ABSTRACT

A BIOLOGICAL MONITORING INTERNSHIP WITH THE OHIO ENVIRONMENTAL PROTECTION AGENCY, DIVISION OF SURFACE WATER

by Rebecca Johnson Longsmith

The following report contains a summary of my experience interning as a Macroinvertebrate Sampling Intern with the Division of Surface Water at the Ohio Environmental Protection Agency. Based out of the Groveport Field Office in Groveport, Ohio, my internship consisted chiefly of assisting in the collection of macroinvertebrate samples from streams and their tributaries throughout the state. This macroinvertebrate data can be used by the agency to make policy decisions, direct enforcement activities, and locate areas for improvement and further study.

A BIOLOGICAL MONITORING INTERNSHIP WITH THE OHIO ENVIRONMENTAL PROTECTION AGENCY, DIVISION OF SURFACE WATER

An Internship Report

Submitted to the

Faculty of Miami University

in partial fulfillment of

the requirements for the degree of

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by

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Ch 1: Introduction

To satisfy the professional experience requirement for the Master of Environmental Science degree at Miami University, I served as a Macroinvertebrate Sampling Intern at the Ohio Environmental Protection Agency (Ohio EPA) from June-October, 2015. My duties included collecting quantitative and qualitative data about macroinvertebrate populations from study sites across the state. This report explains the main projects I worked on with a specific focus on the methods used, as well as the laws and policies that necessitated these projects.

Ohio EPA Background

The Ohio EPA was established in 1972 to consolidate several state programs previously housed in different departments (Ohio EPA, 2015a). The goal of the agency is "to protect the environment and public health by ensuring compliance with environmental laws and demonstrating leadership in environmental stewardship" (Ohio EPA, 2015a).

Figure 1: The five regional district offices of the Ohio EPA. Shown clockwise, the districts are Northwest, Northeast, Southeast, Southwest, and Central. These five districts are coordinated aby a Central Office located in Columbus, Ohio, as shown by the red star (Ohio EPA, 2015b).

The Ohio EPA is composed of both regulatory and non-regulatory divisions that are managed by a Central Office and five district offices (Figure 1). The regulatory divisions are tasked with ensuring compliance with environmental laws related to their respective areas of focus such as air, water, or waste management (Ohio EPA, 2015b). This is done through actions such as reviewing permit applications, responding to citizen complaints, monitoring environmental conditions, clarifying law and permit requirements, and addressing environmental law and policy violations (Ohio EPA, 2015a). Non-regulatory divisions provide support through financial assistance for environmental issues, education, technical assistance for businesses and communities, laboratory analysis, and hazardous spill cleanups (Ohio EPA, 2015a).

For my internship, I worked for the Ohio EPA's Division of Surface Water (DSW). The DSW employs around 240 full-time staff and 50 seasonal interns across the state (Ohio EPA, 2015c). The overall mission of the DSW is to "protect, enhance and restore all waters of the state for the health, safety and welfare of present and future generations," which extends to over 25,000 miles of streams and rivers, more than 5,000 lakes, ponds, and reservoirs, and 236 miles of Lake Erie shoreline (Ohio EPA, 2015c). To achieve this mission, DSW staff monitor aquatic health and enforce pollution prevention through permits, education, and technical assistance. In addition, the DSW enforces state and federal environmental laws, including the Federal Clean Water Act (CWA), the United States' primary legislation for the regulation of water pollution and the protection of surface water (USEPA, 2012a).

The Clean Water Act

The CWA was originally referred to as the Federal Water Pollution Control Act and was first enacted in 1948 (USEPA, 2015a). The Federal Water Pollution Control Act provided local and state governments with federal funds to address water pollution (Copeland, 2010). While the Federal government had some enforcement authority, it was only for interstate waters (Copeland, 2010). In 1972, the Act was amended to place a greater emphasis on federal involvement. This included a federal-state partnership for water pollution control, with the federal government responsible for developing guidelines and objectives and state governments responsible for implementation and enforcement (USEPA, 2012a). With these amendments the act became commonly known as the Clean Water Act. The three components of the CWA that were most relevant to my internship responsibilities included Section 303(c) Water Quality Standards, Section 303(d) Total Maximum Daily Loads and several federal funding provisions of the law.

Water Quality Standards

Section 303(c) of the CWA gives the USEPA the authority to review and approve water quality standards (WQS) that are set by individual states, territories, and authorized tribes (hereafter collectively referred to as "states") under 40 CFR Part 131 (USEPA, 2014). Under Section 510 of the CWA, the states are free to enact any requirements related to water pollution given that these requirements are no less strict than those of the CWA itself. These WQS are required to consist of four elements:

1. Designated use categories for waterbodies such as recreation, drinking water supply, and agricultural use.
2. Water quality criteria that can be used to protect designated use categories.
3. An antidegradation policy to maintain designated use categories and other high quality waters.
4. General policies that address issues for implementation of the WQS, such as low flow periods and mixing zones.
   (USEPA, 2012)

Ohio's WQS are codified under the Ohio Administrative Code (OAC) Section 3745 and the Ohio Revised Code (ORC) Chapter 6111 (Yoder, Rankin, and DeShon, 1986). As a state within the Great Lakes Watershed, Ohio also has additional requirements for its WQS under CFR Part 132 which identifies water quality standards, antidegradation policies, and implementation procedures for the Great Lakes.

Total Maximum Daily Loads

Section 303(d) of the CWA requires that each state identify waters that do not meet the WQS set by the state (USEPA, 2015b; USEPA, 2015c). To help ensure these impaired waters eventually meet the WQS, the states must develop a Total Maximum Daily Load (TMDL) for these waters. A TMDL is the calculated maximum amount (or "load") of each type of pollutant within a water body that can occur and still allow that water body to safely meet

WQS (Ohio EPA, 2015d; USEPA, 2015b). TMDLs also include the development of plans and strategies to restore these waters (Ohio EPA, 2015d; USEPA, 2015b).

Ohio EPA has developed a 12-step project-management-based process to calculate TMDLs for watersheds throughout the state that includes four broad overlapping phases: assessing waterbody health, developing restoration targets, implementing solutions, and monitoring progress (Figure 2).

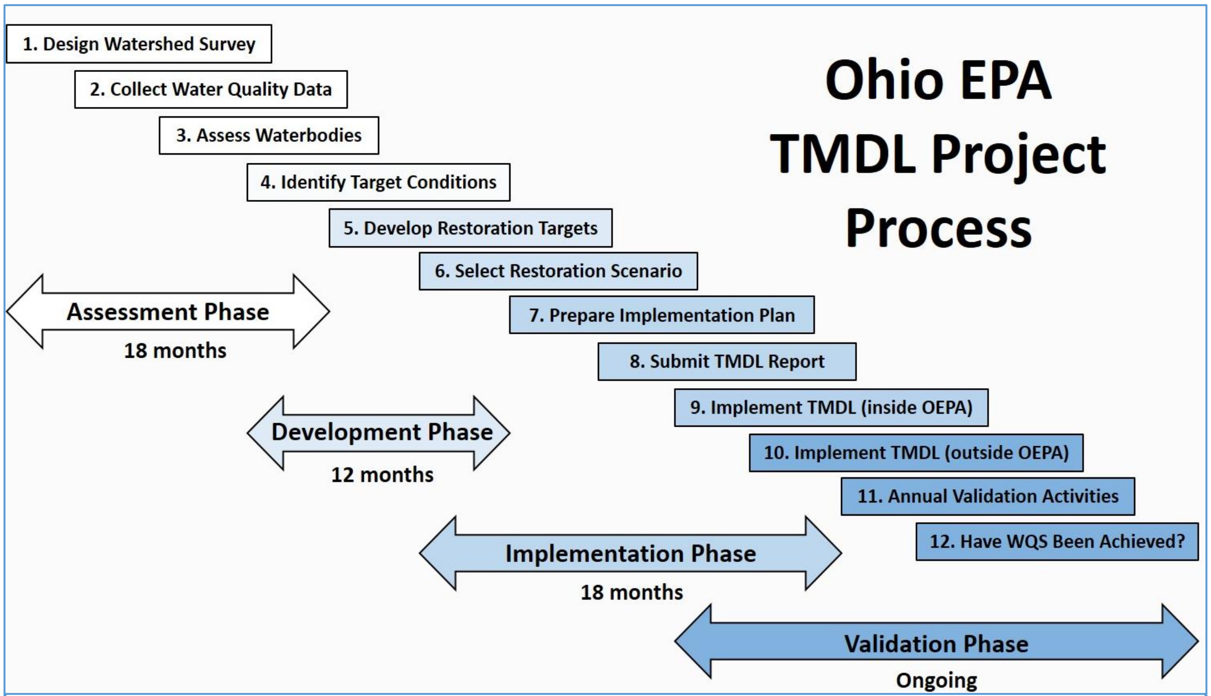

Figure 2: Overview of the Ohio EPA TMDL project process, showing all 12 steps and 4 overlapping phases. This process shows how TMDLs are developed by examining the specific characteristics of each watershed, resulting in individualized evaluations, restoration targets, and implementation plans (Ohio EPA, 2015d).

Federal Funding Provisions in the CWA

Funding for many projects related to or mandated by the CWA, such as TMDLs, can come from provisions within the CWA itself. The most prominent of these federal funding sources is the Clean Water State Revolving Fund (CWSRF). Established through revisions made to the Act in 1987 under 33 U.S. Code §1383, the CWSRF awards grants to states that can be combined with state funds and distributed within the state as low-interest loans for water infrastructure projects (USEPA, 2015d). These projects can include a wide range of activities such as building municipal wastewater facilities, constructing green infrastructure, and controlling nonpoint pollution sources. To date, over 37 billion federal dollars have been invested into the program (USEPA, 2015d).

The CWA also contains two additional funding programs focused on addressing water pollution under sections 319 and 106. The Section 319 Nonpoint Source Management Program provides grant funding to states for programs related to controlling nonpoint source pollution such as education, training, and monitoring (USEPA, 2013). In Ohio, these funds are distributed to local governments and nonprofits as subgrants for stream restoration and storm water management demonstration projects that focus on reducing nonpoint source pollution (Ohio EPA, 2014a).

A similar program, the Section 106 Water Pollution Control Grant Program, provides federal funds that can be used for many different water pollution prevention and control activities. (USEPA, 2015e). However, unlike Section 319, Section 106 funds can be used to address both point and nonpoint pollution sources and are used directly by the state instead of being distributed as subgrants. In 2006, additional funding was designated under Section 106 as part as a monitoring initiative to improve the data collection of state agencies on water quality across the country (USEPA, 2015f).

Ch 2: Biological Monitoring and Macroinvertebrate Sampling Methods

A major responsibility of the DSW is its water quality monitoring program. This program tracks the progress of the water quality of Ohio's streams and rivers (hereafter referred to collectively as "streams") towards the CWA's objective to, "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Clean Water Act of 1972). The DSW employs approximately 50 interns during the summer sampling season of June to October to aid in data collection of chemical, physical, and biological measurements (Ohio EPA, 2015c). My internship position focused on the biological component of the Ohio EPA's water quality monitoring program. This program is a part of the DSW's Ecological Assessment Section (EAS) located at the Groveport Field Office in Groveport, Ohio.

Biological Monitoring

Biological monitoring includes examining the prevalence, distribution, and condition of living organisms, with a focus on identifying certain species or taxa that are known to be indicators of either good or poor water quality conditions (Yoder et al., 1986). Ohio is recognized as a national leader in biological monitoring techniques and was one of the first states to develop an official assessment program (Tucker, 2015). Prior to the adoption of the Ohio EPA's biological monitoring program in 1990, most water quality assessment programs focused solely on physical and chemical measurements (Yoder et al., 1986). The specific mentioning of biological integrity within the CWA was one of the driving factors behind the development of the Ohio EPA's program (Yoder et al., 1986). The Ohio EPA also argues that biological monitoring allows for a more complete picture of water quality than other observations, as organisms are exposed to environmental conditions long-term that may not be reflected in a single chemical sample (Yoder et al., 1986). Fish and macroinvertebrates were chosen as the taxa to be used for sampling due to an existing wealth of knowledge of their life histories and environmental stress responses, as well as for the ease with which both can be sampled. The choice to include multiple taxa was made to increase the certainty in results, as well as to allow for the observance of responses seen in one type of organism that may not appear in the other type (Yoder et al., 1986).

Data Collection Methods

When assessing data and making policy decisions about Ohio's streams, the DSW considers both fish and macroinvertebrate community data together. Along with chemical data, biological data provides a comprehensive overview of the health of the water body being sampled at that moment in time. For each sampling site, data is collected for both fish and macroinvertebrates at the same approximate geographic coordinates within a single sampling season. However, the actual sampling of the two taxa occurs separately and is done by different crews specialized in either fish or macroinvertebrate sampling methods. Working alongside my mentor, Mike Bolton, my internship was focused on macroinvertebrates.

Specific sampling site locations along a stream are selected based on the objectives of the survey being completed and can include the following factors:

- Pollution source locations
- Current or unverified WQS status (designated use category)
- Historical data from the same or nearby sites
- Physical features, both natural and man-made

Other aspects taken into account when selecting sites include personnel, time, and resource constraints, proximity to other sampling locations, and accessibility factors such as topography, road access, and private property permissions (DeShon et al., 2015).

Fish:

For the fish sampling, three different electrofishing techniques are used, depending on the size of the waterway of each site.

- Medium streams (drainage areas typically between 150 and 500 mi^{2}) are sampled by electrofishing from a boat along a distance of 0.5 km (Figure 3; DeShon et al., 2015).
- Smaller streams (drainage areas < 20 to 150 mi^{2}), are sampled using either a wading or long-line electrofishing technique along a distance of 150-200 meters (Figure 4).

Figure 3: The electrofishing boat rig used by the Ohio EPA. Operators use a foot pedal on the bow of the boat to initiate the output of electric current. Current flows into the water from anodes suspended from a boom that extends out in front of the bow (Photo by Rebecca Long).


Figure 4: This vessel, a type of roller pram commonly referred to as a "Rollerbeast", is used for wading electrofishing. A creation of the Ohio EPA, the Rollerbeast is composed of a metal frame with two plastic barrels for buoyancy. Electric current flows into the water directly from the anodes located on the rim of the net. Long-line electrofishing, done in small streams not deep enough for the wading method, uses a similar net-shocking set-up, only with the generator kept on land and connected with a long extension cord or "line" (DeShon et al., 2015).

For all types of sampling, fish are stunned using a non-lethal DC electric current and retrieved with nets. As fish are collected, they are placed into a plastic tank filled with water from the site, referred to as a "live well" (DeShon et al., 2015). Water within the live well is replaced frequently throughout the collection period, either by hand or using a pump, to ensure adequate oxygen availability for the fish. Specimens are then identified to the species level, counted, weighed, and released

(DeShon et al., 2015). Individuals that are unable to be identified are preserved and taken back to the laboratory for further analysis.

Macroinvertebrates:

To sample macroinvertebrates, both qualitative and quantitative data collection methods are used. Qualitative sampling is done by collecting as many diverse macroinvertebrates as possible from the site. This is done by searching in all of this different types of living spaces present in the stream habitat, which are referred to as microhabitats. Examples of the types of microhabitats within a stream include the underside of rocks, clay beds, grassy banks, and tree root wads. For the quantitative sampling, five Hester-Dendy multiplate artificial substrate samplers (HDs) are placed at each site attached to a concrete block buried in the substrate (Figure 5). The HDs are constructed using 1/8 inch Masonite hardboard cut into eight 3 inch square plates and strung onto an eye-bolt separated by various widths using nylon spacers (DeShon et al., 2015). The varied spacing of the Masonite squares mimics the types of microhabitat spaces created by rocks and other stream debris and is designed to attract macroinvertebrates. After six weeks, the HD samplers are collected and the accumulated specimens preserved for later identification to species level (DeShon et al., 2015). As my internship was focused specifically on macroinvertebrate sampling, both methods will be described in greater detail later in the chapter.

Figure 5: Hester-Dendy multiplate artificial substrate samplers. Each sampler block is composed of eight pieces of Masonite hardboard separated in various widths by nylon spacers (Photo by Rebecca Long).

Biological and Habitat Indices

The Ohio EPA quantifies assessments of aquatic life with the use of three biological indices. Two of these indices, the Index of Biological Integrity (IBI), and the Modified Index of Well-Being (Iwb), evaluate fish populations, while the remaining index, the Invertebrate Community Index (ICI), evaluates macroinvertebrate populations.

A biological index is a single number or score assigned to a biological community by compiling the scores of individual aspects, called metrics, of that community. Though the types of metrics used depend on the particular index, they are selected specifically because they have shown to be responsive (i.e. change in score) to whatever characteristic the index is created to measure (Yoder et al., 1986). For example, the ICI is composed of 10 different metrics:

1. Total Number of Taxa
2. Total Number of Mayfly Taxa
3. Total Number of Caddisfly Taxa
4. Total Number of Dipteran Taxa
5. Percent of Organisms Collected that are Mayflies

6. Percent of Organisms Collected that are Caddisflies
7. Percent of Organisms Collected that are Tanytarsini Midges
8. Percent of Organisms Collected that are Dipterans and Non-Insects
9. Percent of Organisms Collected that are Tolerant Organisms
10. Total Number of Qualitative Ephemeroptera, Plecoptera, and Trichoptera (EPT) Taxa

(DeShon et al., 2015)

Each of these 10 metrics can receive a score of 0, 2, 4, or 6 points. Actual criteria for each point value differs for the individual metrics as well as with changes in stream size or drainage area (Figure 6). Criteria delineations are determined by the observation of trends in undisturbed streams throughout Ohio, called reference sites. The metric scores are then all added together (unweighted) for a maximum score of 60, with the higher the score, the healthier the macroinvertebrate community (Yoder et al., 1986).

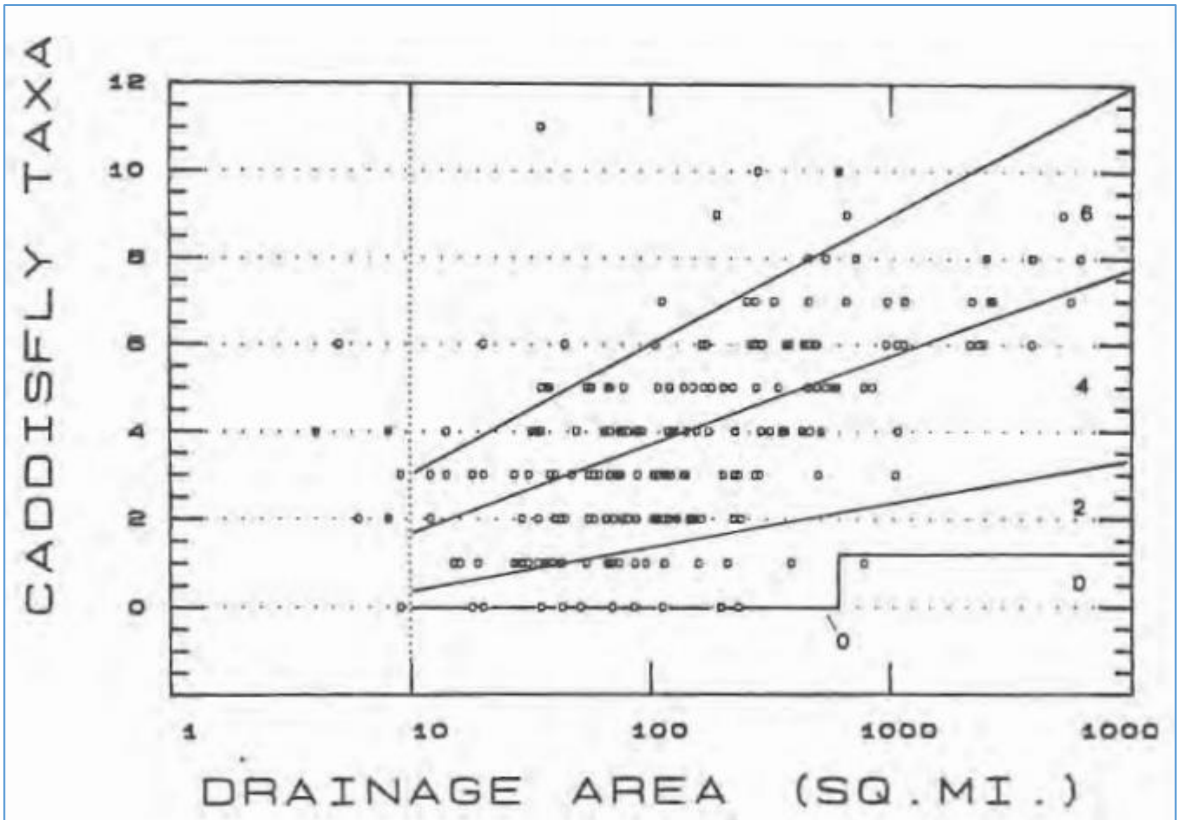

Figure 6: Score Determination Graph for Metric 3 of the ICI. This graph illustrates how metric score criteria differ with drainage area. The number of caddisfly taxa is shown on the left-hand side of the graph, the drainage area on the bottom, and the score (0, 2, 4, or 6) on the right-hand side. The sloping lines indicate the boundaries between the point designations, with the general trend that the greater the drainage area, the greater number of caddisfly taxa needed to achieve a higher score. Reference sites, used to determine the delineation between point ranges, are represented by the scatterplot points (Yoder et al., 1986).

In addition to these three biological indices, the Ohio EPA has also developed a habitat index to evaluate the physical habitat of aquatic organisms called the Qualitative Habitat Evaluation Index (QHEI). Operating in a similar way to a biological index, a habitat index assigns a score to each site sampled using different metrics that look at different aspects of the physical condition of the area (Rankin, 1989). The QHEI was created to be used alongside the IBI to provide supplemental information on the effects of habitat on biological integrity (Rankin, 1989). All four indices used by the Ohio EPA provide means to qualitatively assess biological communities and stream health.

Evaluation of Water Quality

As part of federally mandated WQS requirements, the Ohio EPA has developed criteria with which to classify the quality of different streams as well as what types of activities or uses they are suited for. These different classifications are referred to as designated uses and are codified into Ohio law under OAC §3745 (USEPA, 2012; Ohio EPA, 2014b). The three broad categories of use designations include:

- **Protection of Aquatic Life:** describes the type of organisms it is capable of supporting. Only one aquatic life use can be assigned per waterbody.
- **Protection of Water Supplies:** describes what kind of water resource application the stream is suitable for, such as agricultural. More than one water supply use designation can be assigned.
- **Protection of Recreational Activities:** describes the type of recreational activities that occur within the stream, such as swimming. More than one recreational use can be assigned.

(Table 1; Ohio EPA, 2014b)

Use designations are assigned using both biological (fish and macroinvertebrate) and chemical data (Ohio EPA, 2014c).

The designated use categories most relevant to my internship were the aquatic life use designations. In all of the projects I worked on, each stream sampled was evaluated to measure if it met the criteria of its assigned aquatic life use (called the attainment status) using three different levels: full attainment, partial attainment, and non-attainment (Ohio EPA, 2014b). The purpose of this was to see where water quality improvements could be made and to make enforcement and policy decisions such as listing a stream as a prioritized impaired water. Through improvements made with the implementation of TMDLs and other restoration programs, the Ohio EPA has a goal for 80% of principal streams (drainage area between 20 and 500 mi^2) and 100% of large rivers (drainage area greater than 500 mi^2) to meet full attainment status of their assigned aquatic life use by 2020 (Ohio EPA, 2014b).

Table 1: Designated use categories assigned to waterbodies as part of the WQS requirements. The three broad categories of use designations are aquatic life uses, water supply uses, and recreation uses.	
Designated Use Category	Description
Aquatic Life	
Warmwater Habitat	Supports typical populations of warmwater fish and macroinvertebrates
Exceptional Warmwater Habitat	Supports very diverse populations of warmwater fish and macroinvertebrates
Modified Warmwater Habitat	Supports only limited and tolerant populations of warmwater fish and macroinvertebrates
Seasonal Salmonid Habitat	Supports passage of salmonid fish populations, seasonal designation applicable May-October
Coldwater Habitat	Supports either native coldwater fish and macroinvertebrates or ODNR trout stocking
Limited Resource Water	Supports only severely degraded or nonexistent fish and macroinvertebrate communities
Water Supply	
Public	Suitable for public consumption after treatment
Agricultural	Suitable for crop and livestock use without treatment
Industrial	Suitable for commercial or industrial use with or without treatment
Recreation	
Bathing Waters	Used heavily for swimming
Primary Contact	Used for full-body water contact recreational activities
Secondary Contact	Used rarely for full-body water contact recreational activities

In addition to aquatic designated use categories, the Ohio EPA has also developed a rating system to describe the biological integrity of streams, referred to as narrative evaluations. Narrative evaluations are assigned based on IBI scores for fish and ICI or qualitative data for macroinvertebrates (Yoder et al., 1986). These narrative evaluations correspond with the aquatic life use designations and include eight levels:

- **Exceptional** (Meets Exceptional Warmwater Habitat expectations)
- **Very Good** (Just below Exceptional Warmwater Habitat expectations)
- **Good** (Meets either Warmwater or Coldwater Habitat expectations)
- **Marginally Good** (Just below either Warmwater or Coldwater Habitat expectations)
- **Fair** (Between Warmwater/Coldwater and Modified Warmwater Habitat expectations)
- **Low Fair** (Below Modified Warmwater Habitat expectations)
- **Very Poor** (Below Limited Resource Waters expectations)

(DeShon et al., 2015)

Sample Collection

During my internship, my mentor and I collected macroinvertebrate samples that were used to determine ICI scores and narrative evaluations for each stream sampled. Our data collection was done using two different methods: qualitative sampling and quantitative sampling.

For streams with a drainage area of less than 20 mi^2, only qualitative sampling was used. Quantitative methods are not used in this size stream because it has been shown to produce inaccurate ICI scores. As the ICI used in quantitative methods was developed for use in larger streams, the natural differences seen in macroinvertebrate communities that occur in smaller streams (such as the tendency for species diversity to decrease with stream size) can cause ICI scores to indicate a lower quality community than is actually present (DeShon et al., 2015). For streams with drainage areas greater than or equal to 20 mi^2, both qualitative and quantitative sampling were used (DeShon et al., 2015). Both data collection methods have advantages that provide important insights about the condition of the macroinvertebrate community at a site, but I also observed that each method has its limitations (Table 2).

Table 2: An overview of the advantages and disadvantages of the two types of macroinvertebrate sampling methods used by the Ohio EPA.

	Qualitative Sampling	Quantitative Sampling
Advantages	• Macroinvertebrates collected from natural substrates • Collection occurs in all microhabitats • Can be completed in a single site visit	• Provides a quantitative evaluation of stream health • Less susceptible to inconsistencies due to human error
Disadvantages	• Cannot provide a quantitative evaluation of stream health • Requires normal stream flow with low or absent turbidity • Possibility of inconsistencies due to human error	• Macroinvertebrates collected from an artificial substrate • Collection occurs in single microhabitat • Requires a six-week colonization period • Can be disrupted by water-level changes or removal/destruction by the public

Whether using qualitative or quantitative methods, we examined only the aquatic life stage (not terrestrial life stage) of the macroinvertebrate. This is based on the premise that the aquatic life stages of the macroinvertebrates reflect past and present conditions of the stream (DeShon et al., 2015). Because there is no way to verify if terrestrial life stages of organisms originated from a particular stream or not, they were not included in the sample. Organisms that were caught by coincidence including nonaquatic organisms (such as ants) or organisms other than macroinvertebrates (such as salamanders) were also not included.

Macroinvertebrates sometimes leave behind evidence of their presence such as tracks or discarded shells or cases that I would find while sampling (Figure 7). However, as this type of evidence can remain long after the organism is gone, live specimens must be present to be included in the data for the sample. (DeShon et al., 2015).

Figure 7: An example of the type of macroinvertebrate evidence a researcher might find left behind, using the *Limnephilid* caddisfly. Pictured from top to bottom is the caddisfly in its self-constructed case, the caddisfly without its case, and the case without any inhabiting caddisfly. Caddisflies vacate their old cases as they grow to build new cases, so empty cases can sometimes be found on their own. (Photo by Hodges, 2015).

In addition to the quantitative and qualitative sampling of macroinvertebrates, we also collected "fresh-dead" shells of freshwater mussels if found at a site. Fresh-dead means that the mussels had not been dead for more than one field season to ensure their presence reflected current, not past, water conditions (DeShon et al., 2015).

Fresh-dead shells can be identified in a number of ways including the presence of decomposing flesh, connection between the two shells (called the hinge) still being intact, an unweathered outer shell, and a shiny inner shell lining (called the nacer) (Figure 8; DeShon et al., 2015). Under ORC §1533, it is unlawful to collect live mussels in Ohio, but any live specimens found could still be documented for data collection in our field notes or with photographs for later identification (DeShon et al., 2015).

Figure 8: An example of what a fresh-dead mussel shell looks like, displaying both the inside (left) and outside (right) of the shell. The shiny nacer and unweathered outside of the shell both indicate this is a fresh-dead mussel shell (Bolton, 2015a).

Qualitative Sampling

Qualitative sampling is used to determine the types of macroinvertebrates present in a stream. It does not, however, quantify density or abundance. Data collected through qualitative sampling is used for metric 10 of the ICI, as well as for determining narrative evaluations when completing an ICI is impractical (DeShon et al., 2015).

Qualitative sampling was conducted by using a dip net and forceps to catch macroinvertebrates. During sampling, my mentor and I took notes concerning both the general characteristics of the stream, as well as the types of macroinvertebrates caught and the predominant taxa present (Figure 9, Figure 10). Sampling occurred in all identified microhabitats throughout the four distinct areas of each stream: riffles, runs, margins, and pools (Figure 11). As an intern, I sampled the margins and pools while my mentor sampled the more oxygen-rich (normally more diverse) riffles and runs. The types of microhabitats I typically sampled in the margins included tree root mats, cut banks, and shallows. The qualitative sampling process, or “picking” as it is colloquially referred to, continued until no new species of macroinvertebrates could be located after repeated examinations. This usually took my mentor and me from 30 minutes to two hours.

Stream ____________ Station ID ________ RM ______ Date Collected ________

Location ______________________________ Date Set ________

Lat./Long. ____________ Wpt# ________ Photo # ______ Collected By ________

Sampling Method: HD(No.______) - DN/HP - Surber - Grab (Type______) - Other__________

HD Sampler Site: Depth (Set) ______ Depth (Ret) ______ Canopy ______ Current (Set) ______ Current(Ret)______

HD Condition: Disturbed Yes/No Comment:__________

Debris Yes/No Comment:__________

Silt/Solids None - Slight - Moderate - Heavy

DN/HP Sampling: Start ________ End ________ Habitats: Pool - Riffle - Run - Margin - Backwater

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Physical Characteristics

Flow Condition:	Flood - Above Normal - Normal - Low - Interstitial - Intermittent - Dry								
Current Velocity:	Fast	-	Moderate	-	Slow	-	ND		
Channel Morphology:	Natural - Channelized - Channelized (Recovered) - Impounded								
Bank Erosion:	Extensive	-	Moderate	-	Slight	-	None		
Riffle Development:	Extensive	-	Moderate	-	Sparse	-	Absent		
Riffle Quality:	Good	-	Fair	-	Poor		Embedded:	Yes/No	
Clarity:	Clear	-	Murky	-	Turbid		Temp:______		
Color:	None	-	Green	-	Brown	-	Grey	-	Other (________)
Canopy:	Open	-	75%	-	50%	-	25%	-	Closed

Substrate Characteristics

	Pool	Riffle	Run
Bedrock( )			
Boulder( )			
Rubble( )			
Coarse Gravel			
Fine Gravel			
Sand			
Silt			
Clay/Hardpan			
Detritus			
Peat			
Muck			
Other( )			
Macrophytes			
Algae( )			
Artifacts( )			
Compaction(F,M,S)			
Depth(Average)			
Width(Average)			

Predominant Land Use (L,R,B)

Forest	Open Pasture	Wetland
Shrub	Closed Pasture	Other
Old Field	Urban	( )
Rowcrop	Residential/Park	
Industrial	Mining/Construction	

Predominant Riparian Vegetation Width

Left	Right	Type
		Large Trees
		Small Trees
		Shrubs
		Grass/Weeds
		None

Margin Habitat

Undercut Banks	Root Mats
Grass	Water Willow
Shallows	Clay/Hardpan
Rip Rap	Bulkhead
Other( )	

Margin Quality: Good - Fair - Poor

Figure 9: The front side of the qualitative data collection sheet. This side of the collection sheet is where notes about general information, physical characteristics, composition, and the surroundings of the stream are taken (DeShon et al., 2015).

Biological Characteristics

% Riffle ________

Predominant Organisms: ____________________

Other Common Organisms: ____________________

Density: High - Moderate - Low

Diversity: High - Moderate - Low

% Run ________

Predominant Organisms: ____________________

Other Common Organisms: ____________________

Density: High - Moderate - Low

Diversity: High - Moderate - Low

% Pool ________

Predominant Organisms: ____________________

Other Common Organisms: ____________________

Density: High - Moderate - Low

Diversity: High - Moderate - Low

% Margin ________

Predominant Organisms: ____________________

Other Common Organisms: ____________________

Density: High - Moderate - Low

Diversity: High - Moderate - Low

Other Notable Collections: ____________________

Comments: ____________________

Evidence of Pollution: ____________________

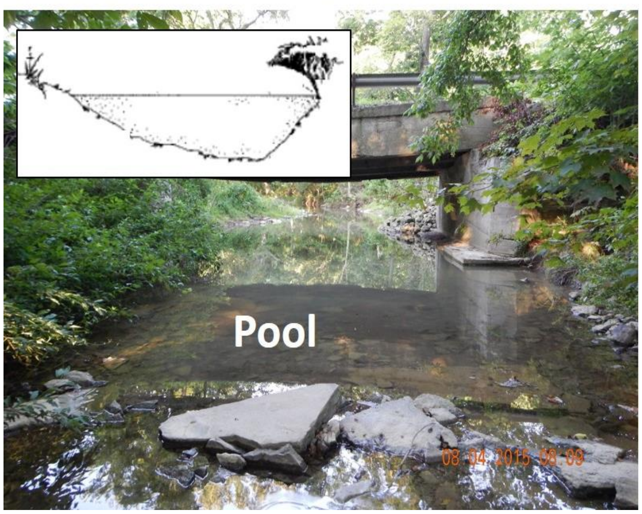
Potential Pollution Sources: ____________________

Predominant Taxa	**Overall Density**	**Field Evaluation**

Figure 10: The back side of the qualitative data collection sheet. This side of the collection sheet is where notes about the organisms collected within each microhabitat are taken (DeShon et al., 2015).

Riffle areas of a stream have a rapid water current and a shallow depth, with the water surface visibly broken by rocks and other objects in the stream

Run areas of a stream have a rapid water current, but are deeper than riffles with no breaks in the water surface. Runs are often located downstream of riffles at a narrow portion of the stream.



Pool areas of a stream have a slow current and often appear completely unmoving. Deeper than riffles and runs, pools have an unbroken water surface.

Figure 11: The differences between riffle, run, and pool areas of a stream. For each stream region, the photo shows an example of that type of area while the diagram displays a generalized conceptual cross-section. Margin areas (not individually pictured) are present along the entire length of a stream where the banks meets the water (Ohio EPA, 2006).

I conducted the qualitative sampling at each site by using the following steps outlined in the Ohio EPA field sampling and laboratory methods manual (DeShon et al., 2015):

1. General notes about the site were made, water temperature was taken, and pictures of both the upstream and downstream view of the site were taken.
2. The target microhabitat was agitated using the feet of the sampler or a Tri-net "Indestructible"® brand dip net by scraping and turning over rocks and other objects such as roots to detach any present macroinvertebrates (Figure 12).
3. The dip net was swept back and forth through the water in a figure-eight motion capturing all of the stirred-up macroinvertebrates, substrate, and debris in that area.
4. The net was rinsed of excess sediment by dunking in the stream before contents was transferred to a shallowly-filled white pan of water for examination (Figure 13).
5. Individual macroinvertebrates were removed from the pan using forceps or pipettes, with the goal of obtaining one example of each species of macroinvertebrate present.
6. Forceps were used to catch macroinvertebrates unable to be caught using nets, located by turning over rocks, and on or within woody debris
7. The macroinvertebrates were placed into a jar of 95% ethanol for preservation and later analysis.

Figure 12: Tri-net "Indestructible"® brand dip net used for qualitative sampling. The net contains muslin sides with a 500 micron netting bottom (Neobits.com, 2015).

Figure 13: The white pan used for picking organisms out of stream debris. The contrast provided the white bottom makes organisms easier to see (DeShon et al., 2015).

Some types of macroinvertebrates are very specialized and can be found only in specific microhabitats, so it was important for us to thoroughly sample all identified microhabitats at a site. For example, the larvae of the *Lype* genus of caddisflies is only found on aged and partially decaying wood debris, while organisms such as the *Stenacron* genus of mayflies can appear in almost all types of microhabitats (Figure 14). As an intern, it was sometimes difficult for me to find the more specialized organisms that can be harder to locate. I found that familiarity with the microhabitats and types of macroinvertebrates that can be found is extremely important for this type of field work. My mentor, Mike Bolton, has had over 30 years of experience in the position and would frequently find organisms I may have missed until I was more familiar with what to look for.

Figure 14: A member of the *Stenacron* genus of mayflies, one of the most common macroinvertebrates I found during sampling. *Stenacron* can inhabit many types of microhabitats (Luk, 2009; Schwiebert, 2007).

Quantitative Sampling

The quantitative sampling method enables the quantification of species present in a stream. This method assigns a numerical value to a stream's macroinvertebrate community through use of the ICI by providing data for metrics 1-9 (DeShon et al., 2015).

Quantitative sampling was conducted using five Hester Dendy traps (HDs) weighed down by a cinder block within the current of the stream and left for at least 6 week to be colonized. Whenever possible, the HDs were placed within the run section of the stream to provide adequate current speed and water depth (DeShon et al., 2015). At the time of collection of the HDs, my mentor and I also completed qualitative evaluations for each site. While the quantitative sampling method provides the data needed for metrics 1-9 of the ICI, the qualitative data is needed for metric 10 (DeShon et al., 2015).

I conducted the quantitative sampling at each site by using the following steps outlined in the Ohio EPA field sampling and laboratory methods manual (DeShon et al., 2015):

1. A site was selected for HD placement by observing current and water depth. The water level needed to be high enough to completely cover the HDs when placed, with a target current speed of between 0.7 and 1.5 feet per second.

2. A shallow hole was dug to secure the traps, just deep enough for the top of the block to sit level with the natural substrate. Five HD samplers were placed within the stream.

3. A flowmeter was used to measure water velocity and height above the HDs (Figure 15).

4. A flag marker was placed in a visible location on the bank (such as a tree or bush) and trap placement was noted both with a GPS and diagrams drawn in a logbook.

5. After the six week period had elapsed, the traps were retrieved. Each trap was cut away from the concrete block and slid into a container while still underwater to minimize any loss of macroinvertebrates from the sample.

6. Excess water was drained from each container, and enough 37% formalin was added to create a ten percent solution to preserve the contents of the HD's until they could be cleaned and processed back in the lab.

Figure 15: Use of a flowmeter in a stream. The sensor at the base of the pole is connected to a monitor that displays the speed of the stream current in feet per second. The flowmeter pole doubles as a depth measuring tool and is marked off in increments of either inches or centimeters (DeShon et al., 2015).

In some instances, we were unable to complete the quantitative evaluation due to some disruption of the samplers such as human disturbance or water level changes. Depending on the time in the field season, the importance of that particular sampling site, and the funding available, the samplers may either be reset to be collected later on that season or the following season, or be eliminated from the study with only qualitative data being used instead (Bolton, 2015b). Low water levels occurred at three of our sampling sites and in all instances it was decided to remove the quantitative samplers and to collect qualitative data only due to the limited time we had left in the sampling season.

Sample Cleaning

Upon our return to the Groveport Field Office Laboratory, the samples were prepared for processing using the method outlined in the Ohio EPA field sampling and laboratory methods manual (DeShon et al., 2015). While most of my internship duties were performed alongside my mentor, sample cleaning was performed only by interns to allow staff members more time for their other in-office duties. For the cleaning, all of the five HD's in each sample were disassembled within a bucket of water and every plate was examined for easily damaged organisms. Easily damaged organisms, such as bryozoans or freshwater sponges, were kept intact by using a scalpel to remove a thin sliver of the plate containing the organism to be placed in the sample jar. All other organisms were removed by scraping the plates against each-other within the bucket of water, which was run through both 30 (0.589 mm openings) and 40 (0.425 mm openings) U.S. Standard Testing Sieves stacked on top of each other over a sink (Figure 16). The contents of the 30 sieve was then placed into the sample jar, while the smaller particle size contents of the 40 sieve was placed into a smaller sample vial. Both jars were topped off with 70% alcohol for preservation. Samples were then labeled and set aside until they could be processed. After processing, samples remained in the lab indefinitely for future reference.

Figure 16: Water used to clean samplers is run through 30 and 40 mesh sieves to trap all organisms and debris (Newark, 2015).

Laboratory Processing

Though not part of my duties as an intern, laboratory processing of samples is one of the most important parts of the macroinvertebrate monitoring process. While basic organism identification occurs in the field, particularly when doing qualitative sampling, the small-scale differences between taxa and species of macroinvertebrates requires observation under a microscope. This process, however, could prove impractical if all organisms collected during the quantitative sampling were identified. To solve this problem, the Ohio EPA has set minimum guidelines for processing to ensure a representative sample is identified. One eighth of the sample must be viewed under a microscope, and a minimum number of individuals must be identified in three different taxa that tend to be present in large numbers (midges, mayflies, and caddisflies) (DeShon et al., 2015).

For quantitative samples with high organism density, subsamples are used to make processing more manageable. First, the sample is poured into a white pan for inspection using the naked eye, a magnifying lens, or a low power of a dissecting microscope depending on organism size. As many different taxa as possible are removed, which is referred to as the "pre-pick." (DeShon et al., 2015). The goal for the pre-pick is to have all taxa present in the sample accounted for, so as not to miss low density taxa that may be overlooked in the subsampling (DeShon et al., 2015). The exception to this rule is the midge taxa, which are difficult to identify without higher magnification due to their small size.

Samples are split into subsamples using a clear Folsom sample splitter (Figure 17). The sample is placed into the splitter drum, rocked back and forth for even distribution, and then rotated downward so that the drum opening splits the sample into the two containers located below (DeShon et al., 2015). Each subsample is referred to as a "cut" and can be subsampled multiple times. For example, the first subsamples made are referred to as ½ cuts as they are each half of the sample. Subsampling one of the 1/2 cuts further results in a 1/4 cut, which can then be subsampled into a 1/8 cut and so on. The number of cuts needed to reduce the number of organisms to a manageable size for processing depends on the sample density. By identifying and counting organisms in a cut, extrapolations can be made about the density and abundance of organisms for the overall sample (DeShon et al., 2015).

Figure 17: A Folsom sample splitter is used to create subsamples of macroinvertebrates. All components are clear to ensure adequate distribution of the sample before splitting (Anderson, 2004).

<u>Organism Identification in the Lab:</u>

Whenever possible, organisms are identified to the species level. When organisms are damaged, taxonomy is incomplete, or identification to species level is impractical, they may be identified to only higher levels such as family or genus (DeShon et al., 2015). To ensure consistency, the Ohio EPA has designated official taxonomic keys for determining the scientific name of each organism identified. The keys used vary by taxa and are described in the Ohio EPA field sampling and laboratory methods manual (DeShon et al., 2015).

One of the most important ways identifying macroinvertebrates helps in determining water quality is that the types of species present in a stream can give researchers an idea of how degraded it is. This is because some species are able more able to tolerate the presence of pollution, toxins, and other types of degraded conditions than others (DeShon et al., 2015). The Ohio EPA has classified organisms based on existing literature by their ability to survive in these types of conditions using six different tolerance designation:

- Intolerant
- Moderately Intolerant
- Facultative
- Moderately Tolerant
- Tolerant
- Very Tolerant

Organisms identified as *intolerant* or *moderately intolerant* are considered to be members of “sensitive” taxa, while those identified as *moderately tolerant, tolerant, or very tolerant* are considered “tolerant” taxa (DeShon et al., 2015). To factor tolerance designations into a quantitative evaluation of a stream’s water quality, the percent of organisms in a sample that are in tolerant taxa is used as metric 9 of the ICI (DeShon et al., 2015).

Ch 3: Survey Projects

Because it is impractical to sample all of Ohio's streams annually, the Ohio EPA samples only a small portion every field season. Each area sampled is referred to as a survey. In 1990, the DSW developed a plan, referred to as the Five-Year Basin Approach, to systematically and routinely survey all areas of Ohio within five years (Ohio EPA, 2014d). To determine which areas to survey, the Ohio EPA used a system that divides Ohio based on the drainage areas of the state's streams. This system is called the Hydrologic Unit Code (HUC) system, which was developed by the United States Geologic Survey (USGS) and is used across the United States (USDA, 2015). Divisions are made using six different levels that divide land based on stream drainage area into successively smaller areas: region, subregion, basin, subasin, watershed, and subwatershed. For database purposes, each individual unit is assigned a unique numerical code (the HUC) (Table 3). The HUC is similar to a street address because it tells the location of the unit in question. The same way a street address includes the city and state that the street is located in, HUC codes identify what larger divisions a unit is a part of (e.g. what region a subregion is in). This is done by separating the HUC into two-digit sections, with each section representing a division level. For example, the first two digits of the HUC represent what region the unit is in, the second two represent the subregion, the third two represent the basin, and so on.

Table 3. Summary of the six levels of HUC system. The example below shows the name and HUC of successively smaller areas, starting with the Ohio River Region. Each subsequent level is a smaller area within the previous level (USDA, 2015; USGS, 2015).

Division Name	HUC Digit Length	Units Nationwide	Average Size (mi2)	Example Name	Example HUC
Region	2	21	177,560	Ohio	**05**
Subregion	4	222	16,800	Upper Ohio	05**03**
Basin	6	352	10,596	Upper Ohio-Little Kanawha	0503**02**
Subbasin	8	2,149	700	Upper Ohio-Shade	050302**02**
Watershed	10	22,000	227	East Branch Shade-Shade	05030202**03**
Subwatershed	12	160,000	40	Horse Cave Creek	0503020203**01**

Ohio's original Five-Year Basin Approach divided the state into 25 sections for routine monitoring based on the subbasin units – generally referred to as HUC 8. Due to budgetary constraints that have arisen since the 1990 five-year plan was developed, a complete state-wide routine monitoring cycle currently takes more than 10 years to complete (Ohio EPA, 2014d). While the DSW still refers to and follows the general outline of the Five-Year Basin Approach, annual surveys now cover less area identified by the HUC 12 subwatershed areas, also called Watershed Assessment Units (WAU) by the Ohio EPA (Ohio EPA, 2014d). Because funding resources vary from year to year, Ohio EPA updates its routine monitoring schedule based on predicted funding in every biennial Ohio Integrated Water Quality Monitoring and Assessment Report (Ohio EPA, 2014e; Figure 18).

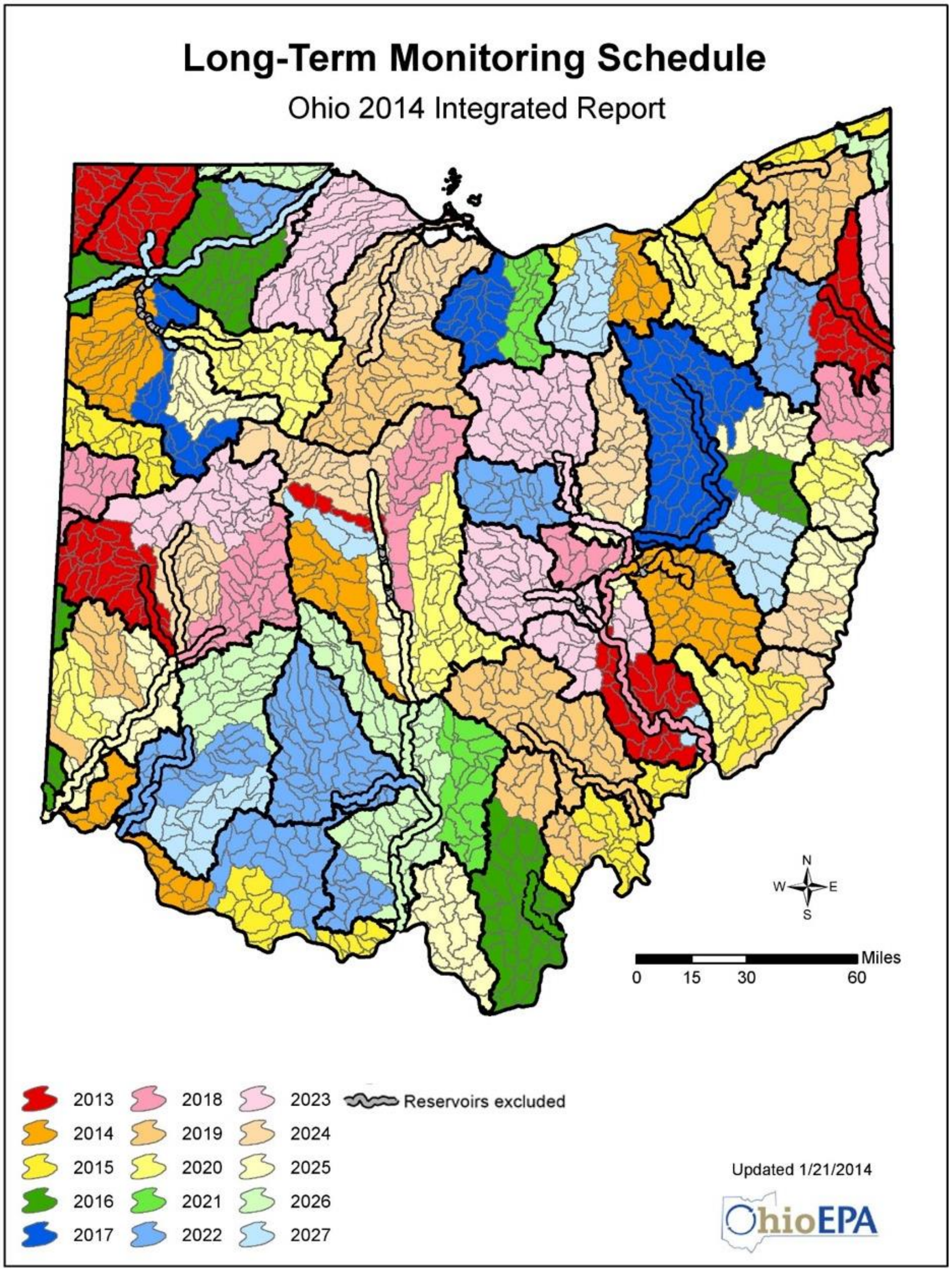


Figure 18: Map displaying the DSW's long term routine stream monitoring schedule. The bold black lines mark the boundaries HUC-12 basins, while the grey lines mark the boundaries of sub-watersheds. Reservoirs, marked by parallel black lines, are not include in sampling (Ohio EPA, 2014e).

On average, the DSW reports that it currently samples between five to seven areas of the state each year (Ohio EPA, 2014d). These routine monitoring assessments, which are referred to as biosurveys, are interdisciplinary studies that look at both biological and water quality (chemical and physical) data. This routine monitoring process has been integrated into the TMDL process, federal WQS survey requirements, and general water monitoring (Ohio EPA, 2014d).

In addition to the biosurveys completed under the Five-Year Basin Approach framework, the DSW periodically samples other streams in areas of special concern, as part of projects that have received special state or federal funding, or in partnership with other state and federal agencies. These surveys are referred to as special monitoring projects (Ohio EPA 2015f). Examples of recent special monitoring projects include a survey of Western Lake Erie Basin tributaries due to phosphorus pollution concerns, a survey of streams restored through the Ohio Surface Water Improvement Fund (SWIF) grants, and a survey of the Broken Sword Creek basin in Crawford County in partnership with the National Resource Conversation Service (NRCS) (Ohio EPA 2015f).

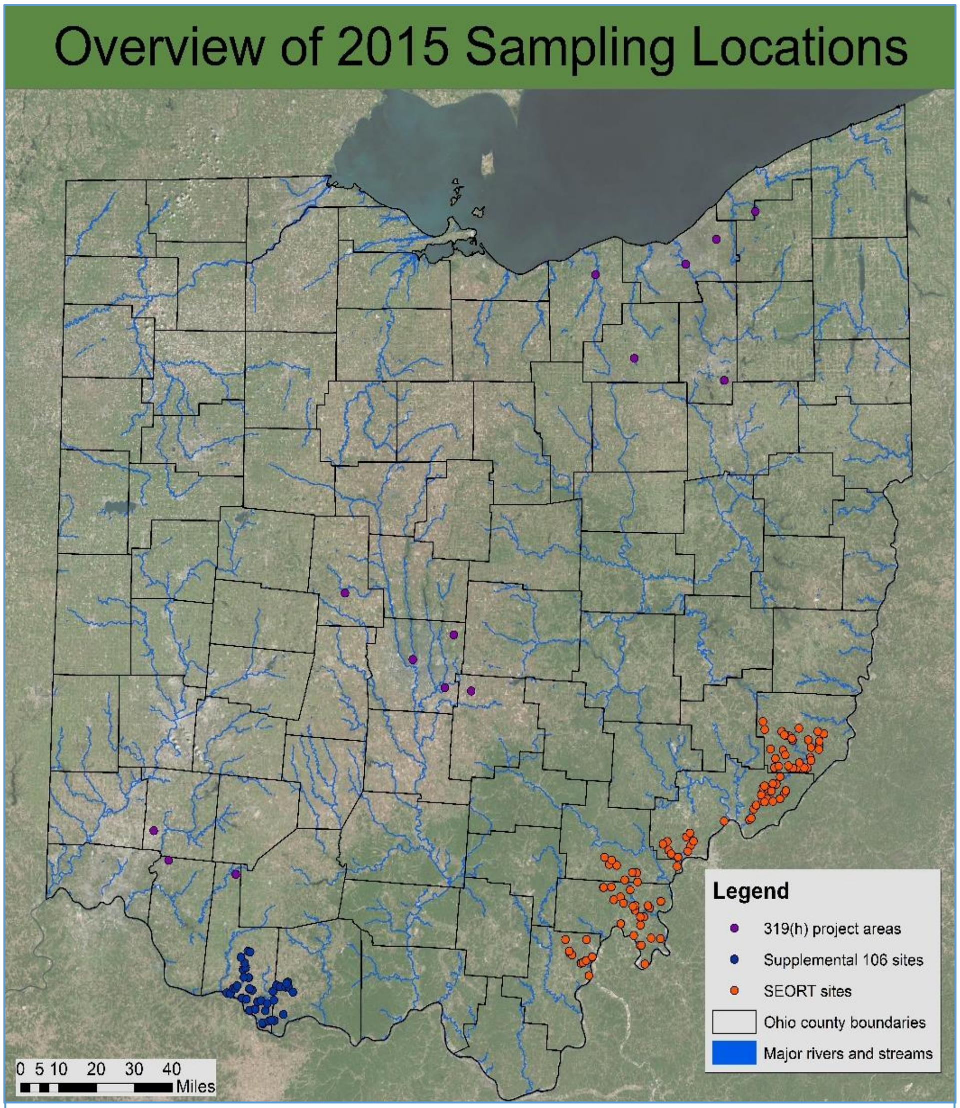


Figure 19: Map showing an overview the sampling locations of the three main surveys I worked on for my internship (Map by Rebecca Long).

South East Ohio River Tributaries Biosurvey

The first major survey I worked on was a biosurvey conducted as part of the Ohio EPA's routine monitoring schedule. The streams I sampled are part of a group called the South East Ohio River Tributaries (SEORT) which included major tributaries such as the Little Muskingum River, the Little Hocking River, and the Shade River (Figure 20). This survey was the first one done by the Ohio EPA to comprehensively sample the study area. Previous sampling in the area focused only on larger rivers or point sources of pollution (Bolton, 2015a). In total, 112 sites were sampled spanning across six counties: Athens, Gallia, Meigs, Monroe, and Washington (Figure 21). My mentor and I sampled approximately 50 of these sites located mainly in Monroe and Washington counties, while the remaining sites were sampled by another macroinvertebrate sampling team.

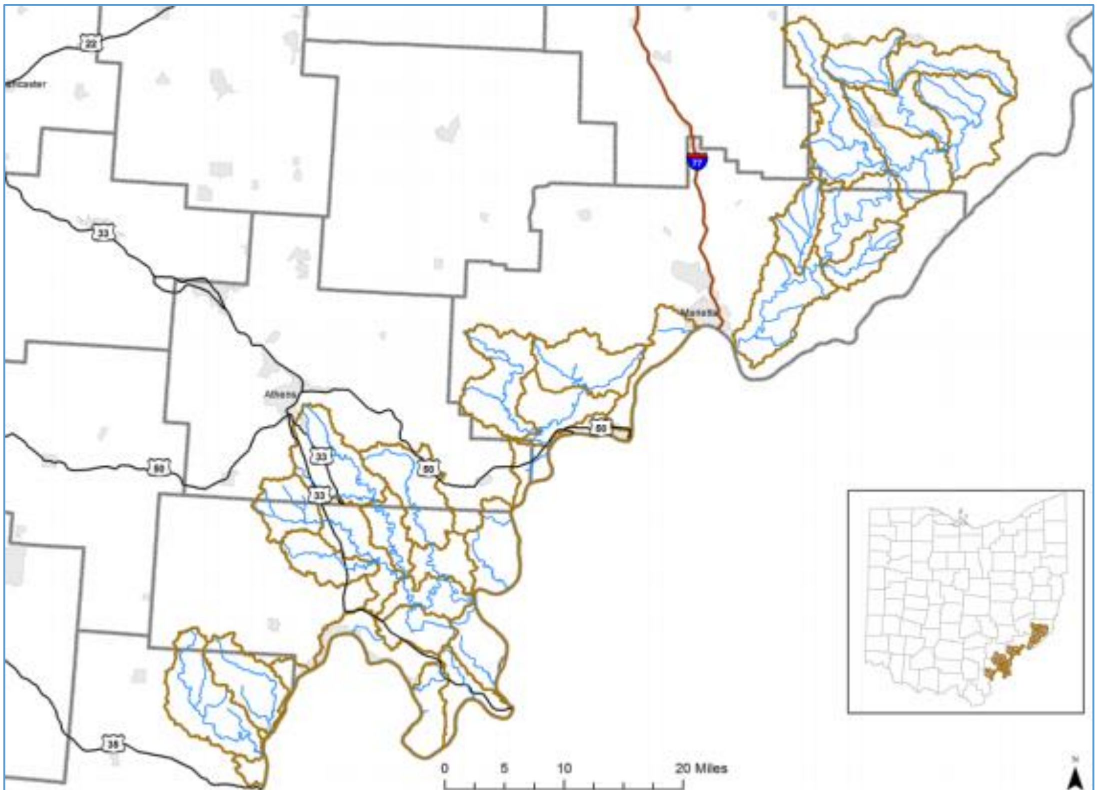


Figure 20: The 32 WAUs (HUC 12) assessed as part of the SEORT biosurvey (Ohio EPA, 2015g).

Along with the macroinvertebrate I collected, fish community data, habitat quality, water and sediment chemistry, bacteriological data, physical measurements, nutrient content, and fish tissue analysis will be used to evaluate the SEORT area (Ohio EPA, 2015g). This data will be used to meet the following objectives:

- Collect data for use in the Total Maximum Daily Load (TMDL) process.
- Assess the applicability of the currently assigned use designations of each waterbody
- Develop baseline ambient biological conditions for reference sites for use in determining the effectiveness of pollution abatement efforts in the future.
- Use in conjunction with historical data when available to determine changes in water quality.

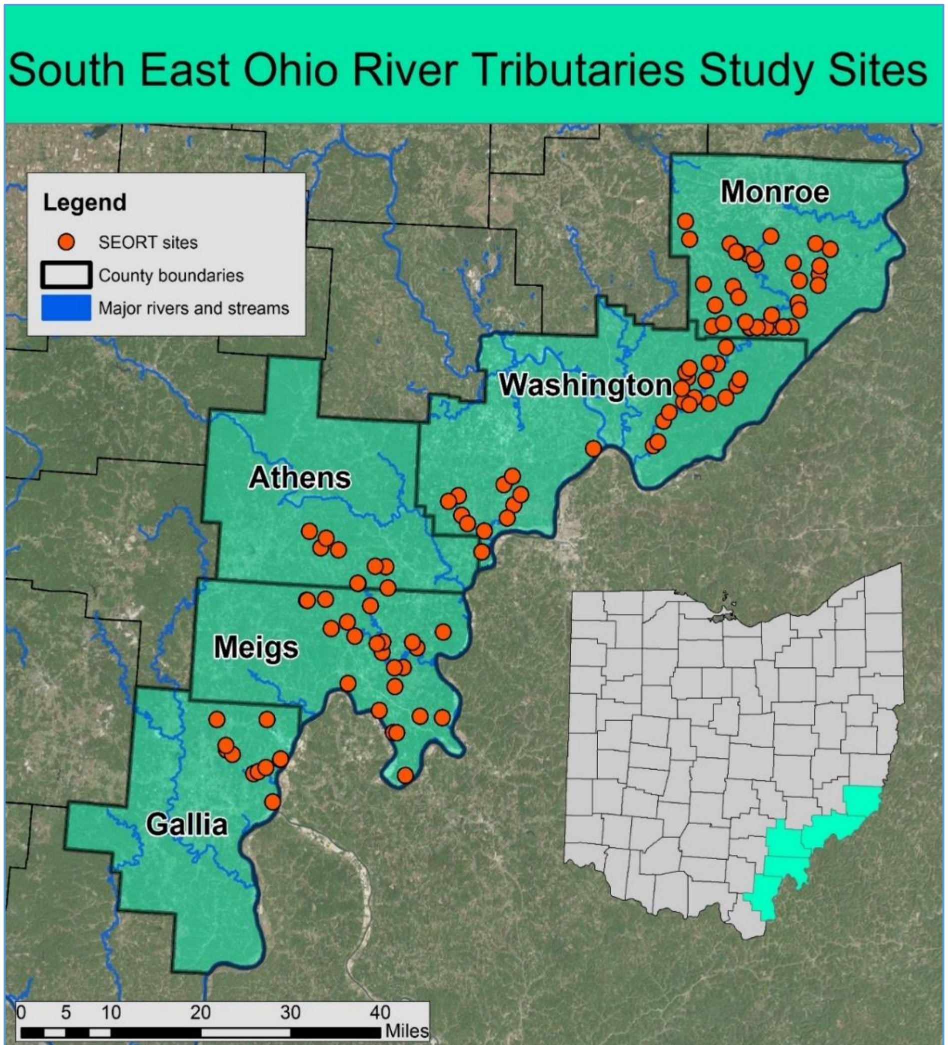


Figure 21: The site locations sampled in the SEORT biosurvey (Map by Rebecca Long).

As mentioned above, one of the main objectives for this survey was the collection of data for the TMDL process. Section 303(d) of the CWA requires all states to develop lists of waters that fail to meet the water quality standards (WQS) set by those states under CFR Title 40 Part 131 due to pollution or degradation (USEPA, 2015b; USEPA, 2015c). Section 303(d) further states that these identified waters, referred to as impaired waters, must be prioritized by urgency and have TMDLs developed for them (USEPA, 2015b) (Figure 22). All 32 WAUs included in this survey are listed by the Ohio EPA as prioritized impaired waters due to either an impaired use designation or complete lack of data, and are thus required to be sampled for the TMDL process (Ohio EPA, 2014f).

The TMDL process includes a written report that quantitatively assesses sources of pollution and degradation within an impaired water, develops maximum amounts of pollutants allowable to still meet state WQS, and allocates pollutant loads among sources of pollution using methods such as permitting, abatement strategies, and storm water management (Ohio EPA, 2015d; USEPA, 2015b).

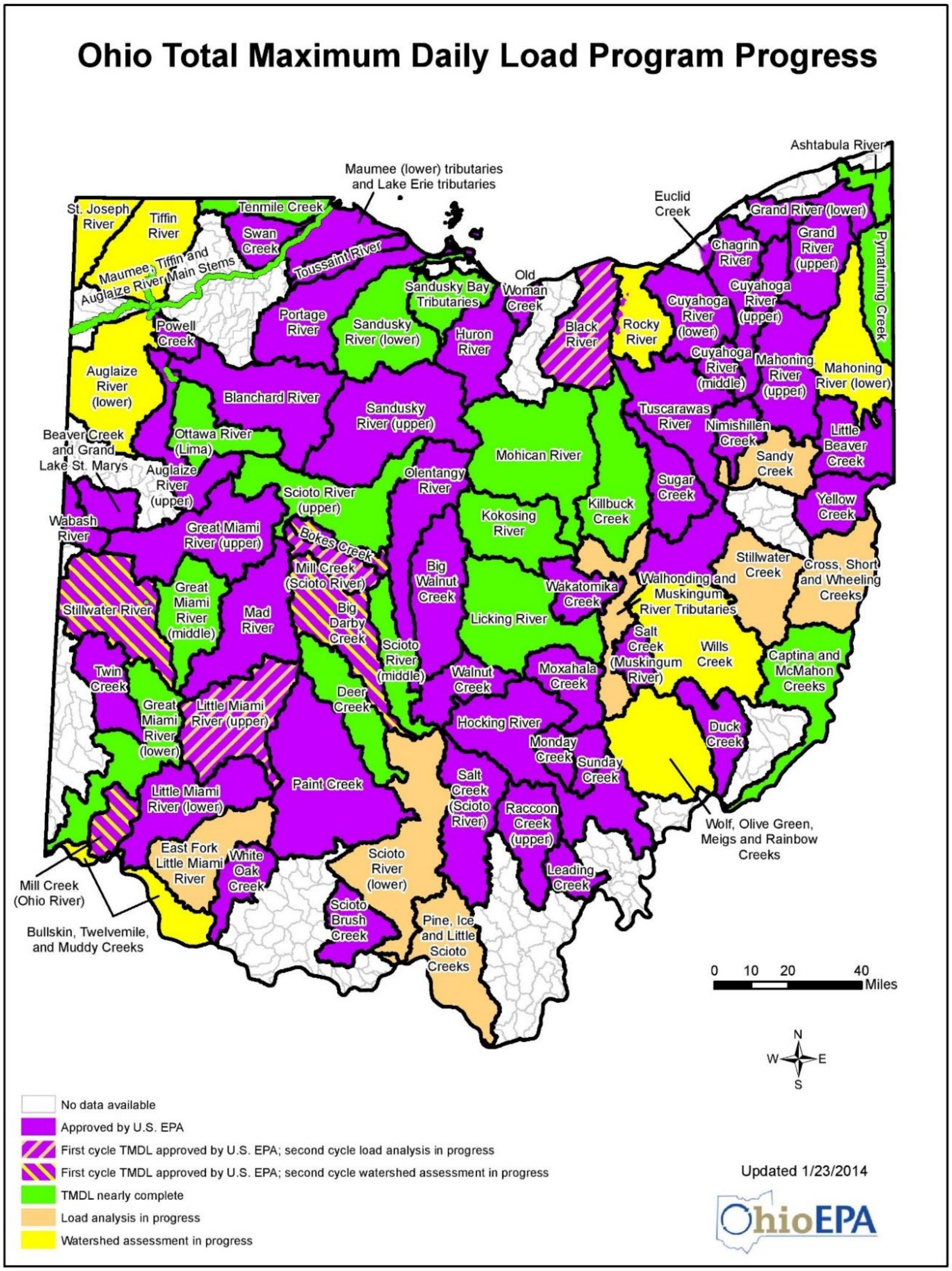


Figure 22: TMDL process progress as of the 2014 Integrated Report. Notice that the areas covered in the SEORT biosurvey were indicated as having no data available at the time of publishing (Ohio EPA, 2014e).

Water Pollution Control (Section 106) Supplemental Sites

The second major project I contributed to during my internship was a survey of four creeks in Brown and Adam's county using CWA Supplemental 106 Funding. Section 106 of the CWA allows the USEPA to distribute funds to states, interstate agencies, and eligible tribes to manage and prevent water pollution. The grants can cover a wide variety of water pollution-related projects including aspects such as monitoring, compliance, and education (USEPA, 2015e). Annually, approximately $18.5 million are allocated specifically for monitoring programs as part of initiative under Section 106 to improve data collection on water quality across the country (USEPA, 2015f). This monitoring initiative was added to Section 106 in 2005 after reports indicated that both federal and state agencies lacked the funds to adequately track changes and trends in water quality over time (USEPA, 2015f).

Under the WQS program, the CWA requires a list of provisions that must be met before approving any activity on a waterbody (such as construction or pollution discharges) that could result in a reduction in water quality (OAC, 2011). Collectively referred to as an antidegradation policy, these provisions are designed to maintain the water quality needed for each waterbody's designated use. Waterbodies are classified using five different water quality antidegradation categories, from highest to lowest:

- Outstanding national resource waters
- Outstanding state waters
- Superior high quality water
- General high quality waters
- Limited quality waters

Classifications are made based on factors such as ecological significance, habitat availability for threatened or endangered species, biological index scores, and the ability to provide unique recreational activities (OAC, 2011). Additional protections are included for waterbodies of general high quality waters or higher. The Supplemental 106 Funding survey that I participated in during my internship was designed to update the antidegradation categories of selected sites that remain classified under an outdated antidegradation policy previously used by the Ohio EPA (Ohio EPA, 2015i). The sites were previously classified as State Resource Waters, which are considered to fall under the new category of general high quality waters. However, the waterways I sampled were being analyzed because the Ohio EPA has some reason to believe their water quality may fall under another tier (Ohio EPA, 2015i). In addition, when these sites were originally classified, it was done so without data verification through biosurveys (Bolton, 2015a). By surveying these four basins, the Ohio EPA will be able to use current data to assign the antidegradation category.

For the project, my mentor and I collected macroinvertebrate data from 50 sites within four river basins that all drain directly to the Ohio River: Redoak Creek, Big Threemile Creek, Eagle Creek, and Straight creek (Ohio EPA, 2015i) (Figure 23). The data utilized for this project included macroinvertebrate and fish community data, habitat quality, water chemistry, and physical measurements (Ohio EPA, 2015i). Unlike the other two projects, I only collected macroinvertebrate data using qualitative sampling methods for each site due to small drainage areas.

The data collected will be used to meet the following objectives for each waterbody:

- Determine the applicable tiered antidegradation category.
- Verify or assign the appropriate aquatic life use.

Because this part of the state is not yet scheduled for routine monitoring following this survey in 2015, it is possible that additional data will not be available for these sites until the completion of the monitoring cycle in around 10 years (Ohio EPA, 2014d; Ohio EPA, 2014e). This makes the data collection enabled by through these Section 106 grant funds essential for up-to-date information with which to make policy and enforcement decisions in the area in the meantime. As the sites sampled in the Section 106 survey are located in watersheds that have never been comprehensively sampled before, it is also possible that impaired waters may be identified. The identification of impaired waters may merit prioritization of the area for further study under Section 303(d) of the CWA in order to develop a TMDL for the area (Ohio EPA, 2014e).

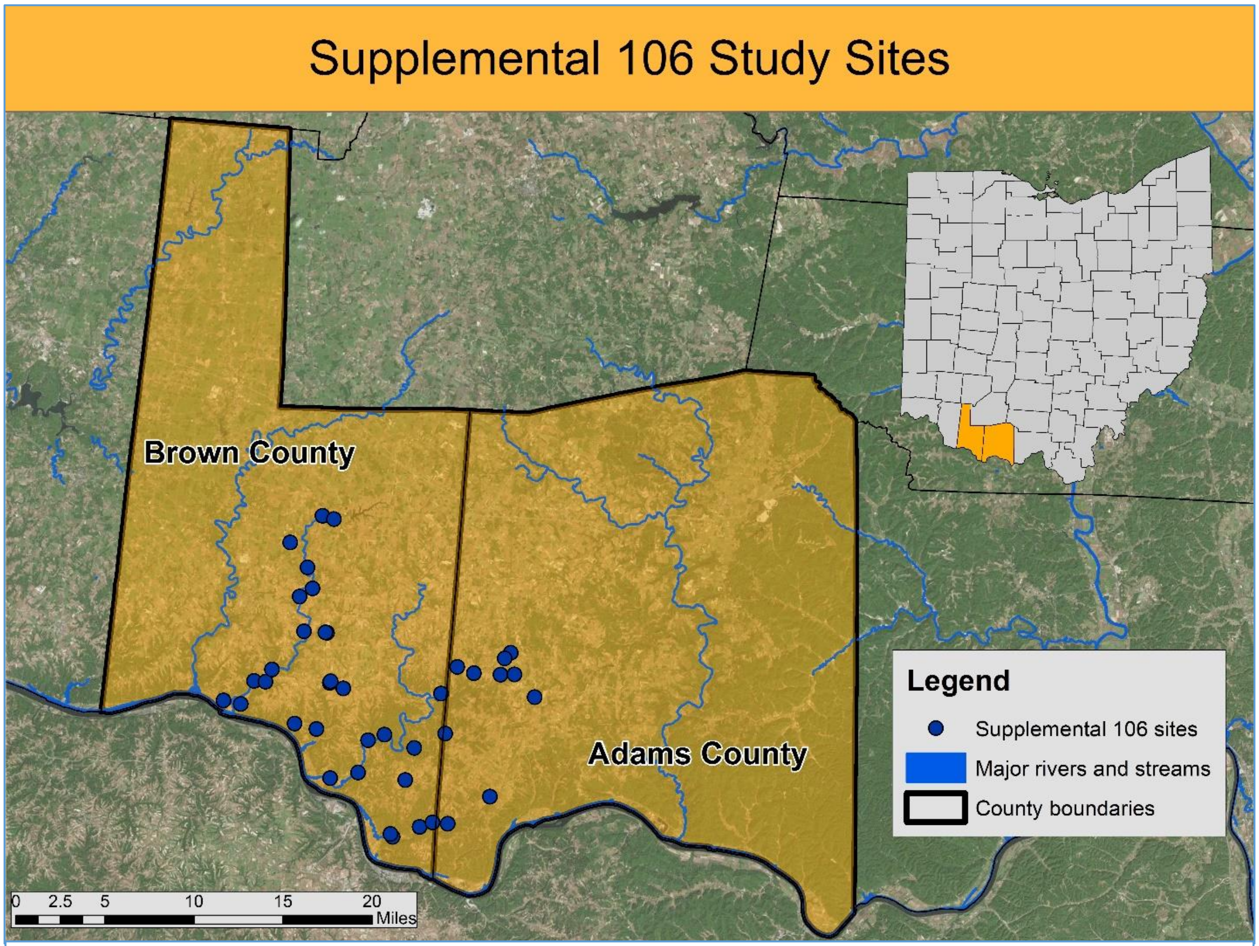


Figure 23: The sites locations sampled in the Supplemental 106 survey (Map by Rebecca Long).

Section 319 Projects

The final survey we worked on was a special monitoring project evaluating 319(h) grant sites. Under section 319(h) of the 1987 CWA amendments, the USEPA created the Nonpoint Source (NPS) Management Program (USEPA, 2013). The NPS Management Program provides states, territories, and authorized tribes with grant money to fund projects related to implementation, promotion, and monitoring of nonpoint source efforts (USEPA, 2013).

In Ohio, the main sources of nonpoint source pollution in streams are habitat alteration, steam channel modification, excess sediment, and nutrient runoff (Ohio EPA, 2015e). Funds awarded to Ohio from the 319(h) NPS Management Program, typically averaging around $3 million per fiscal year, are distributed by the Ohio EPA as subgrants to organizations such as local governments and nonprofits (Ohio EPA, 2014d). As of the 2014 call for submission, entities that apply can receive up to $400,000 to cover as much as 60% of project costs over a three-year term (Ohio EPA 2014a). Preference is given to projects in watersheds that have been identified as being impaired in TMDL and/or State-endorsed watershed plans (Ohio EPA, 2014a). To be available for consideration, each project must include nine requirements:

1. An identified source or cause of degradation that can controlled.
2. An estimate of reduction in pollution load expected from proposed measures.
3. A description of proposed measures and identification of specific areas of application.
4. An estimate of financial needs.
5. An information/education component to inform the public and encourage their participation.
6. A reasonable schedule for implementing proposed measures
7. Set measurable milestones for determining progress on implementing proposed measures.
8. A set of criteria to determine if pollution load reductions and progress toward attaining WQS is being made from proposed measures.
9. A monitoring component to measure effectiveness of proposed measures over time.

(Ohio EPA, 2014a)

Previously, all requirements were the responsibility of the subgrant award recipients. In 2008, the DSW took over the monitoring aspect of 319(h) grant projects (Ohio EPA, 2012). Monitoring done by the DSW includes assessment of the biological communities of macroinvertebrates and fish as well as physical habitat data. Measurements are taken both before (pre-implementation) and after (post-implementation) the completion of the proposed project. For post-implementation sampling, a minimum of one year must elapse after the completion of the grant project to allow for time for organism colonization (Ohio EPA, 2015h). This monitoring, including the macroinvertebrate data I collected, will be used to meet the following objectives for each project area:

- Verify (or assign, if not yet established) the aquatic life use of the waterbody.
- Determine if the site has an attainment or impairment status for its designated aquatic life use.
- Assess the condition of the physical habitat.

Unlike our other two main projects, the 14 sites that I sampled for the 319(h) project were not confined to one geographical area but were instead spread throughout the state (Figure 24). For each project area, my mentor and I sampled three sites: one upstream of the restoration area, one within the restoration area, and one downstream of the restoration area. Three of the project areas contained one less sampling site due to limitations of the area (such as a lake downstream) that prevented sampling. When applicable, both qualitative and quantitative sampling were utilized for these sampling sites.

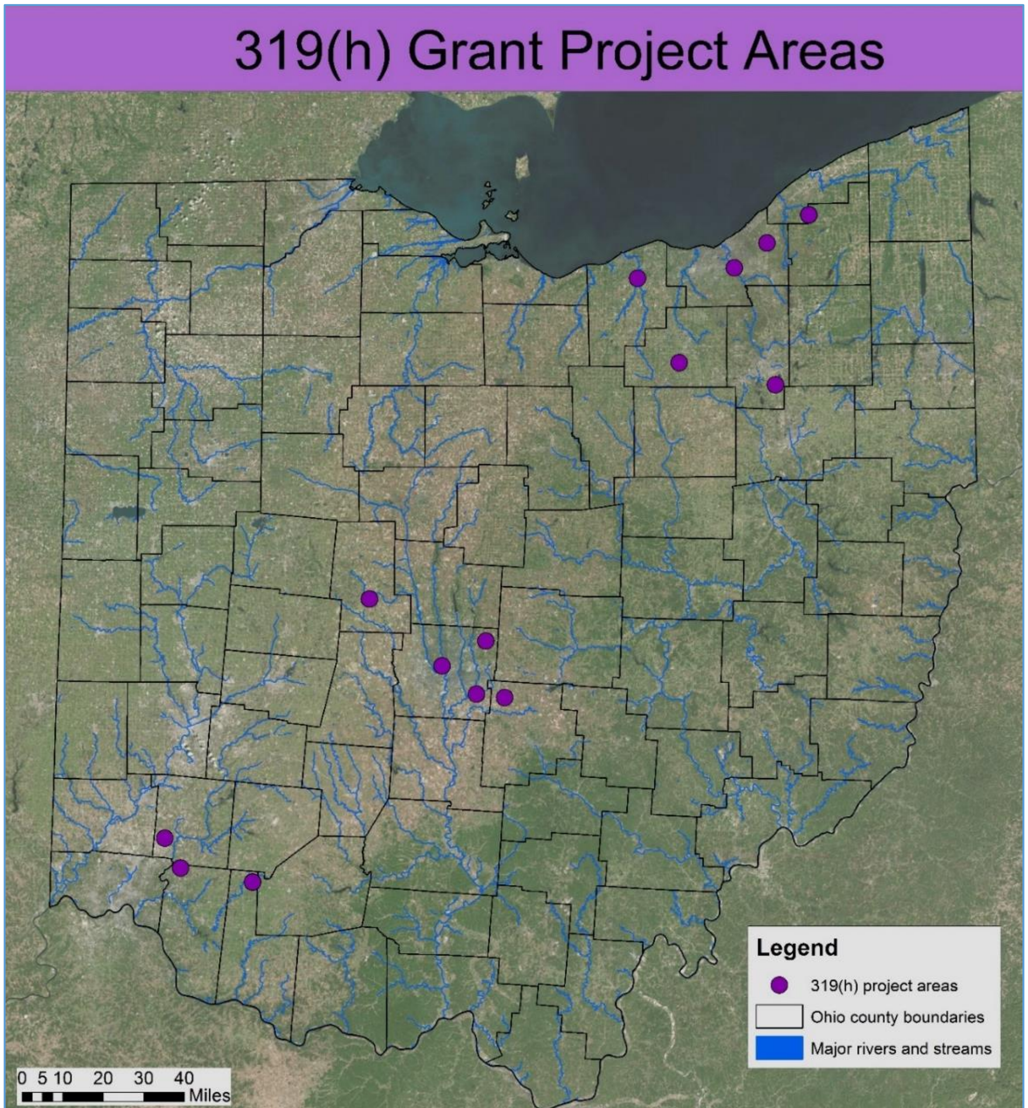


Figure 24: Map showing the 319(h) survey project areas across the state. Note that each project area consists of two to three sampling sites not shown individually due to scale (Map by Rebecca Long).

Sampling for the current year, 2015, included monitoring of sites in both the pre- and post-implementation phases with four pre-implementation and ten post-implementation project areas. The types of restoration efforts funded at these 14 project areas fell into 3 broad categories, with many of the projects including components from more than one category:

- **Dam or levee removal:** removal of a dam or levee to restore natural flow.
- **Bank stabilization:** preventing erosion by altering the grade or contour of the banks, and/or adding control measures such as vegetation or boulders.
- **Channel restoration:** returning a stream to a more natural state by removing human modifications to the path of the stream like concrete, ditches, and culverts, and/or reshaping the path to restore a natural run-riffle-pool sequence.

One of the post-implementation project areas we sampled was at a dam removal site on the Olentangy River in Columbus, Ohio (Figure 25). In 2006, the Olentangy River was identified by the Ohio EPA as an impaired water not meeting WQS (Ohio EPA, 2007). Subsequently, the TMDL process for the Olentangy River was completed in 2007 to identify sources of impairment. One of the sources of impairment identified was stream impoundment caused by the presence of lowhead dams (Ohio EPA, 2007). Lowhead dams can be a source of impairment because they disrupt and slow the flow of streams, replacing the natural run-riffle-pool sequence that creates diverse habitats for aquatic life (Ohio EPA, 2007).

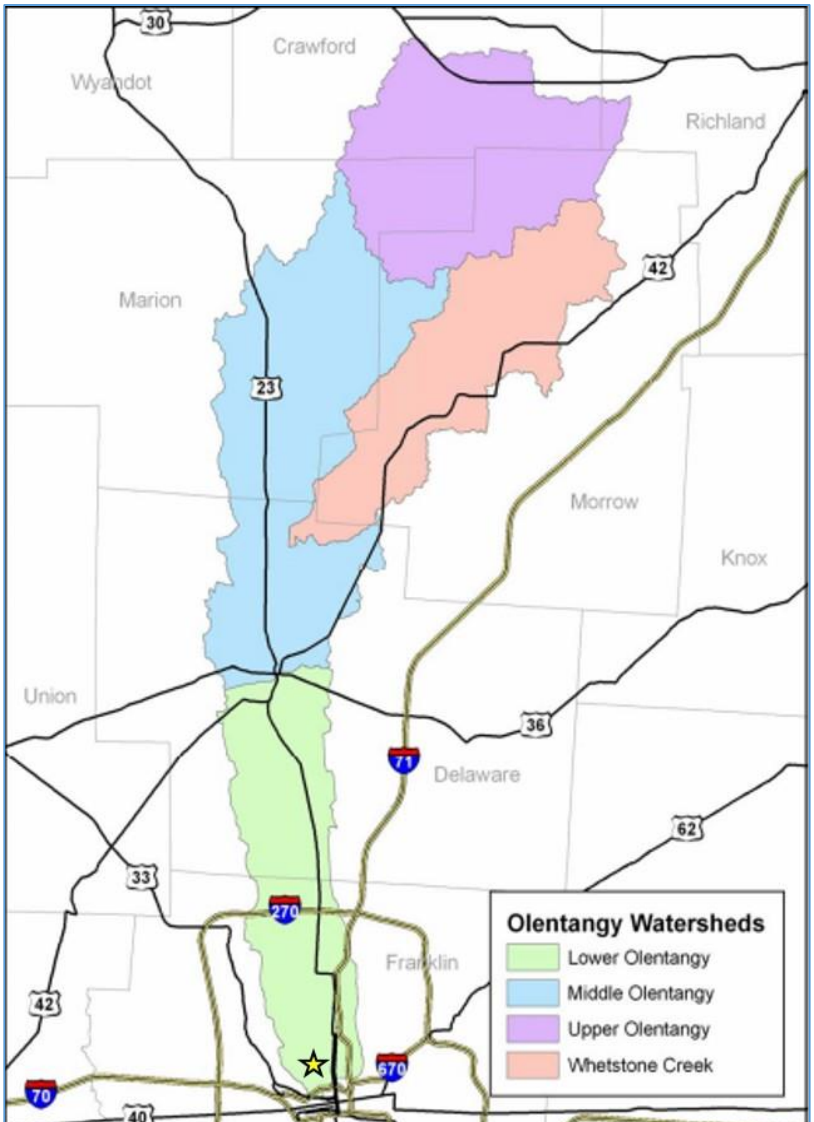


Figure 25: The four WAUs that make up the Olentangy River Watershed. Indicated by a star, the 319(h) project area, and former location of the Fifth Avenue lowhead dam, was located in the lower Olentangy WAU in downtown Columbus, Ohio (Ohio EPA, 2007).

Two dams were listed as a source of impairment, the Panhandle Road dam in Delaware County and the Fifth Avenue dam in Franklin County. The Fifth Avenue dam, located in downtown Columbus was recommended for modification or removal in order to restore the natural flow in that portion of the Olentangy (Ohio EPA, 2007). In 2011, the Columbus Public Utilities Department was selected to receive a Section 319(h) subgrant for $500,000 to aid in the removal of the Fifth Avenue dam and the restoration of the surrounding area. The total project cost came to $6.9 million and was additionally funded by the Ohio EPA's Water Resource Restoration Sponsor Program, the Ohio State University, and the City of Columbus (City of Columbus, 2015).

In 2011, the DSW conducted baseline pre-implementation monitoring as part of the Section 319(h) grant requirements at three sites: upstream of the Fifth Avenue dam, at the impounded area at the dam itself, and downstream of the dam. Results for biological communities resulted narrative assessments of "Excellent" for both the upstream and downstream sites, with a "Fair/Poor" narrative assessment for the dam location site (Ohio EPA, 2012). Dam removal began in August 2012 and finished the following month in September. Restoration work continued in the following years until the completion of the project in September 2014 (Figure 26).

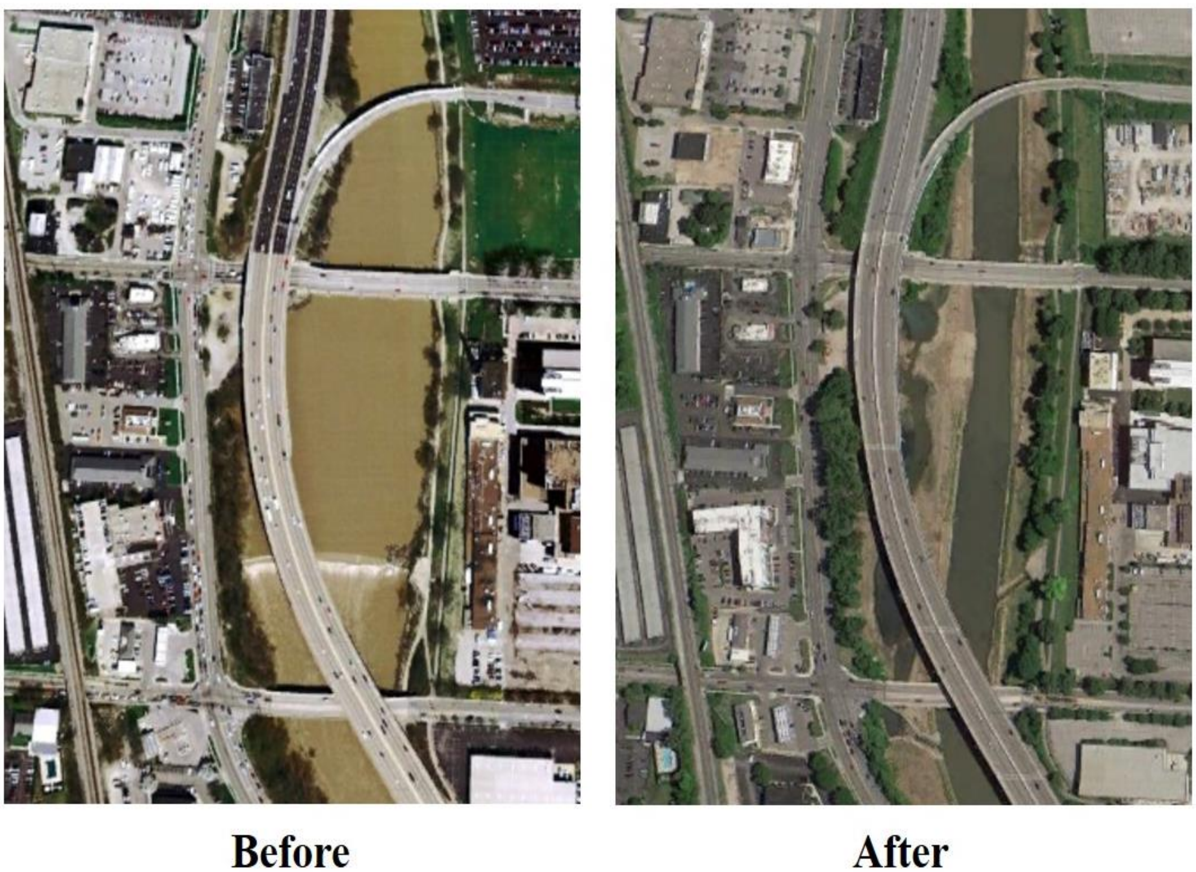


Figure 26: An aerial view of the Fifth Avenue dam project site, before (2008) and after (2014) the dam removal. In addition to removing the dam, the project also established a wetland upstream, narrowed the river channel, restored the banks, and planted native species of plants for erosion control (City of Columbus, 2015; aerial images from Google Earth).

One year later, to allow time for organism colonization, the post-implementation monitoring was done in September 2015. My mentor and I conducted the macroinvertebrate sampling, using both qualitative and quantitative techniques. While an official ICI score and narrative evaluation are not yet available, our visual observations suggested an improvement in habitat. Runs, riffles, and pools were all observed during sampling, whereas before the restoration the area consisted of a single large pool created by the dam (Figure 27). Because sensitive organisms typically require higher oxygen content than is available in a slow-moving pool, the presence of more oxygen-rich habitat such as riffles and runs indicate that an improvement in biological communities is likely (Ohio EPA, 2007).

Figure 27: Upstream view from the Olentangy River sampling site at the former Fifth Avenue dam location. A run is visible in the middle of the picture, flowing under the middle segment of the bridge. Previously, the area consisted of a single large pool (Photograph by Rebecca Long).

Observations about Sampling

While many of my duties during my internship were of a repetitive nature, there were several aspects of the sampling process that added interest and variability to my work.

Sampling Conditions

As with any type of field work, my macroinvertebrate sampling was affected by weather and other environmental conditions. During the earlier part of the summer sampling season, the entire state of Ohio received unusually large amounts of frequent rain. While I did do some data collection in the rain, sampling was not possible many days due to high water levels, turbidity, or safety concerns due to lightning. High water levels were of greatest concern because slow drainage times in some areas could result in these conditions persisting for several days after a large rain event. Because many of the sites required long drive times or overnight travel, one of my daily tasks while at the Groveport office was to check the amount of water flowing in streams, called the discharge level, across the state using the USGS WaterWatch webpage (Figure 28). The USGS provides data from stream gauges set up across the state that helped me determine water levels of streams in the areas we were looking to sample in without actually visiting our sites (USGS, 2015b).

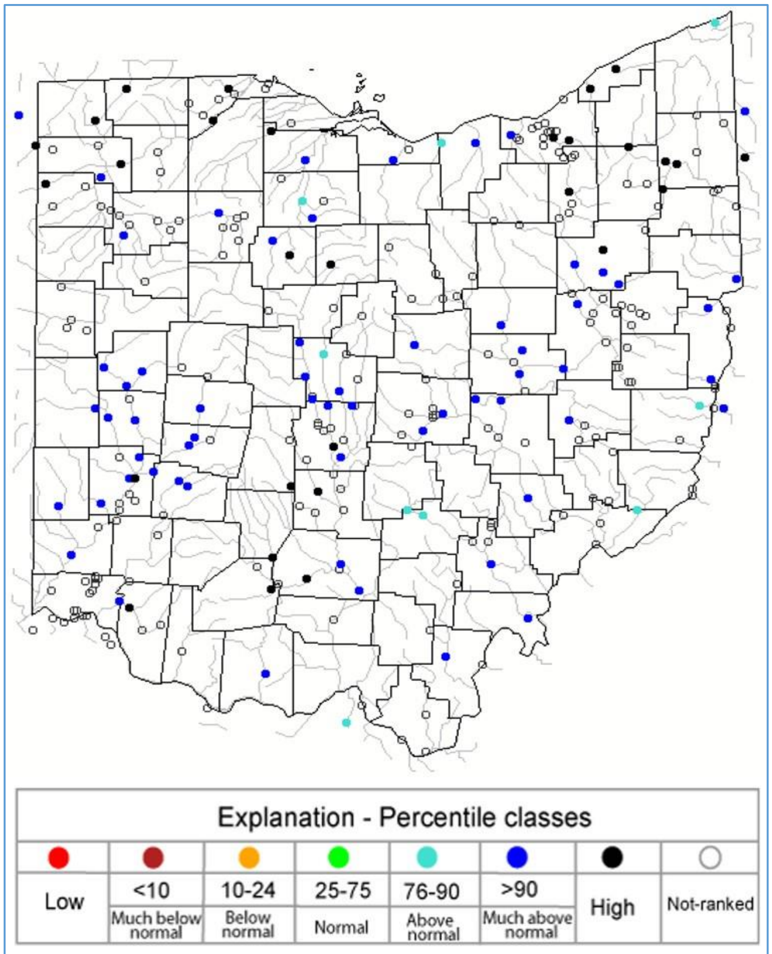


Figure 28: A USGS WaterWatch map of Ohio showing the discharge level of streams across the state on July 1, 2015. Ideal conditions for sampling were when the gages read within the "normal" level (USGS, 2015b).

Another sampling condition that affected my work was the actual locations of the sites. Many sites were in remote areas and special care had to be taken when navigating to and from sites. While site locations are selected in part for ease of accessibility, some were still difficult to access. Steep terrain, one lane roads, private access, and thick vegetation were all factors we encountered when traveling to sites. These remote sites also came with important safety considerations, such as knowing the location of the nearest hospitals, bringing enough water to stay hydrated in summer conditions, and keeping the rest of the DSW staff updated on our location and intended trip duration in the case of an accident. For the majority of sites, especially in the SEORT survey area, cellular and satellite reception was unavailable. Navigation therefore was done using atlases and physical USGS maps. To maximize efficiency and reduce travel frequency to remote areas away from our lodging, my mentor and I worked long field days often as long as 11 hours, completing 4-5 sites in a day. However, it was important for us to be as attentive at our last sampling site as our first to ensure consistent efforts for sampling. As visually searching for macroinvertebrates requires concentration, this was sometimes difficult.

Public Interactions

While interactions with the general public took up a very small part of my time during my internship, it was one of the most interesting aspects. Contact with the public occurred while I was out sampling, both when asking permission to access private property as well as during the sampling itself.

Several of our sites were either located on private property or could only be easily accessed by going through private property. In almost all cases, the property was residential and access required the homeowners' permission. When we encountered a site on private property I would accompany my mentor while we asked residents for permission and provided some basic information about what we were doing. After explaining that we were there to catch insects and other small animals as part of a research project looking at water quality, we would ask if they would mind if we accessed the stream through their property and where to park. All but one of the residents we asked granted permission and most were very interested in what we were doing.

Curious onlookers would often stop by to ask my mentor and me what we were doing whenever we sampled in a highly visible area. Because of our waders, people often would think we were out fishing. During orientation, I was told that these types of interactions are extremely important because they can be the only time a person ever has any real interactions with the Ohio EPA and can serve as teachable moments. One of my favorite instances of public interaction was at a site at a private residence where the 10 year old son of the property owner watched us the entire time we were sampling and asked many questions. Discussing these issues with the public allowed me to better articulate the basic concepts of what we were doing to myself.

Site Differences

One of the most interesting aspects of my internship was the differences I observed between all of the sampling sites I visited. Variation and patterns occurred in the types of organisms I collected, topography, and geological features. I noticed variation among different areas of the state as well as among individual sites.

The variations among the different areas of the state that I sampled were the most apparent. While most interns in the program normally only regularly sample in one region of the state, I was able to see several areas because of the surveys my mentor had been assigned. While this was a great learning experience, it also gave me an added challenge of becoming familiar with the different macroinvertebrates typically found in each survey area. For example, some organisms were common in one survey area but completely absent in another.

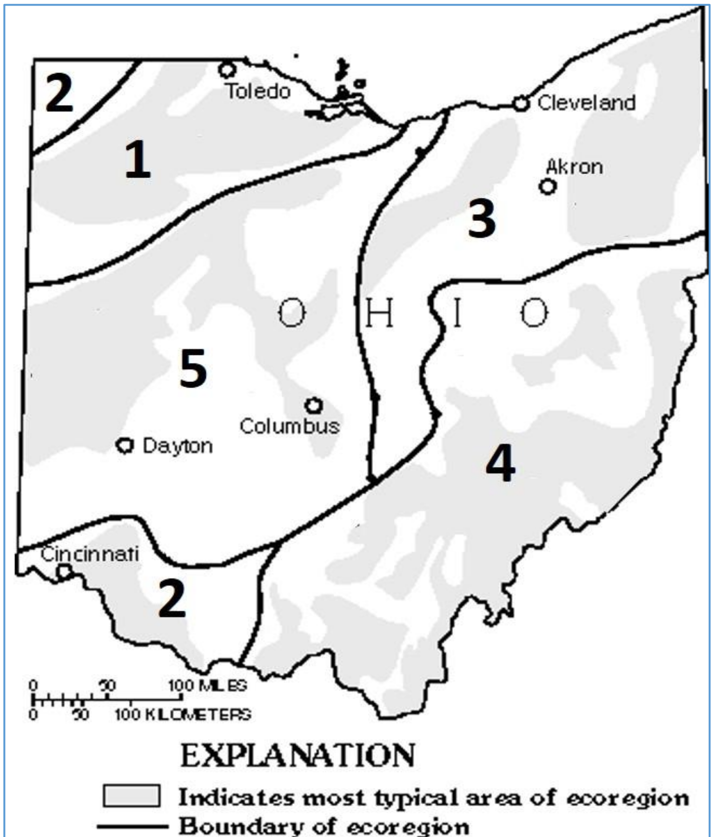


Figure 29: Map showing the five ecoregions of Ohio: Huron/Erie Lake Plains (1), Interior Plateau (2), Erie/Ontario Lake Plains (3), Western Allegheny Plateau (4), and Eastern Corn Belth Plains (5) (Interagency Advisory Committee on Water Data, 1995).

Variation in macroinvertebrate communities can be caused by many things, but most of what I observed were likely caused by the unique characteristics of each survey area. Regional differences are factored into stream sampling at the Ohio EPA by dividing the state into five areas that share similar ecological characteristics called ecoregions (Figure 29):

1. Huron/Erie Lake Plains (HELP)
2. Interior Plateau (IP)
3. Erie/Ontario Lake Plains (EOLP)
4. Western Allegheny Plateau (WAP)
5. Eastern Corn Belt Plains (ECBP)

To account for their differences, the DSW uses slightly adjusts the biological index scoring criteria for each ecoregion (DeShon et al., 2015). Based on my observations, there was significant variation in survey sites between ecoregions.

SEORT:
Sites in the SEORT survey, part of the WAP ecoregion, tended to be the most isolated and least impacted by humans. Located in an unglaciated part of the state, the SEORT sites were located predominately in hilly forested environments with stream beds composed of flat bedrock. Fed by groundwater sources, the SEORT streams contained the clearest and coldest water of all of my surveys. Based on my anecdotal observations, SEORT seemed to contain the highest quality streams containing the most EPT taxa.

Section 106 Supplemental Sites:
In the areas covered by the Section 106 survey, part of the IP ecoregion, most of the land was rural residential, but not heavily agricultural. The topography was less hilly than at the SEORT sites with surrounding vegetation consisting of either grass or forest. Section 106 streams were generally very rocky with high amounts of grey clay deposits present. These sites exhibited the greatest variation in macroinvertebrate communities of all of the surveys.

Section 319 Grant Projects:
Due to being in several different parts of the state, the sites of the Section 319 Grant Projects exhibited the most variation of all the surveys. However, because they were restoration projects, most of the sites were located in populated urban or suburban residential areas. Even including the post-implementation sites, less EPT taxa were found in this survey than the other two.

Differences between individual sites were less apparent than the overall difference between survey areas. One important observation I did make when comparing different sites was that I was not able to reliably predict the diversity and tolerance levels of the macroinvertebrates I would find just by looking at the physical appearance of the stream. For example, some streams appeared to be pristine habitats but would produce only a small variety of taxa. I believe this is a very important concept to understand when dealing with water quality, as conditions of a stream are not only impacted by a small area of land around but can instead be altered based on activity (such as nonpoint pollution) that occurs anywhere in its drainage basin.

Ch 4: Reflection

I am very grateful for the experience I had at the Ohio EPA and learned a large deal during my time there. One of the greatest benefits of my position was getting to experience the day-to-day duties of an environmental specialist at the agency. Specifically, being exposed to a position that consisted mostly of field work showed me that I would enjoy and be successful at a similar job. The writing and research required for this report also provided to be a great learning experience and helped me understand the significance of my data collection work as well as the complex processes and details that go into developing and maintaining a state water quality monitoring program.

My experience in the IES program was essential in preparing me for this internship. During the interview process for the position I was asked many detailed questions about my experience related to environmental issues and data collection and analysis. There were over 300 applicants for the approximately 20 internship positions available and I believe my knowledge and familiarity with a variety of aspects related to environmental monitoring learned in my coursework at Miami made me stand out in the selection process.

Coming into the IES program, I had a firm foundation of environmental knowledge from my undergraduate majors in zoology and environmental science at Miami. Notable courses included my watershed education course where I learned the basics of stream systems as well as my entomology course that was extremely helpful in preparing me for identifying macroinvertebrates. My knowledge was further improved upon by my IES coursework in environmental protocols, soil ecology and geography, GIS, and environmental policy. In environmental protocols, I was taught the basic concepts of Ohio EPA's fish sampling methods and biological metrics which greatly improved my understanding of my internship duties and rationale. Soil ecology and geography taught me the impacts of soil and other land activities on water quality as well as about other geology and geography concepts relevant to my internship such as ecoregions and groundwater. GIS improved my map reading and making skills which were helpful for navigation and interpretation of maps during my internship. Finally, environmental policy increased my knowledge about the Clean Water Act and its relevance to my work.

Other aspects of my IES experience also prepared me for my internship. PSP was instrumental in preparing me for report writing as well as improving my research skills. In teaching undergraduates through my assistantship, I learned how to introduce scientific concepts to a general audience, where my work in Melany Fisk's lab improved my attention to detail working with classifying small root fragments. I also gained valuable experience during my time volunteering with the Butler County Stream Team where I familiarized myself with several water sampling methods.

After having had this internship experience, my goal for the future is to pursue a career related to environmental monitoring. I really enjoyed the fieldwork aspect of my internship and would like to have a job that involves fieldwork in some capacity. Similar to my internship, ideally I would enjoying working for a government agency in water resources. My mentor and other environmental specialists at the Ohio EPA were responsible for a very wide variety of tasks including map making, report writing, field work, education of the public, and specimen identification, which I find appealing. I enjoy applying my skills in different ways so I believe this type of career would be fitting for my working style and skillsets.

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