Evaluation and Mitigation Steps for Threats to the Moshannon Creek Watershed Upstream of Roup Run

Final Report

9/15/2025

1. Executive Summary

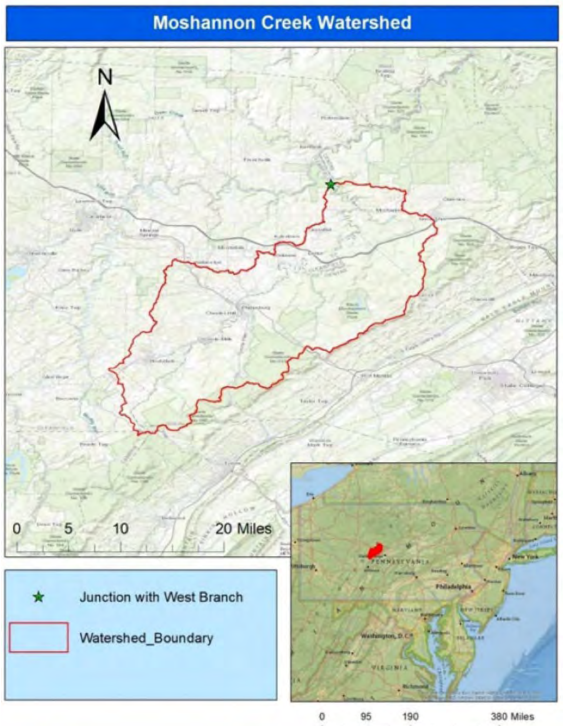
The Moshannon Creek Watershed Association (MCWA) partnered with the Native Fish Coalition – Pennsylvania Chapter (NFC-PA) and the Clearfield County Conservation District to seek and obtain an Eastern Brook Trout Joint Venture Grant for the Moshannon Creek headwaters. The grant funds were used towards the cost of completing a treatment system design for the MC-Fore acid mine drainage discharge. The design was completed by Hedin Environmental and permit applications for construction have been submitted. MCWA plans to seek grant funding for construction of the MC-Fore treatment system in the spring of 2026.

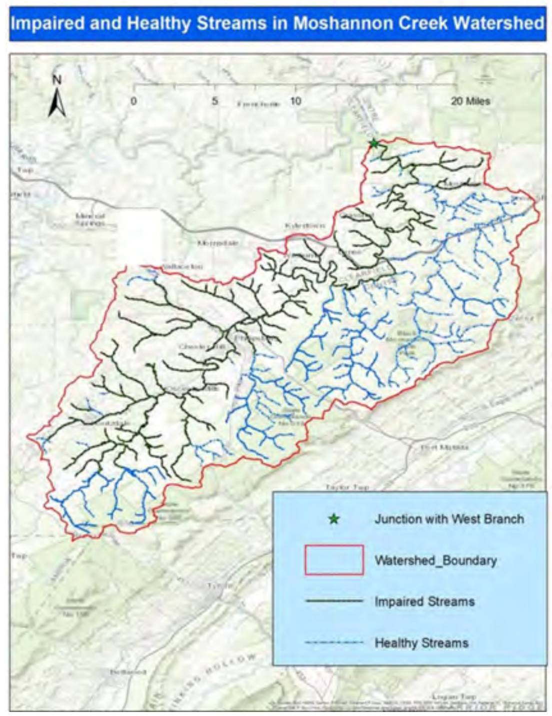
The headwaters project included in the grant proposal involved a detailed evaluation of the Moshannon Creek headwaters for other threats to its aquatic life. Other mine discharges in the Moshannon Creek headwaters that were previously known were sampled monthly and evaluated for a year. The Moshannon watershed upstream of Roup Run was thoroughly explored for additional sources of acid mine drainage, several of which were found and were also sampled for a year.

A coal refuse pile estimated to be approximately 350,000 tons of material sits in and adjacent to the main stem of Moshannon Creek near its confluence with Wilson Run. The pile was evaluated and found unsuitable, for the most part, for use as fuel, so it became a reclamation project. The Pennsylvania Department of Environmental Protection – Bureau of Abandoned Mine Reclamation (BAMR) has included the pile in a reclamation project that is currently in the development and design phase. An area of dry strip mine and flooded strip mine is planned for reclamation in this project, with the coal refuse being relocated and remediated in the dry strip mine. The water from the flooded strip mine cut was one of the mine discharges found as part of this project. Recommendations for each of the mine discharges found are included in the report. Two of them are likely to be affected by the reclamation of the flooded strip mine cut and should be reevaluated after that work is completed.

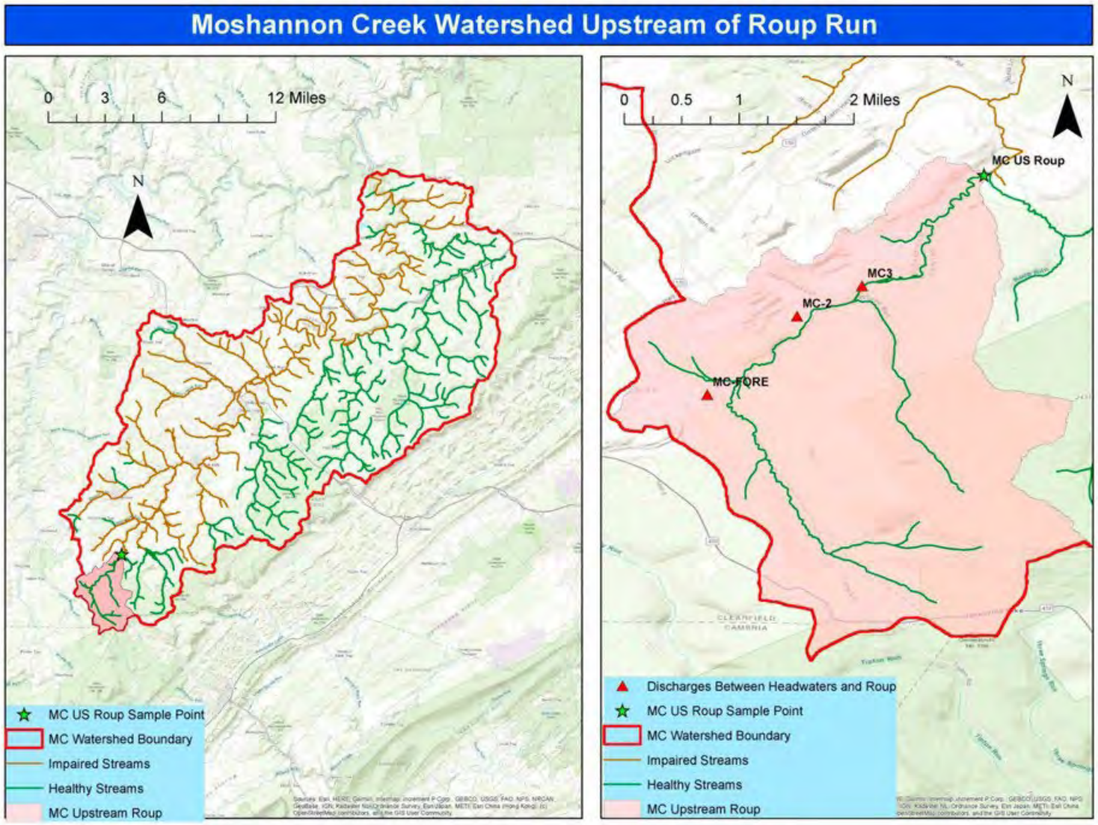
2. Introduction

Moshannon Creek in central Pennsylvania has a 275 square mile watershed that has both clean water streams, many with trout, and streams impacted by abandoned mine drainage. The **Coldwater Conservation Plan for the Moshannon Creek Watershed in Central Pennsylvania**, (www.moshannoncreek.org/reports) was completed in 2021 and outlines a plan for a series of restoration steps for the Moshannon Creek watershed, which if implemented in their specified order, would result in the restoration of health to the main stem of Moshannon Creek. While about half of the tributaries of Moshannon Creek are clean water streams, the entire main stem of Moshannon Creek is severely impaired by abandoned mine drainage except for the 6.3-mile stretch from its origin to its confluence with Roup Run. Because the headwaters are an important biological reservoir for improvements downstream, step A in the Coldwater Conservation Plan involves safeguarding it from threats that could degrade it. Steps B through I in the Coldwater Conservation Plan involve restoration actions to restore stream sections downstream from the headwaters.





The stretch of Moshannon Creek upstream of Roup Run is classified as a Class A brook trout fishery by the Pennsylvania Fish and Boat Commission and as a High-Quality Coldwater Fishery (HQ-CWF) by the Pennsylvania Department of Environmental Protection (PA DEP). As the improvement steps outlined in the Coldwater Conservation Plan are implemented, the upper section of Moshannon will serve as one of the primary sources of brook trout, and other coldwater fishes, to repopulate the recovering main stem sections downstream. While the upper Moshannon Creek is in overall good condition, it is not without threats to its continued health due to impacts from abandoned mine drainage and the related problem of coal refuse piles. If no actions are taken, the potential exists for habitat degradation in the upper Moshannon Creek watershed while restoration is underway farther downstream.



To take steps to prevent habitat degradation in the upper Moshannon Creek watershed, the Moshannon Creek Watershed Association in partnership with the Native Fish Coalition - Pennsylvania Chapter and the Clearfield County Conservation District sought and obtained the EBTJV grant that pertains to this report.

The objectives of this project included the following:

- The design of a treatment system for known mine discharge MC-Fore. The steps included in this portion of the project would include a) site characterization (soils, wetland/stream delineation, survey), b) preliminary design (conceptual plan, permitting assessment, meetings with client and partners), c) first draft of design and submitted permitting applications .
- Better quantifying and understanding mine discharge MC2.
- Quantifying the impacts of mine discharge MC3 and its nearby large coal refuse pile.
- Developing a conceptual design for treating MC3 once the coal refuse pile is removed or mitigated.

- Quantifying and better understanding the impact of and mine drainage sources within an unnamed tributary that discharges into Moshannon Creek at WGS84 lat 40.7752, long -78.3522.

- Searching the watershed for any additional abandoned mine drainage impacts not previously identified and determining their importance once any are found.

These objectives were met by completing the project deliverables explained in the deliverables section of this report.

3. Investigations Performed of the Moshannon Creek headwaters.

Field work on this project began with a sampling program of previously known acid mine drainage sources and field scouting for new ones. Monthly sampling of the MC-Fore discharge began in June of 2023. The channel in which the discharge water flows was found to have water emerging near the head of the channel and acid mine drainage (AMD) seepage flowing overland and into the side of the channel. The monthly samples were drawn downstream of the combination of these flows. The design contractor selected for the project, Hedin Environmental, later discovered that MC-Fore had two pipes that were supposed to be delivering water to the channel, one of which was mostly plugged. When that pipe was opened and repaired the overland flow of AMD at MC-Fore ceased.

MC2 was sampled beginning in September 2023. The first sample of this discharge was taken where a culvert crossed a road. It was soon found that additional flow was emerging in ponds downstream of the culvert crossing, and all subsequent sampling was done downstream of the ponds. MC2 had an unexpected burst of high flow in April 2024. This discharge may episodically have greater importance than previously known, and this is currently being investigated with continuous flow monitoring, as explained in the Deliverables section of this report.

Mine discharge MC3 emerged in a central location near the main stem of Moshannon Creek but then the flow spread out and dropped into the creek over a length of at least 50 feet. MCWA volunteers channeled this flow to a central outlet so flow could be accurately measured during a Saturday workday in August of 2023. Monthly sampling of MC3 began in September 2023.

MC3 Discharge After Flow Consolidation Constructed.

MC3 Consolidated Flow Outlet Used for Water Sampling.

Volunteers from MCWA and the NFC-PA did field scouting of the watershed to look for additional mine discharges and investigate other questions about the headwaters. There were two rounds of exploration performed on 9/30/2023 and 11/04/2023. The NFC-PA volunteers also did benthic macroinvertebrate sampling on 11/04/2023 which is explained further below. Mine discharge sample points MC2.8, MC3.5, MC3.6, and MC3.7 were added because of the September and November field investigations. Monthly sampling of those points began after their discovery. MC3.6 and MC3.7 were found to seldom have flow and only a few water samples of those locations were taken when water was flowing during a year of monthly visits. .

In the Spring of 2021, during the field work for the Coldwater Conservation Plan for the Moshannon Creek Watershed, a team of volunteers from the NFC-PA did macroinvertebrate sampling of the Moshannon Creek watershed both above and below the outlet of the MC-Fore discharge tributary in the main stem of Moshannon Creek. The results of that study are in the appendix of the Coldwater Conservation Plan which is available at www.moshannoncreek.org/reports/ . They found that Moshannon Creek was not impaired above the discharge tributary and was impaired below it. A virtually identical team of macroinvertebrate samplers from NFC-PA performed a more extensive macroinvertebrate sampling of the headwaters of Moshannon Creek on 11/4/2023. Their report from that investigation is included in an appendix of this report. Their macroinvertebrate sampling in 2023 indicated multiple locations showing signs of impairment based upon their IBI scores. This result may be influenced by unusually dry conditions in the Fall of 2023. Clearfield County and Centre County were both in a drought watch at the time of the 11/4/2023 sampling.

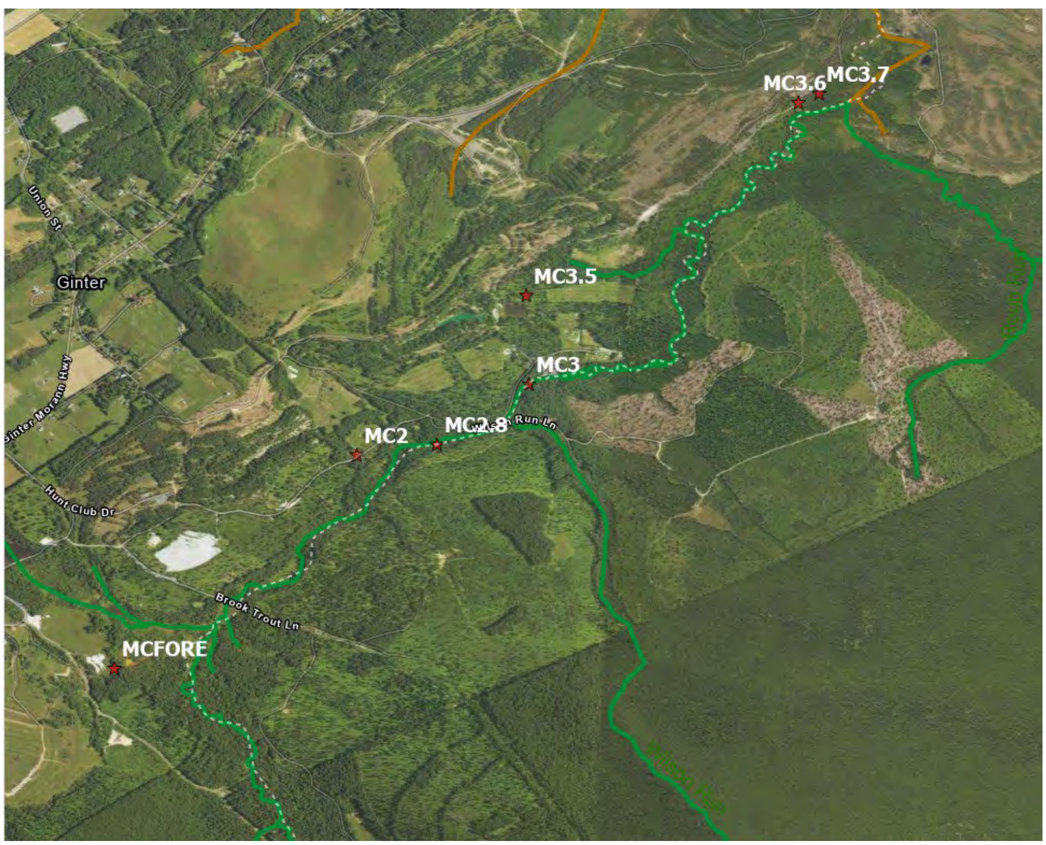
Additional projects that included the Moshannon headwaters were also performed. Trout Unlimited and the Clearfield County Conservation District partnered to seek a Coldwater Heritage Partnership Grant to perform an Aquatic Organism Passage Study of the Moshannon Creek Watershed. This study identified Brook Trout Lane in the headwaters as an aquatic organism passage barrier. Trout Unlimited conducted a biological assessment as part of a Technical Assistance Grant that resulted in a report that included the headwaters area in this project and downstream that is titled ‘Chemical and Biological Assessment of Moshannon Creek Clearfield and Centre Counties, PA’. These reports are obtainable from the MCWA website at www.moshannoncreek.org/reports/ . A screen shot of the reports section of the website is shown below.

Most Recent Moshannon Creek Reports

This section includes the Coldwater Conservation Plan for the Moshannon Creek Watershed that was completed in 2021 and the report from the Trout Unlimited Technical Assistance Grant that investigated the stretch of Moshannon from Hale to Whiteside in 2022.

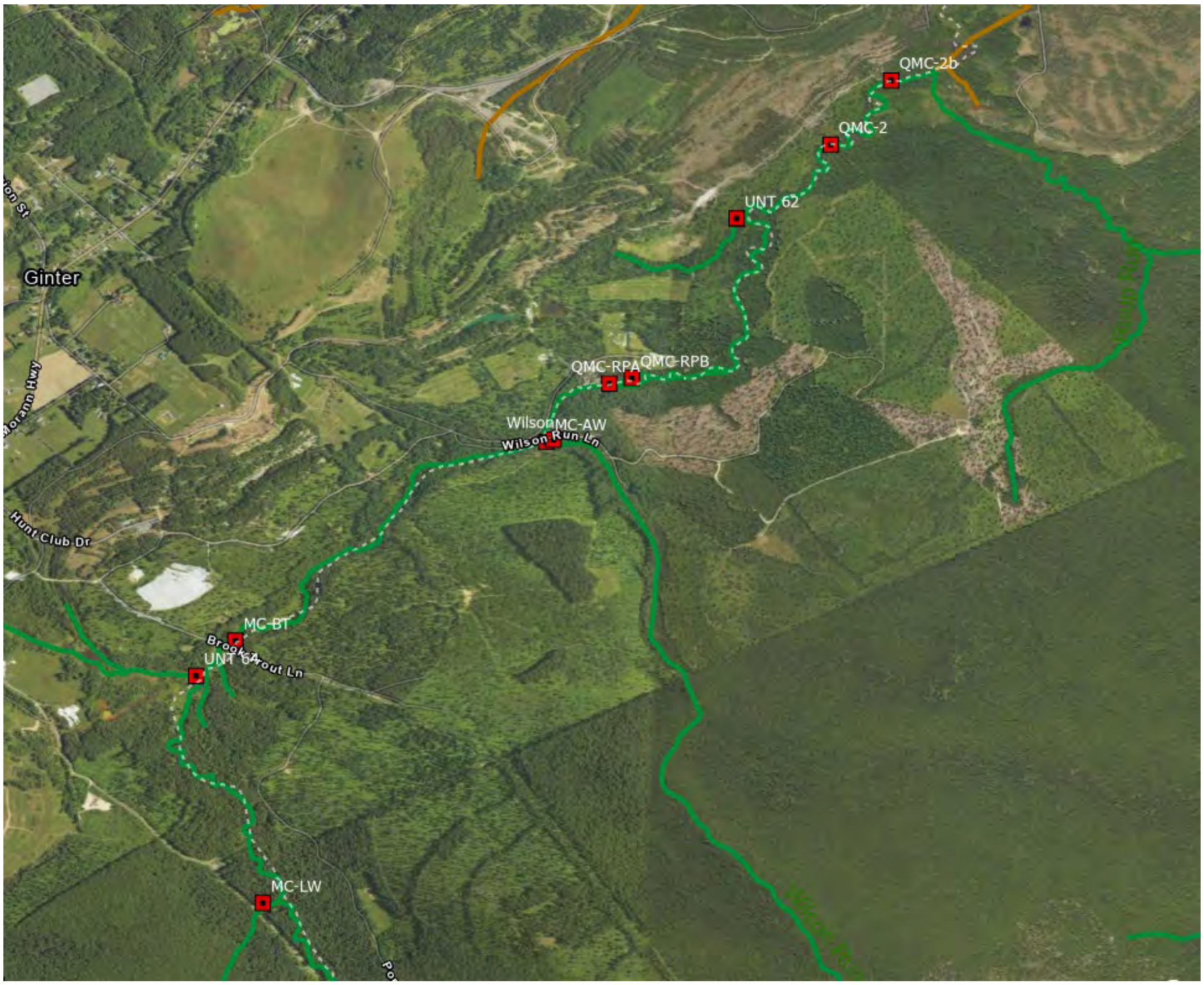
2021 Moshannon Creek Coldwater Conservation Plan (pdf)	Download
Moshannon Hale to Whiteside TAG Final Report (pdf)	Download
Biological Assessment of Upper Moshannon Creek_AMDTAG_FinalReport (pdf)	Download
Aquatic Organism Passage Study of the Moshannon Creek Watershed TU 2023 (pdf)	Download

Additional watershed scouting activity was conducted in the Spring of 2024 and included MCWA volunteers and volunteers from Saint Francis University. There was also scouting done by small groups or individual MCWA volunteers. No significant additional acid mine drainage sources besides the ones listed above were found in this activity. A map of the mine discharge water sampling locations investigated in this project is shown below.



Acid Mine Drainage Discharge Sample Locations in the Moshannon Creek Headwaters

Stream water sampling was conducted in multiple locations. This sampling determined that there was little likelihood of significant AMD sources upstream of a permanent weir located at the edge of property owned by the Houtzdale Municipal Authority, so this project focused on investigating the watershed downstream of the weir and upstream of Roup Run. Stream water sample points for this project are shown below.



Headwaters stream sample points.

MCWA partnered with the Juniata Valley Audubon Society (JVAS) to conduct a three-year bird survey of the headwaters. This survey was partially conducted to determine the presence or absence of Louisiana Waterthrush in the headwaters since they are considered an additional indicator of clean water habitat. They were found in two locations in the watershed all three years of the survey and once at another location. The results of the bird survey are included as an appendix of this report. The data from the survey was uploaded to Cornell University's citizen science bird database eBird.

4. Project Deliverables and Results Explained.

The grant application included a list of project deliverables. Each deliverable will be listed below and the results explained. The last two deliverables and a final report. This document is the final report. The water sampling data for the mine discharges is included with the discussion of each mine discharge. Stream water data will have its own section below.

A. A preliminary design for constructing a treatment system for the MC-FORE discharge, and ...

B. Permit applications for constructing the MC-FORE treatment system.

The MC-FORE discharge was and remains the largest known threat to water quality in the Moshannon headwaters. All the EBTJV funds obtained for this project were designated for the design and permitting of a treatment system for this mine discharge. A year's worth of new water sampling data for this discharge was assembled through volunteer effort. All water sampling data for this project is contained in an appendix to this report. A competitive bid process was followed and experienced treatment system designer Hedin Environmental submitted the low bid for this design, $49,800, and they were selected for this project. During the project, an extra piped source of AMD was found in the MC-Fore channel, and extra excavation and piping costs were associated with capturing the dual piped flows that constitute MC-Fore that were outside the scope of the original bid. Additional permitting costs were also found to exist.

To assist with design costs beyond the funds obtained from EBTJV, MCWA sought and obtained a grant from the Foundation for Pennsylvania Watersheds for an amount of $6300. The final design cost and the funding sources used to pay for it are shown in the table below.

MC-Fore Treatment System Design Expenses	
MC-Fore Design EBTJV Grant Expenses	43,500.00
MC-Fore Design Expenses - Paid by FPW 2025 Grant	6,300.00
MC-Fore Design Expenses Paid by MCWA General Funds	1,837.24
Total for MC-Fore Treatment System Design Expenses	$51,637.24

Funding Sources Used For the MC-Fore Design and Permitting Costs

McFore Project

Report for Invoice #4679

May 28, 2025

Work Completed (April and May 2025)
All project deliverables were finalized and submitted to MCWA during this period. This is the final invoice for the project and is more complicated than normal so it will be explained line-by-line here.

- The first three items are the cost of the total hours worked during the period.
- InKind match applies the rate discount HE offers to non-profit organizations.
- Mileage for meeting to review plans
- The next four charges are permitting fees
- Total Reimbursable Expenses is the total of the permitting fees
- Additional InKind Match not taken on INV - For the invoices listed, the rate discount was mistakenly omitted so this adjustment credits the total amount of those discounts.
- Adjustment to Budget – HE went over budget and this adjustment aligns the total invoiced with the total budget.

During the project, HE incurred charges that were outside the project scope of work. Additional sandstone aggregate and excavator time were needed to accommodate the discovery of a second existing collection system. The second collection system also added an additional sampling point and associated lab costs. Permitting costs specified in the project proposal were for a general permit. However, the site required an individual permit which entails additional fees. The total cost of these expenses is $2,128.24 and has been applied as an adjustment to the total budget.

Item	Quantity	Rate	Cost
AMD collection excavator time	2	$ 125.00	$ 250.00
Sandstone for AMD collection	1	$ 608.24	$ 608.24
Sample analysis	4	$ 67.50	$ 270.00
Additional fees for individual permit	1	$ 1,000.00	$ 1,000.00
Total			$ 2,128.24

Anticipated Work
The project is complete, and this is the final invoice.

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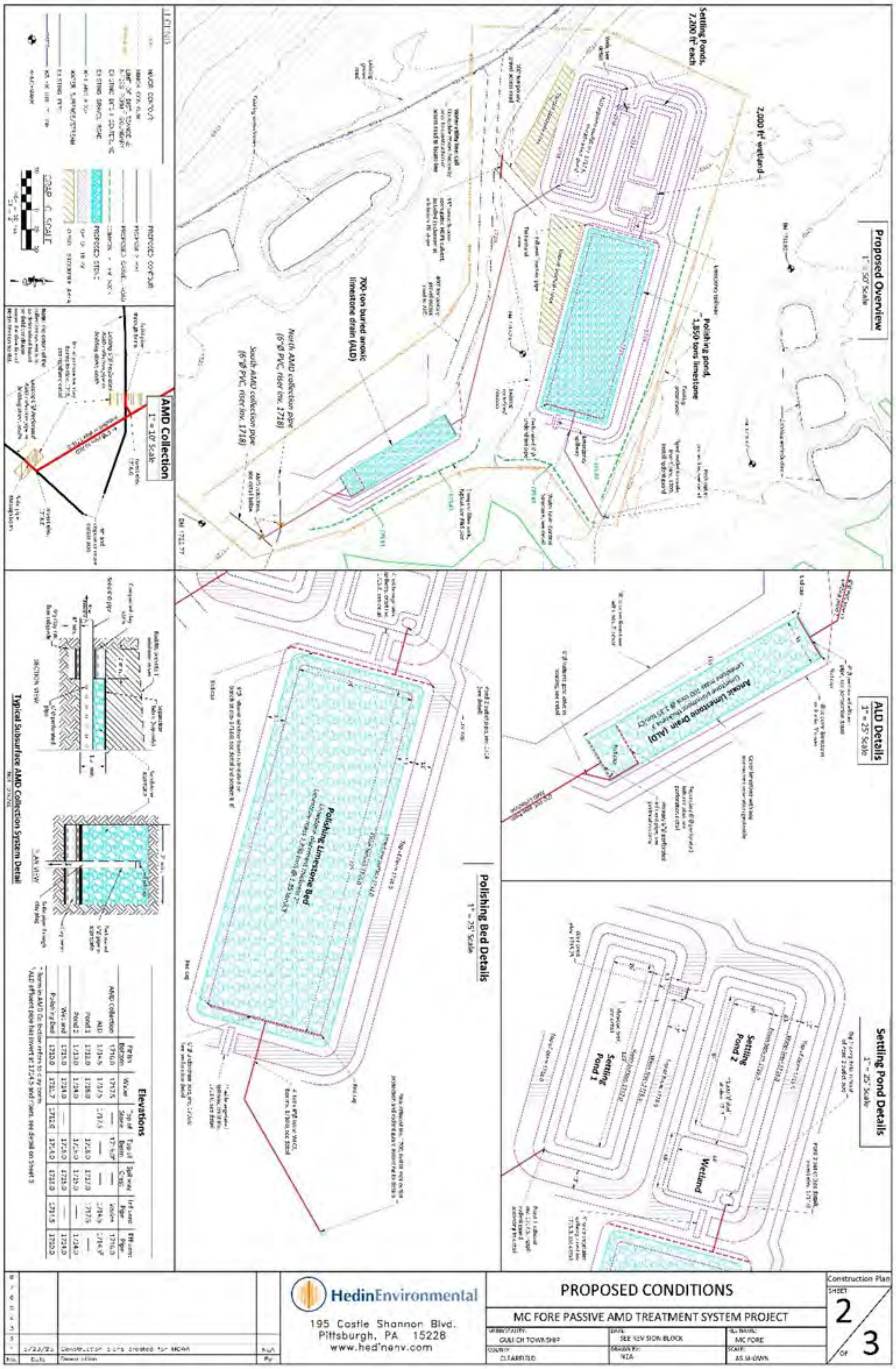
Final Report from the Design Contractor for the MC-Fore Treatment System

A screen shot of one of the pages of the MC-Fore system design is shown below.



Permit applications for construction of the MC-Fore treatment system have been made and are pending as of the time of this report. Provided that no permitting problems develop in the interim, we anticipate seeking construction and project management funding in a rough total of $300,000 for the MC-Fore treatment system construction in the spring of 2026.

Below are pictures of the north and south pipe flows of the MC-Fore discharge after the south pipe was discovered, and piping repairs were made.

Combined view of both flow locations in January 2025.

North Pipe Flow at MC-Fore Discharge August 2025.

South Pipe Flow at MC-Fore Discharge August 2025.

MC FORE RAW WATER														
Date	**Flow**	**F pH**	**F-SC**	**T**	**L pH**	**Acidity**	**Alk**	**S Con**	**TDS**	**TSS**	**Sulfate**	**Al**	**Fe**	**Mn**
04/20/21	10	5.45	1485	10.3	3.58	237.5	<20	1580	1100	20	894	0.3	125	39.2
06/09/23	6	5.32	1684	12.2	5.79	396.9	37.2	1720	1220	9.6	1120	0.203	158	44.3
07/21/23	2	5.82	852	16.7	5.83	183.8	62.8	787	102	9.5	689	0.202	49.9	15.4
08/11/23	2	5.5	1570	13.9	5.25	246	<20	1500	1440	8	904	0.29	140	40
09/08/23	3	5.45	885	14.1	5.71	306	26	1530	1290	<1.6	926	0.24	139	39.4
09/30/23	2	5.44	1460	14.4	5.5	229.9	<0.1	1456	1034	6	1074.3	<0.1	125.63	35.38
11/04/23	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12/21/23	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
01/22/24	3	5.33	541	7	5.49	79.99	9.37	858	698	<5	337.9	0.39	30.72	18.22
02/12/24	13	5.28	686	10.1	5.66	141.88	36.46	1109	960	<5	630.6	0.11	83.23	22.81
03/04/24	14	5.28	1200	18.8	5.64	262.08	<0.10	1294	1080	<5	601.3	0.32	107.88	27.37
04/09/24	24	5.28	1370	11.3	5.74	177.8831	64.88	1459	1328	<5	850.3	0.51	102.15	31.66
05/02/24	30	5.24	1132	12.8	5.52	144.42	110.32	1644	1472	<5	816.1	0.16	107.74	33.80
06/11/24	24	5.19	1399	12.5	5.5	426.09	5.64	1864	1323	8	929.0	0.27	185.25	54.71
14														
Calculated values for acidity used for April, May and June 2024 samples.														

Water Samples of Combined Flow for the MC-Fore Discharge. Additional sampling of the individual pipe flows was conducted by the design contractor.

C. A determination of the necessary next steps for the coal refuse pile if it is found to not be usable and planned for removal as power plant fuel.

A coal refuse pile sits on the banks of Moshannon Creek just downstream of mine discharge MC3. This pile was associated with a coal loading tipple from the Elizabeth #1 mine which was shown to be abandoned in a mine map from 1926. This late 19th century to early 20th century mine dumped refuse associated with coal removal between their tipple and Moshannon Creek, resulting in the nearly barren pile of material still there today.

This pile was first evaluated by RES Fuels, the coal refuse to fuel subsidiary of RES Coal. They estimated the pile contained 350,000 tons of material and concluded that only a small portion of the pile contained enough carbon to make it usable as fuel. There was not enough of this material to make reclaiming the pile financially viable as a stand-alone mining project.

PA DEP's Bureau of Abandoned Mine Reclamation (BAMR) evaluated the pile and have now included it in a larger project which is identified as Gililand Property – Inquiry 2023-08-199; OSM 17(6523)101.1 – Moranne Southeast - project development (Coal refuse pile pit and discharge near Wilson Run). BAMR is currently developing plans for reclaiming areas of flooded and dry strip mine pits and relocating and properly treating and covering the coal refuse pile material as part of that project.

Coal Refuse With Moshannon Creek Flowing Along the Lower Edge of Pile.

A view of a section of the refuse pile away from the creek.

Pile surface showing flattened top recently made for drilling equipment access.

A drill hole from the investigations conducted by BAMR of the pile.

F.

The dark area behind the truck is the only portion of the pile found to be usable as fuel without additional processing to concentrate carbon within the pile.

D. A conceptual design for treatment of the MC3 discharge.

Relocating and reclaiming the coal refuse pile in the Moshannon headwaters from the Elizabeth #1 Mine is important both for the pile's own impact, and because the pile's current location prevents future treatment of mine discharge MC3. MC3 is the second largest source of iron in the Moshannon headwaters. MC3 is chemically similar to the MC-Fore discharge. It emerges with a moderate pH and a lot of dissolved iron. It may not be necessary to treat MC3 after a planned reclamation of a nearby flooded strip mine cut is completed since that may be the source of its water. That reclamation project is discussed further in Deliverable F.

Should it prove to be necessary to treat MC3, it will need a passive system with a similar design to the design now completed for the MC-Fore mine discharge, but it should only need to be about a third as large.

MC3 emerges very close to the main stem of Moshannon and just upstream of the coal refuse pile. To treat MC3, the flow will need to be captured and piped, by gravity flow, away from Moshannon Creek and outside of its flood plain and into an area with sufficient space and vertical drop for a treatment system. Moshannon drops steadily in this vicinity, so a location that fits these requirements wouldn't be far away if there wasn't a large coal refuse pile sitting on that spot. The coal refuse pile is planned to be reclaimed and relocated as part of a strip mine reclamation project. Part of that project under design includes reclamation of a flooded strip mine cut.

The source of the water in the MC3 discharge is uncertain, but the closest substantial quantity of acid mine drainage is the standing water in the flooded strip mine cut. That cut has another outlet that was identified and quantified as part of this project as mine discharge MC3.5. Once the reclamation project encompassing flooded and dry strip mine cuts and relocation of the coal refuse pile are complete. MC3 and MC3.5 will need to be reevaluated for any future improvements that prove necessary.

MC3														
Date	**Flow**	**F pH**	**F-SC**	**T**	**L pH**	**Acidity**	**Alk**	**S Con**	**TDS**	**TSS**	**Sulfate**	**Al**	**Fe**	**Mn**
STREAM		**7.1**	**84.2**	**10.6**										
09/16/23	3	6.62	1745	10.6	5.9	64	<20	1530	1310	34	988	<0.1	59.7	14.1
09/30/23	3	6.31	1670	12.7	5.98	80.55	0.42	1595	1132	28	1102.7	<0.1	83.8	16.91
11/04/23	3	6.01	1765	10.3	5.1	126.02	5.21	1539	1256	569	787.9	0.21	113.17	17.27
12/21/23	5	6.25	1100	8.6	6.07	19.99	21.14	1558	1106	32	868	0.11	80.98	15.18
01/22/24	2	6.45	1003	7.4	6.39	81.59	7.42	1581	1380	18	681.5	<0.1	540.79	15.99
02/12/24	3	6.53	483	10.4	6.5	65.47	9.7	1569	1380	23	875.3	0.37	67.94	14.28
03/04/24	4.5	6.12	1460	17.4	6.11	86.76	8.22	1527	1344	29	898.8	0.1	46.51	12.83
04/09/24	3	6.48	1358	15.5	6.14	-20.13	40.26	1507	1348	22	934.9	0.44	49.04	14.46
05/02/24	4.5	6.71	975	18.22	6.15	-47.95	68.24	1518	1328	24	784.0	<0.10	38.96	12.05
06/11/24	2.5	6.39	1274	11.72	6.35	-32.40	49.80	1577	1119	39	781.4	<0.10	70.48	16.53
07/03/24	3	6.41	1124	13.6	5.96	-20.74	36.08	1556	1456	58	905.3	<0.10	47.65	11.53
08/14/24	3	6.22	996	12.77	6.3	-28.12	42.63	1595	1544	20	882.6	<0.10	55.27	13.64

Water Sampling Data for Mine Discharge MC3.

MC3 Mine Discharge with the Coal Refuse Pile Downstream.

MC3 Discharge After Work to Consolidate Flow for Sampling.

MC3 Mine Discharge Showing the Channel Built to Consolidate the Flow.

E. A better understanding of the importance, if any, of the MC2 discharge.

Mine discharge MC2 was sampled by a former watershed group and environmental contractor New Miles of Blue Stream more than 20 years ago. They concluded that this mine discharge was of secondary importance compared with the MC-Fore and MC3 discharges. The monthly water sampling that was performed as part of this project almost reached the same conclusion until the first round of the bird survey in April of 2024 happened upon large flows of acidic water in unexplained places. Field scouting conducted a few days later traced these large flows back to the MC2 mine discharge. Monthly sampling of the Moshannon headwaters was rescheduled to capture this event, and the flow of water from MC2 was measured at 120 gallons per minute. This was four times the previously measured maximum flow during this study in 2023 and 2024 and twice the maximum flow observed by New Miles of Blue Stream. A pH meter was placed in Moshannon Creek downstream of MC2, and Moshannon was found to drop to a pH of 4.6 on the side where MC2 enters it. This is a concerning result. It is currently unknown how often this happens and what the duration of the high flow events are.

To provide more continuous flow data, MCWA repurposed a weir constructed for another project. The weir was modified from a flat bottom weir to a vee notch weir to better handle widely variable flow measurements. The weir was installed in the MC2 outlet channel. BAMR installed a pressure transducer upstream of the weir. This transducer records depth every 15 minutes, and that measurement can be converted to flow through the weir. At least an additional year's data will be gathered to determine the frequency and duration of high flow events from MC2.

MC2 was researched on mine maps. It appears to be a drainage channel constructed in the vicinity of the entry portals of the Elizabeth #2 Deep Mine. The portals for this mine are no longer clearly visible on the surface after subsequent strip mine activity. The large flows recently found may come from this deep mine when it is full of water. A future high flow event will need to be scouted upstream to identify the emergence area or areas of the higher flow. In low flows, MC2 appears to emerge in the flooded portion of the drainage channel. The water chemistry of MC2 has considerably more sulfate and aluminum and a lower pH during higher flows.

The follow-on investigations of the flow variability in MC2 that are now underway will need to be completed to determine how often high flow events occur and what is their duration. This more detailed information should assist in determining how often high flows occur in MC2 and how important this mine discharge is. Treatment design, if determined necessary, would be a follow-up step.

Flooded Constructed Drainage Channel Containing Water from MC2

MC2 aka MC2LOW															
Date	**Name**	**Flow (gpm)**	**F pH**	**F-SC**	**T**	**L pH**	**Acidity**	**Alk**	**S Con**	**TDS**	**TSS**	**Sulfate**	**Al**	**Fe**	**Mn**
09/30/23	MC2	2	4.71	220	18.2	4.67	10.97	0.19	190	135	<5	175.5	0.63	2.25	1.94
10/12/23	MC2	2	4.3		12.9	3.94	21.95	<0.1	237	168	34	91.3	1.01	12.68	2.84
11/04/23	MC2	4	3.97	229	7.8	4.08	17.64	<0.1	221	110	19	74.2	0.66	2.54	3.14
12/21/23	MC2	8.5	3.81	130	3.4	4.28	32.73	<0.1	193	137	<5	81.8	0.4	1.73	0.2
01/22/24	MC2	10	4.13	113.6	1.6	4.41	26.46	<0.1	180	118	14	65.6	1.21	1.26	1.72
02/12/24	MC2	23	3.23	416	6.4	3.83	124.97	<0.1	673	506	<5	377.5	15.87	2.1	6.87
03/04/24	MC2	30	3.42	290	13	3.99	51.34	<0.1	336	214	<5	124.6	4.77	0.62	2.58
04/09/24	MC2	120	2.92	733	14.1	3.66	197.6	<0.1	818	622	<5	891.6	15.53	0.87	8.53
05/02/24	MC2	24	3.19	684	19.5	3.50	190.24	<0.10	1077	832	<5	590.0	19.56	1.79	10.47
06/11/24	MC2	2.5	2.91	586	17.72	3.46	101.33	<0.10	795		18	363.4	8.78	4.22	7.78
07/03/24	MC2	2	2.88	496	22.94	3.32	259.36	<0.10	740	500	32	361.5	5.52	52.03	7.66
08/14/24	MC2	8	3.3	247	20	3.71	26.46	<0.10	276	180	5	86.6	1.04	3.29	2.42

Water Chemistry Data for MC2. Note the Increase in Aluminum Concentration and Drop in pH During Higher Flow.

Weir and Transducer for MC2 During Low Flow Conditions

Vee Notch Weir for MC2 Showing Low Flow Conditions

Aerial Imagery with the MC2 Channel Circled. A Semi-Transparent Mine Map Overlay Shows the Nearby Underground Mine Elizabeth No. 2

This strip mine map from 1966 shows the drainage channel as an ‘old ditch’. The channel likely dates to either the Elizabeth 2 mine operational period in the early 20th century or to extensive coal seam crop line strip mining that occurred in the 1940’s.

The area circled in red is the drainage channel discussed in this section. This graphic shows the proximity of its upper end to the historic location of the entry portals for the Elizabeth 2 mine. The map from 1926 already shows this mine as abandoned. The Elizabeth 2 was incorporated into the much larger Brookwood Shaft mine. The mine floor in this part of the Elizabeth 2/Brookwood Shaft complex slopes away from the area of this portal. The portal location appears to have been destroyed by later surface mining. If water inside the remaining mine voids in the Elizabeth 2 mine is a major source of the water in MC2, this water is likely only significant when the mine is full of water. This may explain the flashy nature of the high flow events and their sporadic nature.

F. A better understanding of the importance of the unnamed tributary that joins Moshannon Creek at WGS84 lat 40.7752, long -78.3522.

Water sampling done in July of 2020 for the Coldwater Conservation Plan showed that this unnamed tributary of Moshannon Creek had a lower than desirable pH of 5.24 and elevated iron of 1.98 mg/l. Tracing this stream back to its source during this project developed the fact that this stream has the misfortune of beginning with seepage from a flooded strip mine cut. The stream improves enough from later cleaner water inputs to have the water chemistry found at its mouth. The water in the flooded strip mine cut seeps through the roadway fill of a private road into a wetlands area. The wetlands then discharge into the headwaters of the unnamed tributary through a culvert crossing of another private road. This culvert location was sampled for a year and was given the designation of MC3.5.

PA DEP's Bureau of Abandoned Mine Reclamation (BAMR) has included the flooded strip mine cut, a nearby dry strip mine cut, and the coal refuse pile previously mentioned in this report in a reclamation project which is identified as Gililand Property – Inquiry 2023-08-199; OSM 17(6523)101.1 – Moranne Southeast - project development. This project as currently conceived will include reclaiming the flooded strip mine cut with associated water management. The water within the flooded cut currently has a very long contact time with the rock around it. Once reclamation is complete and conditions have stabilized, the water departing the reclamation site should be reevaluated to determine if treatment is necessary. If treatment is necessary, a passive treatment system is likely necessary.

Flooded strip mine cut that provides the water for the wetlands in the unnamed tributary headwaters.

Headwaters wetlands for unnamed tributary.

MC3.5														
Date	**Flow**	**F pH**	**F-SC**	**T**	**L pH**	**Acidity**	**Alk**	**S Con**	**TDS**	**TSS**	**Sulfate**	**Al**	**Fe**	**Mn**
09/30/23	1	5.9	1530	3.44	6.04	5.48	3.44	158	112	<5	95.6	<0.1	3.38	1.97
11/04/23	0.1	6.45	1641	6.4	6.42	-10.97	26.13	150	90	18	63.9	0.12	12.23	2.27
12/21/23	0													
01/22/24	Snowy Road													
02/12/24	6	5.47	95.7	8.2	5.51	7.96	8.29	165	130	<5	75	0.26	2.18	1.43
03/04/24	60	4.9	149.2	17	4.75	21.49	<0.1	166	128	<5	67.4	0.35	1.85	1.1
04/09/24	16	4.41	138.4	16.7	4.69	30.04	<0.10	157	106	11	92.9	0.92	3.49	0.68
05/02/24	24	3.86	170.4	18.5	4.09	46.56	<0.10	265	150	<5	118.2	0.39	1.00	1.29
06/11/24	8	4.91	218	16.2	4.58	69.74	<0.10	294	208	12	126.8	0.25	6.12	2.71
07/03/24	5	6.21	203	21.6	5.82	-29.11	35.28	278	224	<5	146.4	0.32	22.19	2.87
08/14/24	5	5.83	207	19.7	5.98	44.57	18.77	254	240	<5	86.5	0.11	9.46	2.57

Mine discharge MC3.5 is the outlet of the wetlands pictured above.

Road crossing outlet for the unnamed tributary headwaters wetlands showing accumulated iron sediment. A culvert is located at the bottom of the picture. This location was sampled as discharge MC3.5.

This is the upper channel of the unnamed tributary showing iron deposition. This location is just downstream of the culvert location of mine discharge MC3.5.

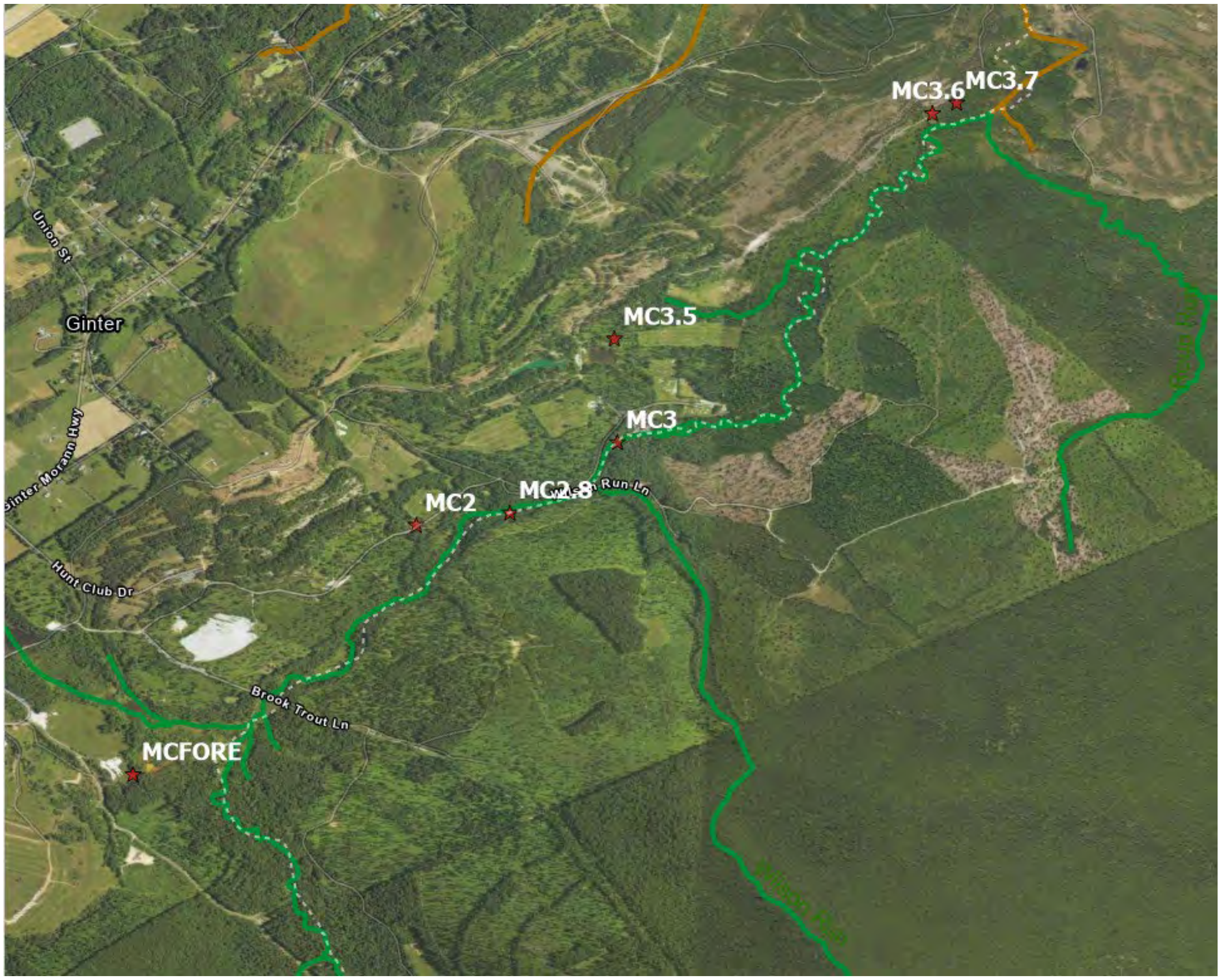
This image is an aerial view of the flooded strip mine cut. Water seeps through the road fill on the right side of the image.

The image above is an overall view showing the area for the BAMR mine reclamation project associated with the unnamed tributary and the coal refuse pile. The numbered locations are explained below.

1. The dry strip mine cut above this number is the likely location for relocating the reclaimed material from the coal refuse pile.
2. The flooded strip mine cut to be reclaimed is below this number. There is likely to still be water departing this location, probably through a piped outlet or constructed channel, but with much less retention time and contact with reactive geology. The water leaving this cut now seeps through the fill for the road running south to north at its eastern edge.
3. The coal refuse pile to be reclaimed is just below this number.
4. The MC3 mine discharge is located just upstream of the coal refuse pile very near the bank of Moshannon Creek. It should be reevaluated after the flooded strip mine cut is reclaimed. The flooded strip mine cut is a possible source of the water that emerges here.
5. The confluence of the unnamed tributary impacted by the flooded strip mine cut and Moshannon Creek is just above this number.

G. A listing of newly found problem areas (if any) and their importance.

A map showing the headwaters sample locations from this project is shown below.



MC-Fore, MC2 and MC3 were known from previous investigations in the Moshannon Creek watershed. MC3.5 was found during this project and discussed in deliverable F since it drains into the unnamed tributary. Three other sites were sampled after they were found during field explorations conducted in this project: MC2.8, MC3.6 and MC3.7. After a year’s worth of water sampling, they were found to be of secondary importance. They are described and photographed briefly below.

MC2.8 was found to flow from a wetlands area with obvious aluminum deposition through a channel with obvious iron deposition. The water in the channel was found to have a moderately low pH in the 4’s, and most of the time the metals dissolved in the water were below the threshold for impairment. It is believed that the pH in the 4’s in this water is a result of natural processes that are depositing the dissolved metals. At normal flows in the stream and the discharge, Moshannon Creek has sufficient flow to overwhelm the negative impact from the acidity found in MC2.8.

Mine discharge MC2.8 viewed, looking upstream, from near Moshannon Creek.

MC2.8														
Date	**Flow (gpm)**	**F pH**	**F-SC**	**T**	**L pH**	**Acidity**	**Alk**	**S Con**	**TDS**	**TSS**	**Sulfate**	**Al**	**Fe**	**Mn**
11/04/23	5	4.2	1220	10.3	5.1	126.02	5.21	114	44	35	<5	0.21	0.78	1.5
12/21/23	14	4.17	66.8	4.5	4.48	40.18	<0.1	102	72	<5	35.8	0.3	0.3	0.97
01/22/24	Frozen													
02/12/24	9	4.15	63.3	5.1	4.58	16.11	0.17	105	100	<5	37.8	1.02	0.18	0.86
03/04/24	25	4.17	91.5	10.2	4.54	120.19	<0.1	104	90	<5	20.4	0.72	0.16	0.81
04/09/24	20	4.14	92.8	9.9	4.62	19.1	<0.10	103	92	<5	38.2	1.12	0.24	1.13
05/02/14	6	4.16	64.5	14.1	4.37	17.71	<0.10	111	80	<5	36.7	0.62	0.66	1.68
06/11/24	0													
07/03/24	trickle													
08/14/24	7	4.04	85.3	17.44	4.39	16.91	<0.10	99	94	<5	32.4	0.35	0.27	1.14

MC3.6 is a constantly saturated area of mine waste near the historic entrances to the Ladysmith deep mine. It remains wet even in the dryest weather. An outlet channel does exist but was only found to have measurable flow in the channel (1.2 gallons per minute) at one sample event in this project. This mine discharge seems to prevent vegetation growth in the saturated area but has little impact on Moshannon Creek.


Mine discharge MC3.6 showing the constantly wet area where it emerges.

MC3.6														
Date	Flow	F pH	F-SC	T	L pH	Acidity	Alk	S Con	TDS	TSS	Sulfate	Al	Fe	Mn
12/21/2023	**0**													
01/22/24	snowy road													
03/04/24	trickle													
04/09/24	1.2	2.84	252	19.5	3.53	68.45	<0.10	289	146	6	120.5	2.31	2.29	2.07
05/02/24	trickle													
06/11/24	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
07/03/24	trickle													
8/14/2024	0													

MC3.7 is a constructed drainage channel either from the Ladysmith Mine or coal seam cropline strip mining conducted in the 1940's. It looks ominous in aerial imagery because the channel is usually full of water, but the water seldom has significant flow. The water chemistry of the water sitting mostly still in this channel would make this an important mine discharge if it had higher flow. MC3.7 sits across Moshannon Creek from much more important mine discharges that enter from the Centre County side of the stream into Roup Run and Moshannon Creek downstream of Roup Run.

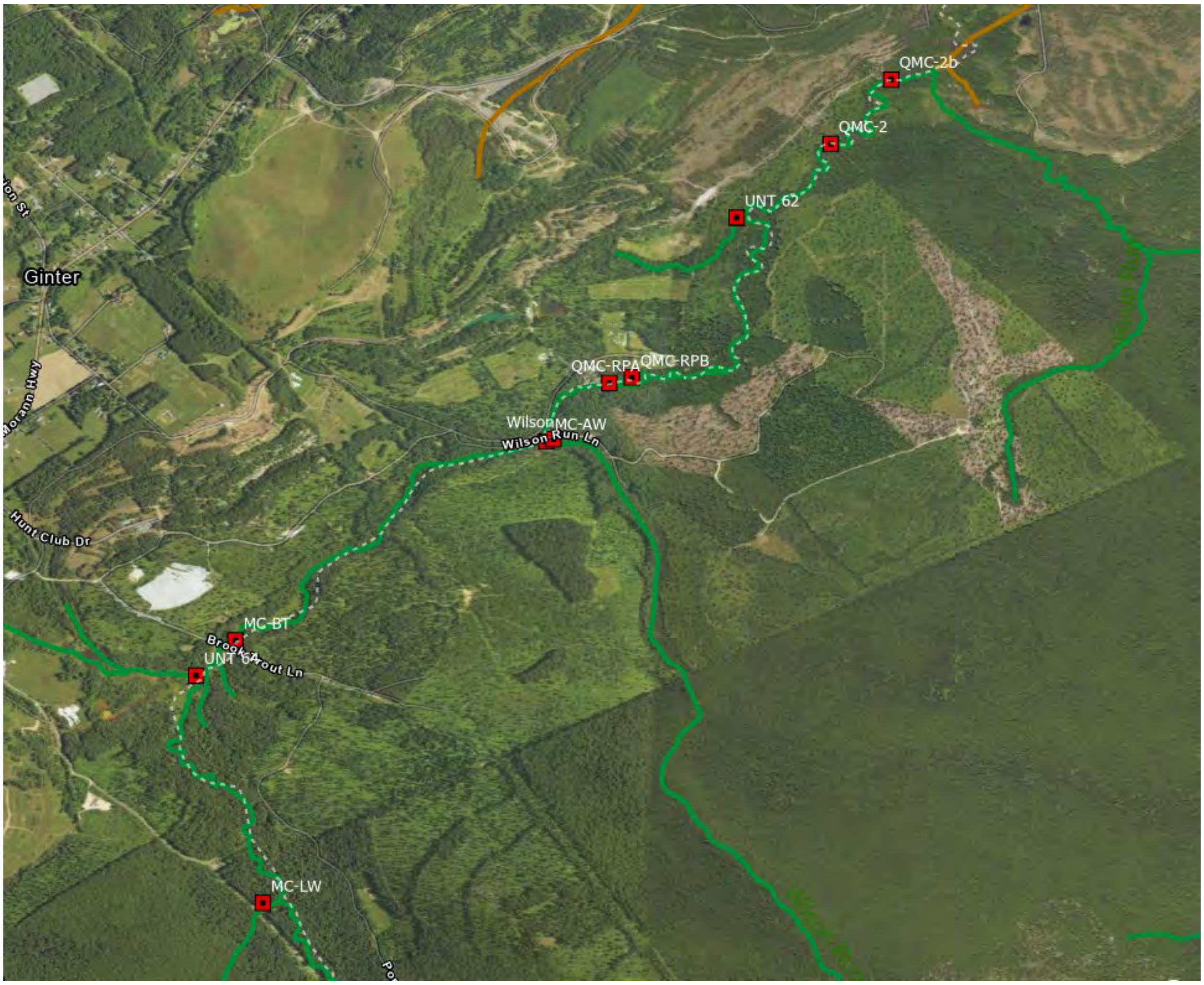
Mine discharge MC3.7 flooded channel looking towards Moshannon Creek.

MC3.7														
Date	Flow	F pH	F-SC	T	L pH	Acidity	Alk	S Con	TDS	TSS	Sulfate	Al	Fe	Mn
09/30/23	pooled													
12/21/23	0	3.13	474											
01/22/24	snowy road													
02/12/24	Trickle	3.25	418	9.9										
03/04/24	Trickle													
04/09/24	4E	3.22	605	18.2	3.81	77.8	<0.10	651	466	6	330.6	1.7	23.54	5.22
05/02/24	2	3.5	776.00	16.9	3.80	72.43	<0.10	1152	904	12	634.8	3.41	5.19	9.50
06/11/24	Trickle													
07/03/24	Trickle													
8/14/2024	0													

H. Water chemistry and benthic macroinvertebrate sampling data for the watershed and its discharges.

Water chemistry data for the mine discharges sampled was included in tables shown in the discussion of those discharges in this report. Stream water was sampled in multiple locations in the fall and spring during this project. A map of stream water sample points and a table of sample results are shown below. UNT 62 was sampled at the source of its impairment (MC3.5) rather than the very difficult to access mouth of the stream. The water chemistry results at MC-LW, a permanent in-stream weir at a property boundary, determined that little would be gained by investigating the Moshannon Creek watershed upstream of that point.

A report from the NFC-PA for the benthic macroinvertebrate sampling conducted in the fall of 2023 is an appendix to this report. As previously mentioned, the benthic macroinvertebrate sampling was conducted during an abnormally dry period and this may exaggerate the indications of stream impairment that were found.



Stream water sample points in this project.

Date	Name	Flow (gpm)	F pH	F-SC	T	L pH	Acidity	Alk	S Con	TDS	TSS	Sulfate	Al	Fe	Mn
09/30/23	MC-AW	707	6.92	94.9	14.4	6.17	-3.72	10.79	104	74	<5	21.8	<0.1	0.27	0.12
09/30/23	MC-BT	597	6.93	85.5	17.4	6.41	5.29	10.7	94	67	<5	13.6	<0.1	0.41	0.18
11/04/23	MC-BT	574	6.78	98.6	6.4	6.74	3.33	9.54	109	40	<5	18.8	<0.1	0.7	0.35
05/02/24	MC-BT	2912	6.76	77.6	16.2	6.61	-40.59	60.80	82	38	<5	13.5	<0.10	0.37	0.33
11/04/23	MC-LW	297	6.57	93.3	6	6.77	-1.17	8.64	101	36	<5	5.2	0.1	<0.1	<0.05
05/02/24	MC-LW	1992	6.94	64.8	14.2	6.70	-33.63	53.98	68	48	6	89.3	<0.10	0.19	<0.05
09/30/23	QMC-2	1032	7.38	82.1	14.8	6.21	-0.98	8.91	92	65	<5	28.2	<0.1	0.14	0.05
05/02/24	QMC-2b	5306	6.53	64.8	14.2	6.61	-68.45	88.92	72	34	<5	16.0	<0.10	0.24	0.17
09/30/23	QMC-RPA	880E	6.93	91	14.8	6.38	0.19	8.76	98	70	<5	27.5	<0.1	0.47	0.18
05/02/24	QMC-RPA		6.71	73.1	14.3	6.54	-53.92	74.34	78	38	<5	16.9	0.14	0.45	0.27
09/30/23	QMC-RPB	885	6.9	90.4	14.6	6.55	8.42	9.05	98	70	5	29.7	<0.1	0.59	0.18
05/02/24	QMC-RPB	4343	6.64	72.6	14.5	6.51	-58.50	78.98	79	40	<5	17.9	0.16	0.58	0.27
05/02/24	UNT 64	111	6.03	284	24	5.88	-49.75	70.06	283	98	6	52.5	<0.10	2.76	3.93
09/30/23	Wilson	100E	6.58	14.4	13.1	6.28	8.23	2.49	22	<20	<5	6.2	<0.1	<0.1	<0.05

5. Project Finances

The funds from the Eastern Brook Trout Joint Venture Grant in this project were designated for the design costs for a treatment system for the MC-Fore acid mine drainage discharge in the Moshannon Creek headwaters. Inflation, combined with the discovery of a second pipe furnishing acid mine drainage in the discharge channel, added additional costs to the project. This necessitated a second grant from the Foundation for Pennsylvania Watersheds and additional funding from MCWA to complete the design. The costs for the design were allocated as follows:

EBTJV Grant - $43,500

FPW Grant - $6,300

MCWA Funds - $1,837.24

Total Design Costs - $51,637.24

The initial grant application promised at least a 1:1 match for the EBTJV grant using a combination of cash expenditures and volunteer and professional labor value and contributed vehicle mileage. The $43,500 grant amount was more than matched by a total match amount of $63,749.38. The match total was calculated by a spreadsheet maintained throughout the project that will be submitted separately with this report to our EBTJV contacts.

6. Final Thoughts

This project was successful because of the combined efforts of the project partners. Each of the partners brought their skills, time and/or financial resources to the project. Each contribution was essential. Thanks to everyone who contributed.

7. Appendices

A. Bird Survey Results

B. Benthic Macroinvertebrate Survey Results

Bird Survey Field Work in the Spring of 2024.

Juniata Valley Audubon Society Report

Bird Survey Report – 2023–2024 Season

Prepared by: Michael Kensinger, President, Juniata Valley Audubon Society

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Introduction

Between April and late June 2021, 2022 and 2023, I conducted a series of nine bird surveys within the Moshannon Watershed region. The goal of these surveys was to document breeding and migratory bird species, evaluate habitat quality, and identify conservation concerns. Surveys were conducted primarily in the morning, with two evening sessions to capture nocturnal and crepuscular activity. Survey points were created by previous President John Carter, and we kept point checklists, as well as "walking" lists of our encounters along the creek.

Across all dates, a total of 98 bird species were observed, representing a diverse mix of waterfowl, raptors, woodland species, as well as wetland specialists. These results highlight the ecological richness of the watershed and underscore the importance of continued monitoring and habitat protection.

Survey Results

- Total Species Recorded: 98
- Survey Effort: 9 dates (7 morning, 2 evening)
- Observers: Michael Kensinger (lead), John Carter (partial), Conner Schmitt (partial),
- Notable Trend: Morning surveys yielded significantly higher species counts (up to 60 species on June 22) compared to evening surveys (32 species on June 24). However, evening and dusk surveys were more effective for detecting species such as the Eastern Whip-poor-will.

Key Highlights

- Waterfowl & Wetland Birds
    - Canada Goose, Mallard, Wood Duck, Hooded Merganser, Spotted Sandpiper, Solitary Sandpiper, American Woodcock, Great Blue Heron, and Green Heron.

    - Wood Duck and Hooded Merganser confirmed as cavity nesters utilizing dead trees.
    - Louisiana Waterthrush detected on eight of nine survey dates, with up to five individuals recorded.
- Raptors & Owls
    - Bald Eagle, Cooper's Hawk, Sharp-shinned Hawk, Red-shouldered Hawk, Broad-winged Hawk (15 observed in a "kettle"), Red-tailed Hawk, Merlin.
    - Great Horned Owl pair confirmed breeding each year
- Forest & Shrubland Species
    - Eastern Whip-poor-will (six individuals heard; significant given regional decline).
    - Scarlet Tanager (likely a dozen breeders).
    - Field Sparrow (most prevalent species recorded).
    - Eastern Towhee, Indigo Bunting, and Yellow-billed Cuckoo all common.
- Migrants of Note
    - Swainson's Thrush, Blackpoll Warbler, and Canada Warbler documented in passage.
    - Yellow-bellied Sapsucker noted in June, suggesting possible breeding in the watershed (an uncommon event).
- Common Species
    - Blue Jay, American Robin, Song Sparrow, Northern Cardinal, Cedar Waxwing, and American Goldfinch were among the most widespread.
- Invasive Species
    - European Starling was detected and noted as a potential competitor with cavity-nesting natives.

Louisiana Waterthrush: Indicator Species

The Louisiana Waterthrush (Parkesia motacilla) was one of the most important findings of this survey, present on nearly every survey date. As a riparian obligate species, its presence reflects high-quality streamside habitat.

- Physical Characteristics: Distinctive white eyebrow stripe, brown back, and streaked underparts.
- Habitat: Small, forested streams and wetlands.
- Behavior: Ground-foraging for aquatic invertebrates.
- Conservation Significance: Listed as "Vulnerable" in Pennsylvania. Populations serve as bioindicators of water quality, riparian integrity, and ecosystem health.

The consistent presence of this species suggests that portions of the watershed are functioning as high-quality habitat. Continued monitoring will help track long-term trends.

Additional Wildlife Observations

- Beaver activity was documented. Beaver dams are likely providing ecological benefits, including wetland creation, sediment capture, and improved buffering of acid mine drainage (AMD). Research shows that beaver wetlands can help neutralize acidity, reduce heavy metal concentrations, and improve water quality—making them valuable allies in watershed restoration.
- Flora: Notable wildflowers included Pink Lady Slippers and Painted Trillium, underscoring the rich plant diversity of the survey sites.

Challenges and Recommendations

- Survey Effort: Surveys enhanced by individuals who can “bird by ear” with accuracy.
- Timing: Morning surveys provided the most comprehensive results, though targeted dusk surveys remain important for nocturnal species.
- Next Steps:
    - Consider annual bird monitoring to track species presence and abundance.
    - Focus on riparian habitats to monitor Louisiana Waterthrush and other stream specialists.
    - Encourage habitat stewardship that protects cavity-bearing trees, wetlands, and scrubland edges.
    - Maintain beaver populations as natural allies in water quality improvement.

Conclusion

The Moshannon Watershed continues to support a diverse bird community, with nearly 100 species observed in this survey period. From waterfowl and raptors to declining songbirds such as the Eastern Whip-poor-will and Louisiana Waterthrush, the results underscore the importance of this landscape for both breeding and migratory birds.

The presence of indicator species, rich plant communities, and ecosystem engineers such as beavers all point to a watershed of high ecological value. Continued monitoring, conservation, and community engagement will be vital in maintaining and enhancing these natural resources.

4 November 2023

Prepared by Philip Light – Chair Pennsylvania chapter of Native Fish Coalition
With Andrew Mickey – Vice Chair PA NFC, Christopher Mickey – Secretary PA NFC, &

For

The Moshannon Creek Watershed Association

MCWA

www.moshannoncreek.org

FOREWORD

Native Fish Coalition (NFC) is a nonpartisan, grassroots, donor-funded, all volunteer, 501(c)(3) non-profit organization dedicated to the conservation, preservation, and restoration of wild native fish.

ACKNOWLEDGEMENTS

Survey work on Moshannon Creek was made possible through the donation of equipment from the Susquehanna River Watershed Basin Commission, the Department of Environmental Protection, and the Potter County Conservation District, with property access provided by Warriors Mark Wingshooting.

INTRODUCTION

Moshannon Creek has a 275 square mile watershed in Central Pennsylvania. This includes one square mile of stream water diverted into the Sevenmile Run watershed from outside of the natural watershed by a mine drainage treatment system. For most of its length, the main stem of Moshannon Creek is the county line between Centre and Clearfield Counties. All of the tributaries and the upper portion of the main stem of Moshannon Creek are classified as coldwater fisheries.

The watershed has a mix of clean streams, many with trout, and streams impacted by abandoned mine drainage (AMD) from long-abandoned coal and clay mines. This mixed legacy has created the situation where the Moshannon Creek watershed is a popular place for fishing and other recreational activities, even with significant AMD impacts to many of the streams. This report documents the sampling methods and summarizes the IBI (Index of Biotic Integrity) observed on November 4th 2023 at four different sample sites in the upper Moshannon Mainstem.

METHODS

Site Selection: The design method chosen for site selection is based on the Cause and Effect Monitoring model. A cause and effect sampling design is employed to investigate possible relationships between point or nonpoint sources of conventional pollutants and known or suspected instream water quality problems through the collection and analysis of biological, physical, and chemical data.

On the day of sampling, the team conducted multiple field tests to sample water quality parameters using an Apera water quality testing kit that was calibrated the night before sample collection. We sampled sites throughout the mainstem of Moshannon Creek to identify inputs with a low pH and/or high Conductivity to determine the best sites on the stream to represent the impact of point source pollution on the macroinvertebrate community.

Site #1 (40.77837, -78.34844) is located in the northern-most corner of the Gillbrook Land & Cattle Co property (Warriors Mark Wingshooting) (field observed pH:5.84 & Conductivity:136, Temperature: 61.2).

Site #1 Photo:

Site #2 (40.76666, -78.36012) was located approximately 1.2 miles upstream of site #1 (field observed pH:6.3, Conductivity:112, Temperature: 57.5)

Site #2 Photo:

Site #3 (40.75805, -78.37065) was located approximately 0.9 miles upstream of site #2 (field observed pH:6.82, Conductivity:97, Temperature: 55.2)

Site #3 Photo:

Site #4 (40.75124, -78.37571) was located approximately 0.6 miles upstream of site #3 (field observed pH:71, Conductivity:108, Temperature: 47.7)

Site #4 Photo:

Habitat observed at sample sites were comprised of Silt/sand/gravel substrate.
This habitat includes sandy, silty, or muddy stream bottoms; rocks along the stream bottom; and/or wetted gravel bars. This habitat may also contain algae covered rocks (sometimes called Aufwuchs).

Moshannon Creek Macro Sample Site Locations

Moshannon Creek Sample Sites

Sample Collection: We employed the USEPA's Rapid Bioassessment Protocol for use in Wadeable Streams and Rivers (Barbour et al.1999) single, most productive habitat (riffle-Run) approach. Two benthic macroinvertebrate sample collection sites were identified by delineating two 100-meter reaches along the stream where the best available representation of riffle-run habitat existed for the stream segment of interest. Within each reach, three, three-foot by three-foot kick stations were established. Each station sampled was kicked for 1 minute directly upstream of a non-truncated D-framed net with 500 µm mesh.

Stations were "kicked" starting with the downstream station first as not to disturb the other two stations upstream.

One member of the team held the D-frame net in a constant location for 1 minute at station #1, while the other team member dislodged macroinvertebrates from large rocks in the 3 foot by 3 foot sample area, and then thoroughly dislodged macroinvertebrates from the smaller cobble in the sample area by "kicking" the streambed with their feet.

Following the capture of specimens from the first of three sample stations in site #1, the contents of the D-frame net were emptied into a clean 5-gallon bucket with a small amount of clean stream water. Water was poured over the outside of the net to dislodge all specimens from the net. Additionally, individual specimens were manually picked from the net to ensure no specimens were lost.

Upon collecting the specimens from the first sample station, the above process was repeated for the final two sample stations at site #1. Specimens from all three sample stations were collected in the same 5-gallon bucket to create a composite score for the sample site based on the three sample stations within the 100-meter reach of the first station.

Upon completion of the collection process for site #1, the contents of the 5-gallon bucket were emptied into a large, shallow white pan. Using tweezers, eye droppers, and a small spatula, individual macroinvertebrates were picked from the shallow pan and sorted into divided white sorting trays. Specimens were sorted by order in each compartment of the sorting trays.

Specimen Sorting Tray

Assessment: The Wadeable Freestone Single, Most Productive Habitat (Riffle-Run) Stream Macroinvertebrate Assessment Method was used to assess the macroinvertebrate community at all four survey sites on Moshannon Creek.

This assessment method is designed to make ALU assessment determinations using benthic macroinvertebrate communities in Pennsylvania's wadeable, freestone, riffle-run streams. Through direct quantification of biological attributes along a gradient of conditions, the index of biotic integrity (IBI) provided in this assessment method measures the extent to which anthropogenic activities compromise a stream's ability to support healthy aquatic communities (Davis and Simon 1995).

Six metrics are included in this assessment protocol:

Total Taxa Richness:
This taxonomic richness metric is a count of the total number of taxa in a subsample. Generally, this metric is expected to decrease with increasing anthropogenic stress to a stream ecosystem, reflecting loss of taxa and increasing dominance of a few pollution-tolerant taxa. Other benefits of including this metric include its common use in many biological monitoring and assessment programs in other parts of the world as well as its ease of explanation and calculation.

Ephemeroptera + Plecoptera + Trichoptera Taxa Richness (Pollution Tolerance Values 0-4 only)

This taxonomic richness metric is a count of the number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) in a sub-sample – 2-5 common names for these orders are mayflies, stoneflies, and caddisflies, respectively. The aquatic life stages of these three insect orders are generally considered sensitive to, or intolerant of, many types of pollution (Lenat and Penrose 1996), although sensitivity to different types of pollution varies among taxa in these insect orders. The version of this metric used here only counts EPT taxa with PTVs of 0 to 4, excluding a few of the most tolerant mayfly and caddisfly taxa. This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of taxa from these largely pollution-sensitive orders. This metric has a history of use across the world and is relatively easy to use, explain, and calculate (Lenat and Penrose 1996).

Beck's Index (version 3)
This taxonomic richness and tolerance metric is a weighted count of taxa with pollution tolerance values of 0, 1, or 2. The name and conceptual basis of this metric are derived from the water quality work of William H. Beck in Florida (Beck 1955). This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution sensitive taxa.

Shannon Diversity
This community composition metric measures taxonomic richness and evenness of individuals across taxa of a sub-sample. This metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive taxa and increasing dominance of a few pollution-tolerant taxa. The name and conceptual basis for this metric are derived from the information theory work of Claude Elwood Shannon (Shannon 1948).

Hilsenhoff Biotic Index
This community composition and tolerance metric is calculated as an average of the number of individuals in a sub-sample, weighted by pollution tolerance values. Developed by William Hilsenhoff, the Hilsenhoff Biotic Index (Hilsenhoff 1977, 1987, 1988; Klemm et al. 1990) generally increases with increasing ecosystem stress, reflecting increasing dominance of pollution-tolerant organisms. Percent Sensitive Individuals (Pollution Tolerance Values 0-3 only) This community composition and tolerance metric is the percentage of individuals with pollution tolerance values of 0 to 3 in a sub-sample and is expected to decrease in value with increasing anthropogenic stress

Percent Sensitive Individuals (Pollution Tolerance Values 0-3 only)
This community composition and tolerance metric is the percentage of individuals with pollution tolerance values of 0 to 3 in a sub-sample and is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting loss of pollution-sensitive organisms.

Site #1 Findings:

Taxa Name	Number of Individuals	Pollution Tolerance Value
Family Chironomidae (non-biting or true midges)	150	0
Phryganeidae	1	4
Heptageniidae	5	3
Hydropsychidae	1	4

Total Taxa Richness: 4

EPT Taxa Richness (PTV 0-4 only)

1 Ephemeroptera taxa
0 Plecoptera taxa
2 Trichoptera taxa

EPT Taxa Richness = 1 + 0 + 2
EPT Taxa Richness = 3

Beck's Index (Version 3):

= 3 * ($n_{taxaPTV0}$) + 4 * ($n_{taxaPTV1}$) + 1 * ($n_{taxaPTV2}$)

Where ntaxaPTV0 is the number of taxa with a PTV attribute of 0, ntaxaPTV1 is the number of taxa with a PTV attribute of 1, and ntaxaPTV2 is the number of taxa with a PTV attribute of 2.

Beck's Index (version 3) = 3(1) + 2(0) + 1(0)
Beck's Index (version 3) = 3 + 4 + 1
Beck's Index (version 3) = 8

Hilsenhoff Biotic Index

$$= \sum_{i=0}^{10} [(i * n_{indvPTVi})] \Big/ N$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.
There are 150 individuals with a PTV = 0

There are 0 individuals with a PTV = 1
There are 0 individuals with a PTV = 2
There are 5 individuals with a PTV = 3
There are 2 individuals with a PTV = 4
There are 0 individuals with a PTV = 5
There are 0 individuals with a PTV = 6
There are 0 individuals with a PTV = 7
There are 0 individuals with a PTV = 8
There are 0 individuals with a PTV = 9
There are 0 individuals with a PTV = 10

There are a total of 157 individuals in this sample.

Hilsenhoff Biotic Index = [(0*150) + (1*0) + (2*0) + (3*5) + (4*2) + (5*0) + (6*0) + (7*0) + (8*0) + (9*0) + (10*0)]/157

Hilsenhoff Biotic Index = .1465

Shannon Diversity Index

$$= -1\left(\sum_{i=1}^{Rich}[(n_i/N)\ \ln(n_i/N)]\right)$$

where ni = the number of individuals in each taxon (relative abundance); N = the total number of individuals in a sub-sample; and Rich = the total number of taxa in a subsample (total taxa richness).

There are 4 taxa in this sample. The number of each taxon are shown in the table above. There are a total of 157 individuals in this sample.

Shannon Diversity Index = -1 [(8/157) ln (8/157) + (1/157) ln (1/157) + (2/157) ln (2/157) + (1/157) ln (1/157) + (1/157) ln (1/157) + (1/157) ln (1/157)

Shannon Diversity Index = .2178

Percent Sensitive Individuals (PTV 0-3 only)

$$= \left(\sum_{i=0}^{3} n_{indvPTVi} / N\right)*100$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.

There are 150 individuals with a PTV = 0
There are 0 individuals with a PTV = 1
There are 0 individuals with a PTV = 2
There are 5 individuals with a PTV = 3

There are a total of 157 individuals in this sub-sample.

Percent Sensitive Individuals (PTV 0-3 only) = (150+0+0+5)/157*100
Percent Sensitive Individuals (PTV 0-3 only) = 155/157*100
Percent Sensitive Individuals (PTV 0-3 only) = 98.73

Site #1 IBI Score

IBI Calculation			
Metric	**Standardization Equation** smaller streams (most 1st to 3rd order) < 25 square miles	**Observed Metric Value**	**Standardized Metric Score**
Total Taxa Richness	(observed value / "factor")*100	4	12.12
EPT Taxa Richness	(observed value / "factor")*100	3	15.79
Beck's Index	(observed value/"factor")*100	8	21.05
Hilsenhoff Biotic Index	[(10-observed value)/(10-"factor")]*100	0.146496815	121.50
Shannon Diversity	(observed value/"factor")*100	0.217758648	7.61
Percent Sensitive Individuals	Observed value/"factor")*100	98.72611465	116.84
Average of standardized core metric scores (IBI Score) =			49.15

Site #2 Findings:

Taxa Name	Number of Individuals	Pollution Tolerance Value
Baetidae	30	5
Hydropsychidae	6	4
Heptageniidae	11	3
Libellulidae	2	2
Aeshnidae	1	3
Capniidae	1	2

Total Taxa Richness: 6

EPT Taxa Richness (PTV 0-4 only)

1 Ephemeroptera taxa
1 Plecoptera taxa
1 Trichoptera taxa

EPT Taxa Richness = 1 + 1 + 1
EPT Taxa Richness = 3

Beck's Index (Version 3):

= 3 * ($n_{taxaPTV0}$) + 2 * ($n_{taxaPTV1}$) + 1 * ($n_{taxaPTV2}$)

Where ntaxaPTV0 is the number of taxa with a PTV attribute of 0, ntaxaPTV1 is the number of taxa with a PTV attribute of 1, and ntaxaPTV2 is the number of taxa with a PTV attribute of 2.

Beck's Index (version 3) = 3(0) + 2(0) + 1(2)
Beck's Index (version 3) = 3 + 4 + 1
Beck's Index (version 3) = 8

Hilsenhoff Biotic Index

$$= \sum_{i=0}^{10} [(i * n_{indvPTVi})] / N$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.
There are 0 individuals with a PTV = 0
There are 0 individuals with a PTV = 1
There are 3 individuals with a PTV = 2
There are 12 individuals with a PTV = 3
There are 6 individuals with a PTV = 4
There are 30 individuals with a PTV = 5
There are 0 individuals with a PTV = 6
There are 0 individuals with a PTV = 7
There are 0 individuals with a PTV = 8
There are 0 individuals with a PTV = 9
There are 0 individuals with a PTV = 10

There are a total of 51 individuals in this sample.

Hilsenhoff Biotic Index = [(0*0) + (1*0) + (2*3) + (3*12) + (4*6) + (5*30) + (6*0) + (7*0) + (8*0) + (9*0) + (10*0)]/51

Hilsenhoff Biotic Index = 4.24

Shannon Diversity Index

$$= -1 \left(\sum_{i=1}^{Rich} [(n_i/N) \ln(n_i/N)] \right)$$

where ni = the number of individuals in each taxon (relative abundance); N = the total number of individuals in a sub-sample; and Rich = the total number of taxa in a subsample (total taxa richness).

There are 6 taxa in this sample. The number of each taxon are shown in the table above. There are a total of 51 individuals in this sample.

Shannon Diversity Index = -1 [(6/51) ln (6/51) + (1/51) ln (1/51) + (2/51) ln (2/51) + (1/51) ln (1/51) + (1/51) ln (1/51) + (1/51) ln (1/51)

Shannon Diversity Index = 1.176

Percent Sensitive Individuals (PTV 0-3 only)

$$= \left(\sum_{i=0}^{3} n_{indvPTVi} \Big/ N \right) * 100$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.

There are 0 individuals with a PTV = 0
There are 0 individuals with a PTV = 1
There are 3 individuals with a PTV = 2
There are 12 individuals with a PTV = 3

There are a total of 51 individuals in this sub-sample.

Percent Sensitive Individuals (PTV 0-3 only) = (0+0+3+12)/51*100
Percent Sensitive Individuals (PTV 0-3 only) = 15/51*100
Percent Sensitive Individuals (PTV 0-3 only) = 29.41

Site #2 IBI Score

IBI Calculation			
Metric	**Standardization Equation** smaller streams (most 1st to 3rd order) < 25 square miles	**Observed Metric Value**	**Standardized Metric Score**
Total Taxa Richness	(observed value / "factor")*100	6	18.18
EPT Taxa Richness	(observed value / "factor")*100	3	15.79
Beck's Index	(observed value/"factor")*100	8	21.05
Hilsenhoff Biotic Index	[(10-observed value)/(10-"factor")]*100	4.235294118	71.08
Shannon Diversity	(observed value/"factor")*100	1.175950718	41.12
Percent Sensitive Individuals	Observed value/"factor")*100	29.41176471	34.81
Average of standardized core metric scores (IBI Score) =			33.67

Site #3 Findings:

Taxa Name	Number of Individuals	Pollution Tolerance Value
Baetidae	120	5
Hydropsychidae	8	4
Heptageniidae	10	3
Perlidae	13	2
Gomphidae	1	3
Isonychiidae	2	2

Total Taxa Richness: 6

EPT Taxa Richness (PTV 0-4 only)

2 Ephemeroptera taxa
1 Plecoptera taxa
1 Trichoptera taxa

EPT Taxa Richness = 2 + 1 + 1
EPT Taxa Richness = 4

Beck's Index (Version 3):

= 3 * ($n_{taxaPTV0}$) + 2 * ($n_{taxaPTV1}$) + 1 * ($n_{taxaPTV2}$)

Where ntaxaPTV0 is the number of taxa with a PTV attribute of 0, ntaxaPTV1 is the number of taxa with a PTV attribute of 1, and ntaxaPTV2 is the number of taxa with a PTV attribute of 2.

Beck's Index (version 3) = 3(0) + 2(0) + 1(2)
Beck's Index (version 3) = 3 + 4 + 1
Beck's Index (version 3) = 8

Hilsenhoff Biotic Index

$$= \sum_{i=0}^{10} [(i * n_{indvPTVi})] / N$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.
There are 0 individuals with a PTV = 0
There are 0 individuals with a PTV = 1
There are 15 individuals with a PTV = 2
There are 11 individuals with a PTV = 3
There are 8 individuals with a PTV = 4
There are 120 individuals with a PTV = 5
There are 0 individuals with a PTV = 6
There are 0 individuals with a PTV = 7
There are 0 individuals with a PTV = 8
There are 0 individuals with a PTV = 9
There are 0 individuals with a PTV = 10

There are a total of 154 individuals in this sample.

Hilsenhoff Biotic Index = [(0*0) + (1*0) + (2*15) + (3*11) + (4*8) + (5*120) + (6*0) + (7*0) + (8*0) + (9*0) + (10*0)]/51

Hilsenhoff Biotic Index = 4.51

Shannon Diversity Index

$$= -1 \left(\sum_{i=1}^{Rich} [(n_i/N) \ln(n_i/N)] \right)$$

where ni = the number of individuals in each taxon (relative abundance); N = the total number of individuals in a sub-sample; and Rich = the total number of taxa in a subsample (total taxa richness).

There are 6 taxa in this sample. The number of each taxon are shown in the table above. There are a total of 154 individuals in this sample.

Shannon Diversity Index = -1 [(6/154) ln (6/154) + (1/154) ln (1/154) + (2/154) ln (2/154) + (1/154) ln (1/154) + (1/154) ln (1/154) + (1/154) ln (1/154)

Shannon Diversity Index = .823

Percent Sensitive Individuals (PTV 0-3 only)

$$= \left(\sum_{i=0}^{3} n_{indvPTVi} \middle/ N \right) * 100$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.

There are 0 individuals with a PTV = 0
There are 0 individuals with a PTV = 1
There are 15 individuals with a PTV = 2
There are 11 individuals with a PTV = 3

There are a total of 154 individuals in this sub-sample.

Percent Sensitive Individuals (PTV 0-3 only) = (0+0+15+11)/154*100
Percent Sensitive Individuals (PTV 0-3 only) = 26/154*100
Percent Sensitive Individuals (PTV 0-3 only) = 16.88

Site #3 IBI Score

IBI Calculation			
Metric	**Standardization Equation** smaller streams (most 1st to 3rd order) < 25 square miles	**Observed Metric Value**	**Standardized Metric Score**
Total Taxa Richness	(observed value / "factor")*100	6	18.18
EPT Taxa Richness	(observed value / "factor")*100	4	21.05
Beck's Index	(observed value/"factor")*100	8	21.05
Hilsenhoff Biotic Index	[(10-observed value)/(10-"factor")]*100	4.512987013	67.66
Shannon Diversity	(observed value/"factor")*100	0.823374496	28.79
Percent Sensitive Individuals	Observed value/"factor")*100	16.88311688	19.98
Average of standardized core metric scores (IBI Score) =			29.45

Site #4 Findings:

Taxa Name	Number of Individuals	Pollution Tolerance Value
Baetidae	136	5
Hydropsychidae	6	4
Heptageniidae	55	3
Perlidae	3	2
Corydalidae (fishflies, dobsonflies, hellgrammites)	2	4

Total Taxa Richness: 5

EPT Taxa Richness (PTV 0-4 only)

1 Ephemeroptera taxa
1 Plecoptera taxa
1 Trichoptera taxa

EPT Taxa Richness = 1 + 1 + 1
EPT Taxa Richness = 3

Beck's Index (Version 3):

$= 3 * (n_{taxaPTV0}) + 2 * (n_{taxaPTV1}) + 1 * (n_{taxaPTV2})$

Where ntaxaPTV0 is the number of taxa with a PTV attribute of 0, ntaxaPTV1 is the number of taxa with a PTV attribute of 1, and ntaxaPTV2 is the number of taxa with a PTV attribute of 2.

Beck's Index (version 3) = 3(0) + 2(0) + 1(1)
Beck's Index (version 3) = 3 + 4 + 1
Beck's Index (version 3) = 8

Hilsenhoff Biotic Index

$$= \sum_{i=0}^{10} [(i * n_{indvPTVi})] \Big/ N$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.
There are 0 individuals with a PTV = 0
There are 0 individuals with a PTV = 1
There are 3 individuals with a PTV = 2
There are 55 individuals with a PTV = 3
There are 8 individuals with a PTV = 4
There are 136 individuals with a PTV = 5
There are 0 individuals with a PTV = 6
There are 0 individuals with a PTV = 7
There are 0 individuals with a PTV = 8
There are 0 individuals with a PTV = 9
There are 0 individuals with a PTV = 10

There are a total of 202 individuals in this sample.

Hilsenhoff Biotic Index = [(0*0) + (1*0) + (2*3) + (3*55) + (4*8) + (5*136) + (6*0) + (7*0) + (8*0) + (9*0) + (10*0)]/202

Hilsenhoff Biotic Index = 4.37

Shannon Diversity Index

$$= -1 \left(\sum_{i=1}^{Rich} [(n_i/N) \ln(n_i/N)] \right)$$

where ni = the number of individuals in each taxon (relative abundance); N = the total number of individuals in a sub-sample; and Rich = the total number of taxa in a subsample (total taxa richness).

There are 5 taxa in this sample. The number of each taxon are shown in the table above. There are a total of 202 individuals in this sample.

Shannon Diversity Index = -1 [(6/202) ln (5/202) + (1/202) ln (1/202) + (2/202) ln (2/202) + (1/202) ln (1/202) + (1/202) ln (1/202) + (1/202) ln (1/202)

Shannon Diversity Index = .833

Percent Sensitive Individuals (PTV 0-3 only)

$$= \left(\sum_{i=0}^{3} n_{indvPTVi} / N \right) * 100$$

where nindvPTVi = the number of individuals in a sub-sample with PTV of i and N = the total number of individuals in a sub-sample.

There are 0 individuals with a PTV = 0
There are 0 individuals with a PTV = 1
There are 3 individuals with a PTV = 2
There are 55 individuals with a PTV = 3

There are a total of 202 individuals in this sub-sample.

Percent Sensitive Individuals (PTV 0-3 only) = (0+0+3+55)/202*100
Percent Sensitive Individuals (PTV 0-3 only) = 58/202*100
Percent Sensitive Individuals (PTV 0-3 only) = 28.71

Site #4 IBI Score

IBI Calculation			
Metric	**Standardization Equation** smaller streams (most 1st to 3rd order) < 25 square miles	**Observed Metric Value**	**Standardized Metric Score**
Total Taxa Richness	(observed value / "factor")*100	5	15.15
EPT Taxa Richness	(observed value / "factor")*100	3	15.79
Beck's Index	(observed value/"factor")*100	8	21.05
Hilsenhoff Biotic Index	[(10-observed value)/(10-"factor")]*100	4.371287129	69.40
Shannon Diversity	(observed value/"factor")*100	0.833232659	29.13
Percent Sensitive Individuals	Observed value/"factor")*100	28.71287129	33.98
Average of standardized core metric scores (IBI Score) =			30.75

Conclusion

All of the sites sampled throughout this section of Moshannon Creek exhibit a similar macroinvertebrate community. Only minor changes in taxa and quantity of individuals were observed from site to site. The resulting IBI scores across all sites indicate a suppressed aquatic invertebrate community due to chemical pollution or habitat disturbance.