

Nine-Element Nonpoint Source Implementation Strategy (NPS-IS)

TOWN OF ZALESKI-RACCOON CREEK:
HUC-12 (05090101 02 05)

VERSION 1.0

January 18, 2018

Approved: March 5, 2018

Brooke Sanderson

VOINOVICH SCHOOL OF LEADERSHIP AND PUBLIC AFFAIRS | OHIO UNIVERSITY

Table of Contents

Acknowledgments.....	3
Chapter 1: Introduction	4
1.1 Background	4
1.2 Watershed Profile and History	6
1.3 Public Participation and Involvement	7
Chapter 2: Town of Zaleski-Raccoon Creek HUC-12 Watershed Characterization and Assessment	
Summary	9
2.1 Summary Watershed Characterization for the Town of Zaleski-Raccoon Creek HUC-12	9
2.1.1 Physical and Natural Features.....	9
2.1.2 Land Use and Protection.....	11
2.2 Summary of Biological Trends for the Town of Zaleski-Raccoon Creek HUC-12	13
2.2.1 Fish	13
2.2.2 Macroinvertebrates	15
2.2.3 Habitat.....	15
2.3 Summary of NPS Pollution Causes and Associated Sources for the Town of Zaleski-Raccoon Creek HUC-12	16
2.4 Additional Information for Determining Critical Areas and Developing Implementation Strategies for the Town of Zaleski-Raccoon Creek HUC-12.....	16
Chapter 3: Conditions & Restoration Strategies for Town of Zaleski-Raccoon Creek HUC-12 Critical Areas	19
3.1 Overview of Critical Areas	19
3.2 Critical Area 1: Conditions, Goals, & Objectives for Big Sandy Run	19
3.2.1 Detailed Characterization	19
3.2.2 Detailed Biological and Chemical Conditions.....	21
3.2.3 Detailed Causes and Associated Sources.....	23
3.2.4 Outline Goals and Objectives for the Critical Area	24
Chapter 4: Projects and Implementation Strategy	26
4.1 Overview Tables and Project Sheets for Critical Areas.....	26
4.2 Critical Area 1: Overview Table and Project Sheet(s) for the Town of Zaleski-Raccoon Creek HUC-12	26
4.2.1 Critical Area 1: Project and Implementation Strategy Overview Table	26
4.2.2 Critical Area 1: Project Summary Sheet(s)	28
Works Cited.....	31

Appendix A: Acronyms and Abbreviations 33
Appendix B: Index of Tables and Figures 35

Acknowledgments

Prepared and written by Brooke Sanderson, Masters Candidate
Voinovich School of Leadership and Public Affairs at Ohio University
The Ridges Building 22, 1 Ohio University, Athens, Ohio 45701
bs341708@ohio.edu

With gratitude for the assistance from:

- Amy Mackey, Raccoon Creek Watershed Coordinator, Raccoon Creek Partnership and the Voinovich School of Leadership and Public Affairs
- Sarah Cornwell, Microenterprise Program Trainer, ACEnet (former Water Quality Specialist at the Voinovich School of Leadership and Public Affairs)
- Dr. Natalie Kruse-Daniels, Associate Professor of Environmental Studies, Advisor, and Graduate Committee Chair, Voinovich School of Leadership and Public Affairs
- Jennifer Bowman, Director of Environmental Programs, Voinovich School of Leadership and Public Affairs
- Graduate Students and AmeriCorps members that helped with baseline monitoring:
 - Jennie Brancho
 - Abby Costilow
 - Jeremy Held
 - Emily Keil-Loudner
 - Caitlyn Park
 - Kara Roberts

Chapter 1: Introduction

The Town of Zaleski-Raccoon Creek HUC-12 (05090101 02 05) is located entirely in northeastern Vinton County, Ohio. Located within this HUC-12 are the town of Zaleski, Ohio, Zaleski State Forest, and Lake Hope State Park. Here, Raccoon Creek runs south, then north near the town of Zaleski, and south again near Lake Hope State Park. The Raccoon Creek mainstem is a tributary to the Ohio River and is approximately 112 miles long with a 683-square mile drainage area. This area spans six southeast Ohio counties including Athens, Hocking, Vinton, Jackson, Meigs, and Gallia. The Town of Zaleski-Raccoon Creek HUC-12 has a drainage area of 136 square miles and has a mean annual precipitation of 38.8 inches (WiM Group, 2016). A map of the Raccoon Creek Watershed and Town of Zaleski-Raccoon Creek HUC-12 can be seen in Figure 1. Abandoned surface and underground coal mines have left Raccoon Creek and its tributaries heavily impacted by acid mine drainage (AMD). Extensive treatment throughout the watershed has resulted in 110 of the 117 monitored stream miles meeting the target pH of 6.5 in 2016 (Bowman and Johnson, 2017). Other sources of non-point source impairment within the watershed include wastewater treatment, industry, farming practices, removal of riparian vegetation, and oil and gas operations (ILGARD, 2003).

Approved nine-element watershed plans are now required for State and Federal non-point source pollution funding. The Voinovich School of Leadership and Public Affairs at Ohio University and the Raccoon Creek Partnership would like this to be the first of many NPS-IS Plans within the Raccoon Creek Watershed and across southeast Ohio.

1.1 Background

This NPS-IS Plan is an update to the *Raccoon Creek Management Plan (2003)* and the *Watershed Action Plan: Raccoon Creek Headwaters to Above Hewett Fork Watershed (2007)*. These plans, developed at the watershed level, are difficult to implement due to the size of the Raccoon Creek Watershed. By focusing on specific projects within the Town of Zaleski-Raccoon Creek HUC-12, this area can continue the trend of water quality improvement and address the water quality concerns of the areas citizens. This management plan, along with Acid Mine Drainage Abatement and Treatment (AMDAT) Plans and Total Maximum Daily Load (TMDL) Plans for the watershed, have been used for nearly twenty years to guide the restoration of the Raccoon Creek Watershed. While Watershed Based Planning (WBP) has proven largely successful in the restoration of the chemical water quality of the Raccoon Creek Watershed, the biological recovery of the watershed needs increased attention. Analysis of data collected in 2016, conducted by the Voinovich School of Leadership and Public Affairs, shows only 82 of the 117 stream miles assessed were meeting biological criteria for Warmwater Habitat (WWH) (Bowman and Johnson, 2017).

Implementing projects at critical areas within the Town of Zaleski-Raccoon Creek HUC-12 will allow for the continued and focused improvement of biological parameters, as well as, protect the valuable water resources for consumption and recreation. It will also allow projects to focus on specific concerns of those living in and directly affected by the water quality within this HUC-12.

Town of Zaleski-Raccoon Creek HUC-12

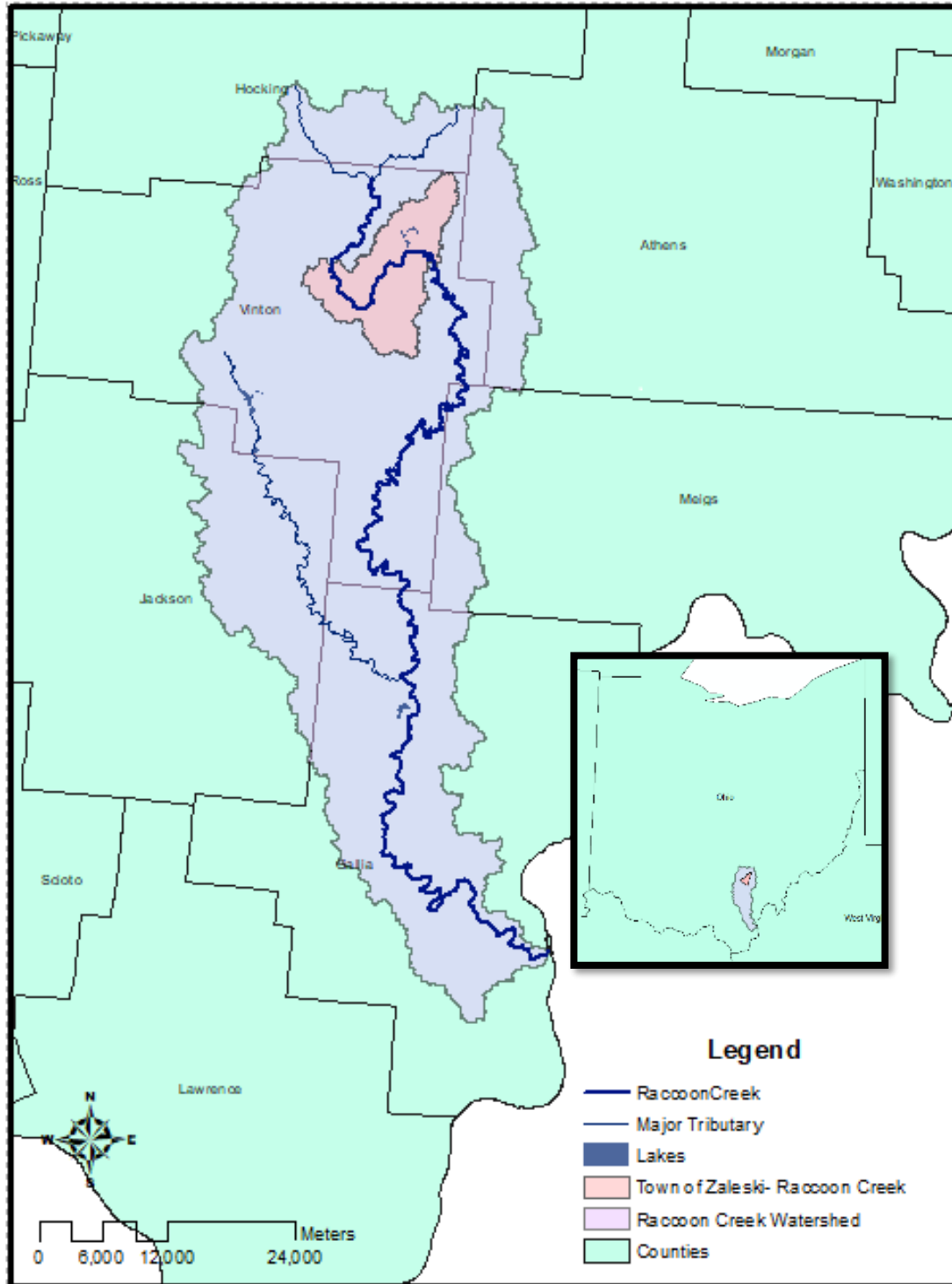


Figure 1. Location of the Town of Zaleski-Raccoon Creek HUC-12 within the Raccoon Creek Watershed

1.2 Watershed Profile and History

The Town of Zaleski-Raccoon Creek HUC-12 is located entirely in Vinton County, Ohio. Vinton County is one of the most rural counties in Ohio and the largest town in the watershed is the Town of Zaleski with 278 residents, as of the 2010 Census (Vinton County, n.d.). The watershed is 82.6% forested (USGS, 2011) with much of that including the Zaleski State Forest and Lake Hope State Park. As part of the Hocking Hills Region of Ohio, this area is a popular destination for outdoor recreation.

The Raccoon Creek Watershed has a history of resource extraction including timber, coal mining, and iron ore. Iron smelting employed thousands of citizens in Vinton County and many small but prosperous towns sprang up throughout the region. The Town of Zaleski is one of the towns that still exists today but many were abandoned (Vinton County Visitors Bureau, 2017a). The remnants of these towns and the large iron furnaces that employed so many can be seen today throughout the county (Figure 2). These iron furnaces burned 24 hours a day to extract the iron ore using charcoal, for which timber was always needed. Today the area is primarily second growth forest and the Zaleski State Forest is the second largest in Ohio (ODNR, 2017).



Figure 2. Hope Furnace located within the Lake Hope State Park near Zaleski, Ohio. Photo credit: Brooke Sanderson (Ohio University)

In addition to iron ore and timber extraction, the area has a history of coal mining. The Town of Zaleski- Raccoon Creek HUC-12 contains abandoned underground and surface coal mines. These mines were abandoned prior to the Surface Mining Control and Reclamation Act of 1977 (SMCRA) regulating the mining companies on the environmental impacts and clean-up requirements for coal mines (Lynch, 2014). The large number of pre-law abandoned underground mines cause widespread impairment from AMD throughout the Raccoon Creek Watershed. To date, watershed planning has focused on remediating these impacts through both passive and active treatment projects.

Today, there is interest in increasing the areas' appeal as a tourist and outdoor recreation destination. Lake Hope State Park boasts seven hiking trails, eight biking trails, two backpack trails, and 33 miles of bridle trails. Lake Hope (Figure 3) is the perfect spot for boating, fishing, and swimming and there are campsites and cabins for those looking to stay in the beautiful rolling hills of southeast Ohio (Vinton County Visitors Bureau, 2017b). The Zaleski State Forest also allows hunting, with a hunter's camp and shooting range as well as Management Areas sustainably managed for Ruffed Grouse and Wild Turkey reproduction (ODNR, 2017).

With increasing interest in outdoor recreation within the Town of Zaleski-Raccoon Creek HUC-12 watershed, it is more important than ever to take calculated steps toward conserving and improving water quality resources in this area. This plan focuses on improving biological water quality near Lake Hope through altered stream and habitat restoration strategies described in *Ohio's Nonpoint Source Management Plan Update* (Ohio EPA, Approved 2014).



Figure 3. Lake Hope is a popular destination for outdoor enthusiasts of all ages. Photo Credit: Brooke Sanderson (Ohio University)

1.3 Public Participation and Involvement

Public participation is critical in the completion of any watershed

project. Raccoon Creek Watershed has a long history of public involvement dating before the 1980's when a group of citizens in Gallia County, Ohio formed the Raccoon Creek Improvement Committee (RCIC). By the 1990's, citizens from all of Raccoon Creek Watershed's six counties joined the RCIC to improve and preserve the watershed and educate communities on the importance of protecting water resources. Then, in 2007, Raccoon Creek Partnership (RCP) was formed. What started as a grass-roots organization to reclaim the mining impacted watershed, is now a certified 501(c)3 organization known and trusted by members of the community (Raccoon Creek Partnership, 2015).

RCP is active in community events throughout the Raccoon Creek Watershed from public meetings to special events. In 2017, these events included:

- Storm Drain Stenciling
- Raccoon Creek Summer Camp
- Ohio Pawpaw Festival
- Raccoon Creek Canoe Floats
- Science Alliance
- Rural Ohio Appalachia Revisited (R.O.A.R.)
- Raccoon Creek Partnership Annual Dinner

RCP recently acquired Ohio Division of Wildlife Aquatic Education grant funds to build an augmented reality sandbox and interactive stream table to bring to events (Figures 4 and 5). These tools have proved wildly popular for people of all ages to learn about watersheds and streams.

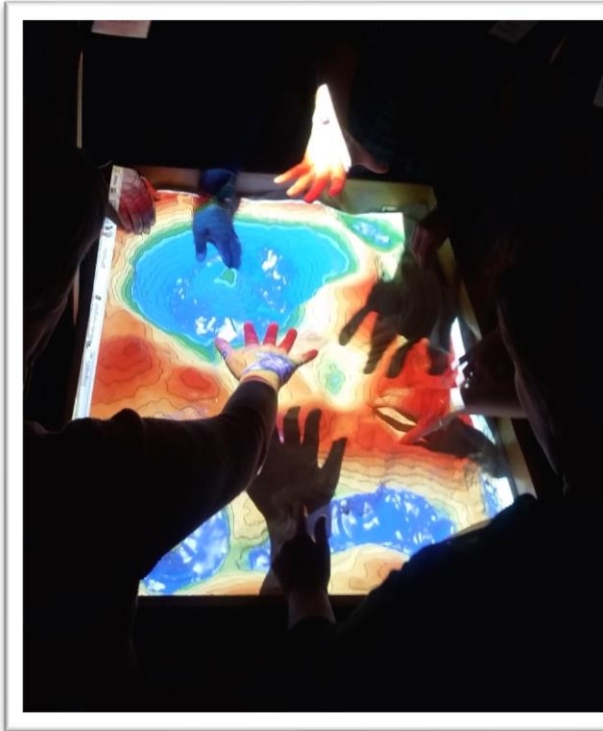


Figure 4. The augmented reality sandbox is used to demonstrate watershed concepts to the public. Photo credit: Amy Mackey (Ohio University)



Figure 5. The interactive stream table brings the fish and macroinvertebrates of the Raccoon Creek Watershed to RCP events. Photo credit: Amy Mackey (Ohio University)

In addition, twice annually RCP sends newsletters out to all members and has them available to the public at their events. There is also a strong connection between RCP and the Ohio University community. The Raccoon Creek Watershed Coordinator works out of the Voinovich School of Leadership and Public Affairs at Ohio University and many students conduct research within the watershed or help with water quality monitoring and events.

Chapter 2: Town of Zaleski-Raccoon Creek HUC-12 Watershed Characterization and Assessment Summary

2.1 Summary Watershed Characterization for the Town of Zaleski-Raccoon Creek HUC-12

2.1.1 Physical and Natural Features

The Raccoon Creek Watershed of southeast Ohio is in the Western Allegheny Plateau (WAP) ecoregion (Ohio EPA, n.d.). The hills of this region consist of Pennsylvanian age bedrock with an abundance of coal and iron deposits, resulting in widespread mining throughout the watershed. These coal deposits are high in sulfur and the abandoned underground and surface mines have caused widespread pollution from AMD (ILGARD, 2003). These abandoned mines can be seen in Figure 6 along with other physical and natural features of the Town of Zaleski-Raccoon Creek HUC-12. Watershed restoration efforts in the Raccoon Creek Watershed have focused on remediating the impacts of AMD through passive and active treatment projects. As of 2016, there has been \$14,521,361 invested in a total of 20 completed projects, resulting in a total acid load reduction of 4,267 lbs/day and 110 of 117 stream miles meeting the pH target of 6.5 (Bowman J. & Johnson K., 2017). One of these projects, Hope Clay, is located within the Town of Zaleski-Raccoon Creek HUC-12. This project was successful in reducing acid loads to Raccoon Creek by 21.53 lbs/day and metals by 3.77 lbs/day by installing a limestone channel and reclaiming the surrounding land to reduce erosion. This project was completed in 2005 (Raccoon Creek Watershed Individual Projects, 2015).

There are four lakes within the Raccoon Creek Watershed and one of these, Lake Hope, lies within the Town of Zaleski-Raccoon Creek HUC-12 (ILGARD, 2003). These lakes are popular recreation areas for boaters, swimmers, and fishermen. In Ohio and across the United States there is growing concern about Harmful Algal Blooms (HABs) and this is also the case for the lakes of Raccoon Creek Watershed. Warning signs are placed along the shores to inform and protect the public. There are also four Category Three Wetlands within the watershed with two of those in the Town of Zaleski-Raccoon Creek HUC-12. They are both located on the Raccoon Creek mainstem at river mile (RM) 90.5 and 89.6 (Raccoon Creek Partnership, 2015).

The Town of Zaleski-Raccoon Creek HUC-12 was assessed by the Ohio Environmental Protection Agency (OEPA) and addressed in their 2014 Integrated Report. This indicated watershed impairments contributed to AMD, sedimentation, excess nutrients, and hydro-modification (Ohio EPA, 2014). The OEPA conducted biological monitoring of the Raccoon Creek Watershed in 2016 and a report is expected to be finalized in 2018.

Physical and Natural Features Town of Zaleski-Raccoon Creek HUC-12

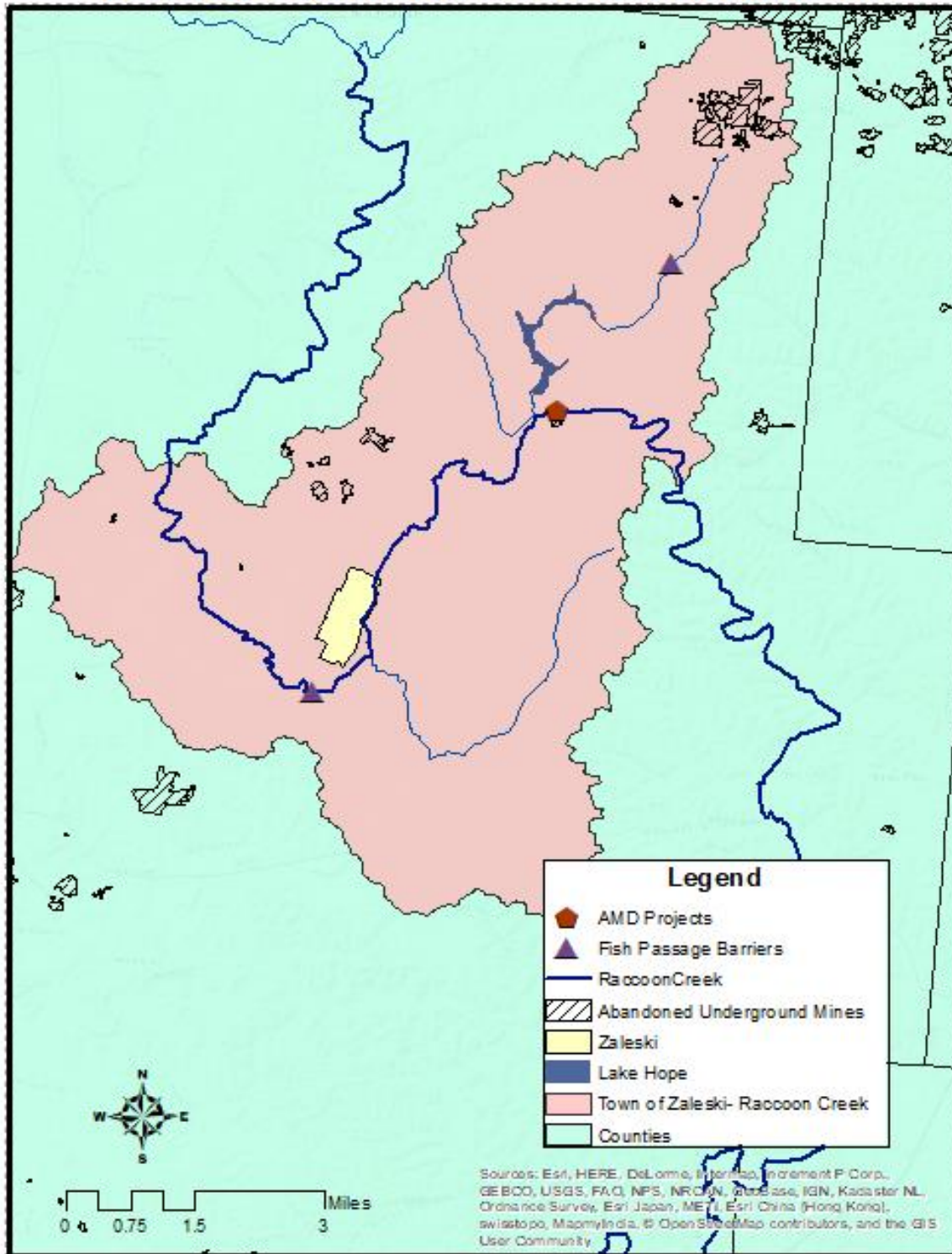


Figure 4. The physical and natural features of the Town of Zaleski-Raccoon Creek HUC-12

2.1.2 Land Use and Protection

The land use of the Town of Zaleski-Raccoon Creek HUC-12 can be seen in Figure 7 and percentage of land use in Table 1. The majority of the watershed is Forest and Woodland with much of that managed by the Ohio Department of Natural Resources (ODNR) as part of the Zaleski State Forest. Approximately 3,361 acres of the Zaleski State Forest are managed for biodiversity through the sustainable use of natural resources and approximately 28,830 acres are managed but subject to resource extraction or off highway vehicle use (HydroVIEW, 2017). As a result, the streams flowing through the watershed typically have a substantial riparian corridor.

Table 1. Percentage of land use in the Town of Zaleski-Raccoon Creek HUC-12 (USGS, 2011).

Land Use	Percentage of HUC-12
Forest & Woodland	82.72
Agricultural Vegetation	9.25
Developed & Other Human Use	6.79
Open Water	0.85
Recently Disturbed or Modified	0.34
Shrubland & Grassland	0.03
Introduced or Semi-Natural Vegetation	0.02

Town of Zaleski-Raccoon Creek Land Use

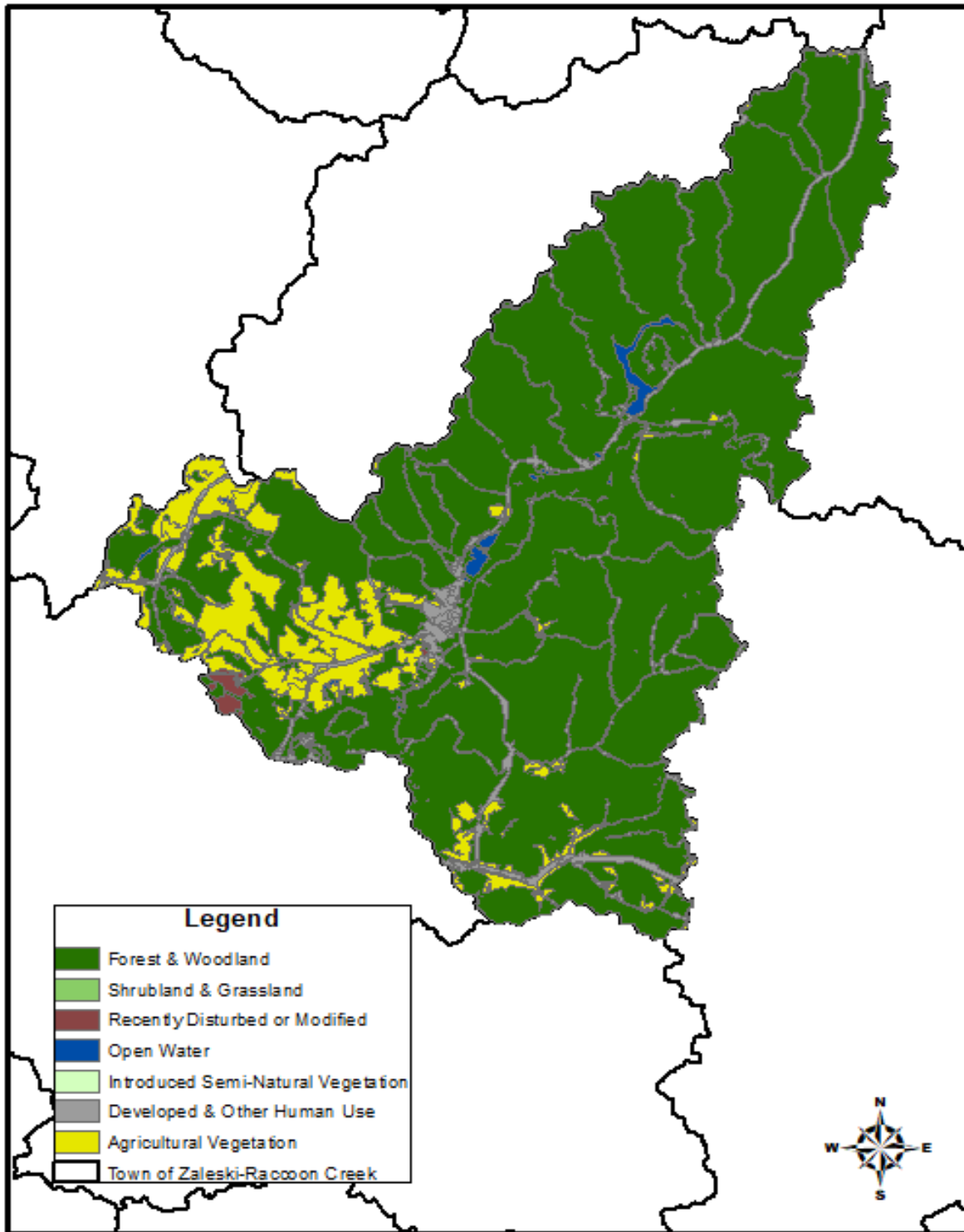


Figure 5. Land use within the Town of Zaleski-Raccoon Creek HUC-12

2.2 Summary of Biological Trends for the Town of Zaleski-Raccoon Creek HUC-12

The designated use goal for the majority of the Town of Zaleski-Raccoon Creek HUC-12 is WWH and Lake Hope is designated Exceptional Warmwater Habitat (EWH). While mainstem Raccoon Creek is in *non-attainment*, there has been incredible water quality improvements over the past few decades (McCament, 2007). In 1998, the OEPA designated mainstem Raccoon Creek as a Limited Resource Water (LRW) impaired by AMD. The stream was not expected to recover to WWH (McCament, 2007). The following sections detail the biological and habitat conditions of the watershed. Sampling sites in the following sections can be seen in Figure 8. All 2016 data was obtained from the OEPA and will be compiled in a report by 2018.

2.2.1 Fish

A summary of Index of Biological Integrity (IBI) scores for the Town of Zaleski-Raccoon Creek HUC-12 can be seen in Table 2. While this watershed has seen steady improvement overall, only two sites (MSBM004 and RC0065) are currently meeting IBI biological health targets for WWH (Raccoon Creek, 2017). In the mainstem Raccoon Creek, IBI scores of 40 or above are meeting the WWH use designation. In headwater streams, such as Big Sandy Run, IBI scores of 44 or above are meeting the WWH use designation. Big Sandy Run (SR0270) is located approximately 1 mile upstream of Lake Hope and has the most potential for improvement with an IBI score of 28. This small stream provides important headwater habitat for fish species.

Table 2. IBI scores in the Town of Zaleski-Raccoon Creek HUC-12 from 1995-2016 (Raccoon Creek, 2017).

Site ID	RM	Stream	1995	2000	2008	2010	2011	2012	2013	2016
MSBM004	89.90	Raccoon Creek			48				43	48
MSLH130	92.30	Raccoon Creek	35					34		
MSLH120	0.40	Big Sandy Run							30	
SR0270	2.70	Big Sandy Run								28
MSLH140	1.35	Wheelabout Creek		28		42				
RC0070	98.40	Raccoon Creek								38
MSLH152	0.10	Unnamed Tributary to Raccoon Creek								38
RC0065	99.70	Raccoon Creek								48
MSLH030	0.10	Infirmiry Road Tributary	22							
MSLH020	102.1	Raccoon Creek					42		36	

Biological Sampling Sites Town of Zaleski-Raccoon Creek HUC-12

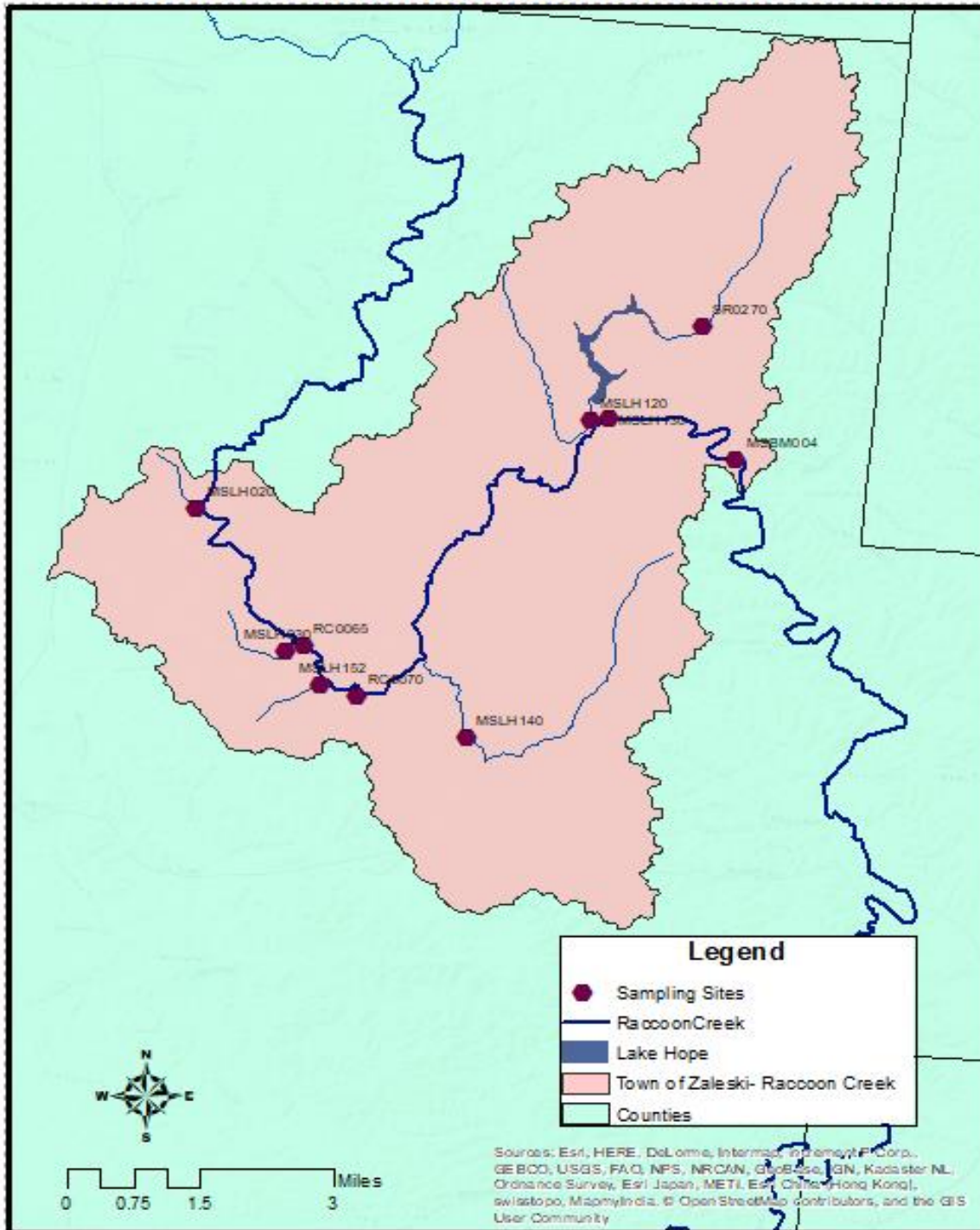


Figure 6. Biological sampling sites in the Town of Zaleski-Raccoon Creek HUC-12 (Raccoon Creek, 2017).

2.2.2 Macroinvertebrates

A summary of Macroinvertebrate Aggregated Index for Streams (MAIS) scores for the Town of Zaleski-Raccoon Creek HUC-12 can be seen in Table 3. A MAIS score of 12 or greater is considered *in attainment* of WWH biological criteria (Kinney, 2006). Sites in this watershed have been meeting MAIS biological health targets for WWH since 2012, apart from MSLH130 in 2015 (Raccoon Creek, 2017).

Table 3. MAIS scores in the Town of Zaleski-Raccoon Creek HUC-12 from 2009-2016 (Raccoon Creek, 2017).

Site ID	RM	Stream	2009	2010	2011	2012	2013	2014	2015	2016
MSBM004	89.90	Raccoon Creek		12	16	14	14	13	16	12
MSLH130	92.30	Raccoon Creek	10	11	11	14	13	14	11	13
MSLH020	102.1	Raccoon Creek		10	11	12	15	15	16	12

2.2.3 Habitat

A summary of Qualitative Habitat Evaluation Index (QHEI) scores for the Town of Zaleski-Raccoon Creek HUC-12 can be seen in Table 4. An evaluation of QHEI scores across Ohio indicate those stream segments scoring greater than 60 can generally support WWH fish and macroinvertebrate communities and scores greater than 75 are able to support EWH communities (Ohio EPA, 1989). Overall, most stream segments within this watershed scored above 60, suggesting the WWH use designation is attainable if other water quality parameters are not limiting.

Table 4. QHEI scores in the Town of Zaleski-Raccoon Creek HUC-12 from 1995-2016 (Raccoon Creek, 2017).

Site ID	RM	Stream	1995	2000	2008	2010	2011	2012	2016
MSBM004	89.90	Raccoon Creek			63.5				87.5
MSLH130	92.30	Raccoon Creek	68.5					67.5	
MSLH120	0.40	Big Sandy Run							39
SR0270	2.70	Big Sandy Run							65
MSLH140	1.35	Wheelabout Creek		67		69.5			
RC0070	98.40	Raccoon Creek							68.5
MSLH152	0.10	Unnamed Tributary to Raccoon Creek							36.5
RC0065	99.70	Raccoon Creek							58.5
MSLH030	0.10	Infirmiry Road Tributary	60.5						
MSLH020	102.1	Raccoon Creek					61		

2.3 Summary of NPS Pollution Causes and Associated Sources for the Town of Zaleski-Raccoon Creek HUC-12

The primary non-point source (NPS) pollution causes are pH and metals, collectively AMD (Ohio EPA, 2002). Table 5 lists the NPS pollution sources according to the Ohio EPA Division of Surface Water’s *Ohio 2016 Integrated Water Quality Monitoring and Assessment Report* (2016).

Most NPS pollution in the watershed result from the extensive mining history of the region. There is also high naturally occurring sand bedload due to the area geology.

Table 5. Causes and associated sources of NPS pollution in the Town of Zaleski-Raccoon Creek HUC-12 (Ohio EPA, 2016).

Causes	Sources
Metals	Non-irrigated Crop Production
Zinc	Surface Mining
Iron	AMD
Aluminum	Natural
Other Metals	
pH	
Siltation	
Direct Habitat Alteration	

2.4 Additional Information for Determining Critical Areas and Developing Implementation Strategies for the Town of Zaleski-Raccoon Creek HUC-12

As described above, the Town of Zaleski-Raccoon Creek HUC-12 has seen nearly twenty years of steady chemical and biological improvement. However, there is still improvement needed to reach the WWH use designation in some reaches. RCP and the Voinovich School of Leadership and Public Affairs at Ohio University have decided to explore Altered Stream and Habitat Restoration Strategies (Ohio EPA, 2013) to increase stream connectivity and restore natural flow to an area impacted by a low-head dam.

Low-head dams throughout the Raccoon Creek Watershed were identified and a mailing was sent to the corresponding landowners. The mailing included, a letter of introduction, a low-head dam information sheet, and a survey that could be voluntarily completed and returned. There was a 78% response rate for this survey and the overwhelming majority of landowners were either willing to have a removal project on their property or were interested in speaking with us further about the possibility. With landowner support we chose the site at which a removal project would have the greatest impact on habitat, fish passage, and public safety. Through this process, Big Sandy Run north of Lake Hope was chosen as *Critical Area 1* (Figure 9).



Figure 9. Low-head dam located in Critical Area 1: Big Sandy Run. Photo Credit: Brooke Sanderson (Ohio University)



Figure 10. Slow moving pool behind the low-head dam. This structure impounds water for approximately 0.1 mile upstream. Photo Credit: Brooke Sanderson (Ohio University)

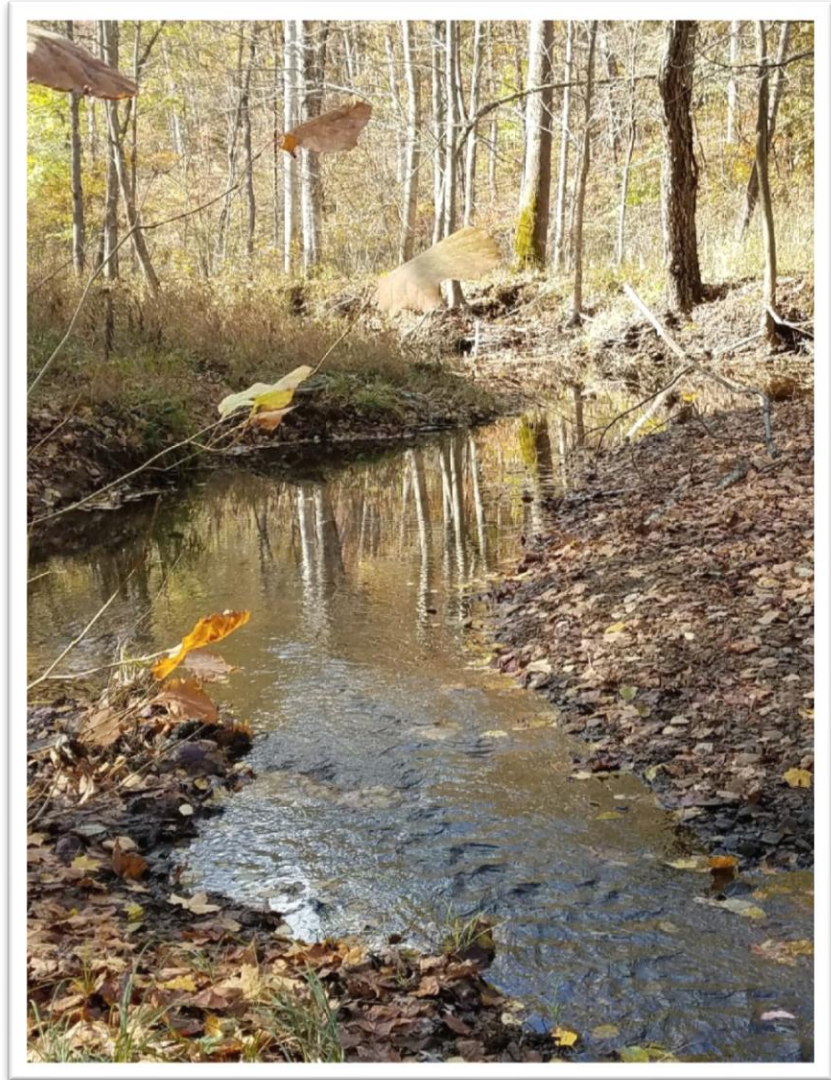


Figure 7. Upstream and downstream (pictured) habitats include essential riffle/run/pool habitats. If removed, the pool behind the low-head dam will be restored to a natural flow regime. Photo Credit: Brooke Sanderson (Ohio University)

Chapter 3: Conditions & Restoration Strategies for Town of Zaleski-Raccoon Creek HUC-12 Critical Areas

3.1 Overview of Critical Areas

The sampling site along Big Sandy Run (SR0270, King Hollow Trail) upstream of Lake Hope is in *partial attainment* of the expected aquatic life use of WWH according to data collected by Ohio University in Fall 2017 as part of the baseline monitoring study to determine the impact of the Big Sandy Run low-head dam on the stream reach. The baseline monitoring study also shows areas upstream of the low-head dam are in *non-attainment* of the WWH designated life use. The monitoring results are explained in the following sections, identifying Big Sandy Run and riparian corridor (approximately 150 feet to either side of the stream) as *Critical Area 1*.

3.2 Critical Area 1: Conditions, Goals, & Objectives for Big Sandy Run

3.2.1 Detailed Characterization

Big Sandy Run is a tributary to Lake Hope which then flows into the Raccoon Creek mainstem. According to data collected by OEPA in 2016, Big Sandy Run is in *partial attainment* of WWH with IBI scores significantly below the biocriterion for headwaters (≥ 44) (Raccoon Creek Partnership 2015). The sources of impairment are naturally occurring sand bedload, AMD, and a low-head dam located at river mile 3.25. This 3.4-foot dam appears to be a significant fish passage barrier and impounds water for just over 0.1 mile upstream. Due to the importance of healthy headwater streams to a river network this site has been selected as *Critical Area 1*. Sites upstream and downstream of the low-head dam were sampled in Fall 2017 to obtain baseline biological and chemical data. The dam location and sampling sites can be seen in Figure 10. Sampling results will be expanded upon in the following sections.

Big Sandy Run Sampling Sites

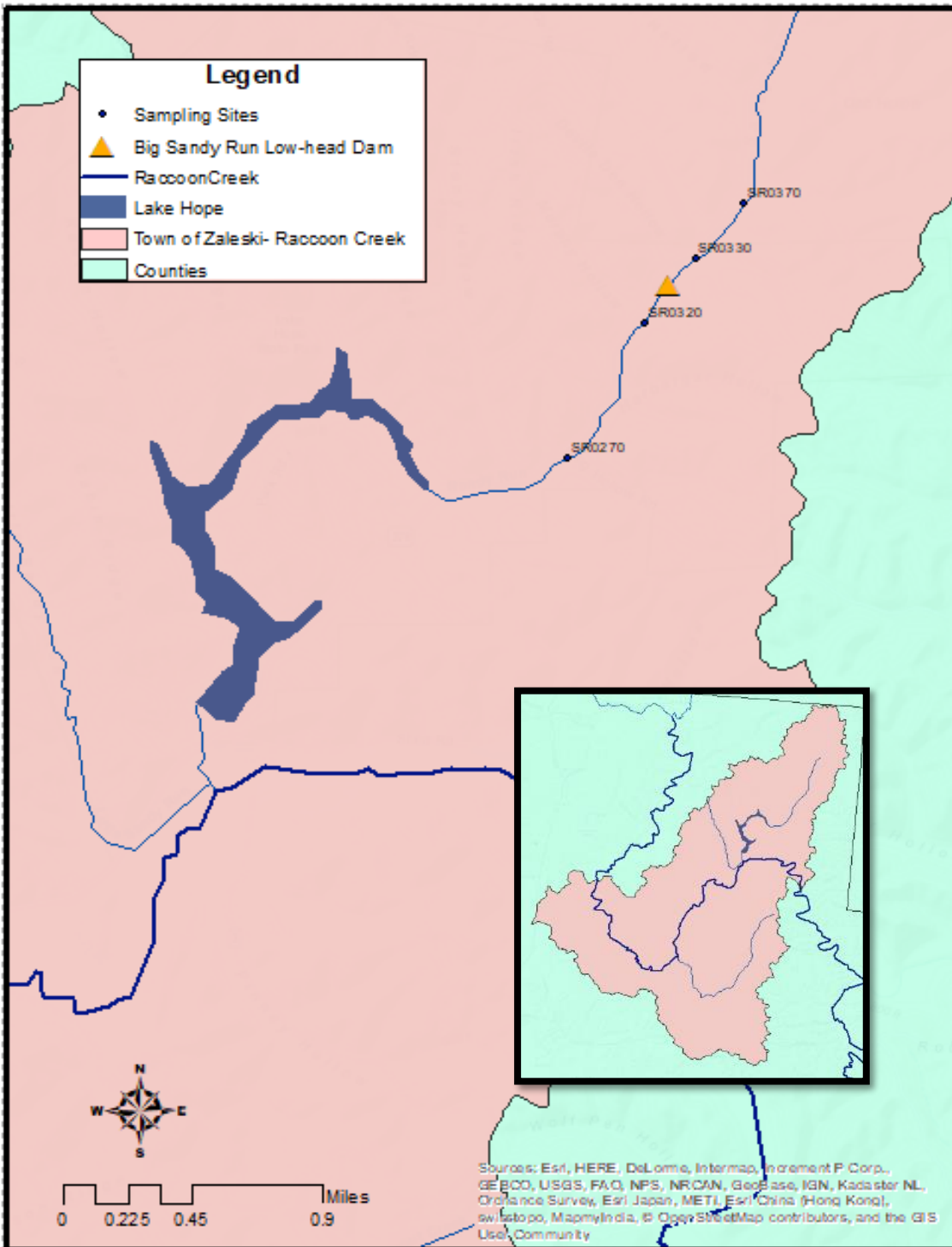


Figure 8. The four sampling sites along Big Sandy Run upstream and downstream of the low-head dam. Critical Area 1 includes Big Sandy Run upstream from Lake Hope and the riparian corridor.



Figure 9. The Creek Chub is the most predominant fish species found in Big Sandy Run. Photo credit: Haldan Kirsch (Ohio University)

3.2.2 Detailed Biological and Chemical Conditions

Table 5 provides a summary of fish community and habitat data upstream and downstream of the Big Sandy Run low-head dam. These results are consistent with those found in other low-head dam removal studies. Less than half of the fish species were found upstream of the low-head dam with downstream sites having a narrative score of “Fair” and those upstream scoring “Poor”. The predominant species at each site was the Creek Chub (Figure 11), with percent of catch increasing upstream of the low-head dam. While habitat immediately

upstream of the structure (SR0320) was given a narrative score of “Fair” the furthest upstream site (SR0370) scored “Excellent”. Given this information, upstream habitat could support a more complex fish community if this barrier to fish migration was removed. The average QHEI score for the entire stream reach is 63.25. Average scores greater than 60 are generally able to support WWH fish and macroinvertebrate communities if the water quality conditions are not limiting (Ohio EPA, 1989).

Increasing IBI scores in the upstream reaches of Big Sandy Run to achieve a narrative score of “Good” would be a significant improvement and is achievable through a low-head dam removal project. This would move the reach from *non-attainment* to *partial attainment* of the WWH use designation. Removing this low-head dam would change the habitat at SR0330 from slow-moving lentic habitat to the natural lotic habitat and increase fish species and abundance in upstream habitats.

Table 6. Critical Area 1 - Fish community and habitat data

Stream/River Mile	Drainage Area (mi ²)	Total Species	QHEI	IBI	Predominant Species (percent of catch)	Narrative Evaluation QHEI/IBI
Big Sandy Run downstream of low-head dam						
2.7	5.33	10	59	30	Creek Chub (65.4%)	Good/Fair
3.2	4.63	10	67.5	30	Creek Chub (63.6%)	Good/Fair
Big Sandy Run upstream of low-head dam						
3.3	4.45	4	51	22	Creek Chub (74.2%)	Fair/Poor
3.7	3.83	4	75.5	22	Creek Chub (82.6%)	Excellent/Poor

Table 6 provides a summary of the macroinvertebrate community of Big Sandy Run. Macroinvertebrate sampling followed the protocols outlined in *Field and Laboratory Methods for using the MAIS (Macroinvertebrate Aggregated Index for Streams) in Rapid Bioassessment of Ohio Streams* (Johnson, 2007).

Table 7. Critical Area 1- Macroinvertebrate community data

Stream/River Mile	MAIS Score	Narrative Score	Notes	Predominant Family
Big Sandy Run downstream of low-head dam				
2.7	14	Good	9/27/2017	Ephemeroptera Leptophlebiidae (52.0%)
3.2	13	Good	9/27/2017	Diptera Chironomidae (38.6%)
Big Sandy Run upstream of low-head dam				
3.3	N/A	N/A	No Riffles Present	N/A
3.7	15	Good	10/5/2017	Ephemeroptera Leptophlebiidae (39.1%)

The scores obtained using this method are comparable to Invertebrate Community Index (ICI) scores. Macroinvertebrate samples were taken in the same locations as fish and habitat, with the exception of SR0330 immediately upstream of the low-head dam. In this reach there were no riffles present to sample which could have resulted in an inaccurate MAIS score. MAIS scores greater than or equal to 12 are considered in attainment of WWH biocriteria (Kinney, 2006).

All three sites sampled in Big Sandy Run are *in attainment* of WWH and a new mayfly species for the Raccoon Creek Watershed was identified in Big Sandy Run during this baseline monitoring study (Figure 12). It should be noted that macroinvertebrate sampling in Big Sandy Run occurred just outside the suggested index period for MAIS monitoring (June 15-September 15) (Johnson, 2007). However, this baseline data will be useful for future monitoring as macroinvertebrate communities often decline immediately following low-head dam removal due to increased bedload and sedimentation.



Figure 10. *Ephemeroptera Ephemerillidae* is a new family of mayfly found for the first time in the Raccoon Creek Watershed at Big Sandy Run sampling sites. Photo credit: Amy Mackey (Ohio University)

Table 7 provides an overview of field water quality parameters taken at each of the four sampling sites. The chemical water quality of Big Sandy Run is comparable to the rest of the Raccoon Creek Watershed with all sites meeting the pH goal of greater than 6.5. Increased turbidity at SR0330 could be associated with increased organic matter accumulating behind the low-head dam.

Table 8. Critical Area 1- Chemical water quality data

Stream/River Mile	Temperature (°C)	Conductivity (µS/mg/L)	Total Dissolved Solids (ppm)	Oxidation Reduction Potential	pH	Turbidity (FAU)
Big Sandy Run downstream of low-head dam						
2.7	14.2	326.8	223.1	118	6.77	2
3.2	14.8	331.1	226.0	66	7.13	0
Big Sandy Run upstream of low-head dam						
3.3	14.3	331.9	226.8	100	6.83	9
3.7	14.7	343.8	235.4	78	7.09	0

3.2.3 Detailed Causes and Associated Sources

The Big Sandy Run sampling site (SR0270; King Hollow Trail) is listed as in *non-attainment* of the WWH aquatic life use designation in the OEPA's *Total Maximum Daily Loads for the Upper Raccoon Creek Final Report* (2002). However, according to our data collected in 2017 and data collected by the OEPA in 2016, Big Sandy Run is currently in *partial attainment* of the WWH aquatic life use designation. Areas upstream of the low-head dam at RM 3.25 are still in *non-attainment*. The causes and associated sources of non-point source impairment are listed below in Table 8.

Table 9. Causes/sources of non-point source pollution for Critical Area 1 (Ohio EPA, 2002; baseline project monitoring)

Cause	Source
Metals/pH	Natural and Mining <ul style="list-style-type: none"> • Sandstone geology • AMD
Embeddedness	Natural and Mining <ul style="list-style-type: none"> • Sandstone geology • Mining
Habitat Alteration	Low-head dam at RM 3.25

While metals, pH, and embeddedness have natural and mining related sources, habitat alteration has a distinct, man-made source: the low-head dam at RM 3.25. Removing this structure would have a direct impact on improving upstream IBI and habitat scores.

3.2.4 Outline Goals and Objectives for the Critical Area

Goals

All NPS-IS plans aim to increase biological indices to move streams from *partial* or *non-attainment* status to achieve *full attainment*. Big Sandy Run downstream of the low-head dam (RM 3.25) is in *partial attainment* of the WWH use designation. MAIS and average QHEI scores in this downstream reach are meeting WWH criteria but IBI scores are not. Upstream of the low-head dam, the stream is in *non-attainment*. MAIS and average QHEI scores are meeting WWH criteria but IBI scores are “Poor” and therefore, the reach cannot be in *partial attainment*. The goal for *Critical Area 1* is to increase IBI scores in Big Sandy Run to achieve *full attainment* of the designated WWH aquatic life use. These goals are to specifically:

Goal 1. Achieve average MAIS score of 12 for Big Sandy Run downstream of RM 3.25.

ACHIEVED: Reach currently has an average score of 13.5

Goal 2. Achieve average QHEI score of 60 for Big Sandy Run downstream of RM 3.25.

ACHIEVED: Reach currently has an average score of 63.25

Goal 3. Achieve average IBI score of 44 for Big Sandy Run downstream of RM 3.25.

NOT ACHIEVED: Reach currently has an average score of 30

Goal 4. Achieve average MAIS score of 12 for Big Sandy Run upstream of RM 3.25.

ACHIEVED: Reach currently has an average score of 15

Goal 5. Achieve average QHEI score of 60 for Big Sandy Run upstream of RM 3.25.

ACHIEVED: Reach currently has an average score of 63.25

Goal 6. Achieve average IBI score of 44 for Big Sandy Run upstream of RM 3.25.

NOT ACHIEVED: Reach currently has an average score of 22

Objectives

Objective 1. Remove/modify dams and levees

- Remove one low-head dam at Big Sandy Run RM 3.25

Objective 2. Restore and maintain native species within riparian corridor

- Plant native species within 50 feet of the newly exposed stream reach
- Manage for invasive species within 50 feet of the newly exposed stream reach

As these objectives are implemented, water quality monitoring related to this project will be conducted to determine progress toward meeting the identified goals (i.e. water quality standards). These objectives

will be reevaluated and modified if determined to be necessary. The OEPA *Nonpoint Source Management Plan Update* (Ohio EPA, Approved 2014) will be referenced when reevaluating objectives to consider all eligible NPS management strategies including:

- Urban Sediment and Nutrient Reduction Strategies
- Altered Stream and Habitat Restoration Strategies
- Nonpoint Source Reduction Strategies
- High Quality Waters Protection Strategies

Chapter 4: Projects and Implementation Strategy

4.1 Overview Tables and Project Sheets for Critical Areas

The projects that are believed to be necessary to remove the impairments to the Town of Zaleski-Raccoon Creek HUC-12 are listed in the Project Overview Table for *Critical Area 1* below. The success of these projects will be based on the biological and habitat conditions, short and long-term monitoring will be necessary to determine if other projects will need to be implemented to achieve biological health targets.

4.2 Critical Area 1: Overview Table and Project Sheet(s) for the Town of Zaleski-Raccoon Creek HUC-12

The information included in the *Critical Area 1: Project Overview Table* is a condensed overview of all identified projects needed for nonpoint source restoration of the Town of Zaleski-Raccoon Creek HUC-12 *Critical Area 1*. Project Summary Sheets are included for short term projects considering seeking funding in the near future. Only those projects with complete Project Summary Sheets will be considered for state and federal NPS program funding.

4.2.1 Critical Area 1: Project and Implementation Strategy Overview Table

Big Sandy Run upstream of the low-head dam near RM 3.25 is not attaining the WWH aquatic life use designation. The *Critical Area 1: Project Overview Table* provides a quick summary of identified projects needed to improve the biological conditions of this stream reach. The table summaries what needs to be done, where, and what problem (cause/source) will be addressed and includes identified projects at all levels of development (i.e. concept, need funding, in progress).

**Critical Area 1: Project Overview Table for
Town of Zaleski-Raccoon Creek HUC-12 (05090101 02 05)**

Goal	Objective	Project #	Project Title (EPA Criteria g)	Lead Organization (EPA Criteria d)	Time Frame (EPA Criteria f)	Estimated Cost (EPA Criteria d)	Potential/Actual Funding Sources (EPA Criteria d)
Urban Sediment and Nutrient Reduction Strategies *							
Altered Stream and Habitat Restoration Strategies *							
3, 6	1	1	Big Sandy Run Low-head Dam Removal	The Voinovich School of Leadership and Public Affairs at Ohio University and Raccoon Creek Partnership	Short	\$155,000	Ohio EPA §319
2, 5	2	2	Riparian Corridor Management	The Voinovich School of Leadership and Public Affairs at Ohio University	Medium to Long		Ohio EPA §319, Local Nonprofit Organizations
Agricultural Nonpoint Source Reduction Strategies *							
High Quality Waters Protection Strategies *							
Other NPS Causes and Associated Sources of Impairment *							

**(Ohio EPA, Approved 2014)*

4.2.2 Critical Area 1: Project Summary Sheet(s)

The Project Summary Sheets provided below were developed based on the actions or activities needed to restore instream habitat in the upstream reach of Big Sandy Run and increase biological scores to work toward attainment of the WWH use designation. These projects are short term projects. Medium and long term projects do not have a Project Summary Sheet, as these projects are not ready for implementation.

Critical Area 1: Project 1		
Nine Element Criteria	Information Needed	Explanation
<i>n/a</i>	Title	Big Sandy Run Low-head Dam Removal
Criteria d	Project Lead Organization & Partners	<ul style="list-style-type: none"> • Raccoon Creek Partnership • Voinovich School of Leadership and Public Affairs at Ohio University • Zaleski State Forest
Criteria c	HUC-12 & Critical Area	Town of Zaleski-Raccoon Creek HUC-12 (05090101 02 05)
Criteria c	Location of Project	Big Sandy Run (RM 3.25) in the Zaleski State Forest
<i>n/a</i>	Which strategy is being addressed by this project?	Altered Stream and Habitat Restoration Strategy
Criteria f	Time Frame	Short (1-3 Years)
Criteria g	Short Description	Remove the low-head dam (two approximately 3.5 feet tall structures) located near RM 3.25 on Big Sandy Run
Criteria g	Project Narrative	<p>The Big Sandy Run Low-head Dam is an impoundment on the small headwater stream of Big Sandy Run. The stream reach drains into Lake Hope and then into the Raccoon Creek mainstem.</p> <p>This low-head dam is a barrier to fish passage. The signature long-ear sunfish was one species collected downstream of the structure and not upstream. However, high QHEI scores suggest that upstream habitats would be able to support these and other important headwater fish species.</p> <p>Local sources indicate this structure was built between 1930-1940 to treat AMD. Currently, the reservoir is filled with sediment and monitoring shows no indication of AMD treatment resulting from the presence of this abandoned structure.</p> <p>Big Sandy Run is located within the Zaleski State Forest. State Forest representatives and</p>

Critical Area 1: Project 1 (cont.)		
Criteria g (cont.)	Project Narrative (cont.)	<p>members of the community are supportive of this project.</p> <p>The lead organization will publish a Request for Proposals to obtain bids for the removal of the low-head dam and dredging/disposal of approximately 25% of the accumulated sediment in the 0.1 mile impoundment upstream of the structure. Due to the remote location and extensive riparian corridor at the project site and small scale of the project, the stream channel will be left to restore through natural processes.</p>
Criteria d	Estimated Total Cost	Total Cost \$155,000
Criteria d	Possible Funding Source	Ohio EPA §319
Criteria a	Identified Causes and Sources	<p>Causes: Physical alterations and habitat alterations</p> <p>Source: Low-head dam</p>
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	<p>Big Sandy Run downstream of the low-head dam needs to increase IBI scores to 44 (currently 30) to meet WWH criteria.</p> <p>Big Sandy Run upstream of the low-head dam needs to increase IBI scores to 44 (currently 22) to meet WWH criteria.</p> <p>QHEI scores immediately upstream of the low-head dam need to increase to at least 60 (currently 51) to support WWH species.</p>
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	<p>This project should increase IBI scores upstream of the low-head dam to be similar to downstream sites (approximately 30). This will put the entire reach in <i>partial attainment</i> of WWH.</p> <p>This project should also increase QHEI scores immediately upstream of the low-head dam (SR0330) to at least 60, the value associated with attaining WWH criteria.</p> <p>After post-project monitoring, the objectives will be reevaluated to determine steps to reach <i>full attainment</i> status.</p>
	Part 3: Load Reduced?	<p>Sediment: 317 tons/year*</p> <p>Phosphorus: 278 lbs/year*</p> <p>Nitrogen: 560 lbs/year*</p> <p>*This is an estimate of load being removed from the river system.</p>
Criteria i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Baseline monitoring has already been completed at sites both upstream and downstream of the low-head dam. If the

Critical Area 1: Project 1 (cont.)		
<i>Criteria i (cont.)</i>	How will the effectiveness of this project in addressing the NPS impairment be measured? (cont.)	project is funded by the Ohio EPA, further monitoring will be conducted by Raccoon Creek Partnership and Ohio University to assess the success of the project. Grant recipients will not use any grant funding for post monitoring.
<i>Criteria e</i>	Information and Education	The project will be described in RCP Newsletters, website, and Facebook page. RCP will conduct pre and post construction tours for the public. Informational signage will be placed near the project site along the backpacking trail.

Works Cited

- Bowman, J. and Johnson, K. (2017). *2016 Stream Health Report*. Voinovich School of Leadership and Public Affairs at Ohio University. Retrieved December 16, 2017, from <http://watersheddata.com/>.
- HydroVIEW. (2017). Retrieved 26 November 2017 from <http://arcg.is/0Ke1Ge>.
- Institute for Local Government Administration and Rural Development (ILGARD). (2003). *Raccoon Creek Management Plan*. Retrieved on 20 August 2017 from raccooncreek.org.
- Johnson, Kelly S. (2007). Field and Laboratory Methods for Using the MAIS (Macroinvertebrate Aggregated Index for Streams) in Rapid Bioassessment of Ohio Streams. Department of Biological Sciences at Ohio University.
- Kinney, Chad J. (2006). A Comparison of Two Methods of Bioassessment in Streams. Electronic Thesis. Retrieved 16 December 2017 from <https://etd.ohiolink.edu/>.
- Lynch, M.J. (2014). *Surface Mining Control and Reclamation Act (SMCRA, US)*. Retrieved 13 October 2017 from <http://greencriminology.org/glossary/surface-mining-and-control-reclamation-act-smcra-us>.
- McCament, Ben. (2007). *Watershed Action Plan: Raccoon Creek Headwaters to above Hewett Fork Watershed*. Voinovich School of Leadership and Public Affairs at Ohio University. Retrieved 27 August 2017 from water.ohiodnr.gov.
- Ohio Department of Natural Resources (ODNR). (2017). *Zaleski State Forest*. Retrieved 12 October 2017 from <http://forestry.ohiodnr.gov/zaleski>.
- Ohio EPA. (1989). The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application. Division of Surface Water and Division of Water Quality.

Ohio EPA. (2002). Total Maximum Daily Loads for the Upper Raccoon Creek Final Report. Division of Surface Water.

Ohio EPA (Approved 2014). Nonpoint Source Management Plan Update. Nonpoint Source Program.

Ohio EPA. (2016). Ohio 2016 Integrated Water Quality Monitoring and Assessment Report. Division of Surface Water.

Ohio EPA (n.d.). Ohio Ecoregions. Retrieved 13 November 2017 from http://www.epa.ohio.gov/portals/35/Ohio_Ecoregions.pdf.

Raccoon Creek. (2017). Retrieved 16 December 2017 from <http://watersheddata.com/map/map.aspx?WaterShed=RC1>.

Raccoon Creek Partnership. (2015). Retrieved 13 November 2017 from <http://www.watersheddata.com/raccoon.aspx>.

Raccoon Creek Watershed Individual Projects. (2015). Retrieved 17 November 2017 from http://www.watersheddata.com/UserView_Report.aspx.

US Geological Survey (USGS), Gap Analysis Program (GAP). August 2011. National Land Cover, Version 2.

Vinton County. (n.d.). *Vinton County Villages*. Retrieved 11 October 2017 from <http://www.vintoncounty.com/vinton-county-villages.html>.

Vinton County Visitors Bureau. (2017a). *Iron Production in Vinton County*. Retrieved on 11 October 2017 from <http://vintoncountytravel.com/history/iron-production-in-vinton-county/>.

Vinton County Visitors Bureau. (2017b). *Lake Hope State Park*. Retrieved on 13 October 2017 from <http://vintoncountytravel.com/parks-and-recreation/lake-hope-state-park>.

Web Informatics and Mapping (WiM) Group. (2016). StreamStats v4 Beta Application (Version 4.0.4). [Computer Software]. Retrieved on 28 July 2017 from streamstats.sgs.cr.usgs.gov.

Appendix A: Acronyms and Abbreviations

A

AMD Acid Mine Drainage
AMDAT Acid Mine Drainage Abatement and Treatment

E

EWH Exceptional Warmwater Habitat

F

FAU Formazin Attenuation Unit

H

HABs Harmful Algal Blooms
HUC Hydrologic Unit Code

I

IBI Index of Biotic Integrity
ICI Invertebrate Community Index
ILGARD Institute for Local Government Administration and Rural Development

L

Lbs/day Pounds per Day
LRW Limited Resource Water

M

MAIS Macroinvertebrate Aggregated Index for Streams
 $\mu\text{S}/\text{mg}/\text{L}$ Microsiemens per Milligram per Liter

N

NPS Nonpoint Source Pollution

O

ODNR Ohio Department of Natural Resources
OEPA Ohio Environmental Protection Agency

P

ppm Parts per Million

Q

QHEI Qualitative Habitat Evaluation Index

R

RCIC Raccoon Creek Improvement Committee

RCP Raccoon Creek Partnership

RM River Mile

S

SMCRA Surface Mining Control and Reclamation Act

T

TMDL Total Maximum Daily Load

W

WAP Western Allegheny Plateau Ecoregion

WBP Watershed Based Planning

WiM Web Informatics and Mapping

WWH Warmwater Habitat

Appendix B: Index of Tables and Figures

Index of Tables

Table 1. Percentage of land use in the Town of Zaleski-Raccoon Creek HUC-12 (USGS, 2011).	11
Table 2. IBI scores in the Town of Zaleski-Raccoon Creek HUC-12 from 1995-2016 (Raccoon Creek, 2017).	13
Table 3. MAIS scores in the Town of Zaleski-Raccoon Creek HUC-12 from 2009-2016 (Raccoon Creek, 2017).	15
Table 4. QHEI scores in the Town of Zaleski-Raccoon Creek HUC-12 from 1995-2016 (Raccoon Creek, 2017).	15
Table 5. Causes and associated sources of NPS pollution in the Town of Zaleski-Raccoon Creek HUC-12 (Ohio EPA, 2016).	16
Table 6. Critical Area 1 - Fish community and habitat data.....	21
Table 7. Critical Area 1- Macroinvertebrate community data.....	22
Table 8. Critical Area 1- Chemical water quality data	23
Table 9. Causes/sources of non-point source pollution for Critical Area 1 (Ohio EPA, 2002; baseline project monitoring)	23

Index of Figures/Photos

Figure 1. Location of the Town of Zaleski-Raccoon Creek HUC-12 within the Raccoon Creek Watershed..... 5

Figure 2. Hope Furnace located within the Lake Hope State Park near Zaleski, Ohio. Photo credit: Brooke Sanderson (Ohio University)..... 6

Figure 3. Lake Hope is a popular destination for outdoor enthusiasts of all ages. Photo Credit: Brooke Sanderson (Ohio University) 7

Figure 4. The augmented reality sandbox is used to demonstrate watershed concepts to the public. Photo credit: Amy Mackey (Ohio University)..... 8

Figure 5. The interactive stream table brings the fish and macroinvertebrates of the Raccoon Creek Watershed to RCP events. Photo credit: Amy Mackey (Ohio University) 8

Figure 6. The physical and natural features of the Town of Zaleski-Raccoon Creek HUC-12 10

Figure 7. Land use within the Town of Zaleski-Raccoon Creek HUC-12 12

Figure 8. Biological sampling sites in the Town of Zaleski-Raccoon Creek HUC-12 (Raccoon Creek, 2017). 14

Figure 9. Low-head dam located in Critical Area 1: Big Sandy Run. Photo Credit: Brooke Sanderson (Ohio University) 17

Figure 10. Slow moving pool behind the low-head dam. This structure impounds water for approximately 0.1 mile upstream. Photo Credit: Brooke Sanderson (Ohio University)..... 17

Figure 11. Upstream and downstream (pictured) habitats include essential riffle/run/pool habitats. If removed, the pool behind the low-head dam will be restored to a natural flow regime. Photo Credit: Brooke Sanderson (Ohio University)..... 18

Figure 12. The four sampling sites along Big Sandy Run upstream and downstream of the low-head dam. Critical Area 1 includes Big Sandy Run upstream from Lake Hope and the riparian corridor..... 20

Figure 13. The Creek Chub is the most predominant fish species found in Big Sandy Run. Photo credit: Haldan Kirsch (Ohio University) 21

Figure 14. Ephemeroptera Ephemerillidae is a new family of mayfly found for the first time in the Raccoon Creek Watershed at Big Sandy Run sampling sites. Photo credit: Amy Mackey (Ohio University) 22