in river reaches adjacent to reservoirs. The New River upstream of Claytor Lake is an important aquatic resource for the region and supports a highly valued sport fishery (Copeland 2014). Therefore, this river reach could be negatively affected if upstream migrations by Grass Carp lead to reductions in native vegetation abundance. In 2012, we documented low levels of Grass Carp migration into this reach of the New River through a concurrent telemetry study (Weberg 2013). Thus, it is important to understand the current aquatic-plant community present within this river reach as a baseline for assessing potential future ecological alterations due to Grass Carp herbivory.

Despite the documentation of Hydrilla within the watershed and the recent introduction of Grass Carp into Claytor Lake, no studies have examined the New River aquatic-plant community since the late 1970s (Hill and Webster 1983, Rodgers et al. 1983). We conducted a drift survey of the aquatic-plant communities at 8 sites along a 39-km reach of the New River directly upstream of Claytor Lake. The objectives of the survey were to: (1) determine if Hydrilla had become established within this reach and (2) document the relative abundances of submersed and emergent macrophytes present within this reach to compare with identified plant preferences of Grass Carp and assess the potential for future herbivory effects should significant Grass Carp migrations occur.

Methods

Study site

The New River originates in the Appalachian highlands of North Carolina and flows northwest through Virginia and West Virginia before joining the Ohio River (Hill and Webster 1982). Within southwest Virginia, the New River is characterized by a steep gradient, narrow floodplain, and primarily bedrock channel. Our study focused on the 39-km river reach between Buck Dam and the head of Claytor Lake (generally marked by a set of riffles located near Allisonia, VA; Fig 1.).

Assessment of aquatic plant community upstream of Claytor Lake

During July 2012, we surveyed the aquatic-plant community by canoe starting at Buck Dam and concluding at the Allisonia rapids at the head of Claytor Lake. We visually surveyed for aquatic plant species along this reach; in deeper pool sections, we randomly threw a double-sided rake attached to a rope and slowly retrieved it to check for plant presence. We recorded all aquatic-plant species as we encountered them, maintained a running list, and placed voucher specimens of each species on ice for verification by taxonomic experts at the Massey Herbarium at Virginia Tech, Blacksburg, VA. To gauge the occurrence and abundance of aquatic-plant species along this reach, we also collected a single 5-minute drift-net sample using a 7.6-m beach seine approximately every 5 river-km using the methodology outlined by Owens et al. (2001). We collected drift samples by wading into the river at each sampling site and stretching the seine net perpendicular to the flow of the river. We removed from the net all aquatic plant fragments collected during each drift sample and stored them on ice. At the conclusion of the survey, we separated the samples by species, and blotted dry and weighed (g fresh weight [FW]) them.

Results

We identified 13 macrophyte species, of which 9 have been identified as readily or moderately consumed by Grass Carp (Table 1; Opuszynski and Shireman 1995).

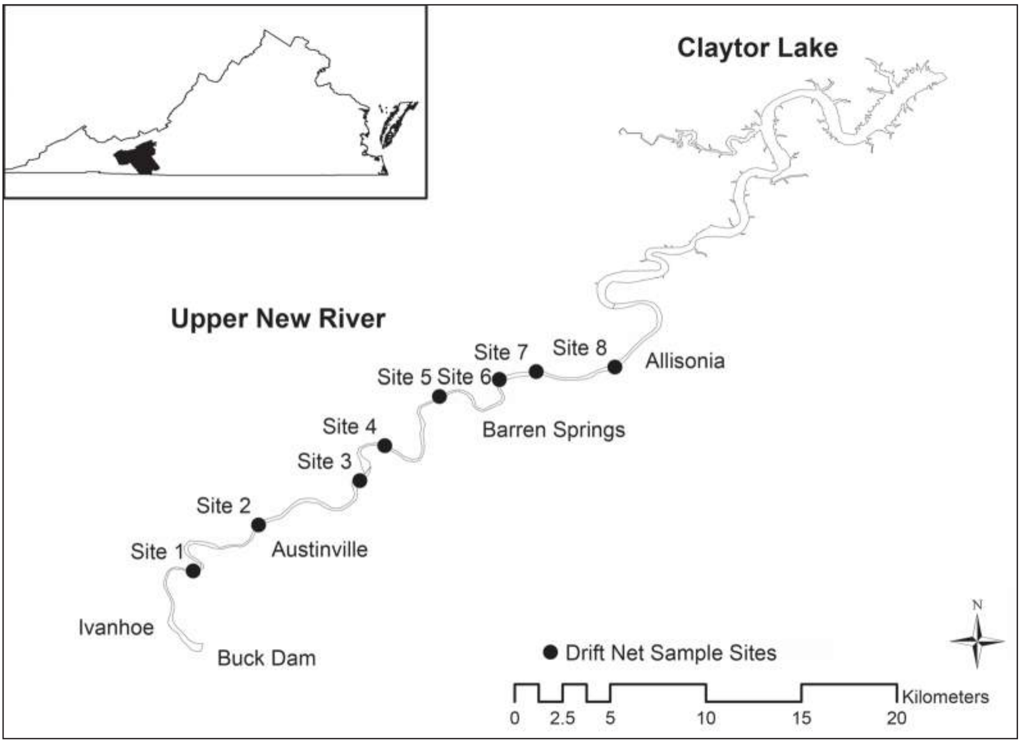

Figure 1. Surveyed section of the Upper New River including locations of drift-net sampling sites between Buck Dam near Ivanhoe, VA, and the start of Claytor Lake near Allisonia, VA.

Four of the 7 species sampled in the drift-net survey occurred in relatively low abundance (less than 21% of the plant-fragment sample per site [g FW]); however, we detected *Elodea canadensis* (Water Weed) and *Potamogeton crispus* (Curly Leaf Pondweed) at all sites (Table 2). While absent from the site-6 drift sample, we also observed *Podostemum ceratophyllum* (Riverweed) throughout the entirety of the survey, especially within shallow run and riffle habitats. The highest amount of plant fragments collected in our drift-net samples was at site 5 (365 g; Fig. 2). We did not detect Hydrilla on the surveyed river reach.

Overall, aquatic plant fragments collected in our drift-net samples were dominated by either Riverweed or Water Weed (Table 2, Fig. 2). In total, Water Weed comprised more than 62% of the total plant-fragment sample (g FW) during all drift-net surveys while Riverweed accounted for of approximately 23%. Interestingly, Riverweed dominated fragment samples at the 4 most-upstream sites, but Water

Table 1. List of aquatic plant species documented during a float survey of the New River between Buck Dam and Allisonia, VA, in July 2012. Determinations of prior species documentations were based on survey results from Hill and Webster (1984). *Indicates plants identified as readily or moderately consumed by Grass Carp (Opuszynski and Shireman 1995).

Common name	Scientific name	Classification	Prior documentation
Water Weed*	*Elodea canadensis* (Michx.) Britton	Submersed	Yes
Curly Leaf Pondweed*	*Potamogeton crispus* L.	Submersed	Yes
Longleaf Pondweed*	*Potamogeton nodosus* Poir.	Floating-leaved	No
Leafy Pondweed*	*Potamogeton foliosus* Raf.	Submersed	No
Wild Celery*	*Vallisneria americana* Michx.	Submersed	Yes
Riverweed	*Podostemum ceratophyllum* Michx.	Submersed	Yes
Musk-grass*	*Chara* L.	Algae	No
American Water-willow	*Justicia americana* (L.) Vahl	Emergent	Yes
Giant Duckweed*	*Spirodela polyrhiza* (L.) Schleid.	Floating-leaved	No
Arrowhead*	*Sagittaria* sp.	Emergent	No
Common Cattail*	*Typha latifolia* L.	Emergent	Yes
American Bulrush	*Schoenoplectus pungens* (Vahl) Palla	Emergent	No
Grassleaf Mudplantain	*Heteranthera dubia*(Jacq.) MacMill	Submersed	No

Table 2. Percent by weight of total sampled plant fragments for each species from drift-net samples taken approximately every 5 river-km during an aquatic plant survey of the New River between Buck Dam and Allisonia, VA, in July 2012.

	Site							
Common name	1	2	3	4	5	6	7	8
Water Weed	29.0	46.9	9.6	9.5	87.5	58.3	69.2	20.2
Curly Leaf Pondweed	0.4	5.4	1.1	0.3	10.8	29.7	12.9	42.0
Longleaf Pondweed	4.6	6.1	1.5	-	0.7	-	-	-
Leafy Pondweed	-	-	0.1	0.3	0.4	1.2	12.9	20.5
Wild Celery	0.4	12.2	0.2	0.6	0.3	10.7	-	-
Riverweed	65.7	29.3	87.5	89.3	0.3	-	4.8	17.3
Musk-grass	-	-	-	-	-	-	0.1	-

Weed dominated the samples obtained at 3 of the 4 lower-most sites. We also detected Curly Leaf Pondweed in low abundance in drift-samples at the 4 upstream sites, but its abundance increased substantially at the 4 downstream sites. The final downstream site was in fact dominated by Curly Leaf Pondweed and also had more equal fractions of Riverweed and Water Weed in sampled drift fragments. Longleaf Pondweed and *Vallisneria americana* (Wild Celery) were relatively uncommon species and appeared to be confined to upstream river reaches.

Discussion

Aquatic plant community of the New River upstream of Claytor Lake

Understanding aquatic-plant communities in mid-sized rivers can provide important insight into ecosystem structure and stability (Gregg and Rose 1982, Minshall 1978). However, comparatively few studies have addressed riverine aquatic-plant communities in the US, especially in the Southeast (Franklin et al. 2008). Our study identified a more-diverse aquatic-plant community in this stretch of the New River than was found during prior investigations (Hill and Webster 1984). In both terrestrial and aquatic-plant communities, greater occurrence and abundance of native species is believed to provide resiliency against the establishment of introduced species (Capers et al. 2007, Dukes 2001, Larson et al. 2013), which could explain the apparent absence of Hydrilla within this reach. However, a lack of Hydrilla may also be a function of early detection within Claytor Lake and the possibility that this section of the New River may have been sampled prior to a

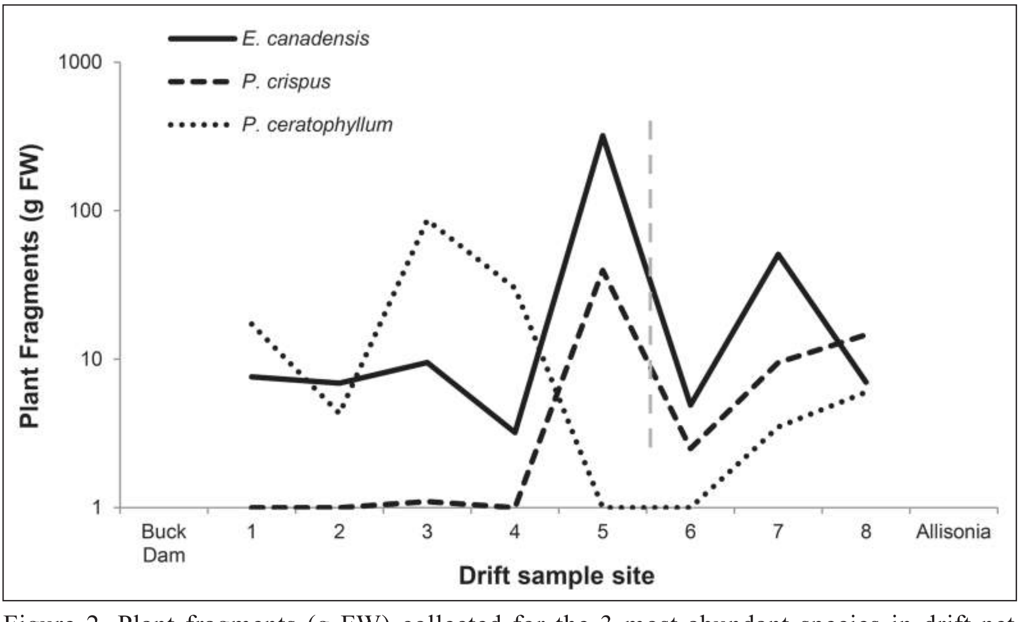

Figure 2. Plant fragments (g FW) collected for the 3 most-abundant species in drift-net samples taken in July 2012 at 8 sites in the New River between Buck Dam and Allisonia. The vertical dashed line (grey) indicates the furthest location upstream of Claytor Lake at which we documented Grass Carp during a concurrent telemetry study (Weberg 2013).

future "invasion wave" (Neubert and Caswell 2000, Skarpaas and Shea 2007). For example, there are increasing reports of established Hydrilla beds within the New River downstream of Claytor Dam (J.R. Copeland, pers. comm.), a reach that was not sampled in this study. Suitable habitat for aquatic plants in riverine environments is often limited by flow conditions (Butcher 1933, Sand-Jensen and Madsen 1992, Sprenkle et al. 2004) as well as through variations in dispersal (Bunn and Arthington 2002, Riis and Sand-Jensen 2005, Santamaria 2002), often leading to patchy distributions on the landscape. Similarly, the amount of plant fragments collected in our drift-net samples varied greatly among sites, which could be attributed to the high gradient and primarily bedrock channel of the upper New River.

The most lush stands of more-abundant species such as Wild Celery, *Potamogeton foliosus* (Leafy Pondweed), and Water Weed appeared to be highly localized at depositional zones within the river. Therefore, these depositional areas may be of significant ecological importance for aquatic biota within this reach. Prior to our study, Hill and Webster (1984) identified Riverweed as the most abundant plant species within this reach of the New River while Water Weed accounted for just 0.03% of macrophyte coverage. Conversely, the results from our drift-net survey indicate Water Weed may be the most abundant macrophyte, possibly suggesting a temporal shift in community structure. Riverweed was also abundant in our drift-net survey, although due to its epilithic nature, our sampling method may have underestimated its true abundance in this reach of the New River. Additionally, Hill and Webster (1984) used aerial photography combined with ground-truthing to determine overall coverage and abundance of plant species, which could further explain the observed differences in results. We collected no emergent plant species during our drift-net survey; however, we observed patchily distributed stands of *Justicia americana* (American Water-willow) throughout the survey. Hill (1981) identified American Water-willow as the most productive macrophyte within the upper New River, although he speculated that its localized distribution limited the species' overall contribution to the stream's energy budget. Although our study provides a much-needed description of the current aquatic-plant community of the New River upstream of Claytor Lake, future monitoring may also be important to identify potential alterations of plant abundance or community structure due to Grass Carp herbivory.

Evidence and implications of Grass Carp herbivory on Riverweed

Riverweed can be the dominant source of autotrophic production in Appalachian Rivers (Hill and Webster 1983) and may promote increased macroinvertebrate production (Hutchens et al. 2004) and stream-fish abundances (Argentina et al. 2010). If Grass Carp herbivory on Riverweed were to increase substantially, it could have major ecological repercussions. Currently, no studies have identified Riverweed as preferred forage for Grass Carp; however, we incidentally observed Riverweed within the alimentary tract of numerous Grass Carp collected near the Allisonia rapids during a concurrent study of Grass Carp growth in fall 2012 (Weberg 2013). The presence of Hydrilla in nearby shoal areas of Claytor Lake at the time of our

Grass Carp sampling efforts offers additional circumstantial evidence of Grass Carp herbivory on Riverweed. Riverweed has been noted as a preferred macrophyte for other herbivorous taxa such as *Branta canadensis* L. (Canadian Geese) and *Procambarus spiculifer* (LeConte) (White-tubercled Crayfish) (Parker et al. 2007); however, the voracious feeding pattern of Grass Carp on preferred plant species (up to 100% of body weight per day; Osborne and Riddle 1999) is of particular concern. For example, prior to 2012 Riverweed was abundant on the substrate at the Allisonia rapids, whereas in fall 2012 the substrate in this area was apparently devoid of Riverweed presumably due to Grass Carp herbivory (J.R. Copeland, pers. comm.). Prior studies have noted overall declines of Riverweed density within Appalachian streams (Argentina et al. 2010, Munch 1993). If this trend has already begun in the New River, it could be compounded by Grass Carp herbivory in this reach.

Implications of potential Grass Carp migrations

The majority of macrophyte species observed in our examination have been documented as preferred forage for Grass Carp that could migrate into that area. These findings, combined with the localization of the most-abundant plant species identified during our survey, indicate that the New River plant community could be vulnerable to Grass Carp herbivory. Beyond our observations during 2012, the overall migration rates of Claytor Lake Grass Carp are unknown. However, additional evidence indicates migration rates could increase as Hydrilla abundance declines in Claytor Lake, and as Grass Carp grow in size and approach sexual maturity. A telemetry study of juvenile Grass Carp stocked into Claytor Lake found that just 2 of 75 radio-tagged fish migrated into the New River over the 2-y study, although the instances of migration occurred in 2012 after Hydrilla abundance in Claytor Lake was significantly reduced (Weberg 2013). Thus, migration rates could increase as a result of Grass Carp searching for food if vegetation resources remain limited within Claytor Lake. Additionally, Grass Carp life stage is believed to influence movement patterns (Gorbach and Krykhtin 1988). For example, mature Grass Carp (600–730 mm total length [TL], 4.0–6.0 kg) stocked in Lake Guntersville, AL showed significantly higher rates of movement than juveniles, and completed migrations as far as 71 km upstream (Bain et al. 1990). Accordingly, 32 Grass Carp (mean TL = 716 mm) were sampled within the New River upstream of Claytor Lake in the spring and early summer 2013 during electrofishing assessments (J.R. Copeland, unpubl. data). During 2011–2012, the first 2 years following the initial stocking of Grass Carp in Claytor Lake, only 4 Grass Carp had been sampled in this reach. The New River was subject to high flows throughout the spring and early summer of 2013, and 27 of the Grass Carp collected in 2013 were captured within close proximity of Allisonia. Therefore, it is possible that the increase in Grass Carp collections may be a result of high flows allowing access to more habitats.

Research implications

Based on our examination of the aquatic-plant community in the New River upstream of Claytor Lake, it appears that greater monitoring is needed to fully understand the effects of Grass Carp in lotic ecosystems. We suggest that annual surveys of water quality and vegetation, fish, and invertebrate abundance, combined with continued monitoring of Grass Carp migration rates, could provide an important case study for resource managers. Grass Carp have been documented in numerous medium–large rivers throughout the US (Elder and Murphy 1997, Guillory and Gasaway 1978, Pflieger 1978), yet examinations of the effects Grass Carp have on the form and function of aquatic ecosystems has been limited to lakes and reservoirs. In Lake Conroe, TX, the complete removal of macrophytes by Grass Carp resulted in a major biomass shift to more-pelagic fish species (Bettoli et al. 1993), increased nutrient levels, and decreased water clarity due to higher algal biomass (Maceina et al. 1992). However, river systems differ greatly in structure and function compared to lentic environments, thus limiting comparability in the assessment of potential Grass Carp effects. Hydrilla continues to pose major threats to aquatic ecosystems at all scales, including to the integrity of riverine aquatic-macrophyte communities. Grass Carp will likely remain a major management tool for addressing invasive Hydrilla infestations and are also likely to spread outside of their introduced range as an invasive species. Future work on the effects of Grass Carp on the macrophyte communities of the New River could contribute to an important case study of the feasibility of Grass Carp as a management tool for Hydrilla balanced against the conservation needs of upstream ecological communities.

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Review

Ecology of the macrophyte *Podostemum ceratophyllum* Michx. (Hornleaf riverweed), a widespread foundation species of eastern North American rivers

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ABSTRACT

Podostemum ceratophyllum, commonly called Hornleaf Riverweed, occurs in mid-order montane and piedmont rivers of eastern North America, where the plant grows submerged and attached to rocks and stable substrates in swift, aerated water. Multiple studies, mostly conducted in the southern portions of the plant's range, have shown that *Podostemum* can variously influence benthic communities in flowing waters. However, a synthetic review of the biology and ecology of the plant is needed to inform conservation, particularly because *P. ceratophyllum* is reported to be in decline in much of its range, for mostly unknown reasons. We have thus summarized the literature showing that *Podostemum* provides substantial habitat for invertebrates and fish, may be consumed by invertebrates, turtles, and other vertebrates, removes and sequesters dissolved elements (i.e., nitrogen, phosphorus, calcium, zinc, etc.) from the water column, and contributes organic matter to the detrital pool. *Podostemum* may be tolerant to some forms of pollution but appears vulnerable to sedimentation, epiphytic over-growth, and hydrologic changes that result in desiccation, and possibly increased herbivory pressure. Much remains unknown about *Podostemum*, including aspects of morphological variation, seed dispersal, and tolerance to changes in temperature and water chemistry. Nonetheless, *Podostemum* may be considered a foundation species, whose loss from eastern North American rivers is likely to affect higher trophic levels and ecosystem processes.

Contents

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1. Introduction

Macrophyte ecology is an active area of aquatic research and research has shown that plants influence aquatic community structure and species composition (Argentina et al., 2010b; Camp et al., 2014), nutrient cycling (Keitel et al., 2016), benthic foodwebs (Lodge, 1991) and ecosystem level processing, and the retention of elements within the system (Vila-Costa et al., 2016). However, there still exist large deficiencies in our understanding of how riverine macrophytes are influenced by land use and subsequent changes in water quality (Argentina et al., 2010a; Manolaki and Papastergiadou, 2013; Bakker et al., 2016). To maintain the ecological integrity of river systems, it is important to be able to identify stressors to riverine macrophytes and predict species persistence for a given environmental change. Here we review the available literature concerning what we believe to be the most ecologically influential macrophytes in mid-order montane and piedmont rivers of eastern North America. *Podostemum ceratophyllum* Michx., commonly called Hornleaf Riverweed, is a flowering plant (angiosperm) that grows submerged and attached to stable benthic substrate (Fig. 1a). The plant is most common in rivers with an open canopy and a cobble or bedrock substrate, but it can also be found in smaller tributaries in locations with abundant light and perennial flow (e.g., waterfalls and cascades). *Podostemum ceratophyllum*, henceforth referred to as *Podostemum* (except where inclusion of the specific epithet provides needed clarity) can cover vast areas of the streambed and provides habitat, and potentially food, for a diverse group of aquatic organisms. *Podostemum* may also influence nutrient and carbon dynamics in the swift-flowing rivers where it occurs (Fig. 2).

Dayton (1972) used the term "foundation species" to describe an organism that strongly influences community structure and function. Later Ellison et al. (2005) employed the foundation species concept to illustrate how the loss of certain tree species altered the local environment and important ecosystem processes like decomposition, nutrient flux, carbon sequestration and energy flow. Similarly, we propose that *Podostemum* can be considered a foundation species based on the plant's extensive geographic range and substantial influence on ecosystem processes and benthic community structure (Nelson and Scott, 1962; Everitt and Burkholder, 1991; Grubaugh and Wallace, 1995; Hutchens et al., 2004). *Podostemum* is morphologically and ecologically similar to riverine bryophytes, which also grow attached to stable substrates, provide substantial habitat for macroinvertebrates and epiphytic biofilms, and increase retention of organic matter and stream metabolism (Stream Bryophyte Group, 1999; Wood et al., 2016). However, we hypothesize that *Podostemum* has a stronger influence on ecosystem processes than bryophytes because it grows more quickly and in a broader range of light conditions, and sustains higher grazing pressure (Parker et al., 2007).

Podostemum is also of interest because the plant appears to be declining across much of its native range. Local extinction or substantial decline of *Podostemum* has been documented in several northern rivers including the Cocheco River near Dover, New Hampshire, the West River near Jamaica, Vermont (Philbrick and Crow, 1983), tributaries of the Roanoke River in Virginia (Connelly et al., 1999), several rivers in Pennsylvania (Munch, 1993) and possibly throughout much of the eastern Piedmont. The species is listed as *Endangered*, *Historical*, a *Species of Concern* or *Threatened* in many northern States (USDA, 2014). Decline and extirpation have been attributed to sedimentation, dewatering, inundation by water impoundment, and unspecified pollutants from industry, mining operations and urban runoff (Adams et al., 1973; Munch, 1993; Connelly et al., 1999). However, neither the underlying factors nor the ecological significance of changes in *Podostemum* abundance have been extensively investigated.

This review provides a synopsis of the biology and ecology of *Podostemum* and identifies research needed to understand the causes and consequences of changes in abundance of the plant across its native range. We review reports describing *Podostemum* occurrence, important life history traits, and its role as a foundation species in eastern North American rivers (Table 1). We then hypothesize how *Podostemum* will likely respond to future environmental change, and how changes in *Podostemum* occurrence will likely affect river ecosystems.

2. Distribution and biology of *Podostemum ceratophyllum*

2.1. Biogeography

The family Podostemaceae Rich. ex C. Agardh is the largest family of strictly aquatic flowering plants in the world (Philbrick and Novelo, 1995; Philbrick and Novelo, 2004). These plants possess distinctive morphological adaptions including specialized root structures and long, thin durable leaves well-adapted to their swift-water habitat (van Steenis, 1981). North, Central, and South America contain about 60% of the species in the family, with the remaining species distributed throughout Africa, Madagascar, and Southeast Asia (Philbrick and Alejandro, 1995). Recent investigations have concluded that the genus *Podostemum* is restricted to the New World (Philbrick and Novelo, 2004), with the greatest species diversity occurring in South America, mainly in Brazil. South American Podostemaceae taxonomy remains uncertain (Philbrick et al., 2010) and ecological studies on these species are sparse. Mexico is reported to have four genera (*Marathrum*, *Oserya*, *Podostemum, Tristicha*) with higher diversity in the Pacific coast slopes compared with Atlantic slopes (Novelo and Philbrick, 1997; Tippery et al., 2011). Altogether, the Americas are thought to contain about 135 species of Podostemaceae with only a single species, *Podostemum ceratophyllum,* known from the continental U.S.A. and Canada (Graham and Wood, 1975; Philbrick et al., 2010; Tippery et al., 2011).

Podostemum ceratophyllum's native range is confined to montane and piedmont regions of the eastern United States and Canada, ranging from Georgia to Ontario, with scattered populations westward as far as Arkansas, Oklahoma, Minnesota and North Dakota, and disjunct populations in Honduras and the Dominican Republic (Philbrick and Crow, 1983; Philbrick and Novelo, 2004). Reduced genetic variation (based on nucleotide markers and isozymes) in populations north of North Carolina indicates range expansion northward following the last glacial-maximum from refugia several hundred km south of the glacial boundary (Philbrick and Crow 1992; Fehrmann et al. 2012).

2.2. Morphology

Two of the earliest papers about *Podostemum* detailed the structure of the plant's vegetative and reproductive organs (Warming, 1881, 1882). *Podostemum* follows the Root-Shoot model with the presence of distinct roots, stems (shoots) and leaves (Rutishauser

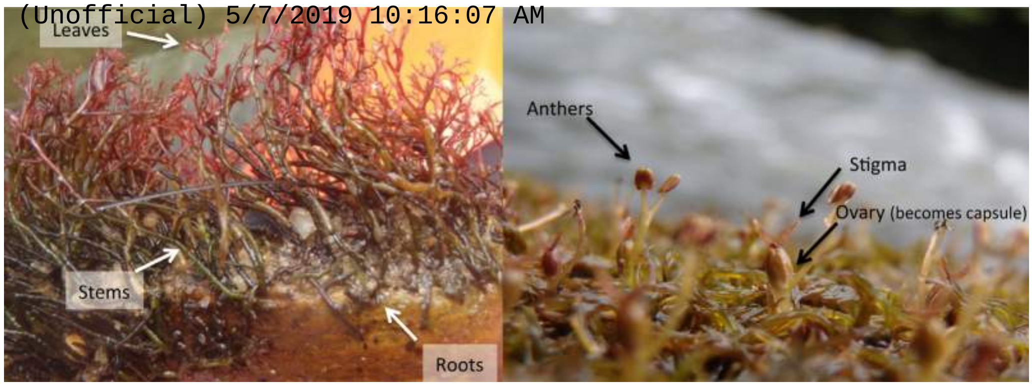

Fig. 1. (a) *Podostemum ceratophyllum* grows submerged, attached directly to rocks in fast flowing eastern rivers. Stems and leaves can be green, black and red and the leaves are deeply dichotomously lobbed. Roots are also green, black and red and attach the plant to the rock with structures called haptera. (b) Flowers emerge as water levels expose the plant above the water's surface. Flowers are small with reduced petals and prominent anthers above the stigma and ovary. Photo by J. Wood. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

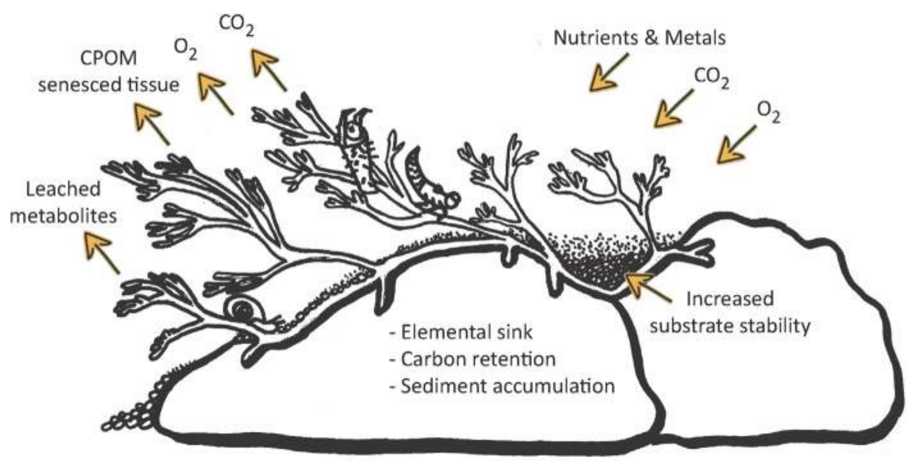

Fig. 2. A diagram illustrating *Podostemum ceratophyllum*'s interactions with the benthic environment. *Podostemum* provides structure and increases habitat complexity over bare rock, which attracts riverine biota. *Podostemum* influences elemental cycling through: retention of detrital material in plant colonies; assimilation of elements from the water column into plant tissue; and leaching of metabolites into the water column. *Podostemum* also increases substrate stability by binding gravels and cobbles together.

et al., 2003). The stems may be heavily cutinized (hardened), appearing dark green to black, often in stark contrast to its leaves, which can be a vibrant green. Cutinization can result from damage to the stem (Hammond, 1937), and heavily cutinized stems may correlate with abrasion from suspended sediments in swift current. New growth is often a luxuriant green in spring and summer, while in the winter leaves often are completely senesced or take on a deep reddish color (Hammond, 1937). The red coloration is caused by an increase in the light-absorbing pigment anthocyanin, which reduces tissue damage from UV light but may have other functions. Production of anthocyanin is a common stress response in plants and has also been linked to nutrient imbalance (Marschner, 1986). Supportive of this conclusion, Munch (1993) only found *Podostemum* exhibiting the red coloration in surface water that had a total nitrate-N to total phosphorous ratio of more than 18:1.

The roots of *Podostemum* attach to stable substrates (rock, wood, and other debris) with distinct root hairs called haptera (Rutishauser et al., 2003). While the root hairs were once thought to exude a sticky substance that attached the plant to rocks, a study of Old World species of Podostemaceae proposed that attachment is facilitated by a film of cyanobacteria (Jäger-Zürn and Grubert, 2000). The nature of this relationship is not understood, and has not been investigated in *P. ceratophyllum.*

Fig. 3. Examples of the morphological variation, from extended, narrow leaves to short, broader leaves, common in *Podostemum ceratophyllum.* These stems were collected on the same day and in close proximity to each other. Small squares in the background are 1 mm × 1 mm. Photo by J. Wood.

Aside from the basic root-stem-leave structure, *Podostemum* is highly variable in appearance (Fig. 3). Four varieties have been described based on this variation (van Royen, 1951) but these varieties have been condensed into one species with highly plastic morphology (Philbrick and Novelo, 2004). *Podostemum* can have long leaves (4–20 cm) in the form once recognized as *P. ceratophyllum* var. *ceratophyllum*, or shorter leaves that are densely

Table 1
Papers on the ecology of *Podostemum ceratophyllum* Michx. or that contain ecologically relevant information on the ecology the plant.

Topic	Foci	Author	Study Location
Macroinvertebrates	secondary production and community composition	Nelson and Scott (1962)	GA, Middle Oconee River
	habitat preference and density of black flies (*Simulium decorum* Walker)	Hudson and Hays (1975)	AL, Alabama Agricultural Experimental Station at Auburn University, Farm Pond no 1. artificial channel
	habitat preference of riverine snails (*Oxytrema (=Goniobasis) suturalis* Haldeman)	Kreiger and Burbanck (1976)	GA, Yellow River
	secondary production and community composition	Grubaugh and Wallace (1995)	GA, Middle Oconee River
	secondary production and impact of plant removal treatment	Hutchens et al. (2004)	NC, Little Tennessee River
	habitat of the caddisfly (*Brachycentrus etowahensis* Wallace)	Duncan PhD Dissertation (2008)	GA, Upper Etowah River
	dietary preference and habitat of Hydropsychid caddisflies	Tinsley BS Thesis (2012)	KY, Upper Green River
Macrophyte community dynamics and regrowth	interspecific competition between benthic autotrophs	Everitt and Burkholder (1991)	NC, Main stem and Cedar Fork of the Little River
	regrowth from root fragments	Philbrick et al. (2015)	CT, Pootatuck River
Fishes	habitat use by Riverweed Darter (*Etheostoma podostemone* Jordan & Jenkins)	Connelly et al. (1999)	VA, North and South Fork of Roanoke River
	habitat preference of riverine fish and influence of *Podostemum*	Argentina et al. (2010b)	GA & TN, Conasauga River
	habitat preference of the Snail Darter (*Percina tanasi* Etnier)	Ashton and Lazer (2010)	TN, French Broad and Hiwassee Rivers
Flow	flow alteration and plant recovery	Pahl MS thesis (2009)	GA, Middle Oconee River, Honeycutt Creek
Herbivory	consumption by River Cooter (*Pseudemys concinna* (LeConte))	Fahey (1987) in Aresco and Dobie (2000)	AL, Tallapoosa River
	consumption by Canada geese, crayfish, & amphipods	Parker et al. (2007)	GA, Chattahoochee River and in the laboratory
	consumption by triploid Grass Carp (*Ctenopharyngodon idella* (Valenciennes))	Weberg et al. (2015)	VA, Upper New River
Habitat	influence of land use, light, and substrate size	Argentina et al. (2010a)	GA & TN, Conasauga River
	influence of channel morphology and substrate size	Duncan et al. (2011)	GA, Upper Etowah River
Decomposition rate	*P. ceratophyllum* breakdown rate	Hill and Webster (1982)	NC & VA New River
		Rodgers et al. (1983)	TN, Watauga & VA, New Rivers
Productivity	*P. ceratophyllum* production	Hill and Webster (1984)	NC & VA New Rivers
Elemental	plant elemental composition	Adams et al. (1973)	DE, Susquehanna
	copper and lead bioaccumulation	Heisey and Damman (1982)	CT, Natchaug, Willimantic and Shetucket Rivers
Biogeography	species distribution	Philbrick and Crow (1983)	Eastern US, Arkansas, Honduras, Dominican Republic
	isozyme variation	Philbrick and Crow (1992)	Eastern US
	interspecific nucleotide diversity	Fehrmann et al. (2012)	Eastern US, Arkansas and Honduras
Other	cyanobacterial symbiotic relationship	Jager-Zurn and Grubert (2000)	herbarium samples (Old World species only)
	carbon Isotope fractionation	Ziegler and Hertel (2007)	herbarium samples

clustered at the end of the stem, giving the plant a distinctly bristly appearance (in the form once recognized as *P. ceratophyllum* var. *circumvallatum*). Hammond (1937) notes that these different forms can grow side by side but that plants in a given colony are generally uniform in size and structure. We hypothesize that specific aspects of the habitat such as flow velocity, herbivory, or both may exert a large influence on growth form.

2.3. Reproduction

Flower buds open as water levels decline and the plant is exposed above the water surface (Philbrick, 1984). Flowers emerge from an enclosed spanthellae, and mature flowers (Fig. 1b) have obvious anthers subtended by an enlarged ovary with two stigma (Philbrick, 1984). Pollination is most likely facilitated by wind or insects, but not water, and pre-anthesis cleistogamy (pollination before the flower opens) has also been reported (Philbrick, 1984). After pollination maturation of the seed capsule is reported to take 2–3 weeks (Philbrick, 1984) and seed capsules may appear mature while still developing (Philbrick and Novelo, 1995). The seeds are small and the seed coat produces a sticky mucilaginous coating when wetted, allowing seeds to stick to suitable substratum. While pollination and seed dispersal mechanisms have not been intensively investigated (Philbrick, 1984), gene flow between populations appears erratic (Fehrmann et al., 2012) and seed dispersal is presumably facilitated by migrating wildlife (birds & large mammals), while long distance dispersal is probably limited to avian vectors (Philbrick and Crow, 1992).

Philbrick and Novelo (1994) propose that Podostemads use the type 1 seed germination strategy, first proposed by Thompson and Grime (1979), where seeds germinate soon after being released from the capsule. Indeed, the seeds lack an endosperm, show no need for cold stratification or dormancy, and seem unlikely to persist for years before germination (Philbrick, 1984). Additionally, asexual reproduction is facilitated by root fragmentation, where detached root segments can reattach to rocks over time (Philbrick et al., 2015). For additional details about morphology, development and reproduction refer to (Graham and Wood, 1975; Philbrick, 1984; Philbrick and Alejandro Novelo, 1997; Rutishauser, 1997; Rutishauser et al., 2003; Philbrick and Novelo, 2004).

2.4. Physiology

Information about oxygen and carbon dioxide uptake rate and almost all other physiological responses of Podostemaceae is limited. Unlike most other aquatic plants which can utilize bicarbonate in addition to dissolved carbon dioxide, *Podostemum* may only be able to absorb dissolved carbon dioxide from the water column (Pannier, 1960; Hill and Webster, 1984) – a trait shared with bryophytes. Thus, a study on the New River attributed reduced ^{14}C uptake at soft-water sites to reduced availability of free CO_2 compared to hard-water sites (Hill and Webster, 1984). While the respiration rate of *Podostemum* has not been investigated, the neo- and paleotropical taxon (*Tristicha trifaria* (Bory ex Willd.) Spreng.) is reported to have an ability to absorb oxygen at an extremely high rate (14 mg O_2 g dry wt^{-1} h^{-1}) in oxygen-saturated water (Pannier, 1960).

3. *Podostemum* as a foundation species

3.1. High biomass and productivity

Several studies have indicated that *Podostemum* is highly productive and capable of obtaining large standing stock biomass, although variation among locations, seasons and years may be substantial. Hill and Webster (1983) estimated that *Podostemum* contributed 1154 T ash free dry weight (AFDM) yr^{-1} to their New River, Virginia study area, approximately 80% of the total macrophyte contribution. *Podostemum* production was 10 times that of periphyton on an aerial basis and the ratio of production to biomass (P/B) was as high as 4 (most aquatic macrophytes are closer to 2; Hill and Webster 1984). The authors interpreted this high production relative to biomass as indicative of substantial biomass loss to scouring (Hill and Webster, 1984), although the potential influence of herbivory was not measured. Not surprisingly, measures of productivity have varied substantially, likely reflecting the influences of flow, water chemistry and location within the channel. For example, estimated productivity spanned 3 orders of magnitude (0.05 g C m^{-2} d^{-1} to 1.08 g C m^{-2} d^{-1}) on the New River and Watauga River (Tennessee) (Hill and Webster, 1984).

Biomass measurements have also varied widely, likely reflecting multiple influences. Rodgers et al. (1983) reported a seasonal maximum biomass between 22 and 98 g AFDW m^{-2} on the New River and Watauga River, in contrast to substantially higher mean monthly standing stocks (between 386 and 587 g AFDM m^{-2}, to a maximum of just over 1000 g AFDM m^{-2} in November) on the Middle Oconee River, Georgia, (Grubaugh and Wallace 1995). Biomass measurements at the same Middle Oconee River site during a prolonged drought were an order of magnitude lower (Pahl, 2009).

3.2. Influences on benthic biota

For almost 100 years, ecologists have known that macroinvertebrates utilize the habitat produced by *Podostemum* (Hammond, 1937) and more recent studies have shown strong correlations between *Podostemum* and abundances of some riverine biota (Hutchens et al., 2004; Argentina et al., 2010b). A study in the Little Tennessee River, North Carolina, found *Podostemum* enhanced the surface area of macroinvertebrate habitat on bedrock by at least 3–4 times, and that removal of *Podostemum* reduced macroinvertebrate biomass by over 90% and abundance by almost 88% (Hutchens et al., 2004). A wide diversity of macroinvertebrates are associated with *Podostemum*. Rocks colonized by *Podostemum* in the Middle Oconee River contained at least thirty-four genera of aquatic insects (plus an additional 13 taxa only identified to family level or the order Hemiptera) representing all major aquatic insect orders, as well as Cnidaria, Tubellaria, Mollusca, Annelida, Hydracarina, Cladocera, and Copepoda (Nelson and Scott, 1962; Grubaugh and Wallace, 1995).

Podostemum may particularly enhance habitat availability for filter-feeding insects by providing points of attachment with access to swiftly-flowing water. The silk nets of hydropsychid caddisfly larvae are commonly observed in *Podostemum* mats (*pers. obs.* J.W.), and the plant is reported to support significantly higher abundances of hydropsychids (Tinsley, 2012) than bare rock. Similarly, densities of the filter-feeding Etowah caddisfly, *Brachycentrus etowahensis Wallace*, have been positively correlated with *Podostemum* (Willats, 1998; Duncan, 2008). The plant also appears to be a preferred habitat for filtering black fly larvae (*Simulium*), with measured densities of 4.2–4.5 individuals per square cm of *Podostemum* stem, among the highest densities recorded for the 54 plant taxa examined in a mesocosom study (Hudson and Hays, 1975). Furthermore, Hutchens et al. (2004) report that filterers were the best represented macroinvertebrate functional feeding group (FFG) in *Podostemum* by biomass.

Podostemum may also attract other FFGs because the plant traps organic matter and provides a substrate for epiphytic overgrowth of diatoms and other algae (Fig. 4). Thus, insects that feed by scraping periphyton (scrapers) or by collecting fine detrital particles (collector-gatherers) can be the most abundant FFGs associated with *Podostemum* (Hutchens et al., 2004; Grubaugh and Wallace, 1995). Similarly, snails, which are among the most endemic and threatened riverine invertebrates in eastern rivers (Johnson et al., 2013), are frequently observed grazing on *Podostemum*. In a study on the Yellow River, Georgia, Krieger and Burbanck (1976) found that *Podostemum* created the optimum habitat for the freshwater snail *Pleurocera catenaria* (Say) and other investigators have concluded that the presence of *Podostemum* and stable benthic substrates were the most important factors in predicting pleurocerid (especially *Elimia* spp.) snail distribution (Mulholland and Lenat, 1992; citing Krieger and Burbanck's 1976 study).

Associations between fish and *Podostemum* have been noted (Freeman and Freeman, 1994; Connelly et al., 1999; Skelton and Albanese, 2006; Argentina et al., 2010b; Ashton and Layzer, 2010) but a general lack of experimental research prohibits definitive conclusions. Short-term experimental manipulations of *Podostemum* in the Conasauga River, Georgia, by Argentina et al. (2010b) showed declines or increases in local benthic fish densities where *Podostemum* was reduced or augmented, respectively. The increased habitat complexity provided by *Podostemum* may benefit fishes by increasing densities of insect prey and by providing shelter from larger predators. However, species associations with *Podostemum* at landscape-scales can be difficult to untangle from other basin wide stressors that negatively influence species (Argentina et al., 2010a).

Podostemum may influence aquatic flora other than epiphytic algae, although we know of only a single study of competition with other submerged macrophytes. Everitt and Burkholder (1991) conclude that *Podostemum* uses a strategy of niche preemption to maintain habitat and prevent invasion by other species such as the red alga *Lemanea australise* Atkinson. In cool temperature months *Lemanea* and *Podostemum* are co-dominant, however, *Podostemum* grows most readily in the spring and summer months wherever light permits. *Podostemum* then dominates during the warm sea-

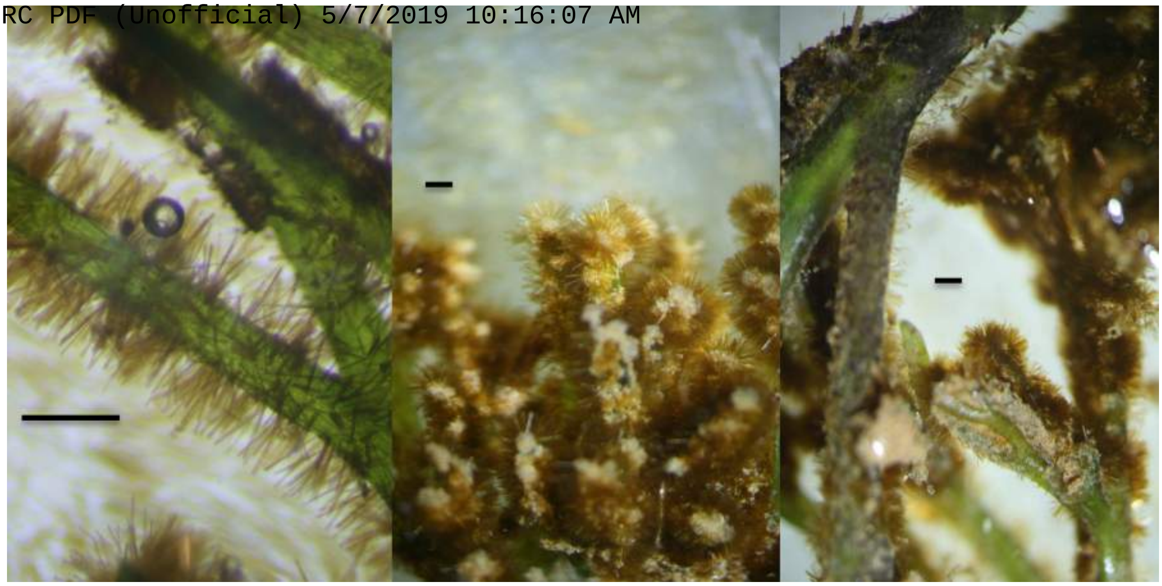

Fig. 4. Magnified images of *Podostemum ceratophyllum* stems with diatom (*Synedra ulna* c.f.) overgrowth. *Synedra ulna* cell length approximately 0.3 mm, scale bar approximately 5 mm in each picture. Fine sediments have accumulated between diatom cells and have encapsulated *Podostemum*'s stems and leaves in a nearly complete overcoating. Photos taken by J. Wood on November 11, 2013 from samples collected on a bedrock shoal on the Middle Oconee River, at Ben Burton Park, Athens, GA.

son but loses ground to other species in the fall and winter (Everitt and Burkholder, 1991).

3.3. Contributions to detrital and autotrophic foodwebs

Podostemum contributes to foodwebs directly and indirectly. *Podostemum* may indirectly enhance organic detritus retention by trapping particles entrained in the water column and accumulating fine sediments around the base of the plant. Stems and leaves directly contribute to detrital pathways (Nelson and Scott, 1962) and may senesce at biologically important times, i.e. late fall and early winter (Hill and Webster, 1982). Indeed, studies of seasonal changes in *Podostemum* biomass generally indicate that biomass is highest in early fall then declines as the plant senesces sensitive tissue (Rodgers et al., 1983; Grubaugh and Wallace, 1995) (*but see* Nelson and Scott, 1962). Seasonal changes in biomass may also be related to minimum water temperature, light availability, or other biotic and abiotic factors.

The leaves and stems of *Podostemum* decompose relatively quickly and contribute to the detrital pool. Rodgers et al. (1983) report a breakdown rate (K) between 0.05 and 0.08 $g\,g^{-1}\,d^{-1}$ (5–8% per day, depending on water temperate), and a 95% loss interval of 60 days in the New and Watauga rivers. Hill and Webster (1982) found a similar breakdown rate of 0.04 $g\,g^{-1}\,d^{-1}$, with a 95% loss interval of 81 days on the New River. These breakdown rates are an order of magnitude (or more) greater than the rate for allochthonous material, where $K < 0.02$ (Petersen and Cummins, 1974; Rodgers et al., 1983; Kominoski et al., 2007), indicating that carbon stored in *Podostemum* tissues is more rapidly recycled through the ecosystem compared to terrestrially-derived leaf litter.

The importance of *Podostemum*'s direct contribution to the food web is uncertain. Herbivory by Canada geese (*Branta canadensis* (Linnaeus)) and White Tubercled crayfish (*Procambarus spiculifer* (LeConte)) has been reported (Parker et al., 2007), and Weberg et al. (2015) raised the possibility of consumption by introduced triploid Grass Carp (*Ctenopharyngodon idella* (Valenciennes)) in the New River. We and others have observed aquatic turtles (e.g., *Pseudemys* spp; Fahey (1987) in Aresco and Dobie (2000)), White-tail deer (*Odocoileus virginianus* (Zimmermann)) and Beaver (*Castor canadensis* Kuhl) grazing on *Podostemum* (*pers. obs.* M.F.). However, quantitative studies of herbivory rates or the relative contribution of *Podostemum* to aquatic primary consumers are lacking.

The nutritional value of *Podostemum* is not well known. At present, only two published studies are known to have reported the elemental composition of *Podostemum* tissue. A study conducted in Pennsylvania rivers by Adams and coauthors (1973) reported concentrations of P, K, Ca, Fe, Mg, B, Cu, Mn, Al, Zn, and Na, while Heisey and Damman (1982) investigated copper and lead accumulation in aquatic plants including *Podostemum* downstream of industrial outfall into the Shetucket and Natchaug Rivers, CT. Adams and coauthors (1973) report that *Podostemum* was 0.25% P by dry mass, while K, Ca, and Mg were 1.63, 1.38 and 0.24% respectively. Unpublished data (J.W.) indicate that on average *Podostemum* is 2.7% nitrogen and 36.4% carbon, with a molar carbon:nitrogen ratio of 16.2:1 (*Unpublished* J.W.), similar to other submerged freshwater plants (Bakker et al., 2016). While only limited inferences can be made from these studies, *Podostemum* may be a source of ecologically important elements for grazing organisms, especially nitrogen, phosphorus, calcium, and trace metals.

4. Environmental stressors

4.1. Sedimentation and flow alteration

Fast-flowing water, stable benthic substrate and sufficient light are the major factors consistently correlated with the occurrence of *Podostemum* (Everitt and Burkholder, 1991; Connelly et al., 1999; Argentina et al., 2010a; Duncan et al., 2011). *Podostemum* commonly occurs on coarse sediments of sandstone, shale, or granite (but rarely limestone (Meijer, 1976)), as well as other submerged substrates including wood, tires, plastics, aluminum, ceramics and other debris (*per. obs.* J.W.). Excessive sedimentation either through increased sediment load in the river or reduced sediment transport capacity, has been cited as a reason for *Podostemum* decline. For example, Connelly et al. (1999) cite sedimentation and streambed instability as possible reasons for declines in *Podostemum* abundance in the Roanoke River, Virginia. Similarly, Grubaugh and Wallace (1995) attribute an increase in *Podostemum* biomass on shoals in the Middle Oconee River to declining agriculture, and presumably sedimentation, in the watershed.

Hydrologic alteration can reduce *Podostemum* cover by decreasing wetted instream habitat and influencing flow velocity. Substantial dieback of *Podostemum* has been documented during a severe drought in the southeast U.S. that resulted in extended exposure of *Podostemum* above the waterline (Pahl, 2009), and flow manipulations downstream from a reservoir are reported to have resulted in the extirpation of a population of *Podostemum* in the West River at Jamaica, VT (Countryman, 1978). Although *Podostemum* has subsequently been found at other locations in the West River (Zika and Thompson, Zika and Thompson, 1986) (*pers. obs.* J.W.), flow regulation may influence population dynamics for many kilometers downstream of the source of regulation. Periodic exposure to drying and substantial reductions in water velocity may be mechanisms by which flow regulation reduces *Podostemum* cover and biomass. Supportive of this idea, Everitt and Burkholder (1991) report that *Podostemum* in their study could not tolerate even short periods of desiccation. Furthermore, slack water behind impoundments may permanently extirpate populations. For example, two populations of *Podostemum* in New Brunswick, Canada are reported to have been inundated to a depth that prevented persistence (Philbrick and Crow, 1983). Collectively, these studies support a conceptual model that includes flow as an important ecological variable, with diminution in water level and flow velocity potentially reducing *Podostemum* occurrence and biomass.

4.2. Influences of temperature and water chemistry

The influence of water temperature and dissolved gas concentration on *Podostemum* have not been evaluated but may be important given predictions of increasing water temperature with climate change (Ficke et al., 2007) and watershed urbanization (Wenger et al., 2009). Munch (1993) reports finding *Podostemum* in rivers in PA between 0 and 30 °C, but some southern populations likely experience water temperatures routinely exceeding 30 °C during summer months. Restricted CO_2 availability, such as in slow moving water or with dense epiphytic algal overgrowth (Fig. 4) may also reduce *Podostemum* growth rate and accrual of biomass. Furthermore, Hill and Webster (1984) hypothesize that differences in water hardness are responsible for a two-fold difference in biomass between study sites on the New River, NC (*see* Section 2.3. *Physiology*). Investigations of variation in stable carbon ratios could elucidate differences in CO_2 availability among habitats. Ziegler and Hertel (2007) argue that observed variation of $\delta^{13}C$ in *Podostemum* leaf tissue reflects variation in boundary layer "diffusional resistance" because the plant appears to preferentially utilize the ^{12}C isotope of CO_2 compared to the heavier ^{13}C isotope.

4.3. Tolerance to environmental pollutants

Meijer (1976) reports that *Podostemum* is generally found in clear streams with good aeration and sufficient light, and speculates that *Podostemum* might be useful as an indicator of clean water. However, Philbrick and Crow (1983) note that several populations have been found in polluted water, including in the Mousam River in Kennebunk Maine, where the river is polluted by domestic sewage. Similarly, a study of nutrient levels in Mexican rivers containing Podostemaceae documented occurrences of *Podostemum ricciiforme* (Liebm.) P. Royen at sites ranging from ultraoligotrophic to hypertrophic (Quiroz et al., 1997), showing that certain species of *Podostemum* can tolerate high nutrient levels or other forms of water pollution. Nonetheless, road salts (Jackson and Jobbagy, 2005; Kaushal et al., 2005), deicers (Fay and Shi, 2012) and other aspect of urbanization (Walsh et al., 2005; Chin, 2006) may constitute significant stressors to *Podostemum*.

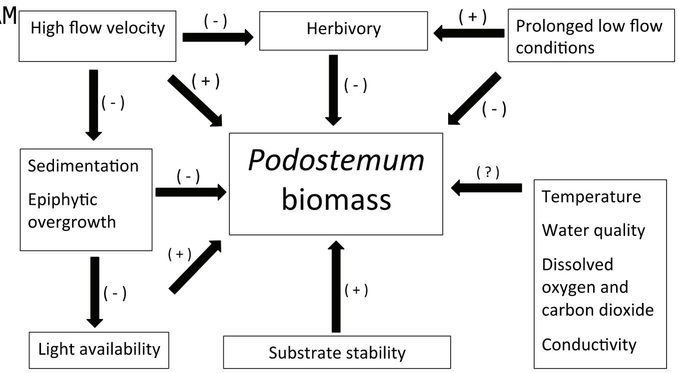

Fig. 5. Hypothesized relationships between *Podostemum ceratophyllum* and the dominant environmental variables of the habitat. Arrows indicate the directional nature of the relationship; positive associations are shown as (+) and negative associations are shown as (−).

4.4. Response to climate and land use change

A warming climate may facilitate the spread of *Podostemum* northward, continuing historical range expansion patterns (Philbrick and Crow, 1992; Fehrmann et al., 2012), Climate change may also exacerbate stresses already experienced by the plant, such as increased flow alteration, increased water temperature and increased sedimentation resulting from intense precipitation events. Accurately predicting the future distribution of *Podostemum* is complicated by the complexity of interacting stressors and the differing scales of controls on species migration (Pearson and Dawson, 2003).

Investigations into how *Podostemum* responds to changes in land use are needed in light of the rapid landscape changes occurring in many parts of this species' range. Isotopic nitrogen signature ($\delta^{15}N$) has been used to investigate the impacts of urbanization and land use on microbial biofilms (Kaushal et al., 2006), fish (Northington and Hershey, 2006) and riparian plants (Kohzu et al., 2008), and could be useful in assessing land use impacts on *Podostemum*, as well as measuring *Podostemum*'s role in food chains (Cabana and Rasmussen, 1996). Urban runoff can also contain high concentrations of metals (Davis et al., 2001; Sörme and Lagerkvist, 2002; Rule et al., 2006) available for uptake by primary producers. If *Podostemum* bioaccumulates metals then herbivory would facilitate the transfer of water column pollutants into higher trophic levels, with possible ecological and human health concerns.

5. Synthesis: causes and consequences of changes in *Podostemum* abundance

Known and hypothesized influences on *Podostemum* biomass include several interacting factors: severity and duration of low-flow periods, water velocity, herbivory, sedimentation, light and nutrient availability, and substrate stability (Fig. 5). Previous studies have shown that prolonged reductions in discharge reduce plant biomass (Nelson and Scott, 1962; Pahl, 2009), thus we hypothesize that high-velocity habitats support higher *Podostemum* biomass by limiting herbivory by consumers unable to hold position in swift currents, and by reducing sedimentation and algal build-up that, in turn, reduce light availability. Discharge and water velocity may also influence water temperature, conductivity and dissolved gases (CO_2 and O_2) but the direct effects of these variables on *Podostemum* are not well known (Fig. 5).

Understanding effects of more frequent and prolonged periods of low-flow may be essential to predicting persistence of *Podostemum* in areas experiencing declining rainfall or increased water diversions for human uses. We expect that *Podostemum* responds

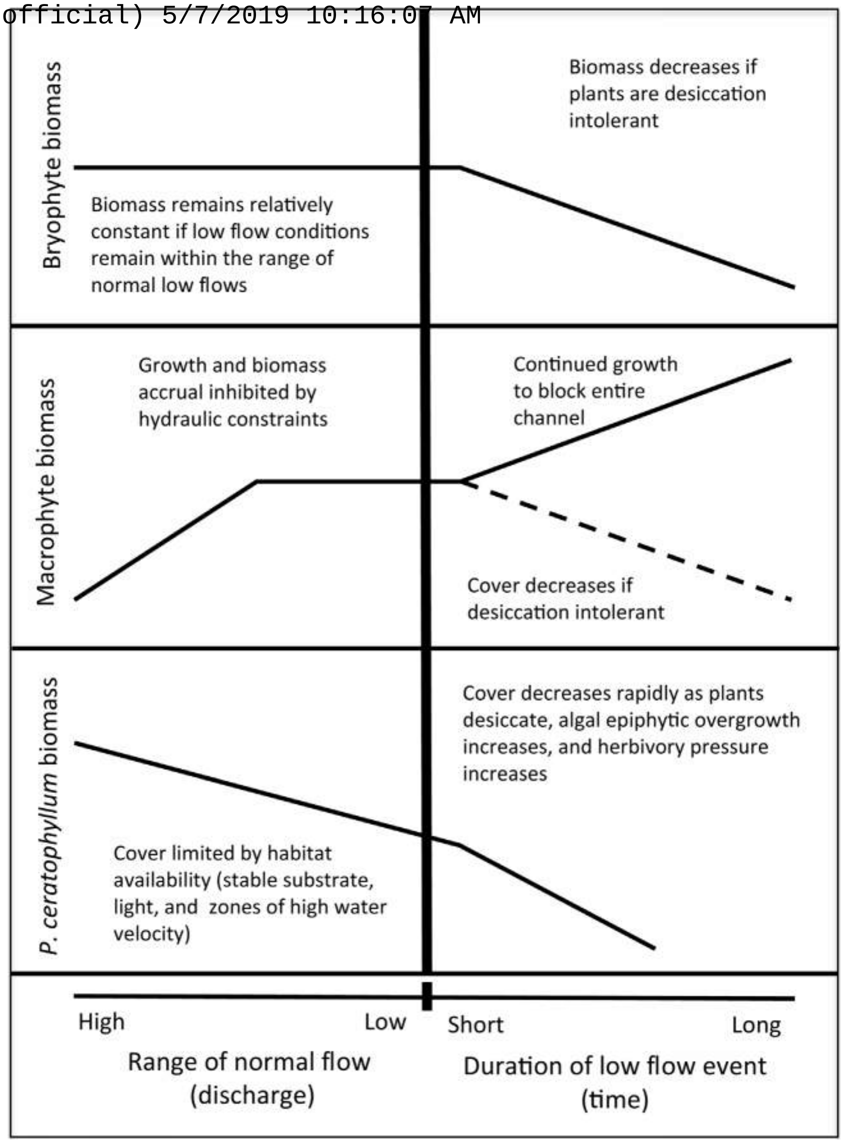

Fig. 6. Hypothesized relationships and comparisons between flow (discharge) and the duration of low flow events (time) for bryophyte, macrophyte, and *Podostemum ceratophyllum* Michx. biomass (modified from Suren and Riis, 2010).

differently to low-flow periods than other aquatic plants, and uniquely different from the macrophyte model proposed by Suren and Riis (2010). Specifically, we hypothesize that *Podostemum* biomass declines as rivers move into seasonal low flow periods, whereas rooted macrophytes exhibit a general increase in biomass with low flow conditions, and bryophytes maintain relatively stable biomass through the river's normal range of flow (Fig. 6). We also hypothesize that *Podostemum* biomass rapidly declines as the duration of low-flow conditions increases in response to increased herbivory, epiphytic overgrowth, and risk of drying, with the effect exacerbated by other water quality stressors.

One challenge for understanding *Podostemum* response to stressors is that field measurements may differ among local habitat types. Rivers in the eastern montane and piedmont regions are frequently characterized by alternating shoal (cascade, riffle, rapid) and pool habitats, and we hypothesize that these two habitats expose *Podostemum* to differing stressors as a result of differences in flow velocity and water depth. We speculate that biomass in pool habitats is strongly controlled by herbivory pressure, light availability and sedimentation rate, whereas shoal habitats provide increased protection from herbivory and sedimentation but expose the plant to increased risk of drying during periods of low flow.

We conclude that evidence supports the notion that *Podostemum* acts as a foundation species in many eastern rivers, removing nutrients from the water column, accumulating substantial benthic biomass, and shuttling resources into the food chain, in addition to providing habitat for a diverse flora and fauna. Loss of the plant from rivers where it presently occurs could thus reduce: 1) invertebrate biomass and resources for aquatic and terrestrial insectivores; 2) retention of nutrients in the benthos, influencing carbon balance and nutrient spiraling length; 3) retention of organic matter and resources for aquatic detritivores; 4) stream bed stability and complexity, increasing the severity of flood scour on the benthos; and, 5) export of autochthonous organic matter and thus resources available downstream. However, much of what we know about the ecology of *Podostemum* derives from studies in the southern portion of the species range (Table 1) and regional differences in genetics may influence responses to stressors. Information on responses of the plant to environmental changes throughout its range is essential to understanding how to conserve or restore populations. Conservation efforts would also benefit from better documentation of *Podostemum* populations, a long recognized deficiency in our understanding of the plant (Muenscher and Maguire, 1931). As pressures on freshwater resources increase, conserving *Podostemum* appears crucial for preserving and improving the health and vitality of many eastern North American Rivers.

Acknowledgments

We would like to thank Alan Covich, Seth Wenger, Megan Hagler, Phillip Bumpers, John Skaggs, Tom Philbrick, two anonymous reviewers, and the many others that have provided feedback for the manuscript and helped with fieldwork. Thank you to Kasey Christian for editorial suggestions and assistance with figures. We would also like to thank the University of Georgia Odum School of Ecology and River Basin Center for support provided to J.W. Use of trade, firm, or product names does not imply endorsement by the U.S. Government. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Document Content(s)

Appendix B

Stakeholder Comments Regarding PSP

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Agenda

Project:	Byllesby-Buck Hydroelectric Project (FERC No. 2514)
Subject:	Proposed Study Plan Meeting
Date:	Thursday, July 18, 2019
Location:	AEP Service Center, Wytheville, Virginia

9 a.m. – 9:30 a.m.	**Introduction** Meeting Objectives Process Plan and Schedule Project and Study Plan Overview
9:30 a.m. – 12:00 p.m. *(15-min. break)*	**Aquatic Studies** Flow and Bypass Reach Aquatic Habitat Aquatic Resources Water Quality
12:00 p.m. – 1:00 p.m.	**Lunch Break**
1:00 p.m. – 3:30 p.m.	**Recreation Study**
	Terrestrial and Shoreline Studies Wetlands, Riparian, and Littoral Habitat Terrestrial Resources Shoreline Stability
	Cultural Resources
3:30 p.m. – 4:00 p.m.	**Closing** Next Steps / Filing Comments on the PSP Open Discussion Adjourn

APPALACHIAN POWER
An AEP Company
BOUNDLESS ENERGY

HDR

Byllesby-Buck Hydroelectric Project (FERC No. 2514)
Proposed Study Plan Meeting
July 18, 2019

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From:	Elizabeth B Parcell
To:	Jody.Callihan@ferc.gov
Cc:	Jonathan M Magalski; Kulpa, Sarah
Subject:	Byllesby/Buck Project No. 2514: Requested Mussel Report
Date:	Tuesday, September 3, 2019 11:02:52 AM
Attachments:	image001.png BuckDamDrawdown_MusselReport_Final 2018.pdf

Hi Jody,

I hope you are well and enjoyed the holiday weekend. At the Byllesby/Buck Proposed Study Plan meeting in July, you requested a copy of the latest report on mussels at the Byllesby/Buck Project. The report, which is attached, was prepared by Stantec Consulting Services, Inc. and is dated August 22, 2018. Please note that I will send Janet Norman (USFWS) a copy by separate email.

Please let me know if we can provide any additional information.

Liz

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From: Elizabeth B Parcell
To: Norman, Janet
Cc: Jonathan M Magalski; Kulpa, Sarah
Subject: Buck Mussel Study - Final Report
Date: Tuesday, September 3, 2019 3:40:48 PM
Attachments: image001.png
BuckDamDrawdown_MusselReport_Final 2018.pdf

Hi Janet,

Hope you had a great holiday weekend. Attached please find the latest report on mussels at the Byllesby/Buck Project. You may recall that you requested a copy of the report at the Proposed Study Plan meeting in July. The report, which was prepared by Stantec Consulting Services, Inc., is dated August 22, 2018. Please note that I sent a copy to FERC by separate email.

Please let me know if we can provide any additional information.

Liz

ELIZABETH B PARCELL | **PROCESS SUPV**
EBPARCELL@AEP.COM | D:540.985.2441
40 FRANKLIN ROAD SW, ROANOKE, VA 24011

From:	Elizabeth B Parcell
To:	John Copeland (John.Copeland@dgif.virginia.gov)
Cc:	Jonathan M Magalski; Kulpa, Sarah
Subject:	RE: Claytor Sediment Study
Date:	Tuesday, September 3, 2019 4:22:40 PM
Attachments:	image001.png Claytor Sediment Final Draft2 with Appendices.pdf

Sorry, I sent you the wrong version (figures after the appendices). Use this one instead.

Liz

From: Elizabeth B Parcell
Sent: Tuesday, September 3, 2019 4:01 PM
To: John Copeland (John.Copeland@dgif.virginia.gov) <John.Copeland@dgif.virginia.gov>
Cc: Jonathan M Magalski (jmmagalski@aep.com) <jmmagalski@aep.com>; 'Kulpa, Sarah' <Sarah.Kulpa@hdrinc.com>
Subject: Claytor Sediment Study

John,

Thanks for returning my call. I'll get back with you asap.

In the meantime, attached is the Claytor Sediment Study that you requested at the Byllesby/Buck Proposed Study Plan meeting in July.

Let us know if you need anything else or if you have any questions.

Liz

ELIZABETH B PARCELL | **PROCESS SUPV**
EBPARCELL@AEP.COM | D:540.985.2441
40 FRANKLIN ROAD SW, ROANOKE, VA 24011

From:	Elizabeth B Parcell
To:	Norman, Janet
Cc:	Jonathan M Magalski; Kulpa, Sarah
Subject:	Additional document
Date:	Tuesday, September 3, 2019 4:42:28 PM
Attachments:	image001.png Byllesby-Buck 1991 fishery survey.pdf

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Janet,

Attached is the 1991 Fish Study that you requested during the Byllesby/Buck Proposed Study Plan meeting held in July.

I believe that is everything that you requested but if I missed anything, just let me know.

Liz

ELIZABETH B PARCELL | **PROCESS SUPV**
EBPARCELL@AEP.COM | D:540.985.2441
40 FRANKLIN ROAD SW, ROANOKE, VA 24011

From:	Elizabeth B Parcell
To:	Norman, Janet
Cc:	Jonathan M Magalski; Kulpa, Sarah
Subject:	RE: [EXTERNAL] Buck Mussel Study - Final Report
Date:	Wednesday, September 4, 2019 9:40:15 AM
Attachments:	image001.png 19970916 ByllsBuck ramping rate assessment.pdf

---

Janet,

Colorado sounds very exciting.

I double checked my list and found one more item for you. If you see anything else, just let me know.

Many thanks.
Liz

ELIZABETH B PARCELL | **PROCESS SUPV**
EBPARCELL@AEP.COM | D:540.985.2441
40 FRANKLIN ROAD SW, ROANOKE, VA 24011

From: Norman, Janet <janet_norman@fws.gov>
Sent: Tuesday, September 3, 2019 8:12 PM
To: Elizabeth B Parcell <ebparcell@aep.com>
Subject: Re: [EXTERNAL] Buck Mussel Study - Final Report

Liz,
Thanks very much for sending the report, and following up from my request.

Labor Day holiday was fun visiting Colorado, as I hope yours was as well.

Janet

On Tue, Sep 3, 2019 at 3:41 PM Elizabeth B Parcell <ebparcell@aep.com> wrote:

> Hi Janet,
>
> Hope you had a great holiday weekend. Attached please find the latest report on mussels at the Byllesby/Buck Project. You may recall that you requested a copy of the report at the Proposed Study Plan meeting in July. The report, which was prepared by Stantec Consulting Services, Inc., is dated August 22, 2018. Please note that I sent a copy to FERC by separate email.
>
> Please let me know if we can provide any additional information.

Liz

ELIZABETH B PARCELL | **PROCESS SUPV**
EBPARCELL@AEP.COM | D:540.985.2441
40 FRANKLIN ROAD SW, ROANOKE, VA 24011

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Janet Norman
Biologist
U.S. Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Dr.
Annapolis, MD 21401
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Fax: 410-269-0832
Janet_Norman@fws.gov
www.fws.gov/chesapeakebay

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, Maryland 21401
http://www.fws.gov/chesapeakebay

September 18, 2019

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N. E.
Washington, DC 20426

Re: Byllesby-Buck Hydroelectric Project (FERC # 2514 - 186) - Review of Proposed Study Plans

Dear Secretary Bose:

The U.S. Fish and Wildlife Service (Service) has reviewed the June 21, 2019, Proposed Study Plan for Relicensing Studies for the Byllesby-Buck Hydroelectric Project (Number 2514-186) (Project), filed by Appalachian Power Company, a unit of American Electric Power. The project is located at the existing Byllesby and Buck Dams on the upper New River, near the city of Galax, in Carroll County, VA. The capacity of the project is 21.6 megawatts (MW) and 8.5 MW, respectively.

The Service filed comments on the Pre-Application Document, Scoping Document 1, and Request for Studies on May 7, 2019. The Service's staff attended the Proposed Study Plan (PSP) meeting on July 18, 2019 in Wytheville, Virginia to discuss the PSP document and project needs and operations.

The following comments are provided pursuant to the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended: 16 U.S.C. 1531 *et seq.*), the Migratory Bird Treaty Act (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat.755), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*).

<u>Section 1.3 Project Description, Location and Study Area</u>
The Byllesby-Buck Project has large ecological process impacts on the New River for many river miles upstream and downstream of the dams and hydroelectric facilities which should be fully considered in the study's examination of impacts. The PSP does not address the magnitude and spatial scale of Project influence. Determining the spatial scale of Project influence should include consideration of Project flow attenuation and downstream turbidity effects of Project operations, as well as other upstream and downstream water quality and recreational impacts. The Project's influence on ambient New River water temperature affects resident coolwater fishes, including New River endemic fishes, and other species such as Eastern hellbender (*Cryptobanchus allieganiensis allieganiensis*) and coolwater fauna. Mussel fauna are lost to suitable upstream habitats due to Project dams blocking migration of host fishes.

Additionally, as the Service stated in our May 7, 2019 comments, we believe the project area delineated for this license application should include the affected impounded area between these two dam hydroelectric facilities that are operated in synchrony.

Section 6.1 Flow and Bypass Reach Aquatic Habitat Study
The current study must sufficiently quantify seepage and leakage rates into the bypass reaches. As leakage is being proposed by the applicant as part of a minimum flow component into the bypass reaches, it must be a quantified value.

As the Service discussed at the PSP meeting in July, data from the USGS 03165500 gage New River at Ivanhoe should be fully considered. The proposed usage of a 21-year hydrographic record of January 1, 1997 to December 31, 2017 has not been proven to be a sufficient period of record to examine for modelling scenarios. Additional data from the Galax, VA gage may be useful to consider as well.

Section 7 Water Quality Study
The Service supports the comments of Virginia Department of Game and Inland Fisheries (VDGIF) that vertical temperature/dissolved oxygen profiles may need to be done bi-weekly to determine stratification depths prior to or in concert with the data sonde deployment. We agree that one season of sampling within the tailrace may not adequately capture what the tailrace may experience over the license term within dry years, and recommend more than one year sampling.

Section 8 Aquatic Resources Study
The Service, other state and Federal resource agency staff, and the applicant discussed at our PSP meeting, what would be required to do a survey for Eastern hellbender, a Virginia species of special concern and a Tier II species in the Virginia Wildlife Action Plan. Eastern hellbender has been documented a number of times recently within the upper New River in the greater vicinity of the Byllesby and Buck dams. A November 19, 2015 correspondence from Professor Don Orth of Virginia Polytechnic Institute and State University on the Fries Dam project (FERC # 2883) confirmed Eastern hellbender existence in the New River at two locations nearby in the vicinity of Independence, Virginia. A February, 2018 angler capture of an adult Eastern hellbender occurred within the Fries Dam impoundment (Carey *et al.* 2017).

The applicant proposed to the agencies that the positive presence of Eastern hellbender within the study area could be assumed from earlier survey data and captures. The Service agrees with this position that based upon the data, Eastern hellbenders can be assumed to occur within the study area and should be considered for habitat water quality and quantity issues, and we would not recommend surveys be conducted.

Section 8.4.3 Mussel Community Study
The Service believes a mussel community study should be conducted for the relicensing process, which is currently not offered in the PSP document. A habitat assessment of the project area can refine focus areas of where mussels should be surveyed. The green floater (*Lasmigona subviridis*) which is under review for listing under the Endangered Species Act, was found live within the April-May 2018 mussel salvage operation above Byllesby Dam. The presence of this mussel species underscores the need for further information on the mussel community and

project impacts upon mussel species and upon host fishes for those species that require them. Earlier records indicate that other species that may occur within the project area include the state listed threatened pistolgrip (*Tritogonia verrucosa*), the purple wartyback (*Cyclonaias tuberculate*), spike (*Elliptio dilatata*), pocketbook (*Lampsilis ovate*), wavy-rayed lampmussel (*Lampsilis fasciola*) and giant floater (*Pyganodon grandis*). The area between Buck Dam and Lake, and Byllesby Dam is especially lacking in current information.

Section 8.4.4 Impingement and Entrainment
The Service recommends the usage of the U.S. Fish and Wildlife Service Turbine Blade Strike Analysis model to assist in the review of fish injury and mortality through the turbines. The model can be found on our Northeast Region website, https://www.fws.gov/northeast/fisheries/fishpassageengineering.html. If specific questions arise in the use of the model, we can coordinate a discussion with our Regional hydropower engineers.

Section 9 Wetlands, Riparian and Littoral Habitat Characterization Study
The Service supports the comment of VDGIF regarding the appropriate study season of August and September for the submerged aquatic vegetation beds, rather than April to June, and the use of transect based sampling.

Section 12 Recreation Study
The Service supports the technical expertise provided by our sister agency, the National Park Service, in their May 7, 2019 comments and our state partner, VDGIF, in their comments on the Proposed Study Plan. Their comments include consideration of recreational use of the river and riparian zone between Buck Dam and Lake and Byllesby Dam, expanded methods of survey outreach, and usage of trail cameras to monitor angler usage of the tailrace areas.

We appreciate the opportunity to provide these recommendations in our review of the Proposed Study Plan developed by the applicant. If you have any questions regarding this matter, please contact Janet Norman of my staff at 410-573-4533 or Janet_Norman@fws.gov.

Sincerely,

Julie Slacum

for Genevieve LaRouche
Field Supervisor

cc: Lindy Nelson
Stephanie Nash

Literature Cited:

Carey, C., D. Orth, and V. Emrick. 2017. Biological Surveys for Fries Hydroelectric Project in the upper New River, Grayson County, Virginia. Final 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-Final Report 04-2018. 65 pp.

FEDERAL ENERGY REGULATORY COMMISSION
WASHINGTON, D.C. 20426
September 19, 2019

OFFICE OF ENERGY PROJECTS

Project No. 2514-186 – Virginia
Byllesby-Buck Hydroelectric Project
Appalachian Power Company

VIA FERC Service

Ms. Elizabeth Parcell, Process Supervisor
American Electric Power Services Corporation
P.O. Box 2021
Roanoke, VA 24022-2021

Reference: Staff Comments on the Proposed Study Plan and Additional Information Requests for the Byllesby-Buck Hydroelectric Project

Dear Ms. Parcell:

We have reviewed your Proposed Study Plan for the Byllesby-Buck Hydroelectric Project (Byllesby-Buck Project), filed with the Federal Energy Regulatory Commission on June 21, 2019. In addition to our verbal comments provided during the July 18, 2019, proposed study plan meeting, we are providing comments (Schedule A) pursuant to section 5.12 of the Commission's regulations. We have also included additional information requests in Schedule B. We anticipate that Appalachian Power Company will take our comments into consideration during development of the revised study plan, which must be filed with the Commission by October 19, 2019.

We appreciate the opportunity to comment on your Proposed Study Plan for the Byllesby-Buck Project. Please contact Allyson Conner at (202) 502-6082 or allyson.conner@ferc.gov if you have any questions.

Sincerely,

John B. Smith, Chief
Mid-Atlantic Branch
Division of Hydropower Licensing

Enclosure: Schedule A
Schedule B

SCHEDULE A

Comments on the Proposed Study Plan (PSP)

Flow and Bypass Reach Aquatic Habitat Study (Flow Study)

1. One objective of the Flow Study is to demonstrate the efficacy of existing ramping rates,[1] but you do not describe how you will meet this objective. Therefore, in the revised study plan (RSP), please describe the methodology that will be used to demonstrate the efficacy of the existing ramping rates for the Buck bypassed reach.

2. You propose to use two-dimensional hydraulic modeling to evaluate both hydraulic connectivity and habitat suitability as a function of flow in each development's bypassed reach. However, the flow ranges for evaluating aquatic habitat suitability and hydraulic connectivity appear to be very different in this case. For instance, the range of flows used to evaluate aquatic habitat suitability (e.g., to support minimum flow recommendations) would likely be on the order of several hundred cubic feet per second (cfs), whereas those to support evaluations of hydraulic connectivity would likely be an order of magnitude higher (several thousand cfs). This disparity is particularly relevant to the 4,100-foot-long Buck bypassed reach, where fish stranding in isolated pools is a concern during receding water levels following spill events in the spring. For the Buck bypassed reach, you propose to link the hydraulic model with an operations model to determine which spillway gates should be used to pass spill events to ensure that hydraulic connectivity in the bypassed reach is optimized such that transient[2] fish (e.g., walleye) that may be attracted to these spill events (which are often about 6,000 cfs in the spring)[3] are afforded a contiguously wetted exit route for a sufficient amount of time that allows them to exit the bypassed reach during receding water levels.

[1] Article 406 of the current license states that following periods of spill from the Buck spillway when a spillway gate has been opened 2 feet or more, the licensee shall discharge flows through a 2-foot-wide gate opening for at least 3 hours. The licensee shall then reduce the opening to 1 foot for at least an additional 3 hours. Thereafter, the licensee may close the gate.

[2] Fish that move in and out of the bypassed reach (e.g., because they are attracted to spillage flows) and do not permanently reside in pool habitats therein.

[3] Ramping Rate Assessment. Appalachian Power Company. Byllesby/Buck Hydroelectric Project. FERC Project No. 2514. June 1997. Accession No. 19970916-0311.

Hydraulic modeling results are most reliable within the range of calibration flows that are used to develop the model as reliability decreases as results are extrapolated to flows beyond the calibration range.[4] You propose to develop the hydraulic model for your Flow Study using just three calibration flows, the values of which would be based on consultation with interested relicensing participants. However, given the wide range of flows that would need to be modeled to assess *both* habitat suitability and hydraulic connectivity in the Buck bypassed reach, additional calibration flows appear warranted. Therefore, in the RSP, please explain why you believe just three calibration flows would provide data of sufficient resolution to determine how both aquatic habitat suitability and hydraulic connectivity vary with flow in the bypassed reaches, particularly at the Buck Development.

Aquatic Resources Survey

1. You do not specify whether the fishery surveys you propose to conduct in the spring and summer of 2020 would include targeted sampling for the federally endangered candy darter. This species is known to occur in the Cripple Creek tributary (5 miles downstream of the Buck Development), but the presence of this species in the immediate vicinity of the project is unknown. Therefore, in the RSP, please indicate if you plan to sample for candy darter as part of your proposed fishery surveys; if so, describe what sampling gear and methodology would be used.

2. In lieu of mussel field surveys, you propose to conduct a desktop literature review to compile and summarize all mussel data that have been collected in the vicinity of the project. In the RSP, please indicate if size (shell length) data are available from these prior collection efforts; and if so, whether size data would be included and analyzed as part of your desktop study.

3. Several different resource agencies and stakeholders (e.g., U.S. Fish and Wildlife Service [FWS], Virginia Department of Game and Inland Fisheries, Virginia Tech, New River Conservancy), in response to the pre-application document (PAD), recommended that the eastern hellbender, a state and federal species of concern, be included in a multi-taxa study of the project area. Although you state that macroinvertebrates, including crayfish, will be included in the study, there is no specific mention of including hellbender in the Aquatic Resources Study or an explanation as to why eastern hellbender

[4] HDR. December 2015. Instream Flow Study Report filed on December 29, 2015, as part of the final license application for the Hawks Nest Hydroelectric Project (FERC Project No. 2512). Accession No. 20151229-4003.

was excluded. Therefore, please explain your rationale for not including the eastern hellbender in the multi-taxa study to assess its presence within the project area.

<u>**SCHEDULE B**</u>

Additional Information Requests

1. In section 4.3 of the PAD, Appalachian Power Company (Appalachian) states that American Electric Power completed installation of a 4-megawatt (MW) energy storage system at the project in partnership with Greensmith Energy (a Wärtsilä Company) in 2018. The storage system is composed of a lithium-ion battery and a software system that operates simultaneously with the powerhouses and provides ancillary services to PJM. In the PAD, Appalachian states that the storage system is outside the scope of the FERC license. However, Appalachian did not explain in the PAD why the battery storage facility was not considered to be a project facility.

At the April 10, 2019 environmental site review and daytime scoping meeting on April 11, 2019, Appalachian explained that the storage facility's batteries did not increase the capacity of the project, but are not sustainable without the hydropower project; electricity generated at the Byllesby-Buck Project provides, in part, the power to maintain charge in the batteries for use at a later time (e.g., to provide a more steady base load to the grid when river flows are low and below the maximum hydraulic capacity of the project during the summer). Therefore, it appears to staff that the battery storage facility may serve a project purpose and may need to be considered a project facility enclosed within the project boundary. In addition, although Appalachian stated that the battery storage facility does not increase the capacity of the project, Appalachian did not explain why this is the case.

Based on the single line diagram included in PJM's combined feasibility and impact study (feasibility study) for the interconnection request,[5] the interconnection point with the grid is shown at the location where project power (either from the Byllesby Development, Buck Development, or battery storage facility) is stepped up from 13.8-kilovolts (kV) to 69-kV. The feasibility study describes this location as the 13.8-kV bus. It is not clear to staff whether the switchyard, buildings, and related components at the Byllesby Development that provide project power to AEP's distribution system would exist were it not for the Byllesby and Buck Project.

[5] Generation Interconnection Combined Feasibility/System Impact Study Report for PJM Generation Interconnection Request Queue Position AD2-205 Buck-Byllesby 69-kV, October 2018. https://www.pjm.com/planning/services-requests/interconnection-queues.aspx

Therefore, please clarify how and where project power currently connects to AEP's distribution system and specify the project component(s) (i.e., bus, switch, transformer, etc.,) where the connection is made; whether the battery storage facility, switchyard, and its related components should be considered project facilities; and how project operation is affected by the presence of the battery storage facility and what factors limit its capacity.

2. In the PSP, you note that sediment was dredged from the front of the intakes at the Byllesby Development in 1997 to create an upland marsh and more recently in 2014 to remove storm-related sand deposits. You indicate this dredged material was tested for polychlorinated biphenyls (PCBs) and these tests indicated the material was safe for its intended uses. To support staff's environmental analysis, please file, with your RSP, the results of these PCB testing results and any accompanying reports.

3. On May 7, 2019, FWS provided comments regarding potential impacts to bog turtles due to proposed drawdown activities. In that letter, FWS noted that it would consult with a FERC representative; however, to date, consultation has not occurred with Commission staff. In the meantime, staff have reviewed available information and found that bog turtles are known or are likely to occur in only four counties in Virginia,[6] including Carroll County (where the Byllesby-Buck Project is located). Therefore, staff requests any information (including past consultation with FWS) on the occurrence of bog turtles within the vicinity of the project.

[6] https://www.dgif.virginia.gov/wildlife/information/bog-muhlenberg-turtle/

Matthew J. Strickler
Secretary of Natural Resources

COMMONWEALTH of VIRGINIA
Department of Game and Inland Fisheries

Ryan J. Brown
Executive Director

September 18, 2019

Secretary Kimberly D. Bose
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Byllesby-Buck Project (P-2514-186) Comments on Proposed Study Plans

Dear Secretary Bose:

We appreciate the opportunity to comment on the Byllesby-Buck Hydroelectric Project (Number 2514-186) Proposed Study Plans. Virginia Department of Game and Inland Fisheries (VDGIF) Aquatic Wildlife Resources staff attended the Proposed Study Plan meeting on July 18, 2019 and reviewed the Proposed Study Plan document. We offer the following comments.

Section 1.3 Project Description, Location, and Study Area: The Byllesby-Buck Project affects a larger area of the New River upstream and downstream from the project area. New River ecological and geologic processes are influenced by the Project for some distance upstream and downstream from the Project Area. Examples include: (1) The Project reservoirs influence ambient New River water temperature and other water quality parameters, with habitat effects on resident coolwater flora and fauna, including New River endemic fishes; (2) Liberation of reservoir sediment deposits during Project operations result in increased turbidity in downstream reaches influenced by Project flow, disrupting ecological processes and negatively affecting angling and recreational use; (3) New River walleye populations are affected by Project placement, with the dams likely inundating historic New River walleye spawning areas; (4) Project dams block New River walleye migration, requiring substantial VDGIF effort and expense to maintain walleye populations upstream and downstream of the Project via hatchery rearing and stocking programs; and, (5) Loss of upstream mussel fauna due to Project dams blocking migration of host fishes.

The magnitude and spatial scale of this Project influence is not adequately addressed in the Proposed Study Plan Study Area, which limits assessment of the Project's influence to a small area upstream and downstream from the Project. Determining the spatial scale of this Project influence will help determine adequate reference conditions for ecological comparisons during multiple study efforts. Determining the downstream spatial influence will involve consideration of Project flow attenuation and downstream turbidity effects of Project operations, as well as other downstream water quality and recreational impacts. Making this determination needs to be a high priority before study plans are finalized.

Section 3.2 Study Requests Not Deemed Appropriate for Study: In our May 7, 2019 comments on the Pre-Application Document, VDGIF requested a Comprehensive Sediment Study, providing the needed justification for that study. We request that FERC determine whether this study is appropriate for the Project.

Section 6.1 Flow and Bypass Reach Aquatic Habitat Study
6.4 Background and Existing Information: This section states that both bypass reaches normally receive seepage and leakage, but there is no mention of existing estimates for the amount of this seepage and leakage, nor is there any mention of a plan to document the amount in the current studies. Existing information should be reported or a plan to document it should be mentioned. The 1997 Ramping Rate Effectiveness study is mentioned in this section as an adequate measure of the impacts of ramping in the Buck bypass reach. At the time of that study, the New River walleye population downstream from Buck dam was not as robust as it is now due to more than 20 years of an active stocking and management program. Walleye are one of the species likely attracted by bypass reach flows, so the 1997 study results may not apply under current Walleye population conditions. The Buck bypass reach receives flow frequently during most normal and wet years in months when Walleye are likely to be attracted to the bypass reach (February to May) during the spawn and post-spawn periods. Finally, this section reviews hydrologic data used in the CHEOPS modeling effort and for use in related flow evaluations during this study, but does not provide enough information to characterize the range of flows typical for the Project Area. More information should be provided about why the proposed 21-year period of record from January 1, 1997 to December 31, 2017 on the Ivanhoe gauge is considered sufficient for these analyses.

Section 6.6.4.3 Substrate Characterization and Mapping: What will be used as a reference condition for this characterization? If data is only collected in these bypass reaches, how will that information be analyzed without an adequate reference data set in a free-flowing section of the New River?

Section 7 Water Quality Study
The study plan indicates this study will provide data to determine if the Project reservoirs undergo thermal and/or dissolved oxygen stratification using data sondes at 2 discrete depths. VDGIF staff question whether vertical temperature/dissolved oxygen profiles need to be done on at least a bi-weekly basis to determine stratification depths prior to or in concert with deploying data sondes. The study plan also indicates that data sondes will be deployed in both Project tailrace areas for a single season. VDGIF staff question whether a single season data collection effort will adequately characterize water quality in these areas, since critical habitat conditions may only be observed in a dry water year. Finally, VDGIF staff mentioned concerns about downstream turbidity effects of the Project in our May 7 comments, but this study fails to provide a plan for assessing turbidity effects.

Section 8 Aquatic Resources Study
8.4.1 Fish Community: The final paragraph on page 49 includes a review of New River Muskellunge stocking. For the record, VDGIF discontinued Muskellunge stocking in the New River downstream from Claytor Dam in 2011 due to documented natural reproduction. Muskellunge stocking in the New River upstream from Claytor Dam was suspended in 2018.

Eastern Hellbender: In the Aquatic Resources Study Plan, there is no mention of survey efforts for the Eastern Hellbender (*Cryptobranchus allieganiensis allieganiensis*). At the July 18, 2019 Study Plan meeting, discussion of this species centered on assuming presence of this species in the Project Area in the absence of directed surveys. VDGIF staff agree that the presence of this species in the Project Area should be assumed by all parties to the Aquatic Resources Study, including FERC.

8.6.2 Field Sampling: VDGIF staff request that spring fish collection efforts be commenced in April for comparability to VDGIF data and for adequate assessment of resident Walleye populations downstream from Buck Dam. We also request total length measurements of up to 100 individuals of each game fish (specifically Walleye, Smallmouth Bass, and Rock Bass) collected during sampling (in place of the proposed 30 individuals in the collection protocols) to allow assessment of angling potential. Having more than 30 individual measurements of the above species in this dataset will provide data for calculating size structure indices and developing length-frequency diagrams, standard techniques used in evaluating angling potential (Zale, Parrish, and Sutton. 2012. Fisheries Techniques, 3rd Edition. American Fisheries Society, Bethesda, Maryland).

Section 8.6.3 Mussel Community Study: The presence in the Project Area of the state threatened Pistolgrip (*Tritogonia verrucosa*) and the likelihood of the presence of the state threatened Green Floater (*Lasmigona subviridis*) justify including a mussel community study. The mussel community data gap from the Buck Reservoir islands upstream to Byllesby Dam needs to be filled. VDGIF staff suggest performing a habitat assessment followed by directed surveys as indicated by habitat availability.

Section 9 Wetlands, Riparian, and Littoral Habitat Characterization Study

In Table 9-1, the schedule for this study is outlined, with field verification planned for April to June. Since submerged aquatic vegetation beds are not fully developed until late summer, this field verification should be performed into the late summer/early fall months of August and September. Regarding the methodology to be employed in these surveys, it is not clear whether transect based sampling will be performed on the submerged aquatic vegetation beds. Without the quantitative information provided by transect based sampling, the extent and composition of these beds will not be adequate, so VDGIF staff recommend transect based sampling be performed on the submerged aquatic vegetation beds.

Section 12 Recreation Study

Section 12.6.3 Recreation Visitor Use Online Survey: Notice of this survey needs to be done in other ways than just posting it at kiosks in the Project Area. The survey can be advertised via local outfitters and river guides as well as social media outlets.

Section 12.6.4: Regarding the use of trail cameras for monitoring recreation use, VDGIF requests that this technique be used for monitoring recreational use of the tailrace areas, particularly given FERC's interest in recreational use of these areas, as expressed in Scoping Document 2.

Thank you for the opportunity to provide comments on the Proposed Study Plans for the Byllesby-Buck Hydroelectric Project. If you have questions regarding our comments, please contact me at the address and phone number listed below.

Sincerely,

William B. Kittrell, Jr.

William B. Kittrell, Jr.
Regional Aquatic Resources Manager
1796 Highway Sixteen
Marion, VA 24354
(276) 783-4860
Email: bill.kittrell@dgif.virginia.gov

WBK/jrc

Cc: E. Aschenbach
M. Bednarski
J. R. Copeland
R. Fernald
M. Pinder
R. Southwick
B. Watson

From: Jonathan M Magalski <jmmagalski@aep.com>
Sent: Wednesday, October 9, 2019 5:51 PM
To: Copeland, John; Bill Kittrell (Bill.Kittrell@dgif.virginia.gov)
Cc: Elizabeth B Parcell; Kulpa, Sarah
Subject: Byllesby / Buck Relicensing Fisheries Study
Attachments: Fish Map 1991 Byllesby-Buck Survey.pdf; Fish_Sampling_Locations_Buck_RSP.PDF; Fish_Sampling_Locations_Byllesby_RSP.PDF

Good afternoon John and Bill,

As we work on the Revised Study Plan (RSP), we wanted to get your thoughts on a few proposed modifications we are considering. We would like to check with you now to potentially avoid unnecessary work on your part (i.e. filing comments on the RSP). Based on a review of historical data, comments and additional information provided to-date, Appalachian proposes to revise the sample locations and methodology for the Fish Community Study being presented in the RSP for the Byllesby-Buck Project. Background and supporting information is provided below for your review along with a summary of the proposed changes in methodology and to sampling locations. See attached figures which demonstrate the revised study design along with a copy of the historical study locations for reference.

Gillnet deployments below Buck dam in the historical study (Appalachian 1991) were eliminated due to difficulties with net fouling and at least one net was believed stolen during field efforts. Additionally, the use of hoop nets resulted in collection of only 4 additional fish taxa (Largemouth Bass, Black Crappie, Yellow Perch, and Muskellunge), all of which are susceptible to electrofishing gear. The previous study also included both day and nighttime boat electrofishing samples, however results were not reported separately for the diel periods.
Under the proposed sampling design, electrofishing samples will be collected during daylight hours to minimize safety concerns associated with nighttime boat work on the New River.

Appalachian proposes to perform the fish community study using a combination of boat electrofishing (reservoirs) and backpack electrofishing with seines in non-reservoir, wadeable habitats. The proposed study replaces the gillnet (6 per reservoir) and hoop net (6 per reservoir) methodologies with boat electrofishing sites (3 per reservoir) in the same pool habitats sampled during the historical study. Appalachian also proposes to add additional backpack electrofishing sites in riffle/run habitats (including one of the tributary streams), which serves to balance the study design and to allow for greater representation/potential collection of non-game species.

These proposed changes would reduce study effort and costs and minimize safety concerns while still providing comparable data and adequate coverage of the project area. We welcome and would appreciate your thoughts on this proposal. If you have any questions or would like to discuss further, please let us know. Thanks....Jon

AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY
JONATHAN M MAGALSKI | **ENVIRONMENTAL SPEC CONSULT**
JMMAGALSKI@AEP.COM | D:614.716.2240
1 RIVERSIDE PLAZA, COLUMBUS, OH 43215

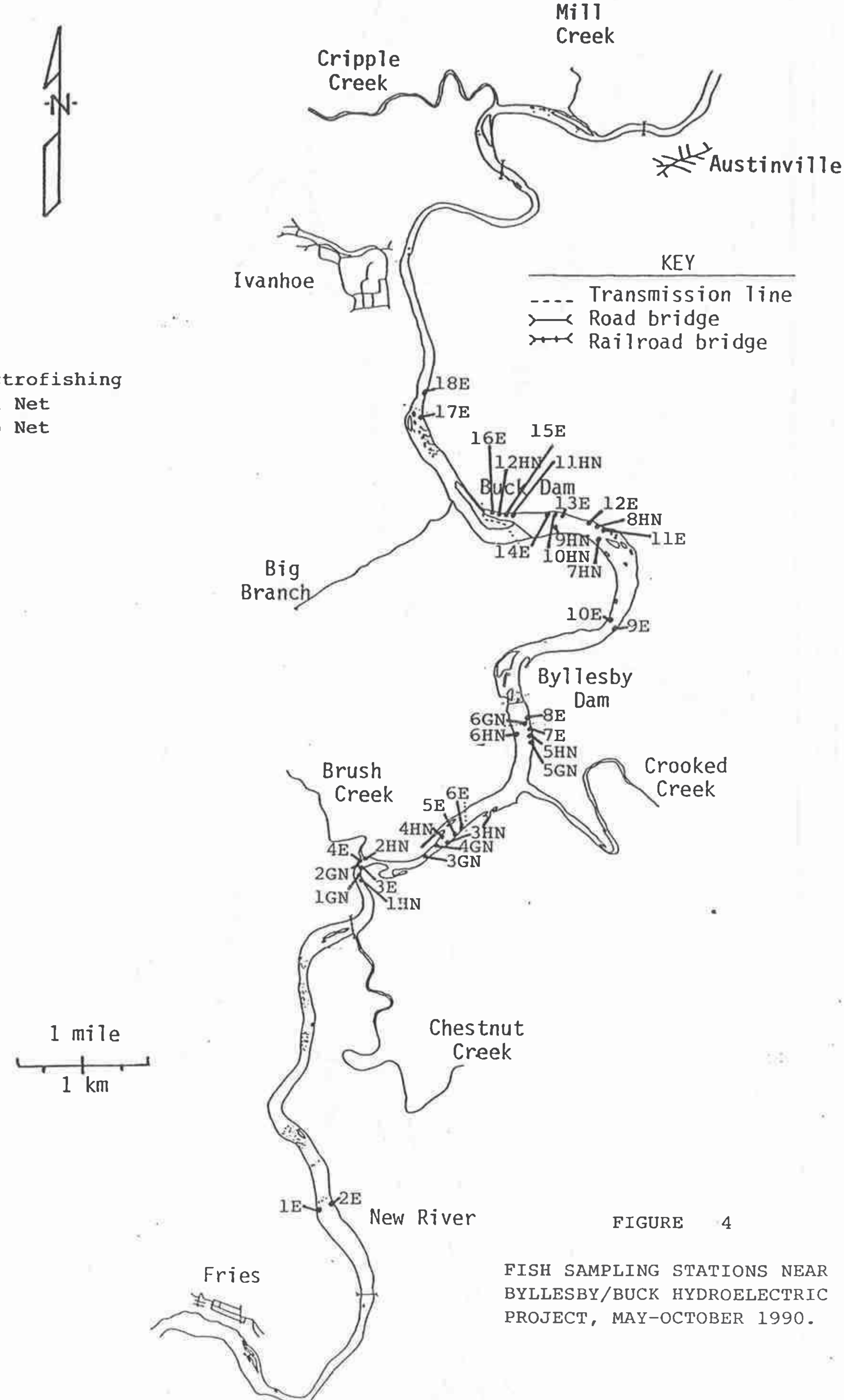
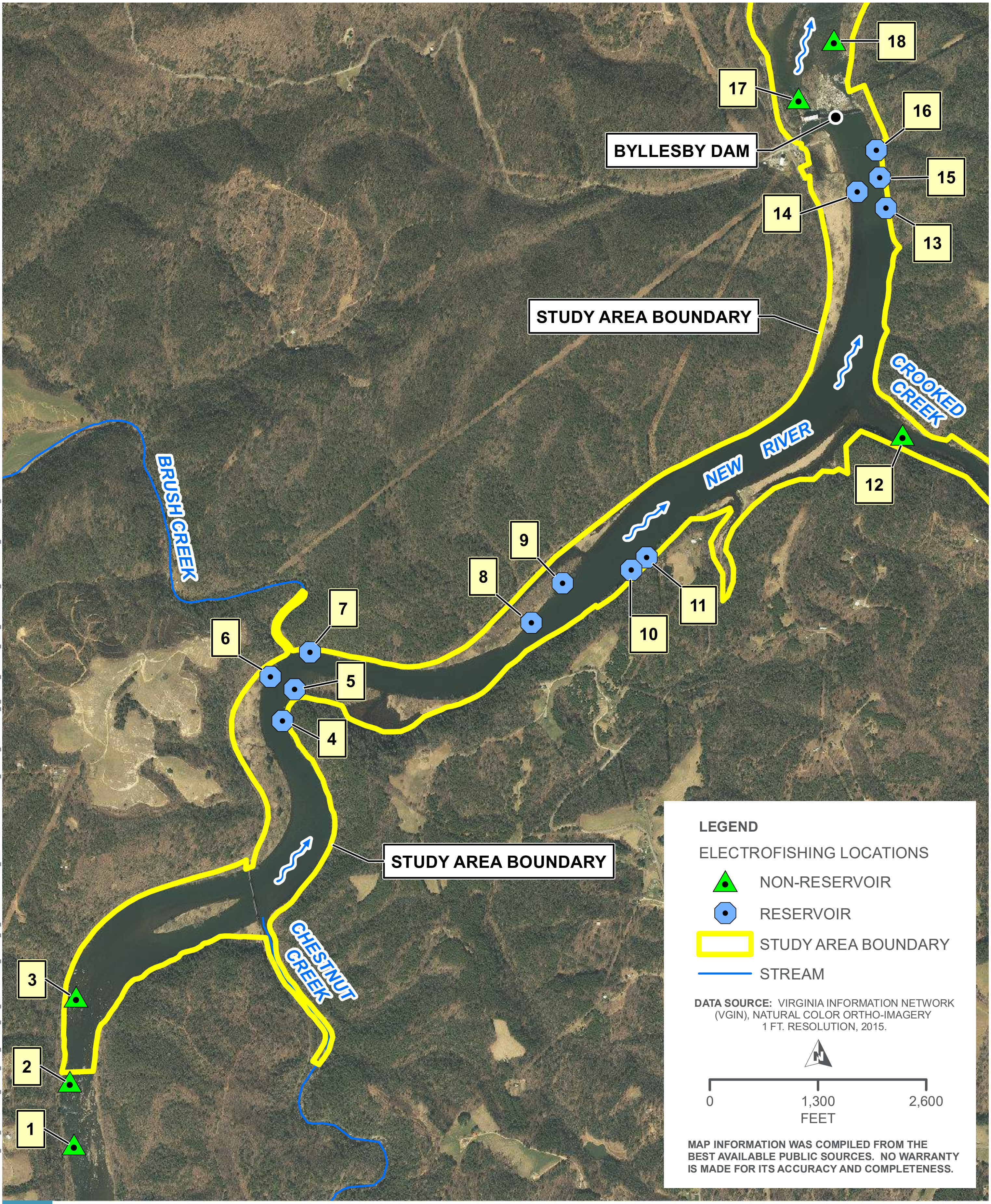


FIGURE 4

FISH SAMPLING STATIONS NEAR BYLLESBY/BUCK HYDROELECTRIC PROJECT, MAY-OCTOBER 1990.



HDR

APPALACHIAN POWER

An AEP Company

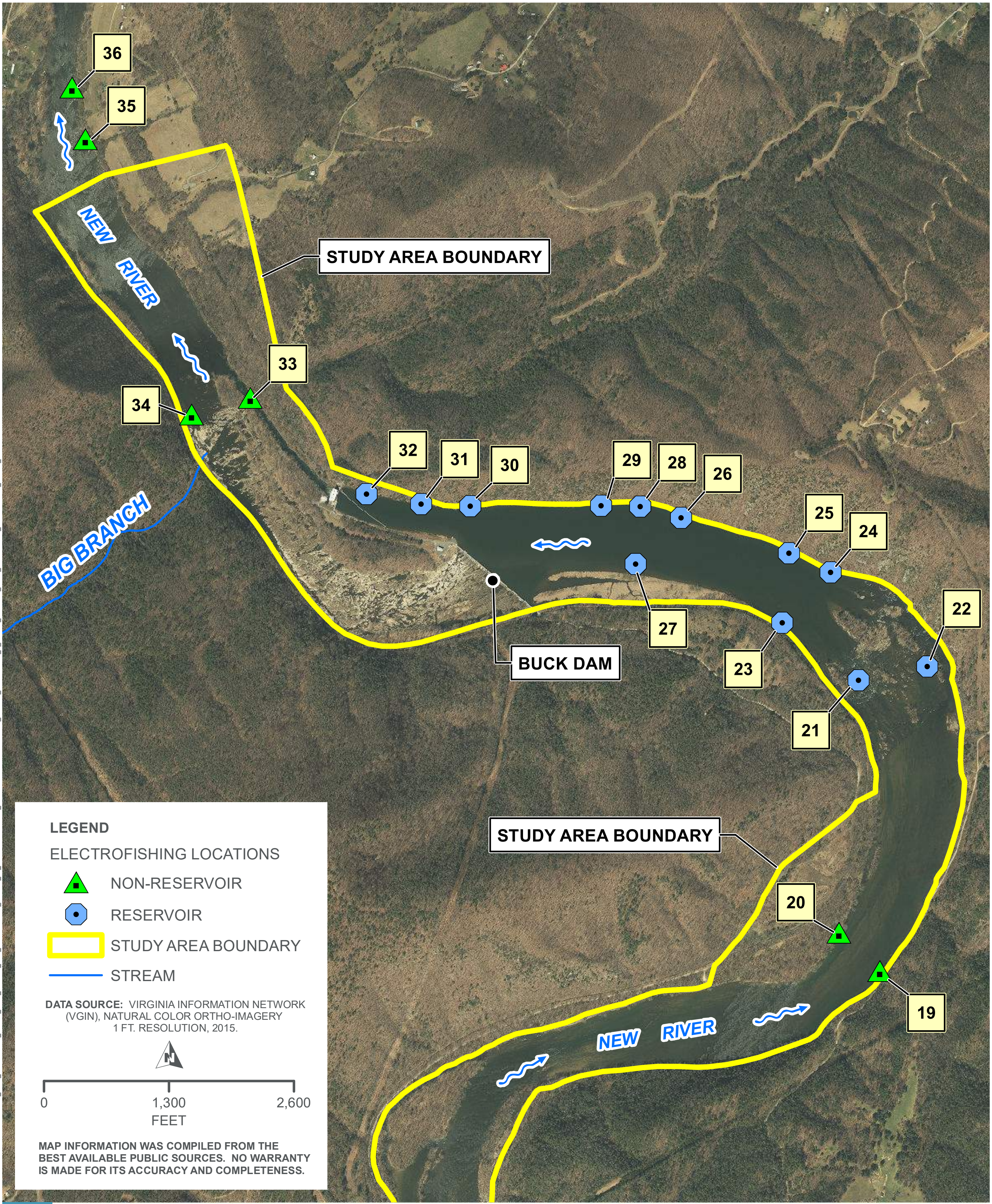
BOUNDLESS ENERGY

BYLLESBY PROPOSED FISH SAMPLING LOCATIONS

BYLLESBY & BUCK HYDROELECTRIC PROJECT (FERC NO. 2514)

CARROLL COUNTY, VIRGINIA

OCTOBER 2019



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HDR | APPALACHIAN POWER — An AEP Company — BOUNDLESS ENERGY

BUCK PROPOSED FISH SAMPLING LOCATIONS

BYLLESBY & BUCK HYDROELECTRIC PROJECT (FERC NO. 2514)

CARROLL COUNTY, VIRGINIA

OCTOBER 2019

Appendix C

Facility Inventory and Condition Assessment Form

RECREATION FACILITY INVENTORY AND CONDITION ASSESSMENT
Byllesby-Buck Hydroelectric Project (FERC No. 2514)

Location:	
Date:	**Surveyor:**
Photo Number(s):	

Type of Amenity	#	ADA	Condition	Notes
Boat Launch Ramp/Lane			N / R / M / G	
Portage (put-in/take-out)			N / R / M / G	
Portage Trail/Walking Trail (include length and footing materials)			N / R / M / G	
Picnic Table			N / R / M / G	
Trash Receptacles			N / R / M / G	
Other			N / R / M / G	
Other			N / R / M / G	
Other			N / R / M / G	

PARKING	Total Spaces: _____ Standard: _____ ADA: _____ Double (trailer): _____ Other: _____	**Condition**
	Surface Type: *Asphalt* *Concrete* *Gravel* *Other:___________*	N / R / M / G

Signs	#	Size	Material	Condition	Comments
FERC Project			wood / metal / other	N / R / M / G	
Facility ID			wood / metal / other	N / R / M / G	
Regulations			wood / metal / other	N / R / M / G	
Directional			wood / metal / other	N / R / M / G	
Interpretive			wood / metal / other	N / R / M / G	

N - Needs replacement (broken or missing components, or non-functional)
R - Needs repair (structural damage or otherwise in obvious disrepair)
M - Needs maintenance (ongoing maintenance issue, primarily cleaning)
G - Good condition (functional and well-maintained)
If a facility is given a rating of “N”, “R”, or “M”, provide specific details.

ADDITIONAL COMMENTS/NOTES:
Note the age of the facilities (if known) as well as any signs of overuse.

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Appendix D

Online Survey Questionnaire

ONLINE RECREATION SURVEY
Byllesby-Buck Hydroelectric Project (FERC No. 2514)
Recreation Survey Questionnaire

Appalachian Power Company (Appalachian), a unit of American Electric Power (AEP), is the Licensee, owner, and operator of the Byllesby-Buck Hydroelectric Project (Project or Byllesby-Buck Project) which is licensed by the Federal Energy Regulatory Commission (FERC). There are six Project-related recreation facilities associated with the Project, two of which are owned and operated by Appalachian, and the remaining sites are owned and operated by Virginia Department of Conservation and Recreation (VDCR) or Virginia Department of Game and Inland Fisheries (VDGIF). The current operating license for the Project expires on February 29, 2024. As part of the relicensing process, Appalachian is conducting studies on environmental resources to enable FERC to prepare an environmental document. The purpose of this survey is to collect information about use of the Project's recreation facilities. A map of the six Project-related recreation facilities is provided in Attachment 1 of this Questionnaire.

Recreation Location (check one):	**Byllesby VDGIF Leased Boat Launch** ☐	**Byllesby Canoe Portage** ☐	
	New River Canoe Launch ☐	**Buck Dam Picnic Area** ☐	
	New River Trail Picnic Area ☐	**Buck Dam Canoe Portage** ☐	
Home Zip Code:	______________________	**Date:**	______________________
Age:	______________________		______________________
Are you:	**Male** ☐	**Female** ☐	**Prefer not to answer** ☐

Q-1. Regarding the Byllesby-Buck Project area, do you consider yourself: (**Please circle one)**

1. A regular visitor to this area (*3 or more times per year*)
2. An occasional visitor (*1-2 times per year*)
3. An infrequent visitor (*Less than 1 time per year*)
4. This is my first visit

Q-2. On this trip to the Byllesby-Buck Project-related recreation facility, when did you arrive?

Arrival Date _____/_____/_____

Arrival Time ____________AM/PM

When did you/or do you expect to leave the Byllesby-Buck Project area?

Departure Date _____/_____/_____

Departure Time ____________AM/PM

Q-3. During the last 12 months (including this trip), which month(s) did you visit the Byllesby-Buck Project area? **(Please select all that apply)**

Jan ☐ Feb ☐ Mar ☐ Apr ☐ May ☐ Jun ☐ Jul ☐ Aug ☐ Sep ☐ Oct ☐ Nov ☐ Dec ☐

Q-4. About how many miles did you travel to get to the Byllesby-Buck Project area?

A. _________miles

Q-5. Are you staying overnight in the Byllesby-Buck Project area (not including at your own home) on this trip?

1. Yes   2. No

Q-6. If you answered yes to **Q-5**, at what type of accommodations will you be staying? (**Please select one)**

1. RV/Auto/Tent Campground
2. Motel/hotel
3. Bed and Breakfast
4. Vacation or rental home
5. Other (Please specify: ____)

Q-7. On this trip to the Byllesby-Buck Project area, in which of the following activities did you participate in? (**Please select all that apply**)

1. Bank fishing	5. Picnicking	8. Hunting
2. Boat fishing	6. Swimming	9. Wildlife viewing
3. Pleasure boating	7. Sight-seeing	10. Other (please describe)
4. Canoeing/kayaking		

Q-8. Of the activities you circled in Q-7 above, what is the primary activity that you participated in on this visit? (**Please write in the corresponding number from above**)

A. Primary activity # _________

Q-9. Regarding the primary activity you participated in on this visit listed in Q-8, please rate the following at the Project:

	Totally Unacceptable	Unacceptable	Neutral	Acceptable	Totally Acceptable
Safety	1	2	3	4	5
Enjoyment	1	2	3	4	5
Crowding	1	2	3	4	5
Overall Experience	1	2	3	4	5

Q-10. If you participated in recreational activities in the Byllesby-Buck Project area today or in the past, rate the following on a 1-5 scale as listed in Q-9:

	Byllesby-Buck Project Area
Accessibility	
Parking	
Crowding	
Safety	
Condition of Recreation Facilities	
Available Facilities	
Overall Experience	

Q-11. Please tell us what type(s) of recreation enhancements you believe are needed at the Byllesby-Buck Project.

Description of recreation enhancement and location:

____

____

____

____

____

Q-12. Please share any other comments that you have regarding recreation near the Byllesby-Buck Project:

____

____

____

____

____

____

____

Thank you for completing the Recreation Survey!

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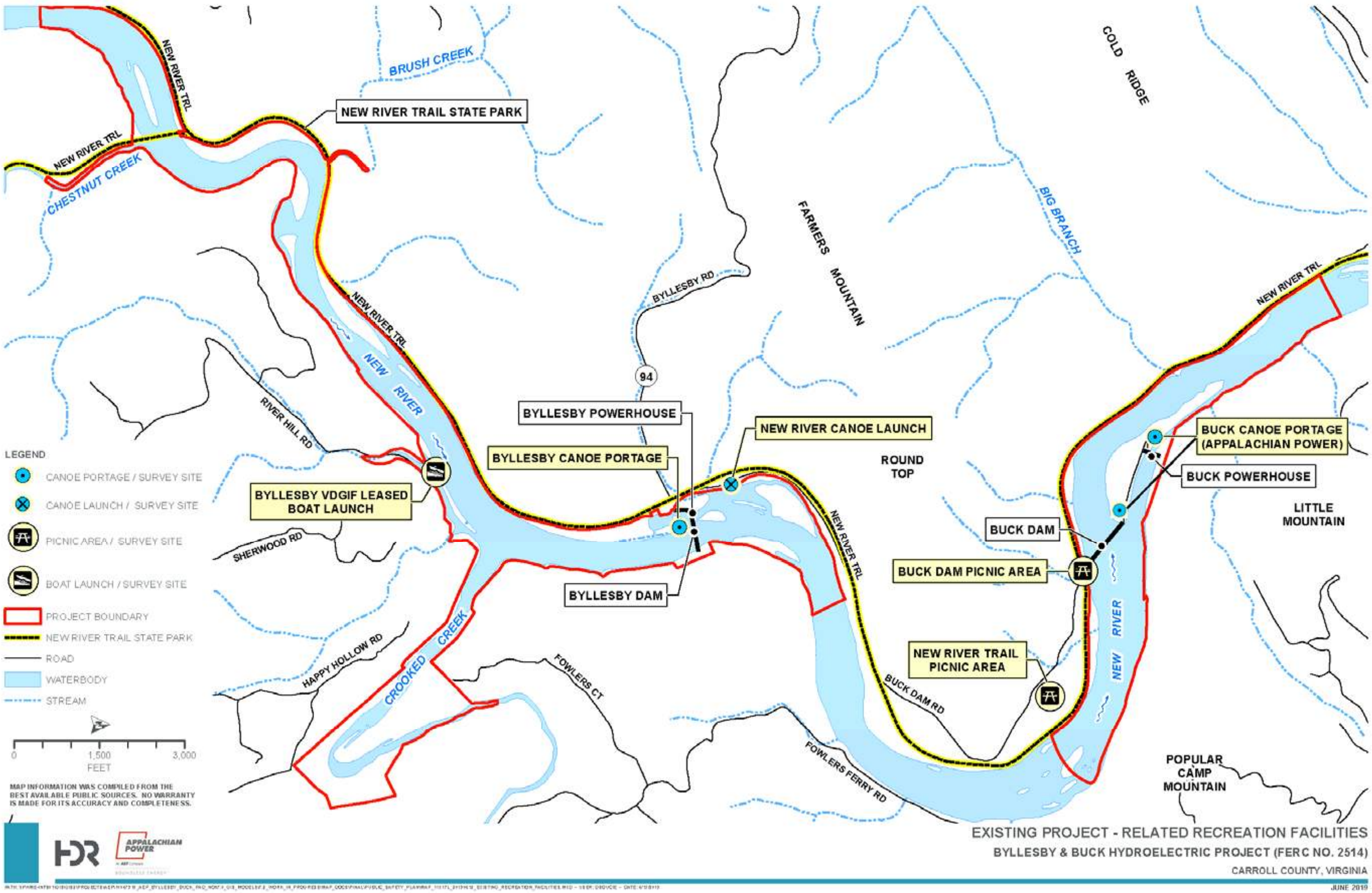
Attachment 1: Project-related Recreational Facilities at the Byllesby-Buck Project



Appendix E

Preliminary Information Form Archaeological Site

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DEPARTMENT OF HISTORIC RESOURCES

2801 Kensington Avenue, Richmond, Virginia 23221

Telephone: (804) 367-2323 Fax: (804) 367-2391

PRELIMINARY INFORMATION FORM
ARCHAEOLOGICAL SITE

The following constitutes an application for preliminary consideration of eligibility for the nomination potential of a site to the Virginia Landmarks Register and the National Register of Historic Places. This does **not** mean that a property is being nominated to the registers at this time. Rather, it is being evaluated by the Virginia Department of Historic Resources (DHR) staff and the State Review Board to determine if the property qualifies for such listings. Applicants will be notified of the staff's and the State Review Board's recommendations.

Contact the appropriate DHR Regional Archaeologist to determine if previous survey material for this site is on file, and if the site has been previously evaluated by DHR. Help identifying the correct regional office is available here. Obtaining previously recorded information could save a significant amount of time in preparing this Preliminary Information Form (PIF). The site must be recorded with DHR, if it has not been previously entered into the DHR inventory. The archaeological inventory manager can assist with the recordation of the site, and will also provide you with the address of the regional office to which you should send your completed PIF materials.

PIF Materials: The printed version of this form should be submitted on 8½" X 11" paper, along with the electronic version, preferably in Word format. The form may be typed or hand-written, if an electronic format is not available. The electronic version of this PIF should be submitted on a disc, or it may be attached to an email to the archivist. In addition, a printout of the site form from the DHR database should be submitted with the PIF. A copy of the site database printout may be obtained from the archaeological inventory manager.

Note: All submitted materials become the property of the Department of Historic Resources and will not be returned. In addition, the materials will be posted on the DHR public website for a period of time during the evaluation process. Please address questions regarding the PIF application to the archivist or regional office staff.

Maps: Please include two (2) maps showing the location of the property:

- A copy of a section of a USGS topographical Quad map with the date, the name of the county/city and the quad printed on the map, and with the name of the site with its state site number and its location on the map labeled with a pencil (USGS Quadrangle maps can be printed free of charge using the Map Locator at the USGS store: http://store.usgs.gov).
- A sketch site plan showing the site boundaries in relationship to other features that are important in conveying the location of the site. Please include the name of the site, the state site number, a "North" arrow, date, and "Not to Scale" (if appropriate).

  Note: Maps may also be generated free-of-charge using DHR's public V-CRIS MapViewer tool.

Before submitting this form, please make sure that you have included the following:

- Section of labeled USGS Quadrangle map showing the location and boundaries of your property
- Sketch site plan map of the site
- Disc with digital files (Word document, TIFs, JPEGs)
- Completed Resource Information Sheet, including
  - Owner's signature – **this is required. The PIF will not be evaluated without owner(s) signature.**
  - Applicant contact information
  - City or county official's contact information

Thank you for taking the time to submit this Preliminary Information Form. Your interest in Virginia's historic resources is helping to provide better stewardship of our cultural past.

Virginia Department of Historic Resources
PIF Resource Information Sheet

This information sheet is designed to provide the Virginia Department of Historic Resources with the necessary data to be able to evaluate the significance of the property for possible listing in the Virginia Landmarks Register and the National Register of Historic Places. This is not a formal nomination, but a necessary step in determining whether or not the property could be considered eligible for listing. Please take the time to fill in as many fields as possible. A greater number of completed fields will result in a more timely and accurate assessment. Staff assistance is available to answer any questions you have in regards to this form.

General Site Information

For Staff Use Only
DHR Site #:

Site Name(s): ____________________

Site Date(s): ____________ ☐Circa ☐Pre ☐Post Open to Public? ☐Yes ☐Limited ☐No

Site Address: ____________________ City: ____________ Zip: ________

County or Ind. City: USGS Quad(s):

Physical Character of General Surroundings

Acreage: ________ Approximate Dimensions:

Site Description Notes/Notable Landscape Features:

Current Use of Site:

Any Known Threats to the Site:

Ownership Category: ☐Private ☐Public-Local ☐Public-State ☐Public-Federal

Archaeological Description: Discuss (a) archaeological deposits present at the site and their level of integrity, and (b) prior investigations at the site as well as prior historical documentation for the site, citing all available references. For sites being evaluated for the Threatened Sites Fund, also discuss types of threats facing the resource, the severity of such threats, and if threats are immediate or long-term in nature.

Archaeological Significance Statement: Discuss historical and archaeological reasons that the site is likely to be significant. Briefly note any significant events, personages, and / or families associated with the site. Detail what research issues could be effectively addressed with the archaeological remains preserved at this site.

Legal Owner(s) of the Property (For more than one owner, please use a separate sheet.)

Mr. ☐ Mrs.☐ Dr. ☐
Miss ☐ Ms. ☐ Hon.☐

(Name) (Firm)

(Address) (City) (State) (Zip Code)

(Email Address) (Daytime telephone including area code)

Owner's Signature: ________________ Date: ________

• • Signature required for processing all applications. • •

In the event of corporate ownership you must provide the name and title of the appropriate contact person.

Contact person: ________________

Daytime Telephone: ( )

Applicant Information (Individual completing form if other than legal owner of property)

Mr. ☐ Mrs.☐ Dr. ☐
Miss ☐ Ms. ☐ Hon.☐

(Name) (Firm)

(Address) (City) (State) (Zip Code)

(Email Address) (Daytime telephone including area code)

Applicant's Signature: Date:

Notification

In some circumstances, it may be necessary for the department to confer with or notify local officials of proposed listings of properties within their jurisdiction. In the following space, please provide the contact information for the local County Administrator or City Manager.

Mr. ☐ Mrs.☐ Dr. ☐
Miss ☐ Ms. ☐ Hon.☐

(Name) (Position)

(Locality) (Address)

(City) (State) (Zip Code) (Daytime telephone including area code)

Please use the following space to explain why you are seeking an evaluation of this site.

Would you be interested in the easement program? Yes ☐ No ☐