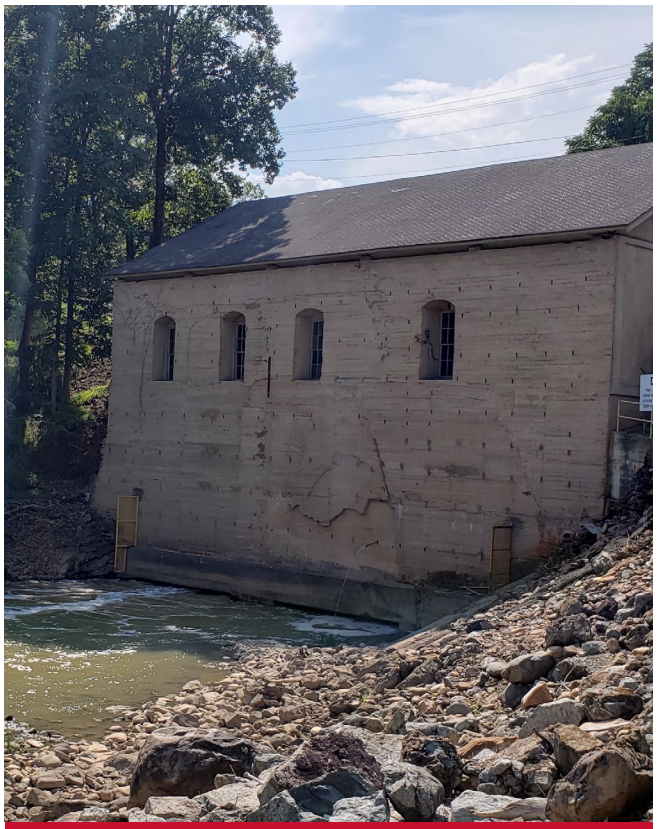


Benthic Aquatic and Mussel Community Report

Niagara Hydroelectric Project (FERC No. 2466)

December 6, 2021

Prepared by:

Edge Engineering and Science, LLC

Prepared for:

Appalachian Power Company

This page intentionally left blank.

Niagara Hydroelectric Project
(FERC Project No. 2466)

2020-2021 Benthic Aquatic Resources Survey Results, Virginia

Prepared for:

AMERICAN ELECTRIC POWER
BOUNDLESS ENERGY™

Niagara → HDR2020-0002

September 24, 2021

Prepared by:

EDGE
ENGINEERING & SCIENCE
further insight.

Edge Engineering and Science, LLC
Cincinnati, Ohio

Table of Contents

1.0 Introduction 1
2.0 Methods 1
2.1 Macroinvertebrate and Crayfish Community 2
2.1.1 Quantitative Sampling 2
2.1.2 Qualitative Sampling 3
2.1.3 Laboratory Processing 3
2.1.4 Data Analysis 3
2.2 Mussel Habitat and Community 4
2.2.1 Transects 4
2.2.2 Abbreviated 4
2.3 Deviations from Revised Study Plan 5
2.3.1 COVID-19 Delays 5
2.3.2 Weather Delays 5
2.3.3 Time-of-Year Restrictions 5
3.0 Results 6
3.1 Macroinvertebrate and Crayfish Community 6
3.1.1 Upstream of Niagara Dam 6
3.1.2 Downstream of Niagara Dam 7
3.2 Mussel Habitat and Community 7
3.2.1 Upstream of Niagara Dam 8
3.2.2 Downstream of Niagara Dam 10
4.0 Discussion 10
4.1 Macroinvertebrate and Crayfish Community 10
4.2 Mussel Habitat and Community 11
5.0 Literature Cited 12

LIST OF FIGURES

Figure 1: Overall Niagara Project area including quantitative and qualitative macroinvertebrate survey sites and transect and abbreviated mussel survey sites on the Roanoke River in Roanoke County, Virginia

Figure 2-6: Quantitative macroinvertebrate and crayfish 100-meter survey extents in riffle/run habitat in Roanoke County, Virginia

Figure 7-11: Qualitative macroinvertebrate and crayfish 100-meter survey extents in mixed habitat in Roanoke County, Virginia

Figure 12-19: Transect mussel survey extents in pool habitat in Roanoke County, Virginia

Figure 20-24: Abbreviated mussel survey extents in mixed habitat in Roanoke County, Virginia

APPENDICES

Appendix A. Scientific Collection Permits

Appendix B. Representative Photographs

Appendix C. Raw Data

LIST OF ACRONYMS

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

1.0 INTRODUCTION

The Niagara Hydroelectric Project (Project) is a 2.4-megawatt hydroelectric generating facility located at river mile 355 of the Roanoke River in Roanoke County, Virginia. Appalachian Power Company (a unit of American Electric Power; AEP) is pursuing a new license from the Federal Energy Regulatory Commission (FERC) for the Project as their existing license (FERC Project No. 2466) expires in 2024. Aquatic biological studies were completed to support their existing FERC license and results of these studies are ultimately used as a record and reference for current relicensing efforts. The Roanoke River, along with the approximately 2-mile-long reservoir resulting from the Niagara Dam, harbors a diverse community of aquatic biota; thus, aquatic biological studies are required to survey and document the contemporary community of organisms present within the Project area (Figure 1). The Roanoke River and lower reaches of tributary streams are included in the Project area. The information gained from these studies will document the current conditions of macroinvertebrate and mussel abundance, diversity, and distribution in the vicinity of the Project.

Study scoping with state and federal agencies resulted in the development and approval of a Project-specific Revised Study Plan (RSP) that identified four objectives for Project studies (AEP 2019) pertaining to benthic aquatic species.

Goals and Objectives

1) Collect a baseline of existing macroinvertebrate and crayfish communities in the vicinity of the Project
2) Confirm the presence or absence of mussels within the study area
3) Characterize the mussel community composition (if present), abundance, and distribution within the study area
4) Determine presence/probable absence of federally or state-listed species within the study area

In accordance with the RSP, field sampling efforts were necessary to satisfy each of the four objectives. Satisfaction of all objectives was not able to be accomplished during the 2020 calendar year due to delays resulting from unforeseeable circumstances including the COVID-19 global pandemic; therefore, an Initial Study Report (ISR) was submitted on January 11, 2021. This report serves as the Update Study Report (USR) now that all field sampling efforts within the RSP have been completed.

2.0 METHODS

The RSP provided guidance on the biological sampling framework for the Project that included macroinvertebrates, crayfish, and freshwater mussels. Macroinvertebrate and crayfish sampling employ a variety of methods to target representative habitat at 10 sites throughout the Project area. Mussel sampling targeted representative habitat at 13 sites throughout the Project area. The methods, number and location of sample sites, and seasonality were developed to document a comprehensive representation of the Project area and to correlate with previous sampling efforts (Appalachian and AEP 1991) for comparison. Replication of fall 2020 macroinvertebrate and crayfish methods and sites occurred in spring 2021, both during the sample index period defined by Virginia Department of Environmental Quality (VDEQ) Biological Monitoring Program Quality Assurance Project Plan (VDEQ 2008).

2.1 Macroinvertebrate and Crayfish Community

Macroinvertebrate and crayfish surveys, detailed in the RSP, include two temporally independent efforts (one survey in fall and one survey in spring). Specific sampling dates within these timeframes are determined based on factors including (but not limited to) weather conditions, water temperatures, river flows and reservoir elevations, and safety of field staff and the public. Sampling methods were derived from National Rivers and Streams Assessment (NRSA) Field Operations Manual (USEPA 2019) and VDEQ (2008) and include quantitative and qualitative sampling methods that target different habitats. Within the constraints of the Project's objectives and geographic limits, quantitative sampling targets riffle/run habitats and qualitative sampling targets available microhabitats in pools. A variety of sampling techniques were used to sample macroinvertebrates using quantitative and qualitative methods as described in subsequent sections. Five sample sites were located upstream of Niagara Dam (two quantitative and three qualitative) and five sites were downstream of Niagara Dam (three quantitative and two qualitative). Site naming conventions are as follows: Location-Seasonality-Method-Site Number. For example, NFQT1 = Niagara Fall Quantitative Site 1, NFQL3 = Niagara Fall Qualitative Site 3, and NSQL3 = Niagara Spring Qualitative Site 3.

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

2.1.1 Quantitative Sampling

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

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

replicate sample was completed downstream of Niagara Dam (one from fall 2020 and one from spring 2021) and was included in data analysis.

2.1.2 Qualitative Sampling

Benthic macroinvertebrates and crayfish were also sampled at five qualitative sites (i.e., multi-habitat; NFQL and NSQL site names) along 100-meter transects following guidelines defined by USEPA (2019) and VDEQ (2008). At pool sites (Figure 1 and Figures 7-11), transects were delineated in near-shore pool habitats and the start and endpoint coordinates were recorded. Site photos, field conditions, habitat characteristics, and water quality parameters were recorded in the same manner as quantitative sites (see Section 2.1.1). In addition, a Secchi disk reading was taken at each sample site at the time of sampling to assess water transparency. Multiple points for habitat and water quality measurements were taken if there was large variation within a single site.

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

2.1.3 Laboratory Processing

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

2.1.4 Data Analysis

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

scores determine the level of impairment at a specific site with scores over 80 indicating "reference" conditions, scores between 60 and 79 indicating "similar to reference" conditions, and scores below 60 indicating "impaired" conditions. The site VSCI scores were also used to make qualitative comparisons of overall reach conditions between different Project areas (i.e., upstream of Niagara Dam and downstream of Niagara Dam).

2.2 Mussel Habitat and Community

Mussel habitat and community study survey efforts included one season of sampling (fall 2020). The survey was developed following the Draft Freshwater Mussel Guidelines for Virginia (USFWS and VDGIF 2018) using habitat (e.g., water depth, substrate, stream flow) dependent methods, which included snorkeling, viewscope, and/or Surface Supply Air. Transect surveys occurred in pool habitats and included searching all habitat along the entire length. Abbreviated surveys occurred at mixed habitat sites and involved searching for mussels in suitable habitat throughout each site. Sampling dates were chosen within the approved survey window and occurred during relatively low-flow and high-visibility conditions. A variety of search techniques were used to survey for mussels at transect and abbreviated sites as described in subsequent sections. Eleven sites were upstream of Niagara Dam (eight transect and three abbreviated) and two sites were downstream of Niagara Dam (both abbreviated). The site naming convention for transect sites is 'T' followed by site number and for abbreviated sites is 'UNIO' followed by site number/descriptor. For example, UNIO-WC is the abbreviated site in Wolf Creek.

2.2.1 Transects

Freshwater mussel surveys in the impounded areas of the Project consisted of searches performed along eight linear transects that extended across the stream channel (varying from approximately 30 to 75 meters long) and perpendicular to stream flow. Due to safety concerns, no transect searches were performed in the 500-meter reach immediately upstream of Niagara Dam. Transects were placed approximately every 500 meters in the Niagara Dam impoundment and the free-flowing reach near the upstream extent of the Project area. Upon arrival at sites T-1 through T-8 (Figure 1 and Figures 12-19), transects were delineated and the start and endpoint coordinates were recorded. Site photos were taken in four directions (90 degrees to one another), and substrate and field conditions were documented (e.g., time, date, temperature, precipitation, cloudy/overcast, etc.). At each sample site, habitat characteristics (e.g., substrate, estimated water velocity, depth, and instream cover) and water quality parameters (e.g., pH, water temperature, DO, and conductivity) were measured and recorded. A Secchi disk reading was taken at each reservoir sample site at the time of sampling. Transects were subdivided into 10-meter intervals and data (i.e., substrate composition, mussel occurrence) was recorded for each interval.

Commercial divers approved by AEP and HDR conducted the mussel surveys at Niagara under the direction of an EDGE mussel biologist, working under Virginia Scientific Collecting Permit No. 068630 (Appendix A). Divers searched transects using Surface Supply Air methods at an approximate rate of one minute per square meter in heterogeneous substrates. All efforts were made to locate mussels including wafting substrates, searching through aquatic vegetation, and turning cobble, boulder, and woody debris. Additionally, divers wafted sediment and raked substrates with their fingertips to uncover buried mussels.

2.2.2 Abbreviated

Sampling for freshwater mussels also involved surveying five abbreviated sites outside the impounded area. (Figure 1 and Figures 20-24). Upon arrival, sites were delineated, and the start and endpoint

coordinates were recorded. Site photos, field conditions, habitat characteristics, and water quality parameters were recorded in the same manner as quantitative sites, as described in Section 2.2.1. Multiple data points, for habitat and water quality measurements, were taken if there was large variation within a single site.

Abbreviated mussel searches were completed throughout the assigned survey reach using viewscopes, snorkeling, and Surface Supply Air methods. Surveyors targeted habitat(s) suitable for the occurrence of freshwater mussels and searched those areas at an approximate rate of one minute per square meter in heterogeneous substrates. All efforts were made to locate mussels as described in Section 2.2.1.

Located mussels were placed in mesh bags and retained in the water for subsequent processing that included species identifications, enumerations, and length measurements. Photographs of representative taxa were taken. No live mussels were retained or injured during survey related activities. Fresh dead (empty valves) and weathered shells were retained as voucher specimens and will be deposited at malacological museums at 1) Marshall University in Huntington, West Virginia, 2) Ohio State University in Columbus, Ohio, 3) Carnegie Museum of Natural History in Pittsburgh, Pennsylvania, or 4) will provided to the United States Fish and Wildlife Service (USFWS), VDWR, and/or appropriate state agency upon request.

2.3 Deviations from Revised Study Plan

2.3.1 COVID-19 Delays

Initially, macroinvertebrate and crayfish surveys were proposed for completion in spring and fall 2020; however, the COVID-19 pandemic, and subsequent restrictions on non-essential travel and safety considerations for field staff, prohibited spring 2020 field efforts. As a result, AEP requested and was granted an extension to accommodate the change in schedule as the USFWS, VDWR, VDEQ, and Virginia Department of Conservation and Recreation (VDCR) all concurred with adaptable schedule revisions. EDGE was contracted and given notice to proceed with fieldwork at the beginning of September 2020. Thus, spring macroinvertebrate and crayfish sampling was completed during spring 2021. Mussel surveys were scheduled for and successfully completed during the 2020 field season

2.3.2 Weather Delays

Periodic delays associated with weather and stream flow conditions plagued the fall of 2020. Average annual rainfall for Roanoke, Virginia (collected at this station since 1981) is approximately 105 centimeters (U.S. Climate Data 2021) and, as of December 1, 2020, Roanoke already accumulated over 157 centimeters of rain (National Weather Service 2020). Sampling efforts were completed at the assumed 2020 baseflow, which was likely around 150-200 cubic feet per second (cfs) during the sampling period. The 47 percent increase in average precipitation made it difficult to sustain contiguous field sampling efforts and did not allow the Roanoke River to reach average annual baseflow throughout the sampling period at the study location. Spring 2021 flows more closely matched average flows during the sampling period.

2.3.3 Time-of-Year Restrictions

Virginia time-of-year restrictions (TOYR) for the protection of the state and federally endangered Roanoke Logperch (*Percina rex*) extend from March 15 through June 30 each year. The VDWR and USFWS were consulted in advance of the spring 2021 field data collections to receive their concurrence that the proposed methodology and timing of macroinvertebrate sampling were appropriate to avoid impacts to

the endangered Roanoke Logperch during the TOYR. Concurrence to perform the sample collection with the proposed methodology during the TOYR was received at the end of May 2021, but the delay resulted in sample collection occurring outside of the spring index period.

3.0 RESULTS

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

3.1 Macroinvertebrate and Crayfish Community

Macroinvertebrate samples were collected from ten sites between September 15 and 16, and on October 5, 2020, during the fall sample index period (September 1 – November 30) defined by VDEQ (2008). Although spring 2021 sampling occurred three days beyond the spring sample index period (March 1 – May 31) defined by VDEQ (2008), the impacts of the delay described in Section 2.3.3 were deemed negligible. Sampling was performed by EDGE's state and federally permitted astacologist under Virginia Scientific Collecting Permit No. 070705 (see Appendix A). There were differences in habitat type and substrates observed between sites (Appendix B); however, differences in sampling dates, time of day, and low number of intra- and inter-site samples do not facilitate statistical comparison of physiochemical properties between sites. Results of physiochemical data collected at sample sites met the state water quality standards established for the New River, indicating that water quality within the Project area is capable of supporting macroinvertebrate communities. Additional water quality data are provided in the Water Quality Study Report presented in the Project USR.

3.1.1 Upstream of Niagara Dam

The substrate at the quantitative macroinvertebrate site at the Tinker Creek, upstream of Niagara Dam, generally consisted of sand (45%), gravel (35%), cobble (18%), and boulder (2%) (Figure 2), and habitat structure consisted of occasional boulders, rootwads and undercut banks particularly along the LDB. Bedrock (35%), boulder (20%), cobble (25%), gravel (10%), and sand (10%) were the dominant substrates at the Roanoke River site (Figure 3), and habitat structure consisted of shallow sheets of bedrock riffles and glides with an overlay of other smaller substrates and occasional patches of submerged aquatic vegetation (SAV) were present as well as filamentous algae. Appalachian Brook Crayfish (*Cambarus bartoni bartoni*) and Ozark Crayfish (*Faxonius ozarkae*) were collected in Tinker Creek and Atlantic Slope Crayfish (*Cambarus longulus*) and Ozark Crayfish were collected in the mainstem Roanoke River. The Appalachian Brook Crayfish and Atlantic Slope Crayfish are both native to the Roanoke River whereas Ozark Crayfish is considered an invasive species. Water quality parameters (temperature, pH, velocity, and conductivity) remained relatively consistent between the two quantitative sites upstream of Niagara Dam, with exception of DO, which was generally higher at the Roanoke River site than the Tinker Creek site (Appendix C), and velocities which were highly variable within and among sites.

The substrate at qualitative macroinvertebrate sites upstream of Niagara Dam generally consisted of bedrock (60%), cobble (30%), and silt (10%) with large quantities of leaf packs, rootwads, and snags along the shore at the upstream most site within the impounded area. The other two sites in the impounded

area upstream of Niagara Dam were dominated by sand (60%) and silt (40%) substrates and with large quantities of leaf packs and snags occurring along the steeply sloping shoreline. Two species of invasive crayfish (Ozark Crayfish and Red Swamp Crayfish [*Procambarus clarkii*]) were collected from the sample sites in the impounded area, with zero crayfish being captured at the downstream most site in the impoundment (Figure 9). Water quality parameters (temperature, pH, DO, velocity, and conductivity) remained relatively consistent within the impoundment, but DO was generally the lowest in the middle of the impoundment.

A total of 38 macroinvertebrate taxa were collected upstream of Niagara Dam from two quantitative sites and three qualitative sites. The average VSCI score for riffle/run sites and pool sites sampled upstream of Niagara Dam in fall 2020 were 48.1 and 34.7, respectively, with all five sites scoring below 60 (Appendix C). The average VSCI score for riffle/run sites and pool sites sampled upstream of Niagara Dam in spring 2021 were 44.1 and 20.6, respectively, with all five sites scoring below 60 (Appendix C). However, a quantitative site (NF/NSQT2) in the mainstem of the Roanoke River in this Project area had HBI value indicating "Good" water quality in fall and spring and one qualitative site (NSQL3) had an HBI value indicating "Excellent" water quality in spring based on the tolerance of the macroinvertebrate community.

3.1.2 Downstream of Niagara Dam

The substrate at the three quantitative macroinvertebrate sites downstream of Niagara Dam generally consisted of bedrock (40%), slab boulder (20%), cobble (20%), and gravel (20%); and habitat structure consisted of shallow riffles and glides with smooth bedrock overlain with small, mixed substrates with sporadic patches of SAV and filamentous algae. One native species (Atlantic Slope Crayfish [*Cambarus longulus*]) and three invasive species (Ozark Crayfish, Virile Crayfish [*Faxonius virilis*], and the Red Swamp Crayfish) were collected at quantitative sites downstream of the Niagara Dam. Water quality parameters (temperature, pH, DO, velocity, and conductivity) remained relatively consistent between the quantitative sites in the reach downstream of Niagara Dam.

The substrate at the two qualitative macroinvertebrate sites downstream of Niagara Dam generally consisted of bedrock (40%), cobble (40%), gravel (10%), and sand (10%) with a moderate amount of rootwads along the shoreline. Based on depth and flow velocity, both sites were best characterized as run habitats. Two species of invasive crayfish were captured at these qualitative sites (Ozark Crayfish and Virile Crayfish), and water quality parameters (temperature, pH, DO, velocity, and conductivity) remained relatively consistent.

A total of 45 macroinvertebrate taxa were collected downstream of Niagara Dam from three quantitative sites and two qualitative sites. The average VSCI score for riffle/run sites and pool sites sampled downstream of Niagara Dam in fall 2020 were 39.0 and 42.8, respectively, with all five sites scoring below 60 (Appendix C). The average VSCI score for riffle/run sites and pool sites sampled downstream of Niagara Dam in spring 2021 were 38.1 and 41.1, respectively, with all five sites scoring below 60 (Appendix C). However, one quantitative site (NFQT6) and one qualitative site (NFQL8) in this Project area had HBI value indicating "Good" water quality in fall and one quantitative site (NSQT10) had an HBI value indicating "Good" water quality in spring 2021 based on the tolerance of the macroinvertebrate community.

3.2 Mussel Habitat and Community

Mussel survey efforts were completed during optimal weather and riverine conditions between October 6-8, 2020, following methods defined in the RSP and derived from the Draft Freshwater Mussel Guidelines

for Virginia (USFWS and VDGIF 2018). Survey efforts were performed by EDGE's state permitted malacologist and a commercial dive team under Virginia Scientific Collecting Permit No. 068630 (see Appendix A).

Unionids were mostly absent throughout all 13 survey reaches. Survey efforts along eight transects located in the Niagara Dam impoundment totaling 430 square meters resulted in the collection of zero live or deadshell specimens. Abbreviated surveys at five locations, with a cumulative search effort of 1,335 minutes, resulted in the collection four live unionids representing one species, Eastern Elliptio (*Elliptio complanata*). The Eastern Elliptio is native to the Roanoke River system and a common species in Atlantic Slope mussel assemblages. Additionally, a single Notched Rainbow (*Villosa constricta*) was observed as weathered deadshell material during quantitative macroinvertebrate and crayfish surveys near the Tinker Creek site. No live mussels or deadshell were collected downstream of Niagara Dam. The invasive Asiatic Clam (*Corbicula fluminea*) was noted at all sites. The highest density of Asiatic Clams in the Project area was noted in Tinker Creek. Asiatic Clams appeared in relatively even densities between sites within the mainstem Roanoke River (above and below Niagara Dam), with slightly higher densities observed where suitable mollusk habitat was present. Asiatic Clams were noted at the mouth of Wolf Creek but did not persist upstream beyond the confluence with the Roanoke River. Representative site and mussel photos are provided in Appendix B. Results of physiochemical data collected at sample sites met the state water quality standards established for the Roanoke River, indicating that water quality within the Project area is capable of supporting macroinvertebrate communities. Additional discussions regarding water quality will be provided in the Project-specific USR water quality study report.

3.2.1 Upstream of Niagara Dam

Abbreviated mussel sites were located in riffle/run habitat upstream of the Niagara Dam, with one site in Tinker Creek and one in the mainstem of the Roanoke River. The Tinker Creek site consisted of riffle/run complexes (Figure 21). During the survey effort, the streamflow was low and clear with a maximum depth of approximately 1.5 meters and an average depth of 0.2 meters. The average stream width at this site was approximately 15 meters. The riffles and thalweg of Tinker Creek were dominated by unstable, mobile sand (65%), gravel (25%), and silt (10%). A small area (~25 square meters) around the Tinker Creek Canoe Launch provided the only coarse substrate (i.e., large, stable cobble) in the stream. Two hundred and forty (240) minutes of qualitative search effort was expended and yielded two live and approximately 12 weathered deadshell Eastern Elliptio specimens, with CPUE of 0.5 individuals per hour and an approximate qualitative density of 0.0018 individuals per square meter. Both live individuals were old and all deadshell specimens were represented by older individuals, suggesting a lack of recruitment. Additionally, a Notched Rainbow was observed as weathered deadshell material during quantitative macroinvertebrate and crayfish surveys near this site in Tinker Creek.

The site was strongly influenced by anthropogenic impacts and featured heavy trash deposits, human feces, and combined sewer outfalls. During high flow events, the stream likely experiences elevated water velocities and unnatural sediment transport as it drains downtown Roanoke with a watershed dominated by impermeable surfaces. However, stable substrates suitable for mussel colonization were present in pockets behind woody debris and along the lateral stream margins. The Tinker Creek site likely supports a minimal population of freshwater mussels that may be greatly degraded due to anthropogenic impacts and a lack of recruitment.

The Roanoke River site consists of several riffle-run complexes and one long pool (Figure 20). During survey efforts, the streamflow was relatively low and clear with a maximum depth of approximately 1.5

meters and an average depth of 0.5 meter. The average stream width at this site was approximately 33 meters. Substrate composition was a heterogeneous mixture of sand (30%), gravel (30%), cobble (25%), and bedrock (10%) with some silt (5%) deposits along the stream margins. Survey efforts included 360 minutes of qualitative searches using snorkel and view scope methods and resulted in the collection of two live Eastern Elliptio (Appendix C). This sampling location resulted in a CPUE of 0.33 individuals per hour with an approximate qualitative density of 0.000148 individuals per square meter. However, both individuals were collected within 3 meters of each other in sand/silt substrates near flow refugia along the LDB. With an abundance of two and a species richness of one, the UNIO-1 site likely supports a minimal population of highly localized freshwater mussels that persist in low densities. No state or federally listed mussels were found.

Wolf Creek is a small tributary that empties into the impounded portion of the Roanoke River along the LDB and consisted of high-gradient riffle/run complexes (Figure 22). The maximum depth was approximately 1.0 meter with an average depth of 8 centimeters. The average stream width at this site was approximately five meters. Substrate composition was dominated by unconsolidated sand (70%) with small pea gravel (25%) and some cobble (5%) present. Survey efforts began at the Wolf Creek confluence with the Roanoke River and extended approximately 500 meters upstream. One hundred and thirty-five (135) minutes of qualitative search efforts yielded no live individuals or deadshell specimens. The stream featured excellent riparian zone coverage but was heavily impacted by unstable sand deposits, likely the result of upstream urban activity. The small stream size (approximately 13 square kilometer drainage area) and unstable substrates provided poor habitat for freshwater mussel colonization.

All mussel transect sites were placed within the impounded section of the Roanoke River and consequently categorized as pool habitats. Substrate composition varied from bedrock to silt, with a general longitudinal pattern observed in substrate sizes that decreased in the downstream direction towards Niagara Dam (Figure 1; T). Transect sites had relatively similar habitat features and all resulted in zero live mussels; therefore, are discussed collectively and in generality.

The Niagara impoundment was surveyed with eight bank-to-bank transects spaced 500 meters apart totaling 430 square meters of search area (averaging approximately 54 meters per transect) (Figures 12-19). Survey efforts yielded zero live freshwater mussels or deadshell specimens. Longitudinal variation in depth and substrate sizes were observed between the upper and lower portions of the impoundment. Water depth along transects 1-3, in the upper portion of the reach, averaged approximately one meter across the channel; water depth along the lower transects (Transects 6-8) averaged approximately two meters, and depth along the middle transects averaged between one and two meters. Substrate composition in the upper impoundment was dominated by coarse materials such as gravel and bedrock and gradually transitioned to less coarse and homogenous substrates such as deep silt and sand deposits at downstream transects. The upper transects had high visibility, shallow stream banks, and a lack of fine sediments. The downstream transects had steep sloping banks, less visibility, and numerous woody debris deposits.

Although the thalweg was typically inundated with thick, mobile silt deposits, the riverine margins were characterized by stable, presumably suitable, unionid habitat. However, no live or deadshell freshwater mussels were encountered, including silt-tolerant species (e.g., Paper Pondshell [*Utterbackia imbecillis*]) which are common in the stable banks of impoundments throughout the Atlantic Slope.

3.2.2 Downstream of Niagara Dam

Downstream of Niagara Dam, one abbreviated mussel site was located in the Bypass Reach and another was located downstream below the tailrace. The Bypass Reach site occurs directly downstream of Niagara Dam and primarily consisted of heavily braided riffle/run habitats and plunge pools (Figure 23). The maximum depth was approximately 1.0 meter with an average depth of 15 centimeters at the time of surveys. The average stream width at this site was approximately 55 meters. The survey area was dominated by scoured bedrock (50%), cobble (40%), and gravel (10%) with very little suitable unionid habitat available. Survey efforts began at the Niagara Pumphouse and extended approximately 315 meters upstream to the base of the Niagara Dam (Figure 23). Three hundred and thirty (330) minutes of qualitative search efforts yielded no live individuals or deadshell specimens. The entire reach is heavily impacted by strong flows from the Niagara Dam; and although minimum flow requirements maintain a wetted channel, portions of the reach may go dry during periods of low flow. Although riverine conditions exhibited high DO and cool temperatures, this site was highly unsuitable for unionid colonization due to large areas of smooth bedrock, heavy scouring and periodic turbulent velocities.

The tailrace site occurs downstream of Niagara Pumphouse and primarily consisted of deep, swift bedrock runs (Figure 24). The maximum depth was approximately 2.5 meters with an average depth of 1.0 meter. The average stream width at this site was approximately 25 meters. The site was dominated by bedrock (90%) substrate in the thalweg with gravel (5%) and sand (5%) along the shorelines. Survey efforts began at the Blueridge Parkway Bridge and extended approximately 500 meters downstream. Two hundred and seventy (270) minutes of qualitative search effort yielded no live individuals or deadshell specimens. Although riverine conditions exhibited high DO and cool water temperatures, the entire reach is heavily impacted by strong flows from the Niagara Dam and deeply scoured into swift chutes of bedrock. A large riffle at the bottom of the site offered the first continuous area of stable gravel/cobble substrate and may represent the beginning of suitable mussel habitat.

4.0 DISCUSSION

4.1 Macroinvertebrate and Crayfish Community

Benthic macroinvertebrate and crayfish species diversity and abundance can be used as indicators of water quality, as these organisms serve as a food resource for fish and other fauna in the riverine community. A healthy stream generally includes habitat diversity and limited pollution, often indicated by a high VSCI metric score, which indicates the presence of an abundance and diversity of pollution intolerant taxa. VDEQ (2017) conducted macroinvertebrate sampling in the Roanoke River downstream of Niagara Dam and demonstrated low diversity and presence of few sensitive taxa overall; despite presence of some optimal habitat. There is no site-specific reference information available for crayfish in the vicinity of the Project; however, Virginia is known to harbor approximately 33 species of crayfish. Several species currently found in Virginia include non-indigenous and/or invasive species such as the Red Swamp Crayfish, Rusty Crayfish (*Faxonius rusticus*), and Virile Crayfish (VDGIF 2018; VISAC 2018).

VSCI scores recorded at each site were greater on average in the fall than in the spring. The average VSCI scores upstream and downstream of Niagara Dam indicated “impaired” conditions during the fall and spring samples. Upstream of Niagara Dam had an overall average VSCI score of 33.8 whereas downstream of Niagara Dam had an overall average VSCI score of 39.7. Zero sites within either Project area, during either season, resulted in a VSCI score above the threshold of “similar to reference” conditions (60). During

both seasonal collections, the lowest VSCI scores were recorded upstream of Niagara Dam and the highest were recorded downstream of Niagara Dam, which indicates less impairment as you move downstream through the project area. This trend likely results from the impacts of point and non-point source pollution from the Roanoke River watershed.

Although the species composition varied, four of five species of crayfish were present above and below Niagara Dam. There were zero crayfish captured at the one qualitative site upstream of Niagara Dam. Above the dam there were two native and two invasive species and below the dam there was one native species and three invasive species. The Appalachian Brook Crayfish (i.e., native) was only collected in Tinker Creek. The invasive Ozark Crayfish and Red Swamp crayfish were collected both above and below the dam, whereas the Virile Crayfish was only collected below the dam (however there are records of Virile Crayfish above the Project in the Roanoke River [Foltz, unpublished data]). Native species were collected at three of the 10 sampled sites while invasive species were collected at eight of the 10 sampled sites. The invasive Ozark Crayfish was collected at all sites where crayfish were present, as one of five sites above the dam resulted in zero crayfish.

4.2 Mussel Habitat and Community

The presence of a diverse and abundance freshwater mussel community can also serve as a biological indicator of a healthy stream because of their typical intolerance to fine sediments and water pollution. The presence of certain invasive mollusks (i.e., Asiatic Clam) can also indicate potentially degraded stream health. Asiatic clams have not been previously identified in the Project area; however, little to no recent mussel surveys have been completed in the vicinity of the Project. A geographic search on VDWR's Fish and Wildlife Information Service and communications with USFWS identified potential occurrence of seven mussel species that may occur in the Project vicinity, including the Atlantic Pigtoe (*Fusconaia masoni*, proposed for federal listing), the Green Floater (*Lasmigona subviridis*, state threatened) and James Spinymussel (*Parvaspina collina*, federally and state endangered). No evidence of these aforementioned species was encountered during 2020 mussel surveys.

Site-specific survey results were presented for abbreviated mussel surveys in Section 3.2.1. Two Eastern Elliptio mussels were collected near one another at the most upstream site in the Roanoke River project area (UNIO-1). Two live Eastern Elliptio mussels and approximately 12 deadshell specimens, were collected in Tinker Creek (UNIO-2). Although these two sites offer minimal suitable mussel habitat, they are likely the most productive within the Project area. Although the measured water quality parameters appear suitable (Appendix C), with high DO and cool temperatures, the habitat at many sites was unsuitable for unionid colonization due to heavy scouring and bedrock substrates and may be impaired due to other water quality issues that were not assessed as part of this study. Anthropogenic impacts to the Roanoke River upstream and within the Project area, along with a dearth of suitable habitat, appear to support marginal populations exhibiting a lack of recruitment and strong presence of invasive Asiatic Clams throughout. The lack of suitable habitat and depauperate unionid community suggests the probable absence of federally or state-listed species within the study area.

This report provides results based on the completion of the study objectives: 1) Collect a baseline of existing macroinvertebrate and crayfish communities in the vicinity of the Project, 2) Confirm the presence or absence of mussels within the study area, 3) Characterize the mussel community composition (if present), abundance, and distribution within the study area, 4) Determine presence/probable absence of federally or state-listed species within the study area.

5.0 LITERATURE CITED

American Electric Power Service Corporation. 2019. Niagara Hydroelectric Project (FERC No. 2466-034) Filing of Revised Study Plan for Relicensing Studies. November 06, 2019.

Appalachian Power Company (Appalachian) and American Electric Power Service Corporation (AEP). 1991. The Status of Fish Populations in the Vicinity of Niagara Hydroelectric Project. April 11, 1991. 37 pp.

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

Gillis P. L., R. McInnis, J. Salerno, S. R. de Solla, M. R. Servos, E. M. Leonard. 2017. Freshwater Mussels in an Urban Watershed: Impacts of Anthropogenic Inputs and Habitat Alterations on Populations. Science of the Total Environment 574: 671-679.

National Weather Service. 2020. https://www.weather.gov/rnk/climatePlotsRoa. Accessed 24 December 2020.

U.S. Climate Data. 2021. https://www.usclimatedata.com/climate/roanoke/virginia/united-states/usva0659. Accessed 5 January 2021.

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

USFWS (U.S. Fish and Wildlife Service) and VDGIF (Virginia Department of Game and Inland Fisheries). 2018. Draft Freshwater Mussel Guidelines for Virginia. Virginia Field Office, Gloucester, Virginia. (https://www.dgif.virginia.gov/wp-content/uploads/mussel-guidelines-11-2018.pdf)

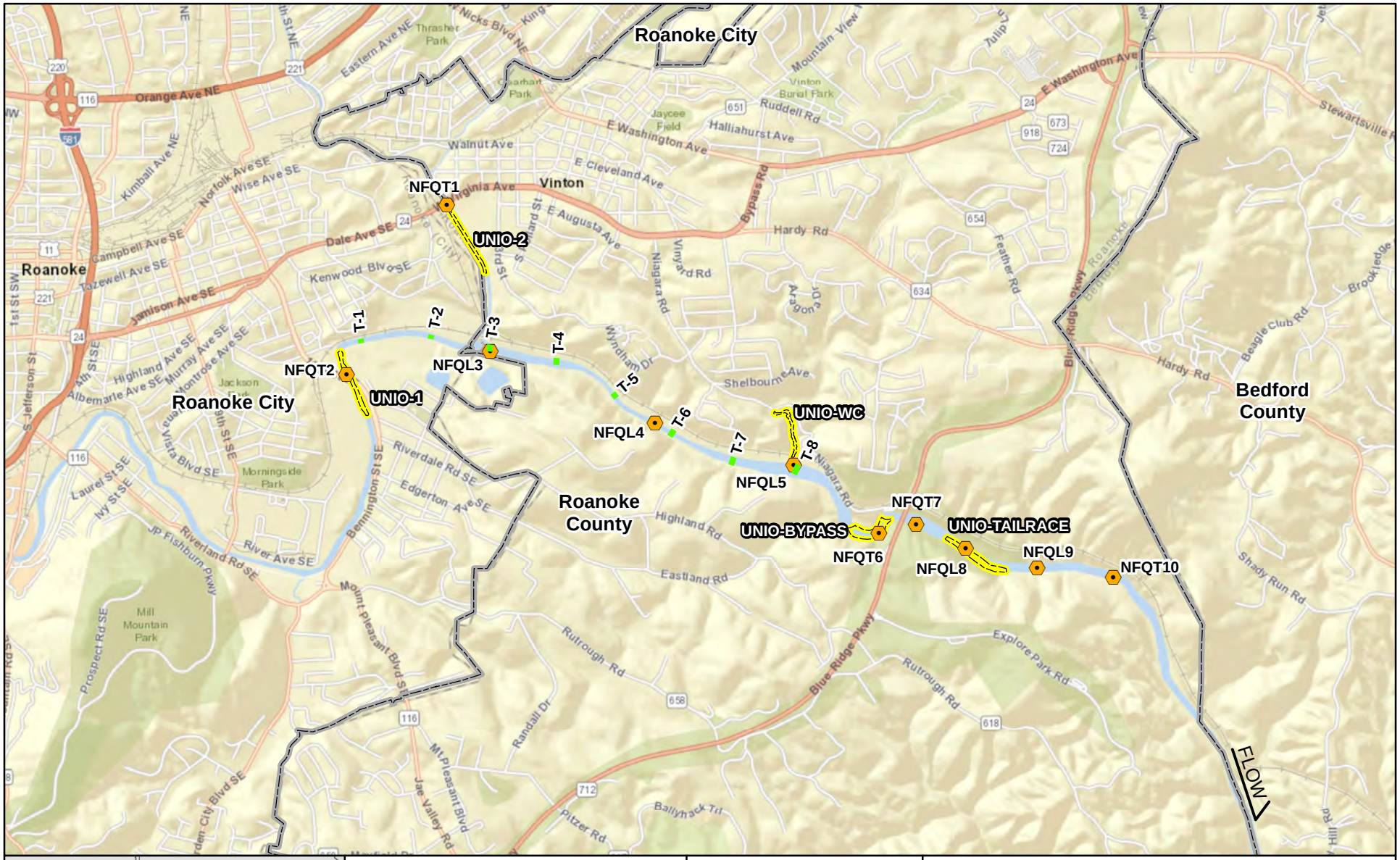
Virginia Department of Environmental Quality (VDEQ). 2008. Biological Monitoring Program Quality Assurance Project Plan for Wadeable Streams and Rivers. Division of Water Quality, Richmond, VA.

Virginia Department of Environmental Quality (VDEQ). 2017. Draft 2016 305(b)/303(d) Water Quality Assessment Integrated Report. Online [URL]: http://www.deq.virginia.gov/ Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2016305b303dI ntegratedReport.aspx#toc (Accessed September 11, 2017).

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

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

Figures

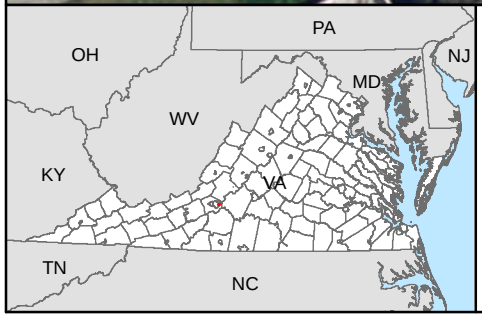


American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 1

Overall Niagara project area including quantitative (NFQT) and qualitative (NFQL) macroinvertebrate survey sites and transect (T) and abbreviated (UNIO) mussel survey sites on the Roanoke River in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig1_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

Meters

Scale: 1:1,181

AMERICAN ELECTRIC POWER

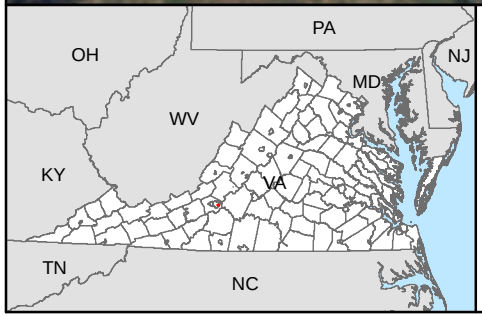
EDGE ENGINEERING & SCIENCE

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 2

Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

Meters

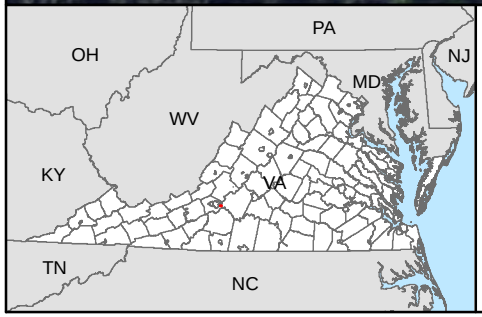
Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 3

Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

Meters

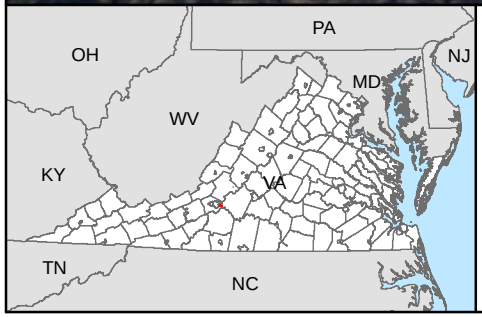
Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 4

Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

Meters

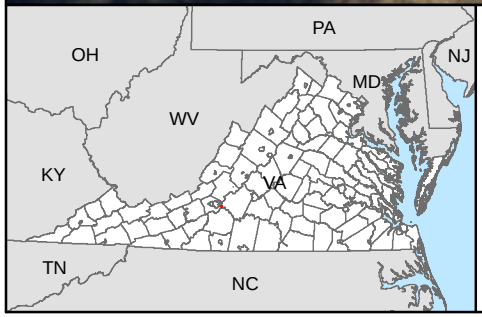
Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 5

Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

Meters

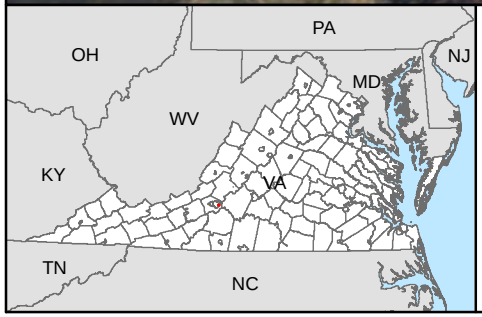
Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 6

Quantitative macroinvertebrate and crayfish 100-meter survey extent in riffle/run habitat in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

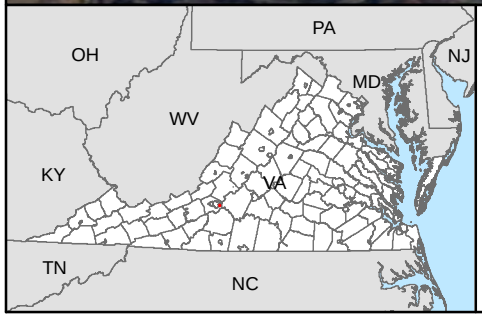
Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

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

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

Meters

Scale: 1:1,181

AMERICAN ELECTRIC POWER

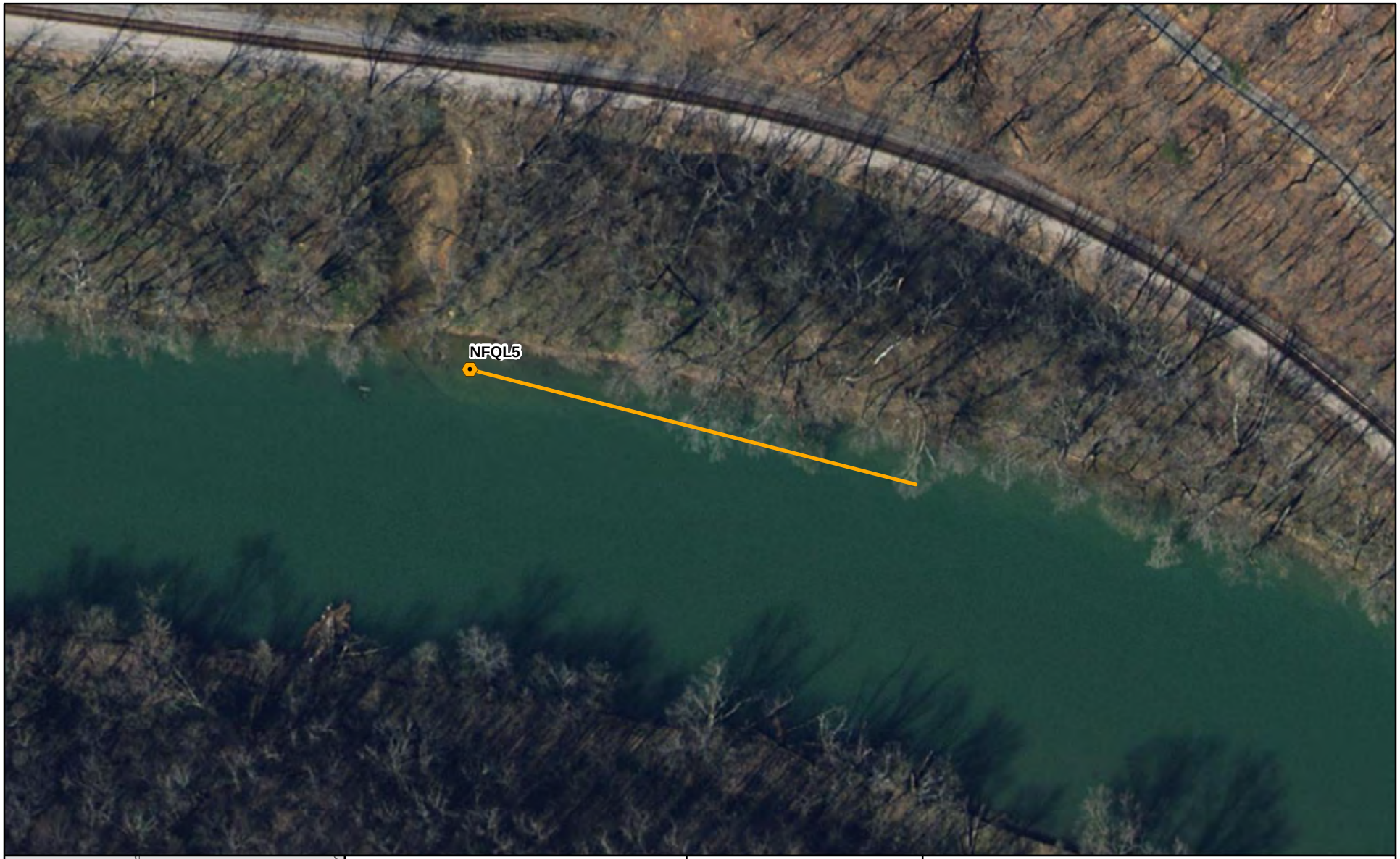
EDGE ENGINEERING & SCIENCE

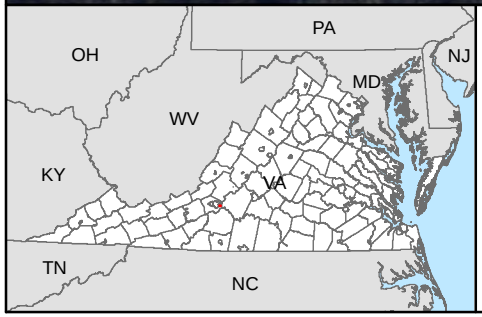
American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 8

Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd





Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

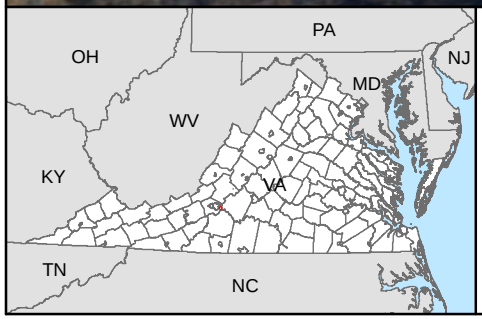
Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

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

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

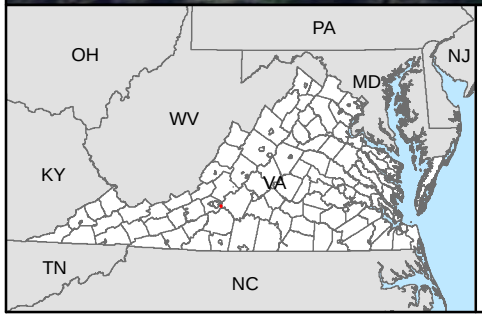
0 15 30

Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 10
Qualitative macroinvertebrate and crayfish 100-meter survey extent
in mixed habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Macroinvertebrate Sample Location

Macroinvertebrate Survey Transect

N

0 15 30

Meters

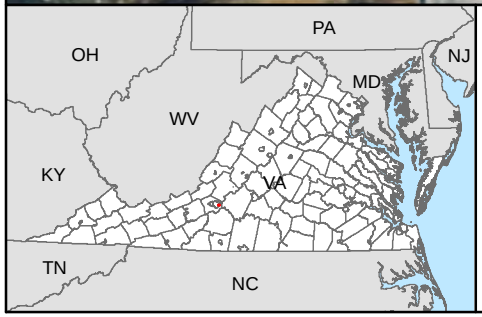
Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study

Figure 11

Qualitative macroinvertebrate and crayfish 100-meter survey extent in mixed habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Transect

N

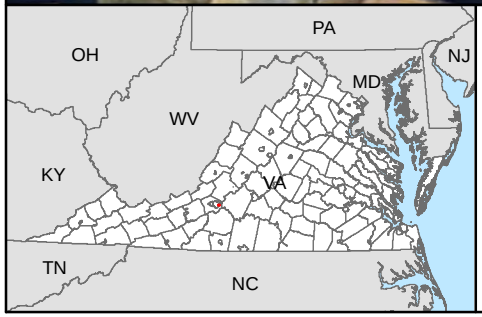
0 15 30

Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 12
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Transect

N

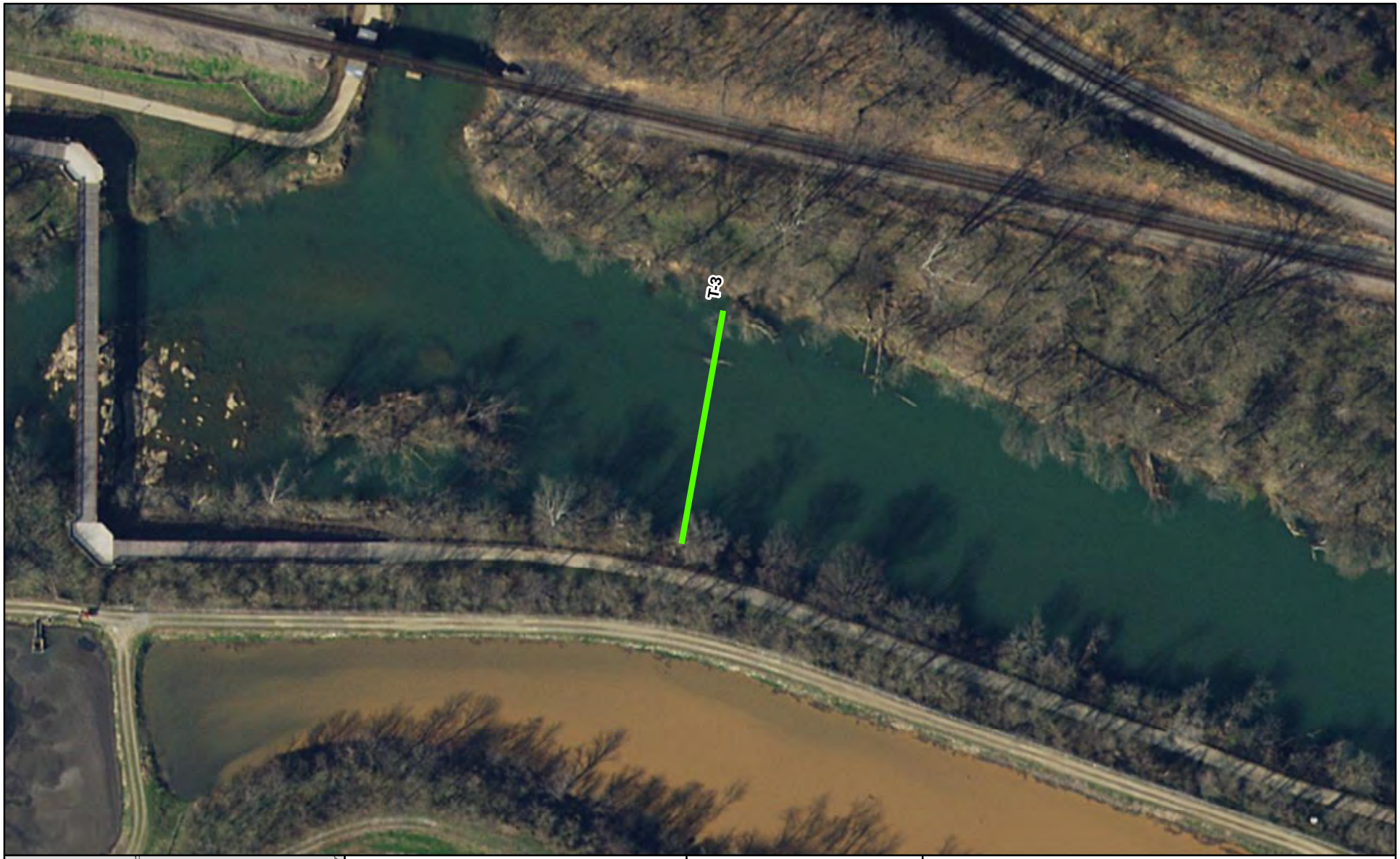
0 15 30

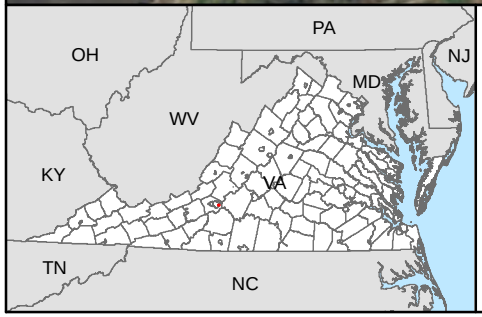
Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 13
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd





Legend

Mussel Survey Transect

N

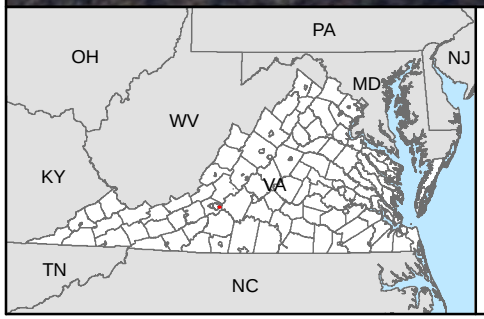
0 15 30

Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 14
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Transect

N

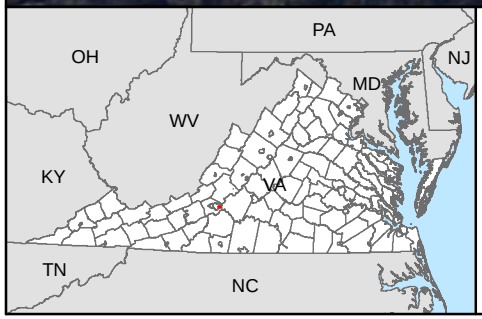
0 15 30

Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 15
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Transect

N

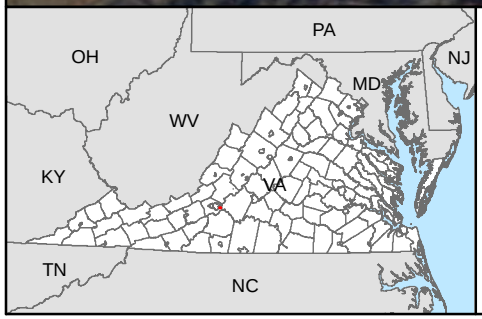
0 15 30

Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 16
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Transect

N

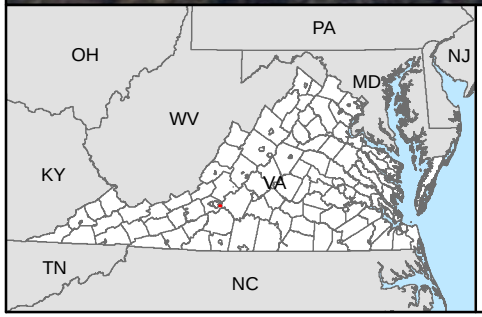
0 15 30

Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 17
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Transect

N

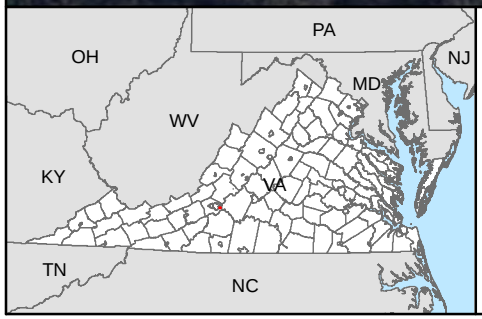
0 15 30

Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 18
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Transect

N

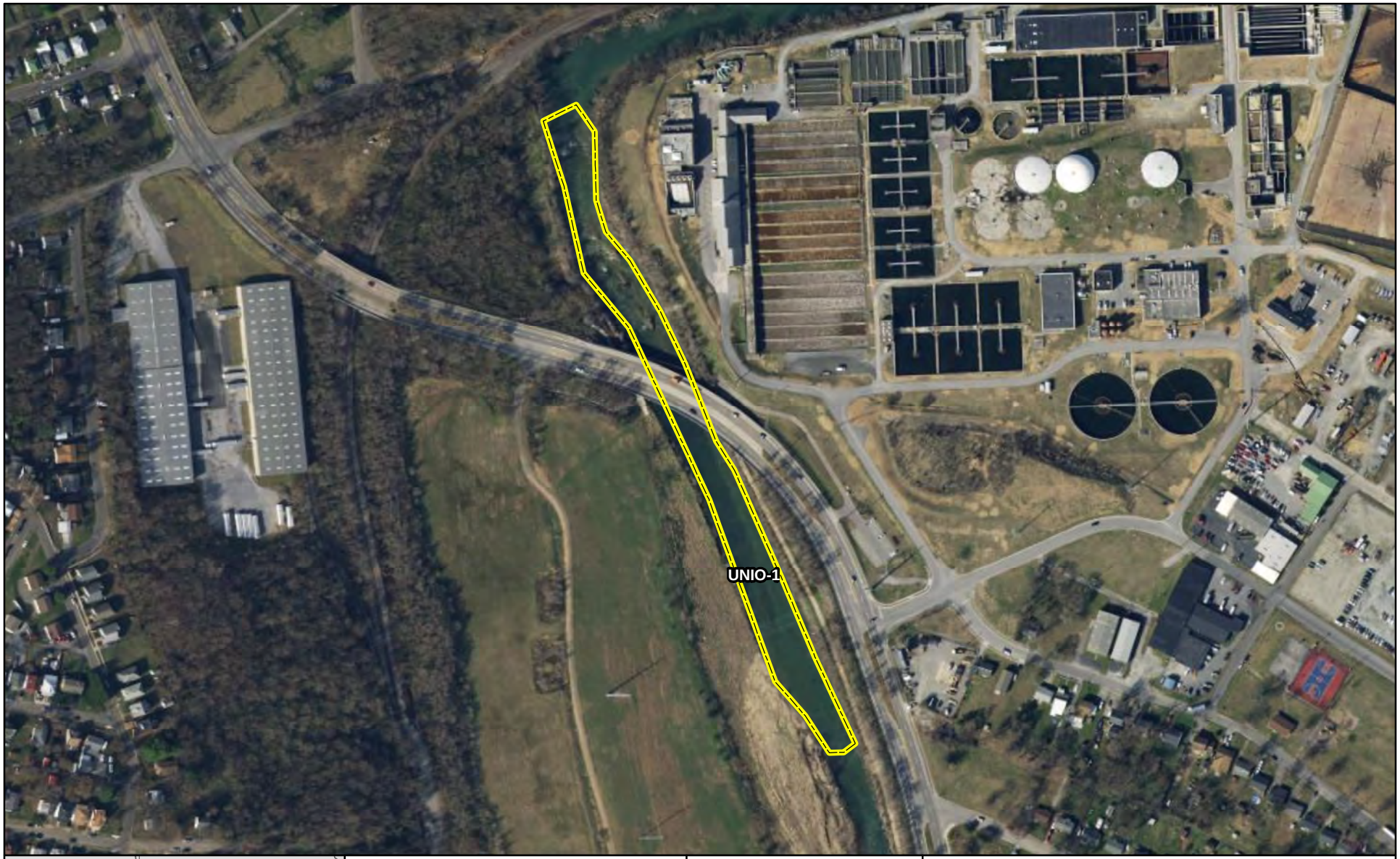
0 15 30

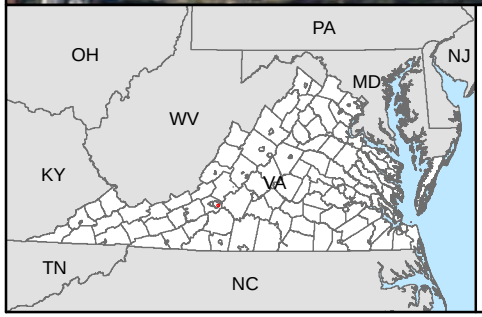
Meters

Scale: 1:1,181

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 19
Transect mussel survey extent in pool habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd





Legend

Mussel Survey Area

N

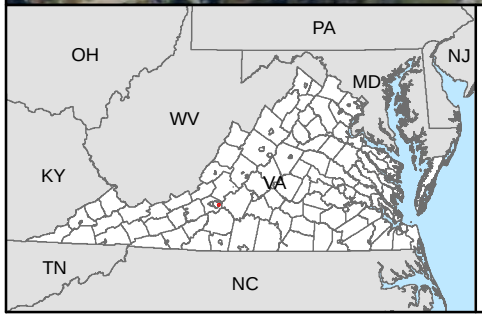
0 50 100

Meters

Scale: 1:3,937

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 20
Abbreviated mussel survey extent in mixed habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Area

N

0 50 100

Meters

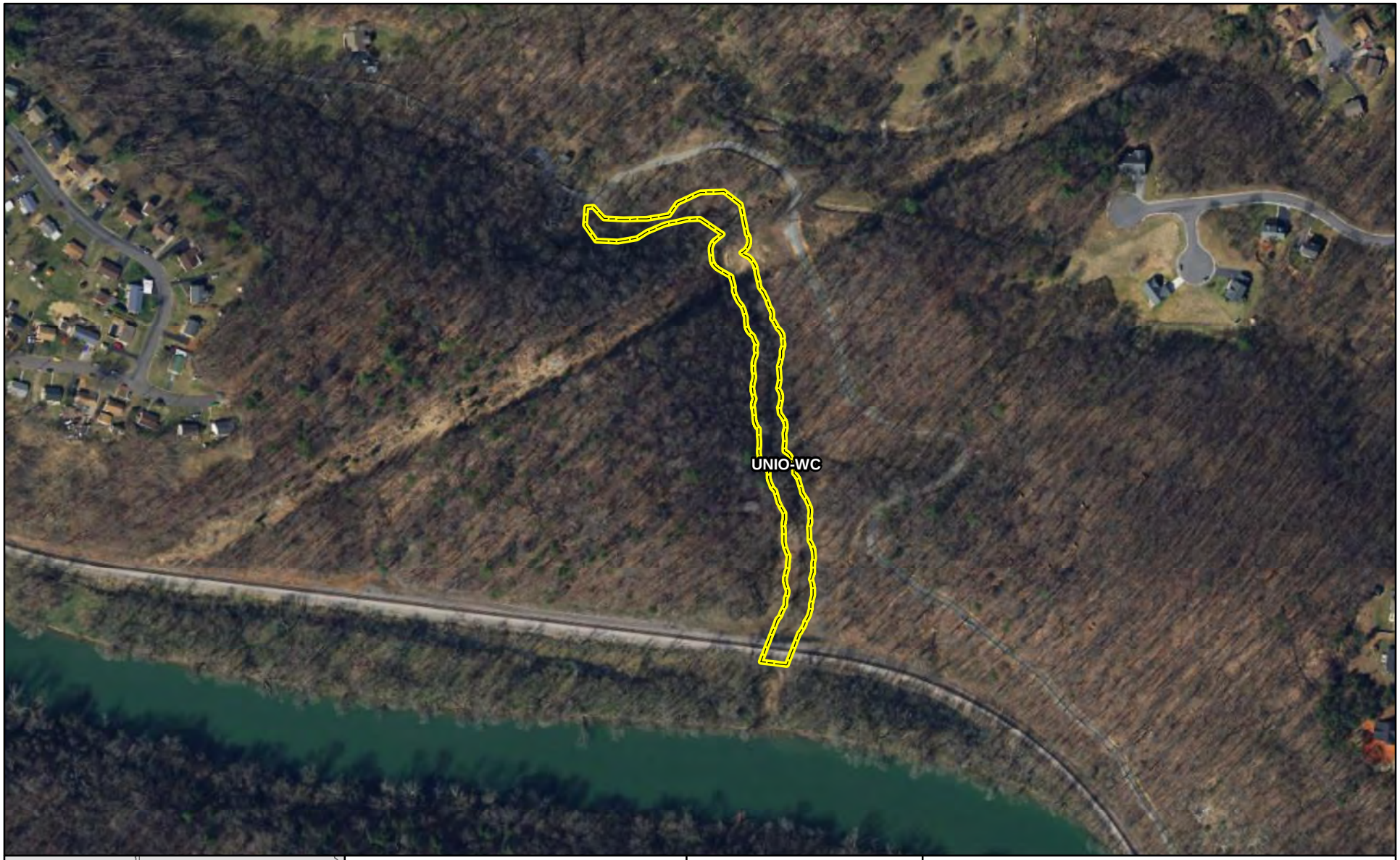
Scale: 1:3,937

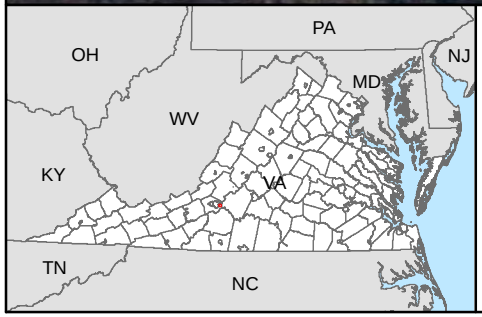
AMERICAN ELECTRIC POWER

EDGE ENGINEERING & SCIENCE

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 21
Abbreviated mussel survey extent in mixed habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd





Legend

Mussel Survey Area

N

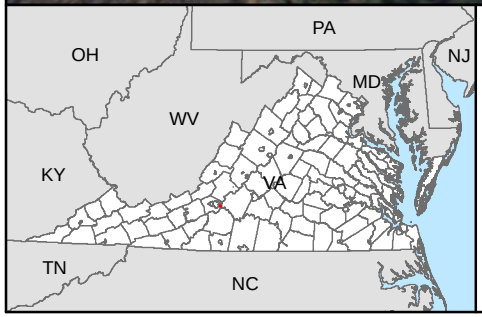
0 50 100

Meters

Scale: 1:3,937

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 22
Abbreviated mussel survey extent in mixed habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd



Legend

Mussel Survey Area

N

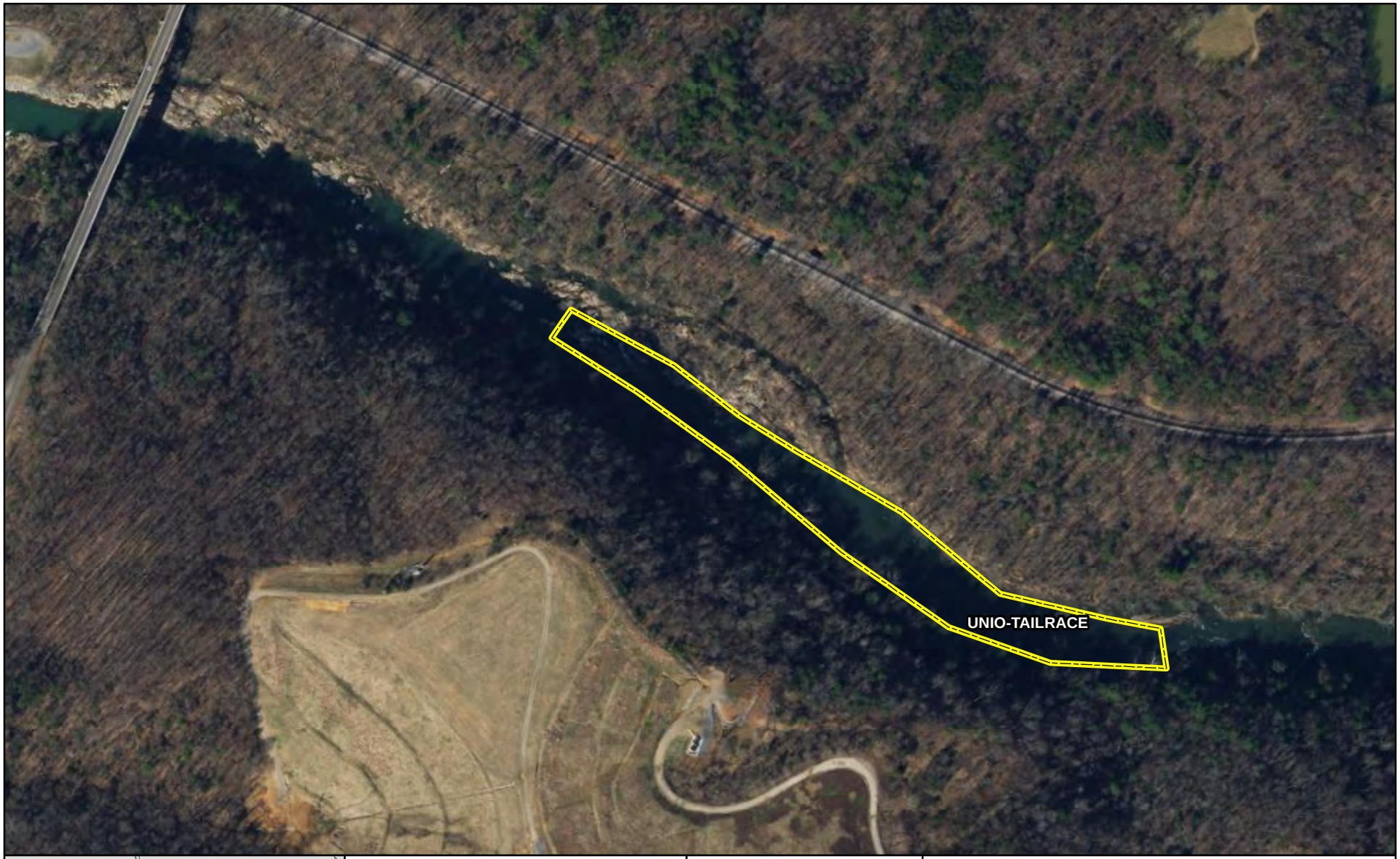
0 50 100

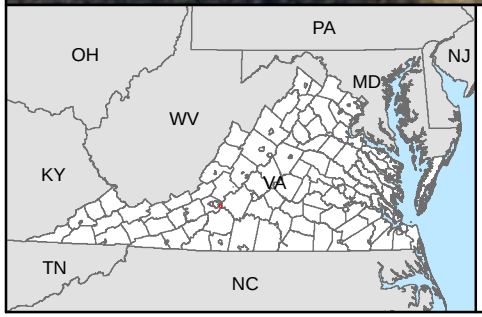
Meters

Scale: 1:3,937

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 23
Abbreviated mussel survey extent in mixed habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd





Legend

Mussel Survey Area

N

0 50 100

Meters

Scale: 1:3,937

American Electric Power
Niagara Dam Benthic Aquatic Resource Study
Figure 24
Abbreviated mussel survey extent in mixed habitat
in Roanoke County, Virginia

D:\PROJECTS\HDR\HDR2020-0002 Niagara Dam Relicensing\GIS\MXD\MacroInvtbrts\Report_Figs\20201124_Sbmtl\HDR2020-0002_McroInvbrts_Fig2_24_20210317.mxd

Appendix A

SCIENTIFIC COLLECTION PERMITS

Virginia Department of Game and Inland Fisheries

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

Scientific Collection Permit

Permit Type: **Renewal** Fee Paid: **$40.00** VADGIF Permit No. **068630**

Permittee: **Casey D Swecker**
Address: **4005 Ponder Drive**
Cincinnati, OH 45245
Email: **cdswecker@edge-es.com**

Home:
Office: **(304) 633-5808**
City/County: **Out of State**

Business: **Edge Engineering and Science, LLC**
4005 Ponder Drive
Cincinnati, OH 45245
City/County: **Out of State**

Contract Species Surveys/Research/Relocation

Authorized Collection Methods: By Hand/Dip Nets/Electrofishing/Gill Nets-Trawl Nets/Seine Nets/Snorkel/View Scope/Aquatic Kick Samples/Scuba/Nets-Traps (Fyke/Hoop/D-Frame)/Hooka (Third Lung)
All methods which are part of the project(s) outlined in the submitted and approved proposal.
Authorized Waterbodies: Blackwater River/New River/Banister River/Sandy River/North Fork Roanoke River/Little Creek/Crooked Creek/Roanoke River/Sinking Creek/North Fork Holston River/Mill Creek
Authorized Marking Techniques: N/A

SPECIAL CONDITIONS: It is recommended that the fish relocation best management practices be utilized while collecting fish for this project.
Permittee is exempt from standard condition #11 (game fish creek limit) during gillnet sampling on the New River above Byllesby Dam.

PERMIT AMENDMENT 9/1/2020: The amendment changes the following:
Principal Permittee & Authorized Subpermittees Affiliation FROM: ESI to Edge Engineering and Science, LLC
This amendment deletes the following:
Authorized Subpermittees: Kyle McGill/Greg Anderson/Robert Paul/Brandon Yates/Keith Gibbs/Kyle Price/Brandon Bassinger/Tyler Slagle
This amendment adds the following: Permittee is exempt from standard condition #11 (game fish creek limit) during gillnet sampling on the New River above Byllesby Dam.

Permittee MUST notify VDGIF a minimum of 7 days prior to each sampling event. Notification must be made via email to: collectionpermits@dgif.virginia.gov

Report Due: 31 January 2021, 31 January 2022

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

STANDARD CONDITIONS ATTACHED APPLY TO THIS PERMIT.

Authorized Counties / Cities:
Augusta
Bath
Brunswick
Buckingham
Carroll
Cumberland
Dinwiddie
Franklin
Giles
Greensville
Highland
Montgomery
Nelson
Nottoway
Pittsylvania
Prince Edward
Pulaski
Roanoke
Scott
Southampton
Radford
Statewide

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)

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

Scientific Collection Permit

Permit Type: **Renewal** Fee Paid: **$40.00** VADGIF Permit No. **068630**

Authorized Species:

Description	ID Number	Scientific Name
Aquatic Insects		
Aquatic Invertebrates (excluding aquatic mollusks)		
Crayfish		
Freshwater Fish		
Freshwater Mussels		
Spiny Riversnail		***Io fluvialis***

Annual Report Due End of Each Year

Authorized Sub-Permittees:
See Attached Sheet

Approved by: Randall T. Francis

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

Title: **Randall T. Francis - Permits Manager** **Date:** **4/21/2020**

20 Permit Effective **4/21/2020** through **12/31/2021** **21**

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)

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

Scientific Collection Permit

Permit Type: **Renewal**	FeePaid:	**$40.00**	VADGIF Permit No.	**068630**

Authorized Sub-Permittees:

Dr. Tom Jones, Edge Engineering & Science, LLC
John Spaeth, Edge Engineering & Science, LLC
Aaron Prewitt, Edge Engineering & Science, LLC
Nancy Scott, Three Oaks Engineering
Adam Benshoff, Edge Engineering & Science, LLC
Dr. Art Bogan, NC Museum of Natural Sciences
Tom Dickinson, Three Oaks Engineering
Nathan Howell, Three Oaks Engineering
David Foltz, Edge Engineering & Science, LLC
Jonathan Studio, Edge Engineering & Science, LLC
Doug Locy, Edge Engineering & Science, LLC
Alyssa Brady, Edge Engineering & Science, LLC
Cody Parks, Three Oaks Engineering
Lizzy Stokes, Three Oaks Engineering
Tim Savage, Three Oaks Engineering
Mitchell Kriege, Edge Engineering & Science, LLC

Virginia Department of Game and Inland Fisheries

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

Scientific Collection Permit

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

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

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

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

Niagara Hydroelectric Project/Byllesby-Buck Hydroelectric Project

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

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

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

Report Due: 31 January 2022, 31 January 2023

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

STANDARD CONDITIONS ATTACHED APPLY TO THIS PERMIT.

Authorized Counties / Cities:
Carroll
Roanoke

Authorized Species:

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

Annual Report Due End of Each Year

Authorized Sub-Permittees:
See Attached Sheet

Approved by: Randall T. Francis

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

Title: **Randall T. Francis - Permits Manager** **Date:** **3/2/2021**

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)

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

Scientific Collection Permit

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

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

Virginia Department of Game and Inland Fisheries

7870 Villa Park Drive, P.O. Box 90778, Henrico, VA 23228-0778
(804) 367-1000 (V/TDD)

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

Scientific Collection Permit

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

Authorized Sub-Permittees:

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

Appendix B

REPRESENTATIVE PHOTOGRAPHS

NFQT1 - Downstream
Quantitative Macroinvertebrate Sample Site

NFQT2 - Downstream
Quantitative Macroinvertebrate Sample Site

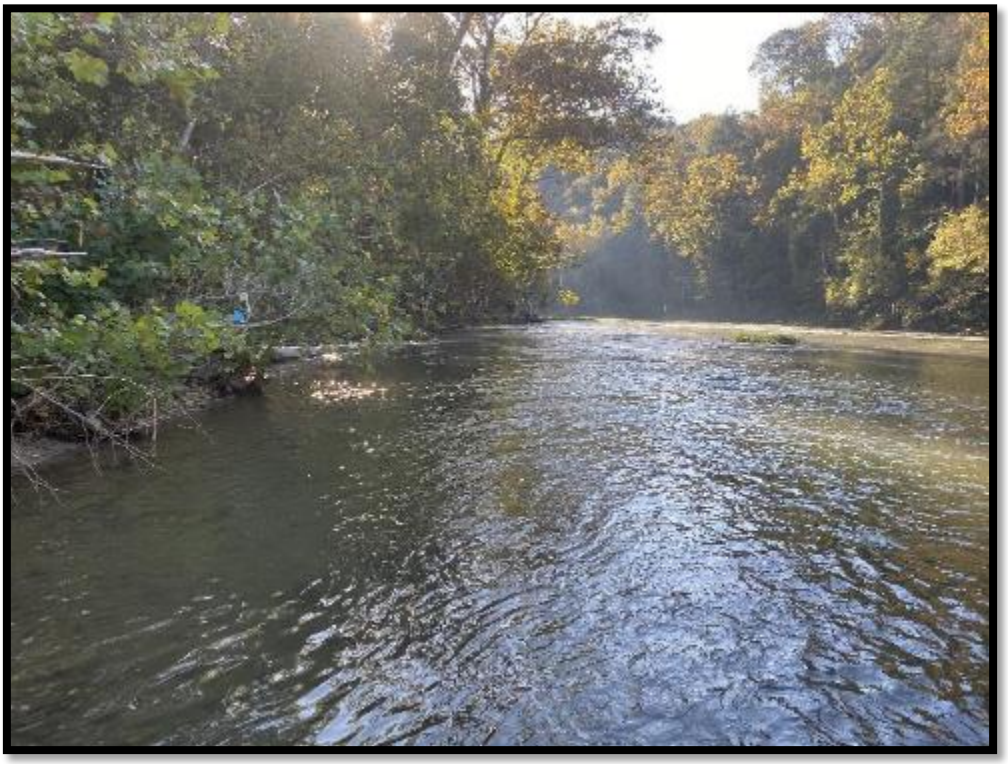
NFQL3 - Upstream
Qualitative Macroinvertebrate Sample Site

NFQL4 - Upstream
Qualitative Macroinvertebrate Sample Site

NFQL5 - Upstream
Qualitative Macroinvertebrate Sample Site

NFQT6 - Upstream
Quantitative Macroinvertebrate Sample Site

NFQT7 - Upstream
Quantitative Macroinvertebrate Sample Site



NFQL8 - Downstream
Qualitative Macroinvertebrate Sample Site

NFQL9 - Upstream
Qualitative Macroinvertebrate Sample Site

NFQT10 - Upstream
Quantitative Macroinvertebrate Sample Site

The single specimen collected was too small for detailed voucher photo.

Appalachian Brook Crayfish
(*Cambarus bartoni bartoni*)

Atlantic Slope Crayfish
(*Cambarus longulus*)

Ozark Crayfish
(*Faxonius ozarkae*)

Virile Crayfish
(*Faxonius virilis*)

Red Swamp Crayfish
(*Procambarus clarkii*)

T-1 - Upstream
Mussel Transect Sample Site

T-2 - Downstream
Mussel Transect Sample Site

T-3 - Downstream
Mussel Transect Sample Site

T-4 - Downstream
Mussel Transect Sample Site

T-5 - Downstream
Mussel Transect Sample Site

T-6 - Downstream
Mussel Transect Sample Site

T-7 - Downstream
Mussel Transect Sample Site

T-8 - Downstream
Mussel Transect Sample Site

UNIO-1 - Downstream
Mussel Abbreviated Sample Site

UNIO-2 - Upstream
Mussel Abbreviated Sample Site

UNIO-WC - Upstream
Mussel Abbreviated Sample Site

UNIO-Bypass - Upstream
Mussel Abbreviated Sample Site

UNIO-Tailrace - Upstream
Mussel Abbreviated Sample Site

Eastern Elliptio
(*Elliptio Complanata*)

Notched Rainbow
(*Villosa constricta*)

Appendix C

RAW DATA

TAXON	Number of Organisms per Taxon per Subsample											
	Tinker Creek	Roanoke River Samples and Collection Dates										
	NFQT1	NFQT2	NFQL3	NFQL4 - ORIGINAL	NFQL4 - REPLICATE	NFQL5	NFQT6 - ORIGINAL	NFQT6 - REPLICATE	NFQT7	NFQL8	NFQL9	NFQT10
	9/15/2020	9/15/2020	9/15/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	10/5/2020	10/5/2020	10/5/2020
PLATYHELMINTHES (flatworms)												
TURBELLARIA												
Planariidae	1		1				9	3		1		1
ANNELIDA (segmented worms)												
HIRUDINEA (leeches)[1]			1						1			
OLIGOCHAETA (aquatic worms)	3		2	2	8	1			2		3	3
ARTHROPODA (arthropods)												
HYDRACARINA (water mites)	1			1	1					2		1
CRUSTACEA (crayfish, scuds, aquatic sow bugs)												
AMPHIPODA (scuds, sideswimmers)												
Crangonyctidae												
Crangonyx sp.			19	1	1				2			
Talitridae												
Hyalella sp.			2			3						
ISOPODA (aquatic sow bugs)												
Asellidae												
Caecidotea sp.			11	1	1	1			2			
DECAPODA (crayfish)												
Cambaridae												
Faxonius sp.	1		3								1	
INSECTA (insects)												
EPHEMEROPTERA (mayflies)												
Baetidae (small minnow mayflies)												
Acentrella sp.		1										
Baetis flavistriga												1
Baetis intercalaris	2											2
Baetis spp.	3	2								2		
Neocloeon sp.				1								
Plauditus sp.		1							1			3
Heptageniidae (flatheaded mayflies)												
Stenacron sp.		1							1			
Isonychiidae (brushlegged mayflies)												
Isonychia sp.		1										
Leptohyphidae (little stout crawlers)[2]												
Tricorythodes sp.									2		1	
TRICHOPTERA (caddisflies)												
Glossosomatidae (saddlecase makers)										2		
Hydropsychidae (common net-spinners)												
Ceratopsyche morosa												1
Cheumatopsyche spp.	7	16						1		18	2	24
Hydropsyche spp.		3	1				1		1	15	6	34
Potamyia flava		1										
Hydroptilidae (micro-caddisflies)										1		
Hydroptila sp.	1		1	1	2		5	4				
Leptoceridae (long-horned caddisflies)				2								
Philopotamidae (fingernet caddisflies)												
Chimarra sp.	4	2					1					
Polycentropodidae (trumpetnet and tubemakers)												
Polycentropus sp.				1		1						

TAXON	Number of Organisms per Taxon per Subsample											
	Tinker Creek	Roanoke River Samples and Collection Dates										
	NFQT1	NFQT2	NFQL3	NFQL4 - ORIGINAL	NFQL4 - REPLICATE	NFQL5	NFQT6 - ORIGINAL	NFQT6 - REPLICATE	NFQT7	NFQL8	NFQL9	NFQT10
	9/15/2020	9/15/2020	9/15/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	10/5/2020	10/5/2020	10/5/2020
Psychomyiidae (net tube-making caddisflies)												
Psychomyia flavida											2	
COLEOPTERA (aquatic beetles)												
Curculionidae (weevils)											1	
Dryopidae (long-toed water beetles)												
Helichus sp.								1				
Elmidae (riffle beetles)												
Ancyronyx sp.			1	3	4							
Dubiraphia sp.	1								4		1	
Gonielmis sp.		5	1									
Macronychus sp.				2	1			1			4	
Microcylloepus sp.		28	1			1		1			1	
Optioservus sp.	1	3	1				2				3	
Stenelmis sp.	15	3	4				1	2		1	1	1
Hydrophilidae (water scavenger beetles)												
Berosus sp.									2			
Psephenidae (water penny beetles)												
Ectopria sp.												1
Psephenus herricki	1									1	3	1
ODONATA (dragonflies, damselflies)												
ANISOPTERA (dragonflies)												
Corduliidae (green-eyed skimmers)												
Epicordulia sp.				2								
Neurocordulia sp.			1									
Gomphidae (clubtails)												
Stylogomphus sp.												1
Macromiidae (cruisers)												
Macromia sp.											1	
ZYGOPTERA (damselflies)												
Coenagrionidae (narrow-winged damselflies)												
Argia sp.	1	2	5	5	5	1			5		7	
Enallagma sp.			16	10	6	25					1	
DIPTERA (true flies)												
Ceratopogonidae (biting midges)												
Atrichopogon sp.				2								
Probezzia sp.					1							
Chironomidae (A)[3] - (midges)	66	7	10	59	71	64	29	9	80	18	49	20
Simuliidae (blackflies)												
Simulium sp.	2	3										
Tipulidae (crane flies)												
Tipula sp.	1			1		1		1				
LEPIDOPTERA (aquatic moths)												
Pyralidae (pyralid moths)												
Petrophila sp.											5	12
HEMIPTERA (water bugs)												
Gerridae (water striders)									1			
MOLLUSCA												
GASTROPODA (snails, limpets)												
Ancylidae (limpets)			1	4	2						2	

TAXON	Number of Organisms per Taxon per Subsample											
	Tinker Creek	Roanoke River Samples and Collection Dates										
	NFQT1	NFQT2	NFQL3	NFQL4 - ORIGINAL	NFQL4 - REPLICATE	NFQL5	NFQT6 - ORIGINAL	NFQT6 - REPLICATE	NFQT7	NFQL8	NFQL9	NFQT10
	9/15/2020	9/15/2020	9/15/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	9/16/2020	10/5/2020	10/5/2020	10/5/2020
Lymnaeidae (pond snails)						3						
Planorbidae (ram's horn snails)			7	1	7	1						
Pleuroceridae (pleurocerid snails)	8	29	3				63	88	1	49		4
Physidae (bladder snails)			10	3		4		1				
BIVALVIA (clams or bivalves)												
Corbiculidae (Asian clam)		5						3	6	3	8	1
Sphaeriidae (fingernail clams)	1								1	1		
TOTAL NUMBER OF TAXA	**19**	**18**	**22**	**19**	**13**	**12**	**8**	**12**	**16**	**13**	**20**	**17**
TOTAL NUMBER OF ORGANISMS	**120**	**113**	**102**	**102**	**110**	**106**	**111**	**115**	**112**	**114**	**102**	**111**

[1] - Class Hirudinea (leeches) is now classified as Class Clitellata

[2] - Family Leptohyphidae previously named Family Tricorythidae

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

TAXON	Number of Organisms per Taxon per Subsample											
	Tinker Creek	Roanoke River Samples and Collection Dates										
	NSQT1	NSQT2	NSQL3	NSQL4 - ORIGINAL	NSQL4 - REPLICATE	NSQL5	NSQT6 - ORIGINAL	NSQT6 - REPLICATE	NSQT7	NSQL8	NSQL9	NSQT10
	6/4/2021	6/3/2021	6/4/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/4/2021	6/4/2021
PLATYHELMINTHES (flatworms)												
TURBELLARIA												
Planariidae	2				1		3	8		2	4	3
ANNELIDA (segmented worms)												
HIRUDINEA (leeches)[1]			3									
OLIGOCHAETA (aquatic worms)	2		22	9	4	1	2		3		1	2
ARTHROPODA (arthropods)												
HYDRACARINA (water mites)	4	3					4	1				2
CRUSTACEA (crayfish, scuds, aquatic sow bugs)												
AMPHIPODA (scuds, sideswimmers)												
Crangonyctidae												
Crangonyx sp.	2		34						2		1	
Talitridae												
Hyalella sp.			1									
ISOPODA (aquatic sow bugs)												
Asellidae												
Caecidotea sp.			8	2					1			
DECAPODA (crayfish)												
Cambaridae												
Faxonius sp.			3						2	10	1	1
INSECTA (insects)												
EPHEMEROPTERA (mayflies)												
Baetidae (small minnow mayflies)												
Acentrella sp.		5										
Baetis flavistriga	8	4						1				9
Baetis intercalaris	3	1										1
Baetis spp.	1									1	1	
Heterocloeon sp.		2										
Labiobaetis sp.										1		
Neocloeon sp.									1	1		
Plauditus sp.		5										6
Ephemerellidae (spiny crawler mayflies)												
Eurylophella spp.										2		
Heptageniidae (flatheaded mayflies)												
Leucrocuta sp.		1										
Maccaffertium spp.		2					1					3
Stenacron sp.		1										
Isonychiidae (brushlegged mayflies)												
Isonychia sp.		1						1				1
PLECOPTERA (stoneflies)												
Leuctridae (rolled-wing stoneflies)												
Leuctra sp.		1										
TRICHOPTERA (caddisflies)												
Brachycentridae (humpless casemakers)												
Brachycentrus sp.												2
Hydropsychidae (common net-spinners)												
Ceratopsyche morosa	1	2										4
Cheumatopsyche spp.	7	8					2	9			6	13
Hydropsyche spp.	3	7					4	8			2	11

TAXON	Number of Organisms per Taxon per Subsample											
	Tinker Creek	Roanoke River Samples and Collection Dates										
	NSQT1	NSQT2	NSQL3	NSQL4 - ORIGINAL	NSQL4 - REPLICATE	NSQL5	NSQT6 - ORIGINAL	NSQT6 - REPLICATE	NSQT7	NSQL8	NSQL9	NSQT10
	6/4/2021	6/3/2021	6/4/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/4/2021	6/4/2021
Hydroptilidae (micro-caddisflies)												
Hydroptila sp.	1						2	1	1	2	3	1
Leucotrichia sp.												1
Leptoceridae (long-horned caddisflies)												
Triaenodes sp.											1	
Psychomyiidae (net tube-making caddisflies)												
Psychomyia flavida		1										
COLEOPTERA (aquatic beetles)												
Elmidae (riffle beetles)												
Dubiraphia sp.			2			1					2	
Macronychus sp.										2		
Microcylloepus sp.		2		1			1	2			3	
Optioservus sp.			2				1	2				
Stenelmis sp.	2	2					1	15				6
Psephenidae (water penny beetles)												
Psephenus herricki											1	
ODONATA (dragonflies, damselflies)												
ANISOPTERA (dragonflies)												
Aeshnidae (darners)										2		
ZYGOPTERA (damselflies)												
Coenagrionidae (narrow-winged damselflies)												
Argia sp.				1	1					2		
Enallagma sp.			1							1		
DIPTERA (true flies)												
Ceratopogonidae (biting midges)												
Atrichopogon sp.					1			1				
Sphaeromias sp.			1									
Chironomidae (A)[2] - (midges)	63	33	23	44	89	89	82	45	97	23	84	12
Chironomidae (B) - (midges)			4	47	6	18			6		2	
Empididae (dance flies)												
Hemerodromia sp.	1									1		
Simuliidae (blackflies)												
Simulium spp.	7	16						1				3
Tipulidae (crane flies)												
Antocha sp.	1							1				3
HEMIPTERA (water bugs)												
Corixidae (water boatmen)						3						
Gerridae (water striders)										11		
Veliidae (broad-shouldered water striders)										3		
MOLLUSCA												
GASTROPODA (snails, limpets)												
Ancylidae (limpets)									4		2	
Lymnaeidae (pond snails)									2			
Planorbidae (ram's horn snails)			2	2	1							
Pleuroceridae (pleurocerid snails)	5	18					13	15		29	1	25
Physidae (bladder snails)	1	1	2	1	2					15		

TAXON	Number of Organisms per Taxon per Subsample											
	Tinker Creek	Roanoke River Samples and Collection Dates										
	NSQT1	NSQT2	NSQL3	NSQL4 - ORIGINAL	NSQL4 - REPLICATE	NSQL5	NSQT6 - ORIGINAL	NSQT6 - REPLICATE	NSQT7	NSQL8	NSQL9	NSQT10
	6/4/2021	6/3/2021	6/4/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/3/2021	6/4/2021	6/4/2021
BIVALVIA (clams or bivalves)												
Corbiculidae							1				1	1
Sphaeriidae (fingernail clams)					1							
TOTAL NUMBER OF TAXA	**18**	**21**	**13**	**7**	**8**	**4**	**13**	**15**	**9**	**17**	**16**	**21**
TOTAL NUMBER OF ORGANISMS	**114**	**116**	**108**	**107**	**106**	**112**	**117**	**111**	**119**	**108**	**116**	**110**

[1] - Class Hirudinea (leeches) is now classified as Class Clitellata

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

Water quality parameters at quantitative and qualitative sites in fall 2020 (NFQT and NFQL site names, respectively) and spring 2021 (NSQT and NSQL site names). Sites above the dashed line are upstream of Niagara Dam and sites below the dashed line are downstream of Niagara Dam.

Date	Site	Water Temp. (C)	pH	DO (%)	Conductivity (us/cm)	Habitat
9/15/2020	NFQT1	18.5	6.90	75.4	416	Riffle/Run
9/15/2020	NFQT2	21.4	8.40	96.9	390	Riffle/Run
9/15/2020	NFQL3	21.2	7.10	79.2	418	Pool
9/16/2020	NFQL4	19.5	7.10	62.6	405	Pool
9/16/2020	NFQL5	20.4	7.10	75.1	413	Pool
6/4/2021	NSQT1	18.5	8.16	87.5	285	Riffle/Run
6/3/2021	NSQT2	22.6	8.11	115.0	281	Riffle/Run
6/4/2021	NSQL3	20.1	8.08	82.8	258	Pool
6/3/2021	NSQL4	20.3	8.17	76.2	275	Pool
6/3/2021	NSQL5	22.8	8.19	77.4	254	Pool
9/16/2020	NFQT6	20.6	7.20	85.4	402	Riffle/Run
9/16/2020	NFQT7	20.8	8.50	80.4	444	Riffle/Run
10/5/2020	NFQL8	15.6	8.10	98.1	413	Run
10/5/2020	NFQL9	15.9	8.00	104.7	345	Run
10/5/2020	NFQT10	16.1	8.20	105.7	418	Riffle
6/3/2021	NSQT6	21.5	8.21	112.6	258	Riffle/Run
6/3/2021	NSQT7	20.9	8.14	95.1	257	Riffle/Run
6/3/2021	NSQL8	21.1	8.12	98.6	261	Run
6/4/2021	NSQL9	21.9	8.26	102.6	261	Run
6/4/2021	NSQT10	22.2	8.26	115.9	250	Riffle

Raw data used to calculate VSCI scores for fall 2020 macroinvertebrate data (family). Sites above and below the dashed line are upstream and downstream of Niagara Dam, respectively.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI
NFQT1	120	16	4	4.17	4.17	22.50	69.17	55.00	**5.21**
NFQT2	113	11	5	5.31	1.77	61.06	60.18	6.19	**4.74**
NFQL3	102	17	2	0.00	0.98	29.41	39.22	9.80	**5.49**
NFQL4 - ORIGINAL	103	17	4	0.97	3.88	13.59	71.84	57.28	**6.03**
NFQL4 - REPLICATE	110	11	1	0.00	1.82	14.55	74.55	64.55	**5.75**
NFQL5	106	11	1	0.00	0.94	8.49	84.91	60.38	**6.59**
NFQT6 - ORIGINAL	110	7	3	0.00	5.45	63.64	83.64	26.36	**4.95**
NFQT6 - REPLICATE	115	10	2	0.00	3.48	84.35	84.35	7.83	**4.49**
NFQT7	112	16	4	3.57	0.00	5.36	76.79	71.43	**5.87**
NFQL8	114	12	4	1.75	2.63	47.37	71.93	15.79	**4.95**
NFQL9	102	14	2	0.98	1.96	14.71	57.84	48.04	**5.76**
NFQT10	111	12	2	5.41	0.00	6.31	71.17	18.02	**5.43**

Site results of VSCI scores for fall 2020 macroinvertebrate data (family). Sites above and below the dashed line are upstream and downstream of Niagara Dam, respectively.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI	VSCI Score
NFQT1	120	72.73	36.36	6.80	11.70	43.60	44.56	45.00	70.47	**41.40**
NFQT2	113	50.00	45.45	8.66	4.97	100.00	57.55	93.81	77.30	**54.72**
NFQL3	102	77.27	18.18	0.00	2.75	57.00	87.84	90.20	66.32	**49.95**
NFQL4 - ORIGINAL	103	77.27	36.36	1.58	10.91	26.34	40.69	42.72	58.40	**36.78**
NFQL4 - REPLICATE	110	50.00	9.09	0.00	5.11	28.19	36.78	35.45	62.57	**28.40**
NFQL5	106	50.00	9.09	0.00	2.65	16.45	21.81	39.62	50.08	**23.71**
NFQT6 - ORIGINAL	110	31.82	27.27	0.00	15.32	100.00	23.65	73.64	74.20	**43.24**
NFQT6 - REPLICATE	115	45.45	18.18	0.00	9.77	100.00	22.62	92.17	81.07	**46.16**
NFQT7	112	72.73	36.36	5.83	0.00	10.38	33.55	28.57	60.79	**31.03**
NFQL8	114	54.55	36.36	2.86	7.39	91.80	40.56	84.21	74.30	**49.01**
NFQL9	102	63.64	18.18	1.60	5.51	28.50	60.92	51.96	62.28	**36.57**
NFQT10	111	54.55	18.18	8.82	0.00	12.22	41.66	81.98	67.17	**35.57**

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

Raw data used to calculate VSCI scores for spring 2021 macroinvertebrate data (family). Sites above and below the dashed line are upstream and downstream of Niagara Dam, respectively.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI
NSQT1	114	14	3	10.53	0.88	7.89	65.79	55.26	**5.27**
NSQT2	116	12	6	18.97	1.72	23.28	43.97	28.45	**4.98**
NSQL3	108	13	0	0.00	0.00	7.41	52.78	25.00	**2.91**
NSQL4 - ORIGINAL	107	8	0	0.00	0.00	3.74	85.05	85.05	**6.90**
NSQL4 - REPLICATE	106	9	0	0.00	0.00	2.83	89.62	89.62	**6.06**
NSQL5	112	5	0	0.00	0.00	0.89	95.54	95.54	**6.38**
NSQT6 - ORIGINAL	117	10	3	0.85	1.71	16.24	84.82	70.09	**5.47**
NSQT6 - REPLICATE	111	12	4	1.80	0.90	31.53	57.66	40.54	**5.38**
NSQT7	119	10	2	0.84	0.84	5.88	86.55	86.55	**5.90**
NSQL8	108	14	3	4.63	1.85	44.44	48.15	21.30	**5.79**
NSQL9	116	15	4	0.86	3.45	10.34	79.31	74.14	**5.87**
NSQT10	110	16	6	18.18	3.64	32.73	48.18	10.91	**4.71**

Site results of VSCI scores for spring 2021 macroinvertebrate data (family). Sites above and below the dashed line are upstream and downstream of Niagara Dam, respectively.

Site	Total	Total Taxa	EPT Taxa	% Eph.	% Plec. + Trich. - Hydropsych.	% Scrapers	% Top 2 Dominant	% Chironomidae	HBI	VSCI Score
NSQT1	114	63.64	27.27	17.17	2.46	15.30	49.44	44.74	69.53	**36.19**
NSQT2	116	54.55	54.55	30.94	4.84	45.11	80.97	71.55	73.78	**52.04**
NSQL3	108	59.09	0.00	0.00	0.00	14.36	68.24	75.00	100.00	**39.59**
NSQL4 - ORIGINAL	107	36.36	0.00	0.00	0.00	7.24	21.61	14.95	45.63	**15.72**
NSQL4 - REPLICATE	106	40.91	0.00	0.00	0.00	5.48	15.00	10.38	57.99	**16.22**
NSQL5	112	22.73	0.00	0.00	0.00	1.73	6.45	4.46	53.18	**11.07**
NSQT6 - ORIGINAL	117	45.45	27.27	1.39	4.80	31.47	21.93	29.91	66.62	**28.61**
NSQT6 - REPLICATE	111	54.55	36.36	2.94	2.53	61.11	61.19	59.46	67.97	**43.26**
NSQT7	119	45.45	18.18	1.37	2.36	11.40	19.43	13.45	60.31	**21.49**
NSQL8	108	63.64	27.27	7.55	5.20	86.13	74.93	78.70	61.96	**50.67**
NSQL9	116	68.18	36.36	1.41	9.69	20.05	29.90	25.86	60.73	**31.52**
NSQT10	110	72.73	54.55	29.66	10.21	63.42	74.88	89.09	77.81	**59.04**

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

Crayfish observations. Sites above and below the dashed line are upstream and downstream of Niagara Dam, respectively. Shaded species names are invasive.

Site	Appalachian Brook Crayfish	Atlantic Slope Crayfish	Ozark Crayfish	Virile Crayfish	Red Swamp Crayfish
NFQT1	present		abundant		
NFQT2		present	abundant		
NFQL3			present		present
NFQL4			present		
NFQL5					
NFQT6			present		present
NFQT7			abundant		
NFQL8			abundant		
NFQL9			abundant	present	
NFQT10		present	abundant	abundant	

Water quality parameters at mussel sites in fall 2020. Sites above the dashed line are upstream of Niagara Dam and sites below the dashed line are downstream of Niagara Dam.

Date	Site	Water Temp. (C)	pH	DO (%)	Conductivity (us/cm)	Habitat
10/6/2020	T-1	15.8	7.9	96.9	336	Pool
10/6/2020	T-2	16.1	7.7	96.8	390	Pool
10/6/2020	T-3	15.4	7.8	79.2	384	Pool
10/6/2020	T-4	15.0	7.9	94.6	406	Pool
10/6/2020	T-5	14.9	7.9	62.6	399	Pool
10/6/2020	T-6	15.0	7.9	75.0	400	Pool
10/6/2020	T-7	15.2	7.9	96.9	404	Pool
10/6/2020	T-8	15.5	7.9	60.2	402	Pool
10/8/2020	UNIO-1	16.4	8.4	96.9	352	Riffle/Run
10/8/2020	UNIO-2	16.4	8.6	130.3	466	Riffle/Run
10/6/2020	UNIO-WC	16.4	8.0	85.4	213	Riffle/Run
10/7/2020	UNIO-Bypass	16.8	8.4	102.1	409	Riffle/Run
10/7/2020	UNIO-Tailrace	16.7	8.1	103.3	404	Run

Mussel observation in fall 2020. Both sites are upstream of Niagara Dam

Date	Site	Common Name	Species	Length (mm)	Dom. Substrate
10/8/2020	UNIO-1	Eastern Elliptio	*Elliptio complanata*	88.9	Course
10/8/2020	UNIO-1	Eastern Elliptio	*Elliptio complanata*	96.2	Course
10/8/2020	UNIO-2	Eastern Elliptio	*Elliptio complanata*	105.4	Sand
10/8/2020	UNIO-2	Eastern Elliptio	*Elliptio complanata*	73.5	Sand