Morgan Run Watershed Implementation Plan

Developed by
Clearfield County Conservation District
6395 Clearfield Woodland Highway, Suite 2
Clearfield, PA 16830

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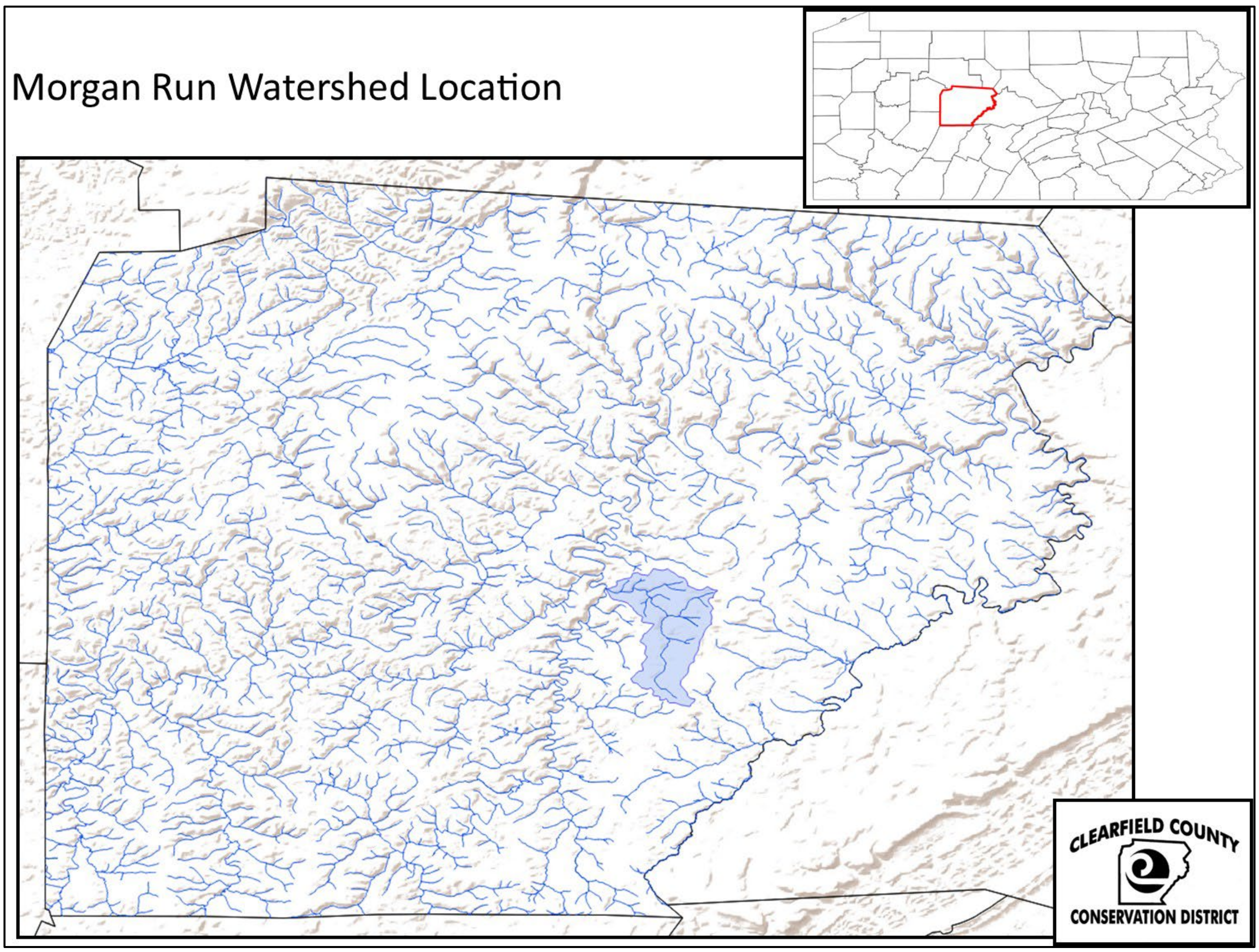
Contents

Background

Morgan Run is a tributary to Clearfield Creek in Boggs and Decatur Townships in Clearfield County. The watershed contains 20.2 miles of stream and encompasses an area of 14.6 square miles. According to the 2024 Integrated Water Quality Report, 8.3 miles of Morgan Run are impaired by pH and metals from abandoned mine drainage. Previous studies of the watershed include the original Clearfield Creek Assessment in 2002, a Susquehanna River Subbasin Study in 2005, and a Watershed Mine Drainage Assessment and Restoration Plan completed in 2006. Additionally, an unpublished watershed mass balance was completed in 2014. All these studies focused on abandoned mine drainage impacts in the watershed.

Figure 1 Morgan Run Watershed Location Map



Results of the 2002 Clearfield Creek Assessment showed that the Morgan Run watershed was one of the top contributors of abandoned mine drainage (AMD) pollution to Clearfield Creek. This led to the development of the Morgan Run Watershed Mine Drainage Assessment and Restoration Plan which identified all sources of AMD in the watershed and prioritized discharges for treatment. That plan proposed a top-down approach to remediation meaning the priorities were ranked based on their location in the watershed as opposed to a prioritization based on metal loadings.

Since the completion of the Assessment and Restoration Plan, no new mining has taken place in the watershed, but several passive treatment systems have been constructed under the direction of the Clearfield County Conservation District. All the systems were recommendations made in the 2006 Assessment and Restoration Plan. See Table 1 showing the identified discharges in the watershed, the status of treatment, and the priority assigned to each in this WIP. Section C on Page 25 explains in greater detail the current recommendations made in this WIP which are:

1. MR7 Prime and Steve's Spring treatment
2. MRSGL98 treatment
3. Monitor and maintain the Morgan Run treatment systems

Table 1 Treatment Recommendations from 2006 Morgan Run Mine Drainage Assessment & Restoration Plan and Current Status

Sites	Treatment Status	WIP Priority
MRTUFF	Built	3
MRFROG	Built	3
MRSMITH	Further studied, deemed unnecessary	N/A
MR8	Built	3
MR7 Discharges: MR7 Prime, Steve's Spring, North Culvert, & Pit Spring	North Culvert & Pit Spring systems build MR7 & Steve's Spring systems to be built in 2025	1
MRROSS	Built	3
MRSGL98 Discharges	Being studied as a combined area, collection ditches installed in 2023, conceptual design completed, funding for future construction needed	2

Methods

Given the extensive history of monitoring and treatment in the watershed, sample points were chosen to best characterize the current water quality conditions and be comparable to previous sampling efforts. The raw untreated discharges and the treated effluent of all existing treatment systems were sampled as well as 4 stream sites. The stream sites were chosen to capture water quality changes in sections of the watershed from the headwaters to the mouth of Morgan Run. All water samples were collected monthly for 6 months to show how the discharges and treatment systems impacted the watershed throughout different seasons and conditions. Fishery and macroinvertebrate samples were taken at the stream sample points once during the assessment period. All samples (chemical and biological) were collected per the protocols identified in the approved Morgan Run Quality Assurance Project Plan, DCN 230100.

Flow, temperature, pH, and conductivity were collected in the field. Chemical analyses performed by G&C Coal Analysis Lab were:

- pH (s.u.)
- Alkalinity (mg/L)
- Acidity (mg/L)
- Iron (mg/L)
- Manganese (mg/L)
- Aluminum (mg/L)
- Sulfates (mg/L)
- Total Suspended Solids (mg/L)

Some values reported by the lab were below the limit of detection (LOD), for example <0.05 mg/L. To be able to perform statistical analyses, these values were substituted with a constant value. To be as accurate as possible, the LOD values were divided by the square root of 2. This method was found to have the lowest error rate compared to other replacement methods as studied and reported in the paper "Methods of Dealing with Values Below the Limit of Detection Using SAS" presented by C. Croghan and P. Egeghy in 2003. This paper can be downloaded from: https://ntrl.ntis.gov/NTRL/dashboard/searchResults.xhtml?searchQuery=PB2004-100886.

Concentrations of aluminum, iron, manganese, and sulfate as well as pH readings were compared to the PA DEP Chapter 93 Water Quality Standards. The pertinent values are listed in Table 2.

Table 2 PA DEP Chapter 93 Water Quality Standards

Parameter	**Criteria Value (mg/L)**	**Total Recoverable/Dissolved**
Aluminum (Al)	0.75	Total Recoverable
Iron (Fe)	1.50	Total Recoverable
Manganese (Mn)	1.00	Total Recoverable
pH	6.0-9.0	N/A
Sulfate (SO4)	250	N/A
Total Dissolved Solids (TDS)	500	N/A

Concentrations and flow were used to calculate the loading in pounds per day of alkalinity, acidity, iron, manganese, and aluminum at each site using the following calculation:

Loading (ppd) = flow (gpm) x concentration (mg/L) x 0.012

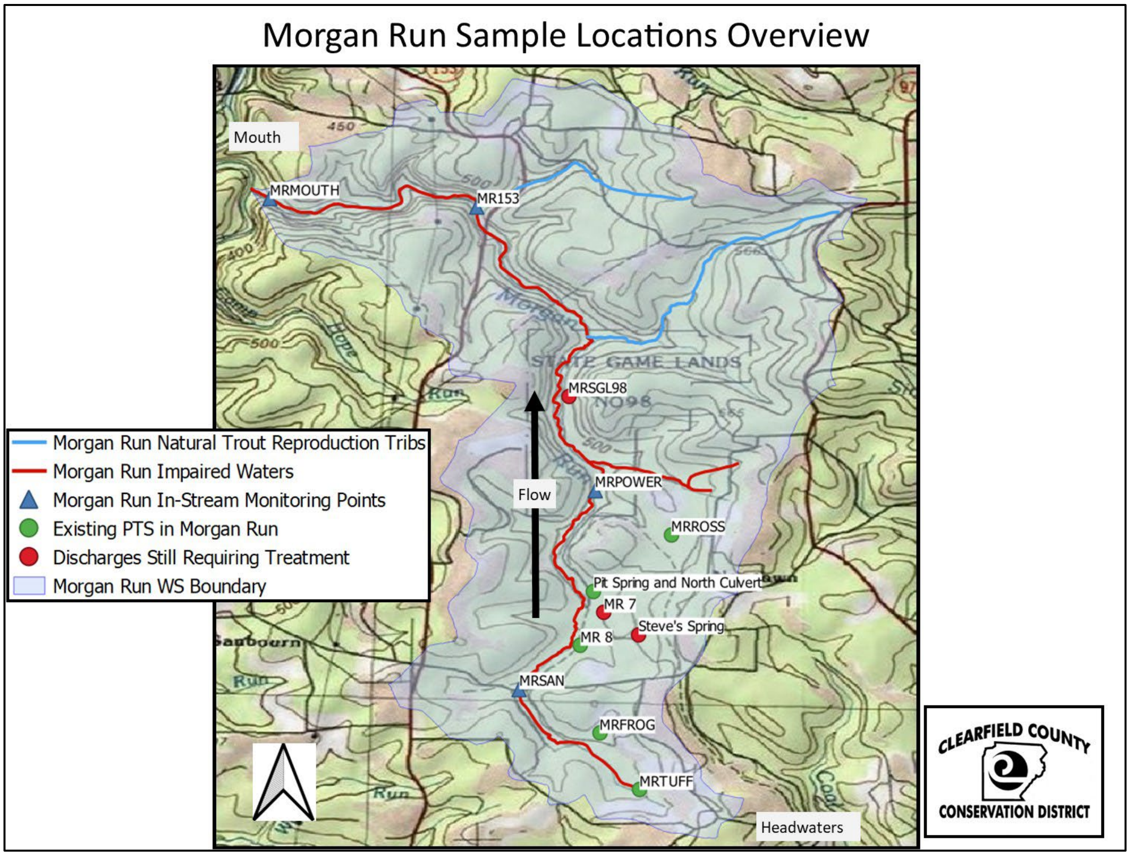
Macroinvertebrates were collected at 3 of the 4 stream locations in the spring of 2023. One site could not be sampled due to beaver dam activity. These samples were processed and identified by the North American Benthological Society to genus, or the next highest possible taxonomic level. Samples containing 160-240 individuals were evaluated according to the 6 metrics comprising DEP's Index of Biological Integrity (IBI Score). This includes Total Taxa Richness, EPT Taxa Richness, Beck's Index V.3, Shannon Diversity, Hilsenhoff Biotoc Index, and Percent Sensitive Individuals.

Fishery surveys were completed at all 4 stream locations in July 2023 using backpack electrofishing gear. Surveys were led by National Trout Unlimited staff trained and permitted in the use of electrofishing equipment.

A. Identification of Causes and Sources of Impairment

As previously mentioned in the METHODS section, given the extensive history of monitoring and treatment in the watershed, sample points were chosen to best characterize the current water quality conditions and be comparable to previous sampling efforts. See Figure 2 below for a map of all sampling locations.

Figure 2 Morgan Run Sample Locations



Morgan Run Stream Sampling (presented from the headwaters down)

MRSAN
This sample point is located at the Sanborn Road crossing of Morgan Run. This point is below the MRTUFF and MRFROG systems, and upstream of all other systems identified below.

MRPOWER
This sample point is located at a large powerline crossing over Morgan Run. This point is immediately downstream of MR8, MR7 discharges, and MRROSS and upstream of only the MRSGL98 discharges. This site was sampled to provide the loadings upstream of the MRSGL98 discharges.

MR153
This sample point is just downstream of the SR153 crossing of Morgan Run but upstream of the confluence of the Crooked Sewer tributary (known to support naturally reproducing brook trout). All passive treatment systems are located above this point.

MRMOUTH
This sample was taken at the mouth of Morgan Run, just upstream of the confluence with Clearfield Creek. This sample is also downstream of all passive treatment systems in the watershed. Water quality results and loading reductions achieved at the MRMOUTH site will be the ultimate determination of success in the watershed.

Table 3 below shows the average water quality results of each stream site sampled for the development of this WIP.

Table 3 Average Stream Water Quality of Morgan Run

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
MRSAN	142.18	6.40	235.83	18.22	14.43	-2.09	1.10	0.73	0.16	96.35	3.54	24.62	-3.56	1.87	1.24	0.27	164.39
MRPOWER	875.12	5.12	433.00	15.20	1.17	31.87	0.56	2.88	1.42	161.00	4.02	12.31	334.68	5.85	30.23	14.88	1690.73
MR153	2115.33	5.36	453.50	14.30	0.21	33.32	0.45	5.07	1.77	207.90	4.86	5.35	845.71	11.43	128.70	44.80	5277.33
MRMOUTH	2674.50	5.28	393.00	14.83	0.82	37.48	0.52	3.85	1.46	175.63	5.19	26.27	1202.99	16.64	123.40	46.86	5636.78

Passive Treatment System and Discharge Sampling

MRTUFF

The MRTUFF Passive Treatment System was constructed in the very headwaters of Morgan Run in 2009 and rehabilitated in 2017. Water is directed from the stream through a series of treatment cells before flowing back to Morgan Run. There is an A side, treating the majority of the flow, and a B side, treating a smaller portion of the flow. Flow on the A side is split between two drainable limestone beds (DLB), differentiated as A1 and A2. Each DLB flows into a settling/flush pond. Each settling pond discharges back into Morgan Run. The B side consists of a DLB, settling/flush pond, and final discharge back to the stream. See Figure 3, Figure 4, and Figure 5 below for the schematics of the MRTUFF system.

Figure 3 MRTUFFA1 Treatment Schematic

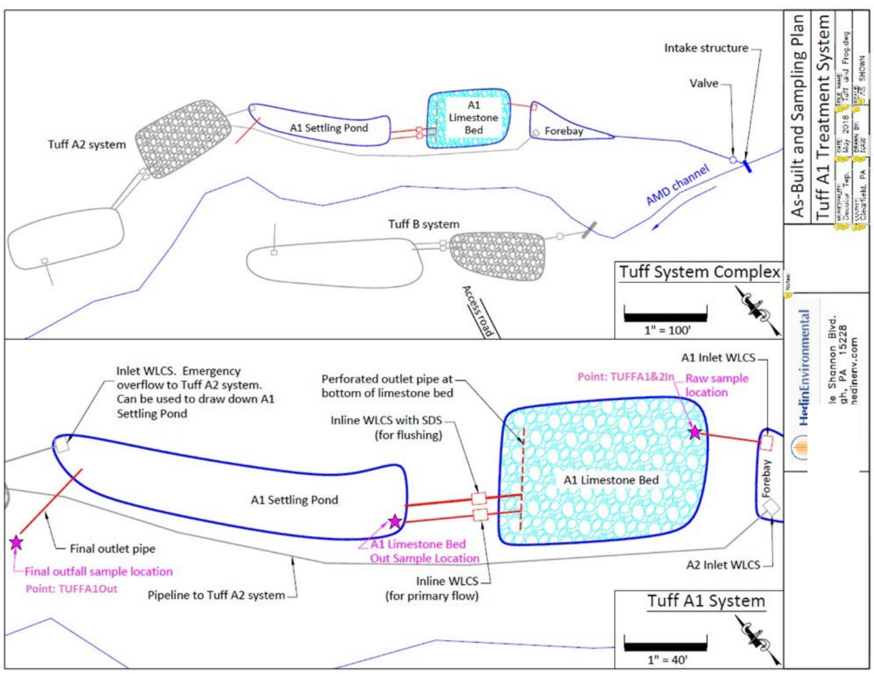


Table 4 shows the average results from sampling of the TUFFA1 system and reductions/improvements achieved as a result of treatment.

Table 4 Average Water Quality of the MRTUFFA1 System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
TUFFA1In	10.50	5.08	770.17	15.95	1.74	42.13	2.28	8.40	0.72	364.52	4.11	0.22	5.31	0.29	1.06	0.09	45.93
TUFFA1Out	13.00	6.60	732.33	16.97	47.72	-32.14	0.09	0.84	0.24	312.23	3.54	7.44	-5.01	0.01	0.13	0.04	48.71
Reductions/ Improvements Achieved		1.52	-37.83	1.02	45.98	-74.27	-2.19	-7.56	-0.48	-52.28	-0.58	7.22	-10.32	-0.27	-0.93	-0.05	2.78

Figure 4 MRTUFFA2 Treatment Schematic

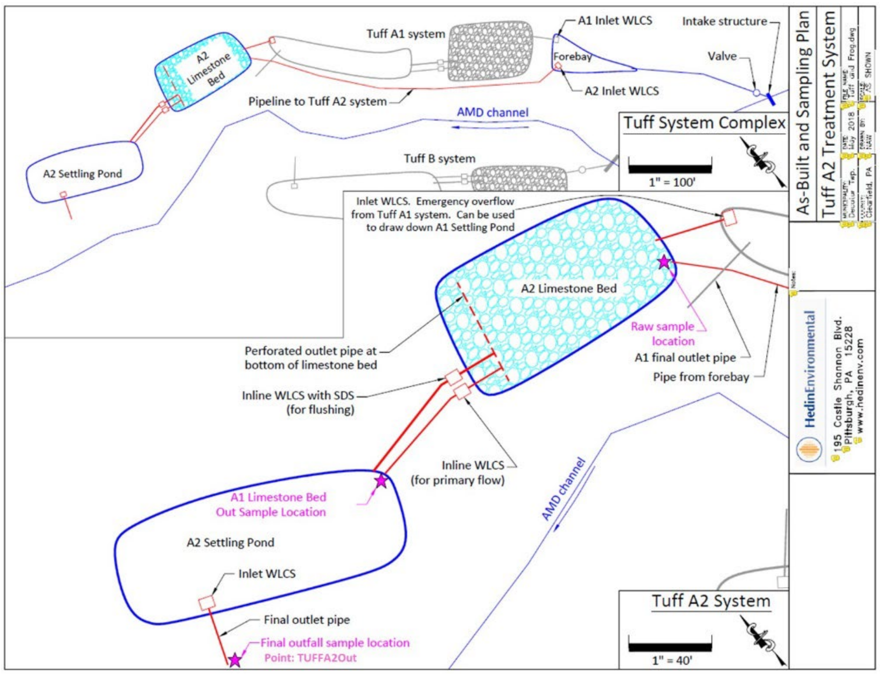


Table 5 shows the average results from sampling of the TUFFA2 system and reductions/improvements achieved as a result of treatment.

Table 5 Average Water Quality of the MRTUFFA2 System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
TUFFA2In	12.25	5.08	770.17	15.95	1.74	42.13	2.28	8.40	0.72	364.52	4.11	0.26	6.19	0.34	1.23	0.11	53.58
TUFFA2Out	9.25	7.39	727.33	17.85	54.37	-41.52	0.12	0.43	0.13	306.48	6.45	6.03	-4.61	0.01	0.05	0.01	34.02
Reductions/ Improvements Achieved		2.31	-42.83	1.90	52.62	-83.64	-2.16	-7.97	-0.59	-58.03	2.33	5.78	-10.80	-0.32	-1.19	-0.09	-19.56

Figure 5 MRTUFFB Treatment Schematic

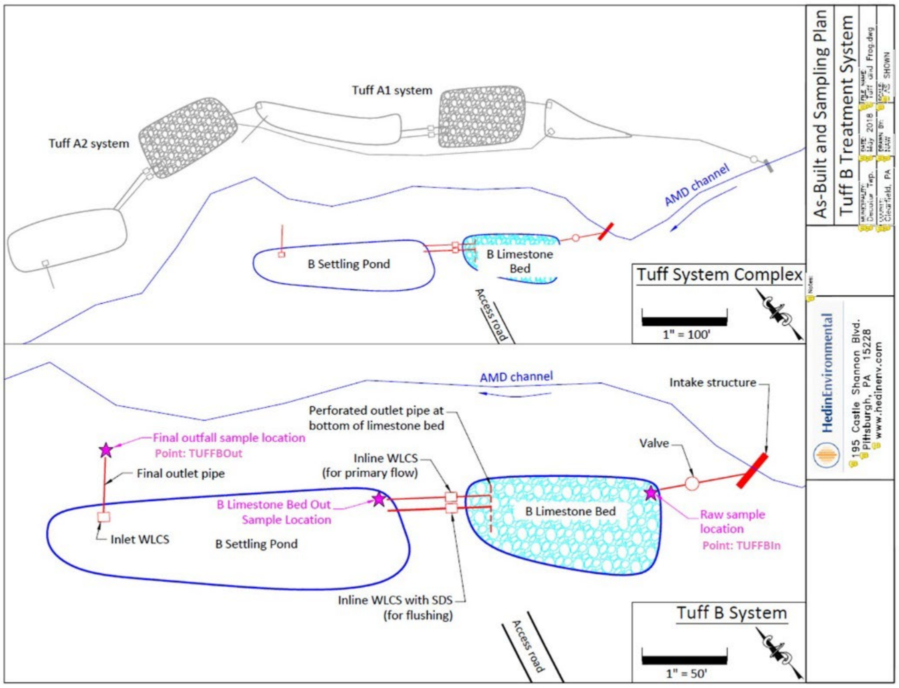


Table 6 shows the average results from sampling of the TUFFB system and reductions/improvements achieved as a result of treatment.

Table 6 Average Water Quality of the MRTUFFB System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
TUFFBIn	2.25	6.01	606.67	13.62	10.78	12.16	10.53	6.47	0.30	325.68	6.93	0.29	0.33	0.28	0.17	0.01	8.79
TUFFBOut	2.98	6.87	586.67	17.47	67.60	-45.03	0.11	0.10	0.07	224.52	3.54	2.42	-1.61	0.00	0.00	0.00	8.04
Reductions/ Improvements Achieved		0.86	-20.00	3.85	56.82	-57.19	-10.42	-6.37	-0.23	-101.17	-3.40	2.13	-1.94	-0.28	-0.17	-0.01	-0.76

MRFROG

The MRFROG Passive Treatment System was constructed in the headwaters of Morgan Run in 2009 and rehabilitated in 2017. Two independent discharges are collected and diverted into separate treatment systems, the East side and the West side. Despite the rehabilitation of the East side in 2017, these treatment cells are the least effective of the Morgan Run treatment systems. Though this system was rehabilitated once, water quality results indicate it may need additional work. Fortunately, the flow is minimal on this side. There is a small DLB that overflows to one pond but flushes to another. Each of those ponds then flows to a polishing wetland and to a UNT to Morgan Run. The treatment cells on the West side are performing far better. This side consists of a DLB, settling/flush pond, and polishing wetland. The wetland discharges to the same UNT to Morgan Run. See Figure 6 and Figure 7 below for the schematics of the MRFROG treatment system.

Figure 6 MRFROG EAST Treatment Schematic

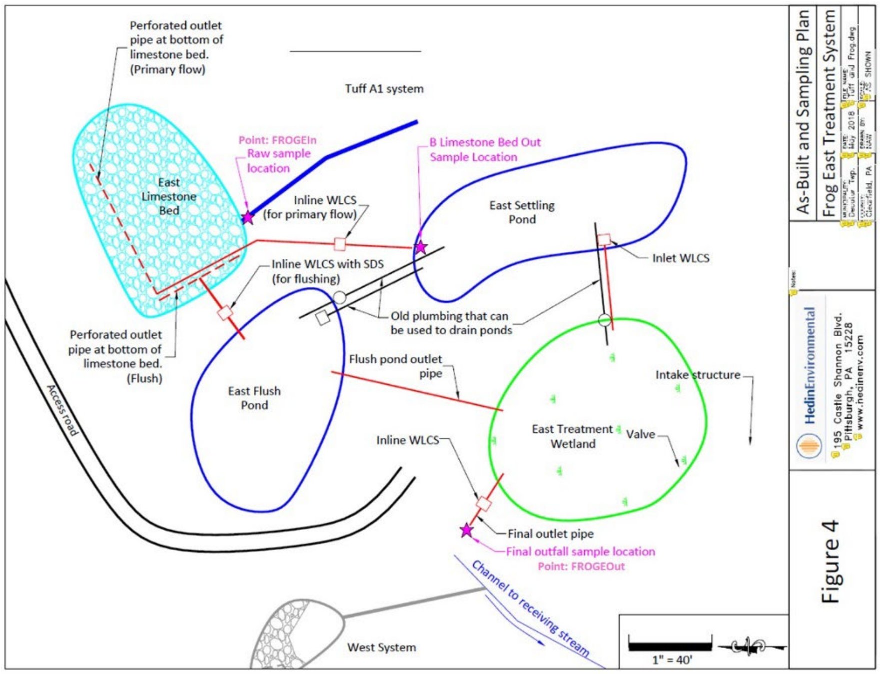


Table 7 shows the average results from sampling of the FROG East system and reductions/improvements achieved as a result of treatment.

Table 7 Average Water Quality of the MRFROG East System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
FROGEIn	5.38	3.68	367.20	15.76	0.07	108.59	3.02	2.87	4.83	126.16	80.92	0.00	7.01	0.20	0.19	0.31	8.14
FROGEOut	1.80	4.36	281.80	16.62	0.15	78.48	29.12	2.70	7.47	119.20	116.81	0.00	1.70	0.63	0.06	0.16	2.57
Reductions/ Improvements Achieved		0.68	-85.40	0.86	0.08	-30.12	26.10	-0.16	2.65	-6.96	35.89	0.00	-5.32	0.43	-0.13	-0.15	-5.57

Figure 7 MRFROG WEST Treatment Schematic

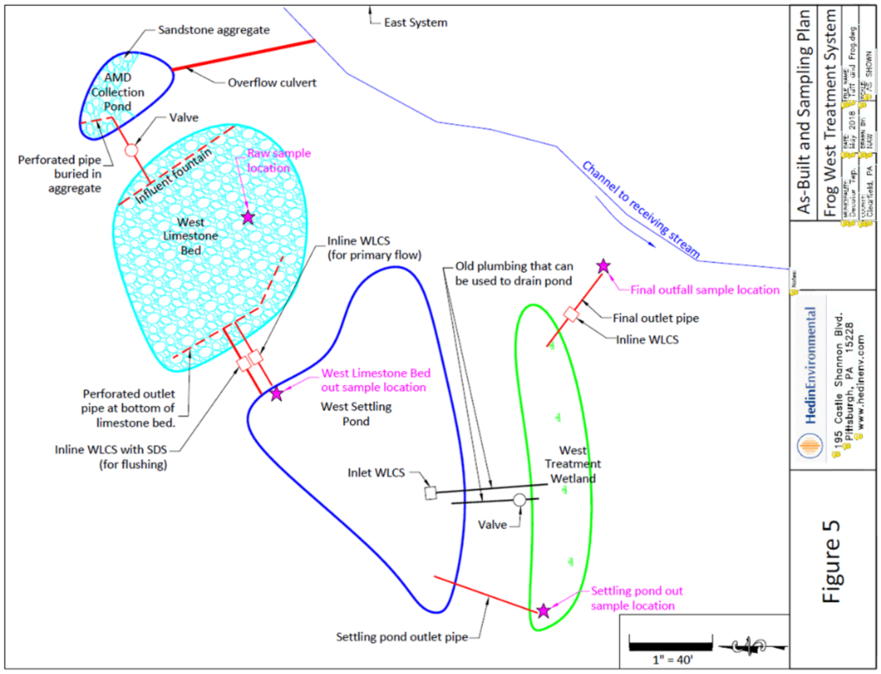


Table 8 shows the average results from sampling of the FROG West system and reductions/improvements achieved as a result of treatment.

Table 8 Average Water Quality of the MRFROG West System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
FROGWIn	8.18	3.97	217.67	12.30	0.07	56.49	0.12	2.03	2.38	71.30	3.95	0.01	5.55	0.01	0.20	0.23	7.00
FROGWOut	6.60	6.57	305.67	17.28	75.41	-63.10	0.07	0.14	0.09	67.57	3.54	5.97	-5.00	0.01	0.01	0.01	5.35
Reductions/ Improvements Achieved		2.60	88.00	4.98	75.34	-119.59	-0.05	-1.89	-2.29	-3.73	-0.41	5.97	-10.54	-0.01	-0.19	-0.23	-1.65

MR8

The MR8 Passive Treatment System was constructed in 2016 and will undergo some rehabilitation in 2025. The primary MR8 discharge was collected and distributed evenly between 2 Vertical Flow Ponds (VFPs). These VFPs flow into a final polishing wetland before returning to an unnamed tributary of Morgan Run. An additional discharge was located on site but due to elevation and chemistry, it could not be diverted into either VFP. Instead, a separate Drainable Limestone Bed (DLB) was installed to treat it. This DLB also discharges to the final polishing wetland and ultimately the UNT. This system has been operating well since it was installed though some minor issues have come up in the last 5 years. To remedy these, the Conservation District will be performing proactive rehabilitation of the site in 2025 to include replacing the compost in the VFPs and adding limestone to the DLB. Funds for these activities come from an AML/AMD Grant that was awarded for rehabilitation of MR8 and treatment system construction at MR7. See the MR8 Treatment Schematic in Figure 8 below.

Figure 8 MR8 Treatment Schematic

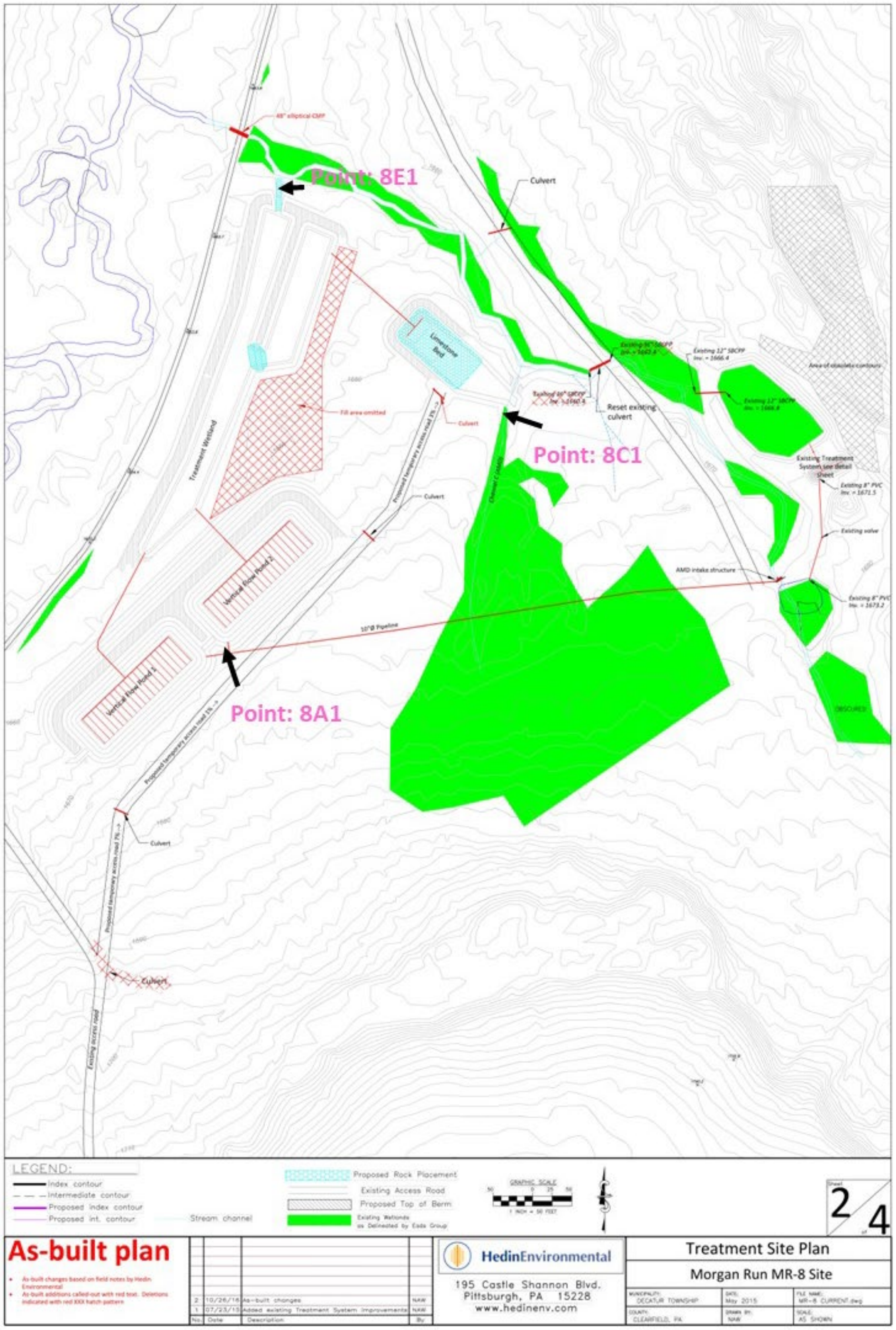


Table 9 shows the average results from sampling of the MR8 system and reductions/improvements achieved as a result of treatment.

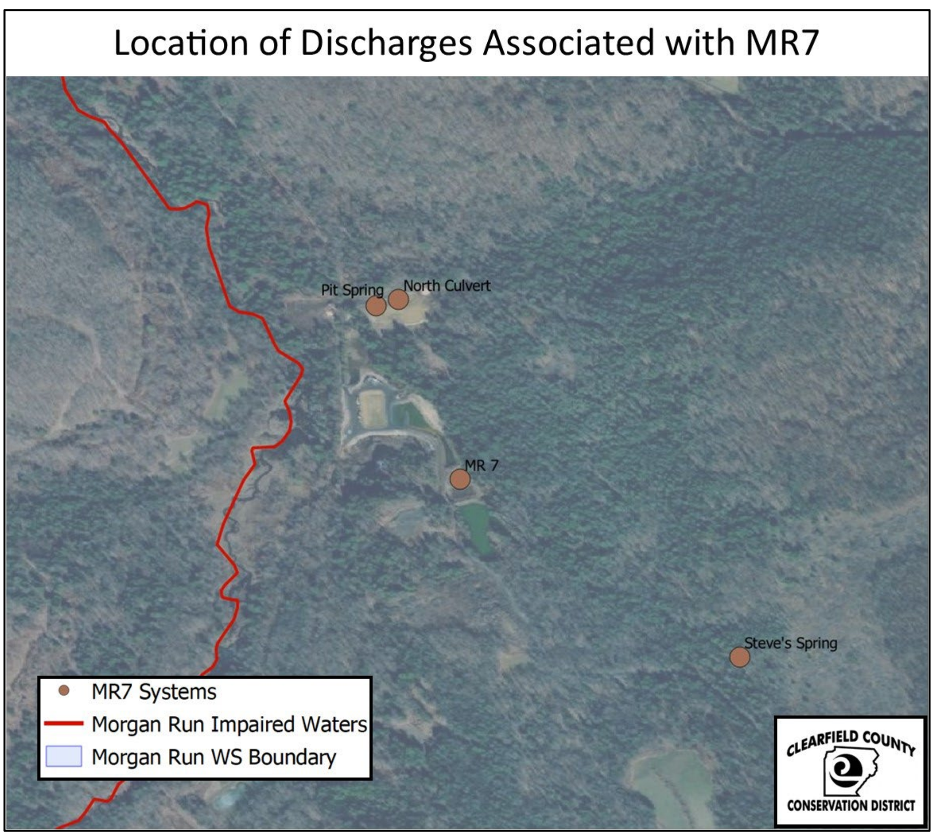
Table 9 Average Water Quality of the MR8 System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
8A1	17.38	4.72	394.67	14.87	0.07	39.71	1.03	3.37	1.98	148.85	3.54	0.01	8.28	0.21	0.70	0.41	31.05
8C1	12.52	3.70	541.33	14.83	0.07	142.17	3.15	6.95	9.20	228.48	3.54	0.01	21.35	0.47	1.04	1.38	34.32
8E1	27.67	6.46	518.00	17.66	61.60	-51.05	0.15	0.58	0.52	205.50	5.45	20.45	-16.95	0.05	0.19	0.17	68.23
Reductions/ Improvements Achieved		2.25	50.00	2.81	61.46	-232.93	-4.03	-9.74	-10.66	-171.83	-1.62	20.42	-46.59	-0.64	-1.55	-1.62	2.86

MR7 Discharges

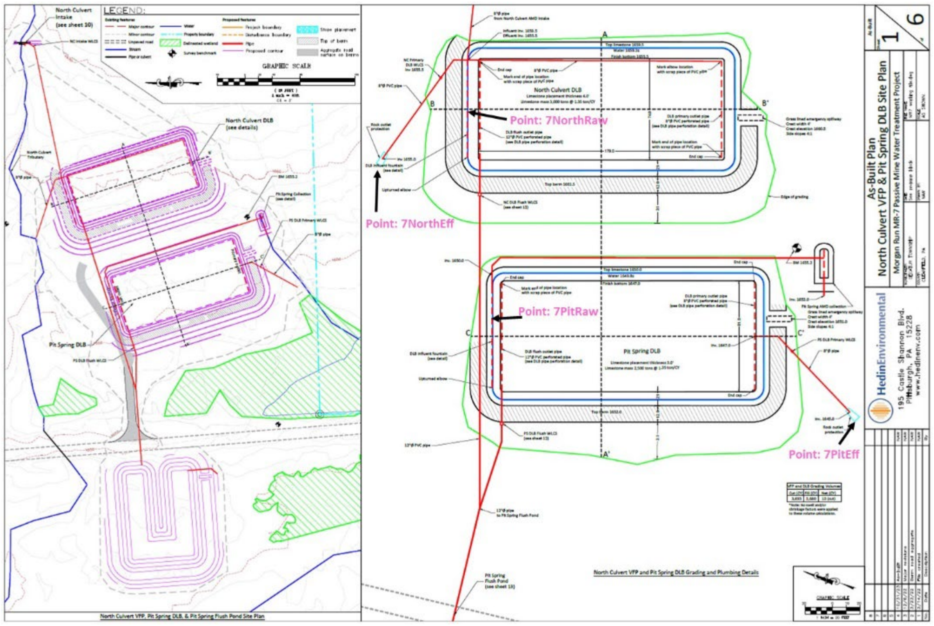
The MR7 discharge area is the largest contributor of acidity and metal loadings in the Morgan Run watershed. During the original 2006 assessment, MR7 was thought to be only one large discharge. Further investigation in 2014 showed that there were 4 discharges contributing to the historic MR7 sampling location. Since that discovery, the Conservation District has treated these 4 discharges as separate pieces of the MR7 puzzle. Each of these discharges must be treated for the restoration of Morgan Run to be realized. These 4 discharges are known as the North Culvert, Pit Spring, Steve's Spring, and MR7 Prime discharges. See Figure 9 below for the locations of these 4 discharges. Note, the ponds observed in Figure 9 under the MR7 point were constructed in 2011 to test whether the discharge could be treated passively. A small VFP, a small limestone cell, and a large settling pond were installed. Each treatment pond was designed to treat only 10gpm. The new treatment ponds planned for the MR7 Prime discharge will be constructed in the same footprint of these pilot scale ponds, see Figure 12.

Figure 9 Location of Discharges Associated with the MR7 Discharge Area



Utilizing Growing Greener funding, the Conservation District installed Drainable Limestone Beds (DLBs) on the North Culvert and Pit Spring discharges in 2023. Construction of these DLBs was completed during the assessment for the development of this WIP and improvement resulting from their installation can be seen in the downstream samples. See Figure 10 of the treatment schematics below.

Figure 10 MR7 North Culvert and MR7 Pit Spring Treatment Schematics



Tables 10 and 11 show the average results from sampling of the MR7 Pit Spring and North Culvert systems and reductions/improvements achieved as a result of treatment.

Table 10 Average Water Quality of MR7 Pit Spring System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
7PitRaw	32.92	4.03	315.83	11.78	0.07	90.91	0.07	2.41	8.87	113.83	5.95	0.03	35.91	0.03	0.95	3.50	44.96
7PitEff	26.50	6.32	498.00	14.43	107.74	-87.28	0.10	0.04	0.07	136.40	3.54	34.26	-27.76	0.03	0.01	0.02	43.38
Reductions/ Improvements Achieved		2.29	182.17	2.65	107.67	-178.19	0.03	-2.38	-8.80	22.57	-2.41	34.23	-63.66	0.00	-0.94	-3.48	-1.59

Table 11 Average Water Quality of the MR7 North Culvert System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
7NorthRaw	11.32	3.96	324.00	14.47	0.07	117.68	0.42	2.15	10.48	122.87	3.54	0.01	15.98	0.06	0.29	1.42	16.69
7NorthEff	5.00	6.62	633.00	13.10	89.40	-70.16	0.07	0.63	0.07	218.30	3.54	5.36	-4.21	0.00	0.04	0.00	13.10
Reductions/ Improvements Achieved		2.66	309.00	-1.37	89.33	-187.84	-0.35	-1.52	-10.41	95.43	0.00	5.35	-20.19	-0.05	-0.25	-1.42	-3.59

Treatment systems for the remaining discharges, MR7 Prime and Steve's Spring, will be built in 2025. The Conservation District secured funding from the AML/AMD Grant program administered by DEP BAMR to install these systems. Once complete, these will remove significant metal and acidity loading from Morgan Run. Reference Sections B and C.1 below for modelled loading reductions and a description of the Proposed Management Measures to be installed on the Steve's Spring and MR7 Prime discharges.

Table 12 shows the average results from sampling of the MR7 Prime and MR7 Steve's Spring discharges.

Table 12 Average Water Quality of the MR7 Prime and Steve's Spring Discharges

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
7SS	21.32	3.95	403.50	12.25	0.07	108.28	0.10	2.71	10.93	151.07	3.54	0.02	27.70	0.03	0.69	2.80	38.65
7Prime	186.97	3.58	1412.33	17.43	0.07	194.39	39.37	12.73	2.87	634.32	3.95	0.16	436.13	88.32	28.56	6.43	1423.15

MRROSS

The MRROSS treatment system was installed in 2012. The land around this discharge had been reclaimed years prior, but the poor water quality remained. Treatment involves a Vertical Flow Pond (VFP), followed by a Settling Pond, a Limestone Cell, and a final Settling Pond. The discharge flows through these cells in sequence. This system has performed well since being installed but given its age and water quality results, the Conservation District is hoping to perform rehabilitation on it in the next 2 -3 years. See Figure 11 for the MRROSS schematic.

Figure 11 MRROSS Treatment Schematic

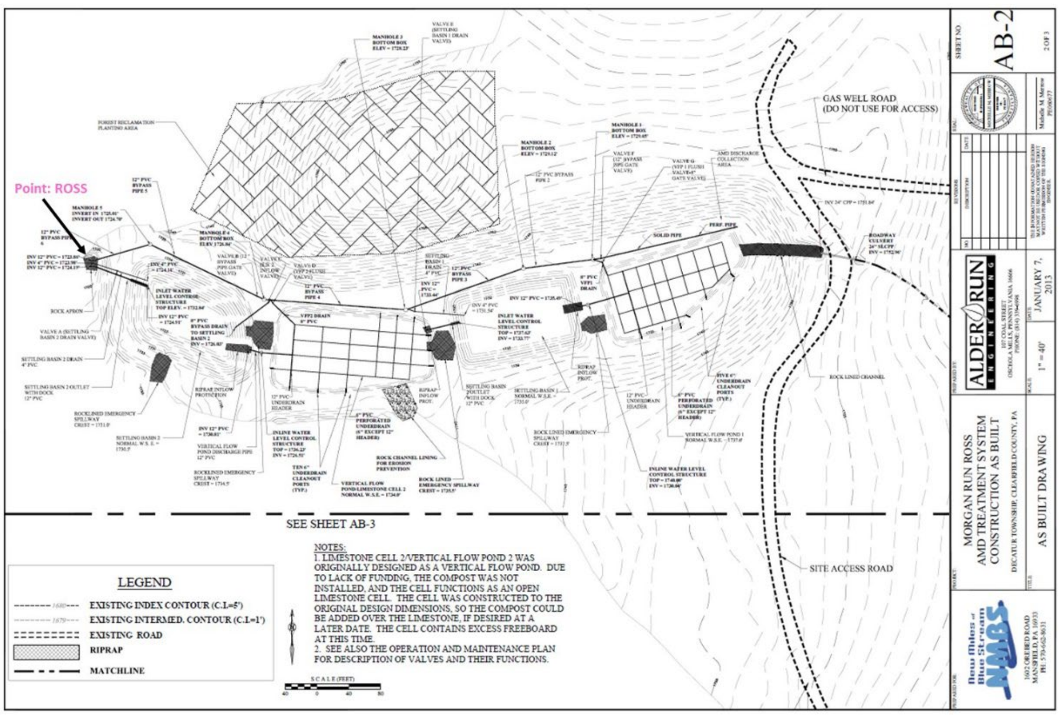


Table 13 shows the average results from sampling of the MRROSS system. Unfortunately, there is no way to access the raw water so reduction calculations cannot be performed for this site.

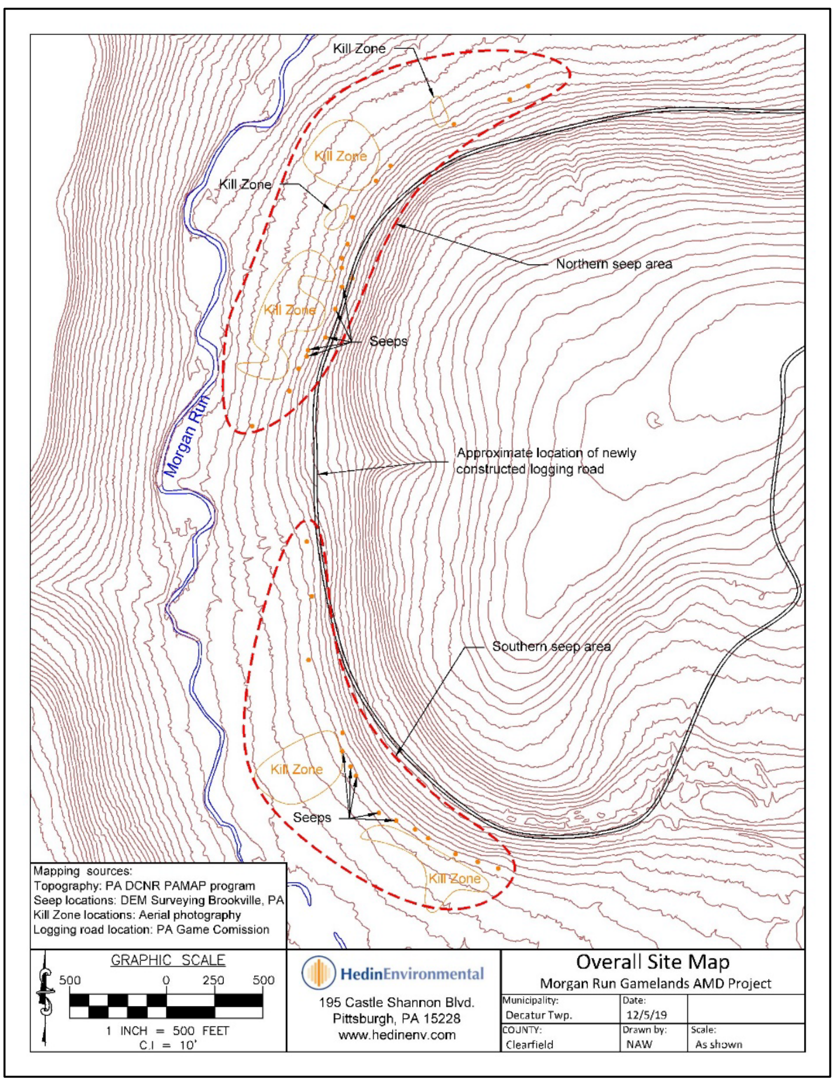
Table 13 Average Water Quality of the MRROSS System

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
ROSS	120.26	6.16	988.67	18.55	19.40	-7.90	3.90	15.94	0.42	591.12	6.68	46.66	-11.41	5.62	23.01	0.60	853.04

MRSGL98 Discharges

These discharges can all be found in State Game Lands 98 and are the same as the discharges referenced in the 2006 assessment as MR1-6. These discharges emanate from the toe of slope of a "reclaimed" surface mine that was originally mined by Al Hamilton in the early nineties. During the original 2006 assessment, there were only 8 distinct discharges. However, since that time more have appeared and there are now more than 30 small discharges all along the toe of slope. In addition to contributing to the impairment of Morgan Run, these discharges have been creating large kill zones and have killed hundreds of board feet of marketable timber on the Game Lands. Figure 12 shows how diffuse the MRSGL98 discharges are. Because there are so many, we reference them as the Northern Seeps and the Southern Seeps. To remediate these discharges, the Conservation District worked with Hedin Environmental and the PA Game Commission to collect these diffuse discharges into collection ditches in 2022. Since then, Hedin has been studying the collected water quality and developed designs for treatment of these discharges, see Section B for expected loading reductions and Section C.2 for the treatment schematic. For this assessment, trying to sample each discharge would have been too costly. Instead, the loadings from the upstream and downstream samples of Morgan Run proper are being used to document current loading contributions from this area.

Figure 12 Diagram of all discharges associated with MRSGL98



OVERALL RESULTS

Table 14 displays the average sampling results for all locations listed in order from upstream to downstream with the stream sample points highlighted in light blue. The highest contributors of metal and acidity are highlighted in this table for both concentrations and loadings. This table makes it clear that the MR7 Prime site is the top contributor of acidity and metal loadings in the watershed.

Table 14 Overall Sampling Results and Loading Calculations

	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
TUFFA1In	10.50	5.08	770.17	15.95	1.74	42.13	2.28	8.40	0.72	364.52	4.11	0.22	5.31	0.29	1.06	0.09	45.93
TUFFA1Out	13.00	6.60	732.33	16.97	47.72	-32.14	0.09	0.84	0.24	312.23	3.54	7.44	-5.01	0.01	0.13	0.04	48.71
TUFFA2In	12.25	5.08	770.17	15.95	1.74	42.13	2.28	8.40	0.72	364.52	4.11	0.26	6.19	0.34	1.23	0.11	53.58
TUFFA2Out	9.25	7.39	727.33	17.85	54.37	-41.52	0.12	0.43	0.13	306.48	6.45	6.03	-4.61	0.01	0.05	0.01	34.02
TUFFBIn	2.25	6.01	606.67	13.62	10.78	12.16	10.53	6.47	0.30	325.68	6.93	0.29	0.33	0.28	0.17	0.01	8.79
TUFFBOut	2.98	6.87	586.67	17.47	67.60	-45.03	0.11	0.10	0.07	224.52	3.54	2.42	-1.61	0.00	0.00	0.00	8.04
FROGEIn	5.38	3.68	367.20	15.76	0.07	108.59	3.02	2.87	4.83	126.16	80.92	0.00	7.01	0.20	0.19	0.31	8.14
FROGEOut	1.80	4.36	281.80	16.62	0.15	78.48	29.12	2.70	7.47	119.20	116.81	0.00	1.70	0.63	0.06	0.16	2.57
FROGWIn	8.18	3.97	217.67	12.30	0.07	56.49	0.12	2.03	2.38	71.30	3.95	0.01	5.55	0.01	0.20	0.23	7.00
FROGWOut	6.60	6.57	305.67	17.28	75.41	-63.10	0.07	0.14	0.09	67.57	3.54	5.97	-5.00	0.01	0.01	0.01	5.35
MRSAN	142.18	6.40	235.83	18.22	14.43	-2.09	1.10	0.73	0.16	96.35	3.54	24.62	-3.56	1.87	1.24	0.27	164.39
8A1	17.38	4.72	394.67	14.87	0.07	39.71	1.03	3.37	1.98	148.85	3.54	0.01	8.28	0.21	0.70	0.41	31.05
8C1	12.52	3.70	541.33	14.83	0.07	142.17	3.15	6.95	9.20	228.48	3.54	0.01	21.35	0.47	1.04	1.38	34.32
8E1	27.67	6.46	518.00	17.66	61.60	-51.05	0.15	0.58	0.52	205.50	5.45	20.45	-16.95	0.05	0.19	0.17	68.23
7SS	21.32	3.95	403.50	12.25	0.07	108.28	0.10	2.71	10.93	151.07	3.54	0.02	27.70	0.03	0.69	2.80	38.65
7Prime	186.97	3.58	1412.33	17.43	0.07	194.39	39.37	12.73	2.87	634.32	3.95	0.16	436.13	88.32	28.56	6.43	1423.15
7PitRaw	32.92	4.03	315.83	11.78	0.07	90.91	0.07	2.41	8.87	113.83	5.95	0.03	35.91	0.03	0.95	3.50	44.96
7PitEff	26.50	6.32	498.00	14.43	107.74	-87.28	0.10	0.04	0.07	136.40	3.54	34.26	-27.76	0.03	0.01	0.02	43.38
7NorthRaw	11.32	3.96	324.00	14.47	0.07	117.68	0.42	2.15	10.48	122.87	3.54	0.01	15.98	0.06	0.29	1.42	16.69
7NorthEff	5.00	6.62	633.00	13.10	89.40	-70.16	0.07	0.63	0.07	218.30	3.54	5.36	-4.21	0.00	0.04	0.00	13.10
ROSS	120.26	6.16	988.67	18.55	19.40	-7.90	3.90	15.94	0.42	591.12	6.68	46.66	-11.41	5.62	23.01	0.60	853.04
MRPOWER	875.12	5.12	433.00	15.20	1.17	31.87	0.56	2.88	1.42	161.00	4.02	12.31	334.68	5.85	30.23	14.88	1690.73
MR153	2115.33	5.36	453.50	14.30	0.21	33.32	0.45	5.07	1.77	207.90	4.86	5.35	845.71	11.43	128.70	44.80	5277.33
MRMOUTH	2674.50	5.28	393.00	14.83	0.82	37.48	0.52	3.85	1.46	175.63	5.19	26.27	1202.99	16.64	123.40	46.86	5636.78

B. Expected Loading Reductions

Loading Reductions Already Achieved Through Treatment

Water quality presented for each treatment system in Section A contains the loading reductions achieved at the existing passive treatment systems. Maintaining the performance of the existing systems is vital to preserving the improvements and reductions achieved.

Loading Reductions Expected Through Additional Treatment

The loading reductions expected from proposed treatment efforts explained in Section C were calculated from the existing contaminant loading and the predicted treatment system effluent loading. The passive treatment recommendations in this WIP include organic substrate and limestone systems that are commonly referred to as vertical flow ponds (VPF), drainable limestone beds (DLB), manganese removal beds (Mn Beds), and wetlands. The performance of these systems in PA has been well documented and established by the dozens of installed and functional systems across the state. The effluent of a properly designed and constructed system typically has neutral pH with 80 mg/L net alkalinity, < 2 mg/L Fe, and < 1 mg/L Al. The predicted effluent loading of passive systems is calculated from the flow rate and each of these chemical parameters. The loading reduction calculation was the difference of the observed current conditions and the predicted treatment system effluent.

Modelling of the expected loading reductions from the construction of the MR7 Prime, Steve's Spring, and the MRSGL98 treatment systems as well as rehabilitation of the MRROSS and MRFROG East systems can be found in Table 15, Table 16, and Table 17. These values are further compared to the loading reductions necessary at the mouth of Morgan Run (MRMOUTH) in Table 32 and Table 33 on page 25 to show that these reductions will lead to restoration of the Morgan Run watershed.

Table 15 Expected Loading Reductions from Treatment of MR7 Prime and Steve's Spring

	Fe, ppd	Al, ppd	Mn, ppd	Acid, ppd
MR7 Prime (raw)	88.3	6.4	28.6	436.1
Steve's Spring (raw)	0.0	2.8	0.7	27.7
Total (raw)	88.3	9.2	29.3	463.8
Final Effluent	1.0	2.0	10.0	-562.0
Change in loading	-87.3	-7.2	-19.3	-1025.8

Table 16 Expected Loading Reductions from Treatment of MRSGL98 Discharges

	Fe, ppd	Al, ppd	Mn, ppd	Acid, ppd
Northern seeps (raw)	2.6	7.1	26	123
Southern seeps (raw)	10.1	15.1	36.6	252
Totals North and South seeps (raw)	12.7	22.1	62.7	375
Totals Final Effluent	1.5	3	7.5	-28
Change in loading	-11.2	-19.1	-55.2	-403

Table 17 Expected Loading Reductions from Rehabilitation of MRROSS and MRFROG East

	Fe, ppd	Al, ppd	Mn, ppd
MRROSS Reductions Expected	-3.46	0.00	-21.56
MRFROG East Reductions Expected	-0.53	-0.11	0.00
Total Reductions Possible	-3.99	-0.11	-21.56

Relation to TMDL/Achieving Environmental Goals

The Conservation District consulted with the TMDL Section of the Water Quality Division of the PA DEP regarding the status of Morgan Run as well as the analytical methods that we should utilize to align with their methodology for developing TMDLs and assigning loading reduction requirements.

As of the writing of the WIP, no TMDL has been developed specifically for Morgan Run yet the stream is listed as Category 4a in the 2024 Integrated Water Quality Report. However, as a tributary to Clearfield Creek, Morgan Run is considered to be covered by the Clearfield Creek TMDL, though there are no specific loading reductions attributed to the stream. Regarding the status of Morgan Run and other streams listed in Category 4a of the 2024 Integrated Water Quality Report, representative of the Water Quality Division prepared this clarification:

"Morgan Run and every AMD waterbody currently in 4a are being evaluated to determine if the 4a status is warranted by the design of the specific TMDL. The possibility exists that a more thorough examination could determine that though the waterbody lies within the geographic domain of the TMDL, any of several required elements for inclusion in 4a may not have been met and the waterbody will be moved back to Category 5. However, this WIP is unaffected by any such potential Category switch as the WIP itself provides all information that was to be provided from a TMDL."

This WIP is extensive, and the data gathered for it was done in a manner that allows us to apply the methodology for developing TMDLs for abandoned mine drainage impacts to the watershed. The method for calculating the required loading reductions for Morgan Run was done according to recommendations from the TMDL Section as described below.

The reference watershed approach is not used for streams impacted by abandoned mine drainage. Instead, the specific water quality criteria for iron, manganese, and aluminum found in the PA DEP Chapter 93 Water Quality Standards, displayed in Table 2, is used to calculate the Allowable Load for each parameter. The flow of each discharge was used to calculate the Allowable Load for iron, manganese, and aluminum. The Allowable Load was then compared to the Final Treated Effluent for each system. For untreated discharges, the Allowable Load was compared to the current raw water quality data. If the loading for any given parameter exceeded the Allowable Load, then a reduction for that parameter was identified as being required.

For example, the average flow of the TUFFA1In point is 10.5 GPM and the water quality standard for iron is 1.5 mg/L. Multiplying 10.5 * 1.5 * 0.012 = 0.19, meaning the Allowable Load for iron at the flow rate observed at the TUFFA1In raw discharge is 0.19 PPD. The calculated Final Treated Effluent for Iron at the TUFFA1Out (treated effluent) is 0.01 PPD which is less than the Allowable Load, therefore there are no additional reductions necessary for iron.

<u>MRTUFF Passive Treatment System</u>

At the MRTUFF site, the Final Treated Effluent Loadings (TUFFA1Out, TUFFA2Out, and TUFFBOut) were all less than the calculated Allowable Load for iron, manganese, and aluminum. This means that there are no additional Loading Reductions necessary at any of the MRTUFF treatment cells, note Table 18, Table 19, and Table 20, below.

Table 18 MRTUFFA1 Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
TUFFA1In	10.50	0.22	5.31	0.29	1.06	0.09	45.93
Allowable Load	10.50			0.19	0.13	0.09	
TUFFA1Out	13.00	7.44	-5.01	0.01	0.13	0.04	48.71
Additional Reductions Necessary at TUFFA1				none	none	none	
Reductions/ Improvements Achieved		7.22	-10.32	-0.27	-0.93	-0.05	2.78

Table 19 MRTUFFA2 Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
TUFFA2In	12.25	0.26	6.19	0.34	1.23	0.11	53.58
Allowable Load	12.25			0.22	0.15	0.11	
TUFFA2Out	9.25	6.03	-4.61	0.01	0.05	0.01	34.02
Additional Reductions Necessary at TUFFA2				none	none	none	
Reductions/ Improvements Achieved		5.78	-10.80	-0.32	-1.19	-0.09	-19.56

Table 20 MRTUFFB Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
TUFFBIn	2.25	0.29	0.33	0.28	0.17	0.01	8.79
Allowable Load	2.25			0.04	0.03	0.02	
TUFFBOut	2.98	2.42	-1.61	0.00	0.00	0.00	8.04
Additional Reductions Necessary at TUFFB				none	none	none	
Reductions/ Improvements Achieved		2.13	-1.94	-0.28	-0.17	-0.01	-0.76

MRFROG Passive Treatment System

At the MRFROG site, the Final Treated Effluent Loading for the FROG West cells were all less than the calculated Allowable Load for iron, manganese, and aluminum. This means that there are no additional Loading Reductions necessary at the MRFROG West treatment cells, reference Table 22 below. The Final Treated Effluent Loading for the FROG East cells for iron and aluminum were more than the calculated Allowable Load, meaning there are additional reductions of 0.53 PPD of iron and 0.11 PPD of aluminum necessary at the FROG East cells. The Allowable Load for manganese was less than the Final Treated Effluent at Frog East, therefore no additional reductions are necessary for manganese. See Table 21 below. This data does show that these treatment cells could benefit from rehabilitation if it's deemed environmentally necessary and makes financial sense.

Table 21 MRFROG East Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
FROGEIn	5.38	0.00	7.01	0.20	0.19	0.31	8.14
Allowable Load	5.38			0.10	0.06	0.05	
FROGEOut	1.80	0.00	1.70	0.63	0.06	0.16	2.57
Additional Reductions Necessary at FROGE				0.53	none	0.11	
Reductions/ Improvements Achieved		0.00	-5.32	0.43	-0.13	-0.15	-5.57

Table 22 MRFROG West Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
FROGWIn	8.18	0.01	5.55	0.01	0.20	0.23	7.00
Allowable Load	8.18			0.15	0.10	0.07	
FROGWOut	6.60	5.97	-5.00	0.01	0.01	0.01	5.35
Additional Reductions Necessary at FROGW				none	none	none	
Reductions/ Improvements Achieved		5.97	-10.54	-0.01	-0.19	-0.23	-1.65

<u>MRSAN Stream Site</u>

This is a stream site located downstream of the MRTUFF and MRFROG passive treatment systems. Loadings for iron, manganese, and aluminum were all less than the calculated Allowable Load for this stream point meaning there are no additional required reductions from upstream points at this location. See Table 23 below. Maintaining functionality of MRTUFF and MRFROG is necessary to maintain the improved water quality and loading reductions already achieved at this location

Table 23 MRSAN Stream Site Calculation of Allowable Load and Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
MRSAN	**142.18**	**24.62**	**-3.56**	**1.87**	**1.24**	**0.27**	**164.39**
Allowable Load	142.18			2.56	1.71	1.28	
Reductions Necessary at MRSAN				**none**	**none**	**none**	

<u>MR8 Passive Treatment System</u>

At the MR8 site, the Final Treated Effluent Loadings at 8E1 were all less than the calculated Allowable Load for iron, manganese, and aluminum. This means that there are no additional Loading Reductions necessary at the MR8 passive treatment system, reference Table 24.

Table 24 MR8 Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
8A1	17.38	0.01	8.28	0.21	0.70	0.41	31.05
8C1	12.52	0.01	21.35	0.47	1.04	1.38	34.32
Allowable Load	29.90			0.54	0.36	0.27	
8E1	27.67	20.45	-16.95	0.05	0.19	0.17	68.23
Additional Reductions Necessary at MR8				none	none	none	
Reductions/ Improvements Achieved		20.42	-46.59	-0.64	-1.55	-1.62	2.86

MR7 Discharge Complex

As mentioned earlier, there are 4 discharges that make up the MR7 complex: MR7 Prime & Steve's Spring for which treatment has yet to be built and the North Culvert & Pit Spring for which treatment systems were constructed in 2023.

At the Pit Spring DLB, the Final Treated Effluent Loadings at 7PitEff were all less than the calculated Allowable Load for iron, manganese, and aluminum. This means that there are no additional Loading Reductions necessary at the Pit Spring DLB, see Table 25.

Table 25 MR7 Pit Spring Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
7PitRaw	32.92	0.03	35.91	0.03	0.95	3.50	44.96
Allowable Load	32.92			0.59	0.40	0.30	
7PitEff	26.50	34.26	-27.76	0.03	0.01	0.02	43.38
Additional Reductions Necessary at PitRaw				none	none	none	
Reductions/ Improvements Achieved		34.23	-63.66	0.00	-0.94	-3.48	-1.59

At the North Culvert DLB, the Final Treated Effluent Loadings at 7NorthEff were all less than the calculated Allowable Load for iron, manganese, and aluminum. This means that there are no additional Loading Reductions necessary at the North Culvert DLB, see Table 26.

Table 26 MR7 North Culvert Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
7NorthRaw	11.32	0.01	15.98	0.06	0.29	1.42	16.69
Allowable Load	11.32			0.20	0.14	0.10	
7NorthEff	5.00	5.36	-4.21	0.00	0.04	0.00	13.10
Additonal Reductions Necessary at NorthCulvert				none	none	none	
Reductions/ Improvements Achieved		5.35	-20.19	-0.05	-0.25	-1.42	-3.59

At the untreated MR7 Prime discharge, the Raw Loadings at 7Prime all exceeded the calculated Allowable Load for iron, manganese, and aluminum. This means that there are required loading reductions of 84.96 PPD of iron, 26.32 PPD of manganese, and 4.75 PPD of aluminum, see Table 27.

Table 27 MR7 Prime Calculation of Allowable Load and Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
7Prime	186.97	0.16	436.13	88.32	28.56	6.43	1423.15
Allowable Load	186.97			3.37	2.24	1.68	
Reductions Necessary at 7Prime				84.96	26.32	4.75	

At the untreated Steve's Spring discharge, the Raw Loadings at 7SS exceeded the calculated Allowable Load for manganese, and aluminum. This means that there are required loading reductions of 0.44 PPD of manganese and 2.61 PPD of aluminum. The Raw Loadings for manganese did not exceed the Allowable Load at this point, meaning there is no additional reduction required for manganese, see Table 28.

Table 28 MR7 Steve's Spring Calculation of Allowable Load and Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
7SS	21.32	0.02	27.70	0.03	0.69	2.80	38.65
Allowable Load	21.32			0.38	0.26	0.19	
Reductions Necessary at 7SS				none	0.44	2.61	

<u>MRROSS Passive Treatment System</u>

At the MRROSS passive treatment system, the Final Treated Effluent Loadings at ROSS exceeded the calculated Allowable Load for iron and manganese. This means that there are required loading reductions of 3.46 PPD of iron and 21.56 PPD of manganese. The Final Treated Effluent Loading for aluminum did not exceed the Allowable Load at this point, meaning there is no additional reduction required for aluminum. See Table 29 below. As previously mentioned, the MRROSS system is 12 years old and the Conservation District would like to perform some rehabilitation in the near future to keep the system functioning as designed. This data proves the need for this rehabilitation before there is an even more significant drop in system performance.

Table 29 MRROSS Calculation of Allowable Load and Additional Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
ROSS	120.26	46.66	-11.41	5.62	23.01	0.60	853.04
Allowable Load	120.26			2.16	1.44	1.08	
Additional Reductions Necessary at ROSS				3.46	21.56	none	

<u>MRPOWER Stream Site</u>

This is a stream site located immediately downstream of MR8, MR7 Prime, MR7 Steve's Spring, MR7 North Culvert, MR7 Pit Spring, and MRROSS. Iron loading was less than the calculated Allowable Load for this stream point meaning there is no required reduction for iron from upstream points at this location. However, loadings for both manganese and aluminum exceeded the calculated Allowable Load meaning there are required reductions of 19.73 PPD of manganese and 7.0 PPD of aluminum from upstream sources. Reference Table 30 below. Rehabilitating the MRROSS system and constructing treatment at the

MR7 Prime and Steve's Spring discharges will help achieve these reductions as well as maintaining functionality of MRTUFF and MRFROG, MR8, MR7 North Culvert, and MR7 Pit Spring.

Table 30 MRPOWER Stream Site Calculation of Allowable Load and Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
MRPOWER	**875.12**	**12.31**	**334.68**	**5.85**	**30.23**	**14.88**	**1690.73**
Allowable Load	875.12			15.75	10.50	7.88	
Reductions Necessary at MRPOWER				**none**	**19.73**	**7.00**	

<u>MR153 Stream Site</u>

This is a stream site located immediately downstream of the MRSGL98 discharges. Iron loading was less than the calculated Allowable Load for this stream point meaning there is no required reduction for iron from upstream points at this location. However, loadings for both manganese and aluminum exceeded the calculated Allowable Load meaning there are required reductions of 103.31 PPD of manganese and 25.76 PPD of aluminum from upstream sources. Reference Table 31 below. Rehabilitating the MRROSS system and constructing treatment at the MRSGL98, MR7 Prime, and Steve's Spring discharges will help achieve these reductions as well as maintaining functionality of MRTUFF, MRFROG, MR8, MR7 North Culvert, and MR7 Pit Spring.

Table 31 MR153 Stream Site Calculation of Allowable Load and Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
MR153	**2115.33**	**5.35**	**845.71**	**11.43**	**128.70**	**44.80**	**5277.33**
Allowable Load	2115.33			38.08	25.38	19.04	
Reductions Necessary at MR153				**none**	**103.31**	**25.76**	

<u>MRMOUTH Stream Site</u>

This is a stream site located at the mouth of the watershed, downstream of all treatment systems and untreated discharges in the Morgan Run watershed. Water quality results and loading reductions achieved at the MRMOUTH site will be the ultimate determination of success in the watershed. Iron loading was less than the calculated Allowable Load for this stream point meaning there is no required reduction for iron from upstream points at this location. However, loadings for both manganese and aluminum exceeded the calculated Allowable Load meaning there are required reductions of 91.31 PPD of manganese and 22.79 PPD of aluminum from upstream sources, reference Table 32 below. Table 33 shows that in total, we expect to remove 96.06 PPD of manganese and 26.41 PPD of aluminum by implementing the recommendations in this WIP. If all the recommendations in this plan are implemented, restoration of the Morgan Run watershed will be achieved.

Table 32 MRMOUTH Stream Site Calculation of Allowable Load and Reductions Necessary

	Flow	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
Sample Point	GPM	PPD	PPD	PPD	PPD	PPD	PPD
MRMOUTH	**2674.50**	**26.27**	**1202.99**	**16.64**	**123.40**	**46.86**	**5636.78**
Allowable Load	2674.50			48.14	32.09	24.07	
Reductions Necessary at MRMOUTH				**none**	**91.31**	**22.79**	

Table 33 Reductions Achieved Through Treatment of MR7 Prime, Steve's Spring, & MRSGL98 and Rehabilitation of MRROSS and MRFROG East

	Fe, ppd	Mn, ppd	Al, ppd
MRROSS	3.46	21.56	0.00
MRFROG East	0.53	0.00	0.11
MR7 Prime and Steve's Spring	87.30	19.30	7.20
MRSGL98	11.20	55.20	19.10
Total Reductions Possible	102.49	96.06	26.41

Note, the loading reductions already achieved at the MRTUFF and MR8 treatment systems are contributing to the current water quality at the MRMOUTH sample site. As the systems age, the water quality will gradually decrease for each system and the treated effluents will exceed the calculated Allowable Loads for each site described earlier in this section and the loading reductions achieved at the MRMOUTH will suffer as well. Once this occurs, these sites will need to be rehabilitated to bring the loadings for the AMD parameters below the Allowable Load once again. There is no way to accurately predict what loading reductions can be achieved from rehabilitating the MRTUFF and MR8 systems in the future since it's dependent on how degraded the water quality becomes triggering the need for rehabilitation.

C. Proposed Management Measures

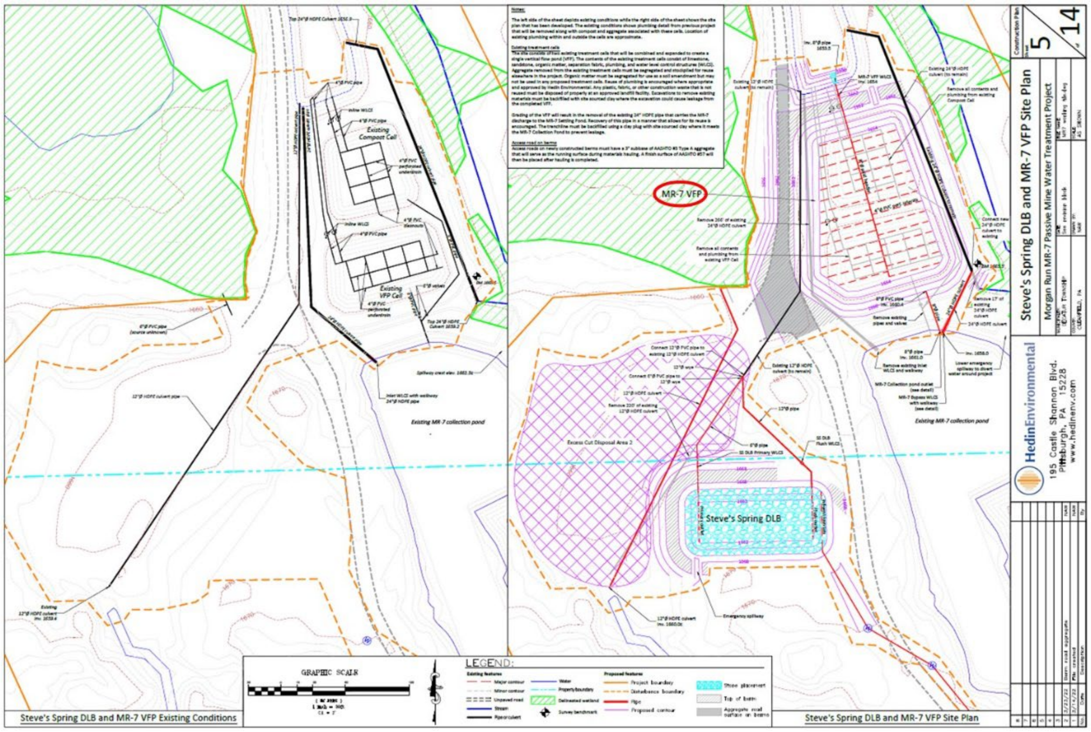
The basic goals for restoration of this watershed are to complete construction of passive treatment systems to remediate the remaining untreated discharges and maintain the existing systems to preserve the loading reductions that are already being achieved. To that end, the proposed management measures are identified and prioritized below.

1. MR7 Prime and Steve's Spring treatment
2. MRSGL98 treatment
3. Monitor, maintain, and rehabilitate the Morgan Run treatment systems

1. MR7 Prime and Steve's Spring Treatment

As mentioned previously, the MR7 discharge area is the largest contributor of AMD pollutants to Morgan Run. DLBs have already been constructed on the North Culvert and Pit Spring discharges. It is crucial that the necessary treatment systems are constructed on the remaining Steve's Spring and MR7 Prime discharges if restoration of the Morgan Run watershed is to be achieved. Because this area has been a priority since 2006, the Conservation District has already completed investigating, monitoring, and designing treatment to remediate the Steve's Spring and MR7 Prime discharges. Fortunately, at the time of the writing of this WIP, AML/AMD Grant Funding has been secured to install the treatment as shown in Figure 13 below. Subsidence reclamation will be completed upslope of the MR7 Prime discharge to reduce the source of surface water infiltration to the discharge. Once completed, a Vertical Flow Pond (VFP) will be constructed to treat MR7 Prime. The Steve's Spring discharge will be piped to a suitable treatment area where a Drainable Limestone Bed (DLB) will be constructed.

Figure 13 MR7 Prime and Steve's Spring Site Plan



2. MRSGL98 Treatment

Once the MR7 discharges are fully treated, the only remaining untreated site in the watershed is the MRSGL98 discharge area. In 2022 collection ditches were installed to gather the diffuse discharges and direct them to areas suitable for treatment system construction. The collected discharges were studied for a year before conceptual treatment designs were developed, see Figure 14 and Figure 15.

The collection ditches were designed to gather the extremely diffuse discharges into fewer points and direct them to areas more suitable for treatment system construction. A minimum of 4 separate treatment systems utilizing a combination of Vertical Flow Ponds (VFPs), Drainable Limestone Beds (DLBs), Manganese Removal Beds, Flush Ponds, Polishing Wetlands, and Settling Ponds will be utilized to treat the SGL98 discharges.

Figure 14 MRSGL98 North Treatment Systems Conceptual Site Plan

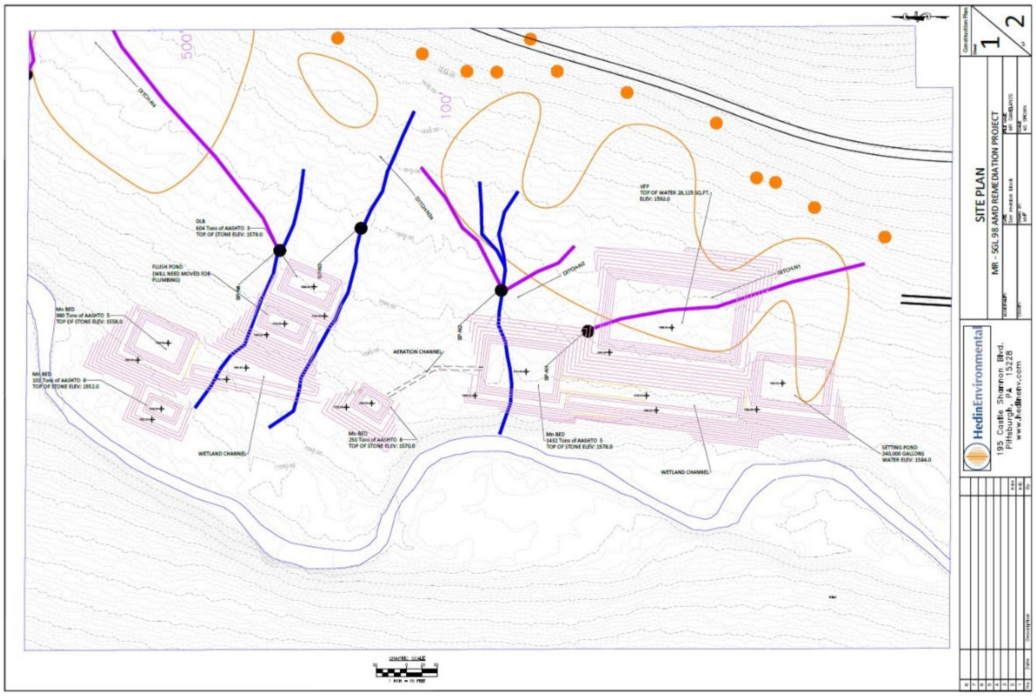
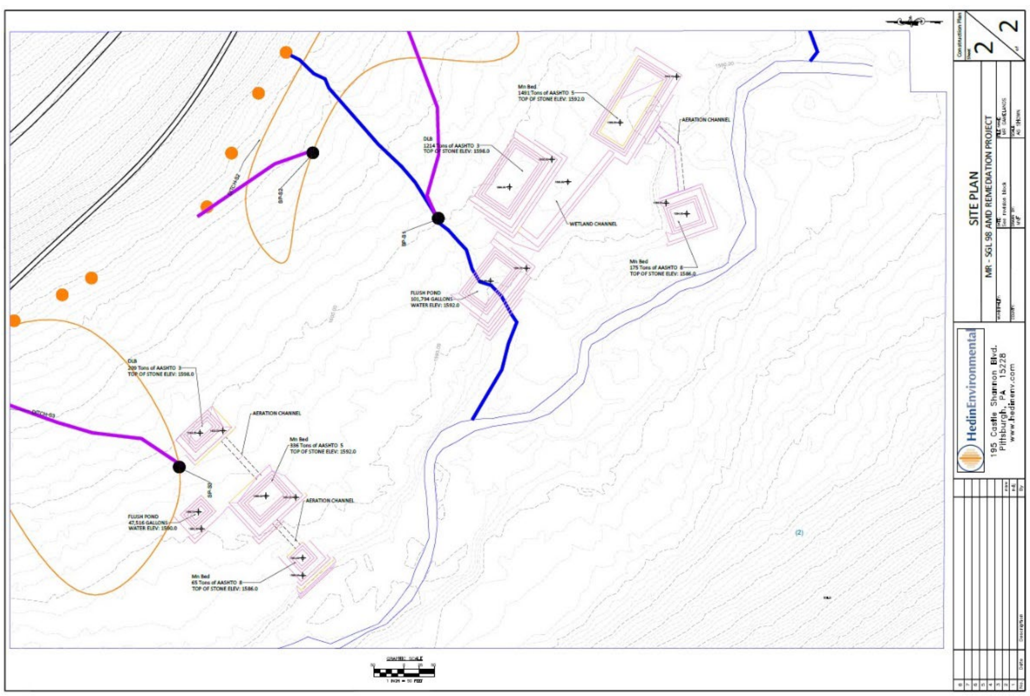


Figure 15 MRSGL98 South Treatment Systems Conceptual Site Plan



3. Monitor, maintain, and rehabilitate the Morgan Run Treatment Systems

Monitoring and maintaining the existing and future passive treatment systems will be critical for the restoration of the watershed to be realized. Keeping up with regular operational and maintenance tasks as well as rehabilitation activities is a must. Monitoring of the raw and treated water is important because it can show slight decreases in system performance indicating the need for basic maintenance or site rehabilitation.

Regular maintenance activities are tasks that can occur regularly at any given time in the life of treatment systems or happen because of unforeseen acts of nature such as animal problems. These routine maintenance tasks cannot be completed with 319 funds. At least one of these tasks has been necessary at all the existing systems since they were built. This can include (but is not limited to):

- Clearing intake structures
- Vegetation removal (both terrestrial and in the ponds)
- Flushing unit repair
- Pipe flushing and clog removal
- Replacing damaged pipes or valves
- Minor plumbing adjustments to alter water levels

There are also more intense and costly rehabilitation tasks that should be considered every 5-10 years post construction. These are "larger ticket items" that would likely require the assistance of engineers and contractors to complete. When the TUFF and FROG systems reached 10 years in operation, the sites were overhauled and needed several limestone cleaning, flushing unit replacement, and major plumbing adjustments. Rehabilitation can include (but is not limited to) tasks such as those listed below:

- Limestone cleaning
- Limestone replenishment
- Compost replacement
- Flushing unit replacement
- Berm resealing or reconstruction
- Treatment overhaul
- Major plumbing adjustments to increase system efficiency
- Removing and disposing of solids from settling ponds

Table 21 and Table 29 show that there are currently additional loading reductions necessary at the MRFROG East and MRROSS sites, respectively. This means that these existing systems need rehabilitation more immediately than the other existing systems that do not have additional loading reductions identified. MRFROG East and MRROSS will need to be investigated to determine what tasks listed above are needed to improve system performance.

For reference, the date each system was built and went online as well as the year any rehabilitation occurred is identified in Table 34. This table also identifies when we may expect to rehabilitate each system in the future. Note, these future dates are for planning purposes only. Actual water quality results should be used to determine when a system needs rehabilitation. Minor maintenance tasks that take place annually have not been tracked.

Table 34 Year Each System Built, Rehabilitated Already, Future Rehabilitation Expected

Sites	Year Built	Year Rehabilitated	Future Rehabilitation Expected
MR TUFF	2009	2017	2027
MR FROG	2009	2017	2026
MR 8	2016	Scheduled for 2025	2035
MR7 North Culvert	2023	N/A	2033
MR7 Pit Spring	2023	N/A	2033
MR7 Steve's Spring	Scheduled for 2025	N/A	2035
MR7 Prime	Scheduled for 2025	N/A	2028
MR ROSS	2012	N/A	2026
MRSGL98 (4 systems)	Not as of WIP Approval	N/A	N/A

Monitoring of the watershed will be in the form of both sampling the water quality of the systems as well as that of the main stem at Morgan Run, ideally at the same points found in this report for comparison purposes. Both the macroinvertebrate and fishery surveys should be replicated as well to document watershed recovery.

Additionally, it is during this phase that the overall efficacy of the treatment can be evaluated on the watershed scale to see if more treatment is necessary to achieve restoration. If the water quality and biological community doesn't respond after the discharges are treated, the watershed will need to be investigated to see if there are any other possible areas where treatment or reclamation would be beneficial or if improvements can be made to the existing systems to achieve greater loading reductions.

D. Technical and Financial Assistance Needs

Technical Needs

AMD treatment is a specialized field and requires knowledge of chemistry and geological processes that create AMD as well as an in-depth understanding of the necessary treatment technologies to treat the discharges. Additionally, a consultant must be able to develop engineered plans detailing the necessary treatment and be capable of overseeing the technical aspects of construction. There are numerous AMD scientists and engineers throughout PA that possess these skills. The District has experience with several of them, most notably Hedin Environmental, who are currently working on both the MR7 and MRSGL98 projects. As of the writing of this report, there are others operating in and around Clearfield County including Tetra Tech, Skelly and Loy, Kleinfelder, Larson Design Group, and others.

Potential Funding Sources

The Morgan Run WIP Recommendations can be implemented with funds from several federal and state sources. Recommendations from this plan and operation of the existing treatment systems are already eligible for Growing Greener funding. Once the 319 WIP is approved, recommendations in this plan will also be eligible for funding from the EPA 319 Nonpoint Source Program.

Discharges abandoned prior to August 3, 1977 are also eligible for funding from the Office of Surface Mining Watershed Cooperative Agreement Program (OSM WCAP) and the AML/AMD Grant Program funding supported by the Federal Investment in Infrastructure and Jobs Act. Additionally, the AMD Set Aside Program does fund AMD treatment but to be eligible for funding from this program, the abandoned discharge must also be in a watershed with an approved Qualified Hydrologic Unit Plan (QHUP). While the WIP fulfills most requirements of the QHUP, there are no examples of a WIP being accepted as a QHUP so one would need to be approved for Morgan Run for this funding source to apply.

Unfortunately, the MRSGL98 discharges were caused by mining in the early 1990's meaning they are not eligible for OSM or AML/AMD Grant funds. When it comes to grant sources with maximum funding limits high enough to cover the costs associated with AMD treatment construction, these discharges are only eligible for Growing Greener and funding from the EPA 319 Nonpoint Source Program. There are smaller sources such as the Foundation for PA Watersheds (max award <$20,000), Eastern Brook Trout Joint Venture (max award <$50,000), Coldwater Heritage Partnership grants (max award <$25,000), etc. While these could act as match, it's not feasible to fully fund AMD treatment by combining so many smaller grants. Section 319 Nonpoint Source Funds will be key to remediating the SGL98 discharges.

<u>Estimated Financial Needs for Each Recommended Management Measure</u>

1. MR7 Prime and Steve's Spring Treatment

As mentioned previously, funding for the construction of the MR7 Prime and Steve's Spring discharges has already been secured. Because of this we are reporting the funds necessary to complete this recommendation as what was awarded from the AML/AMD Grant Program: $1,155,543. With assistance from the Western PA Coalition for Abandoned Mine Reclamation, the District also applied for an additional $100,000 through the OSM WCAP bringing the total cost for this project to $1,255,543.

2. MRSGL98 Treatment

The District and Hedin Environmental are currently working on finalizing the conceptual treatment designs presented earlier in this report. There are a series of 4 treatment areas needed to remediate all the discharges in the State Game Lands. The preliminary construction cost for all the necessary treatment is approximately $2.2 million, or $500,000 per individual system.

3. Monitor, maintain, and rehabilitate the Morgan Run Treatment Systems

Costs of maintenance and rehabilitation tasks vary greatly depending on how complex the task is. Annual visits to do things like intake clearing, vegetation management, and monitoring could just involve staff time while limestone clearing and replenishment would require the assistance of a contractor for several weeks at a time, as well as the cost of new limestone delivery. The approximate cost estimates provided here are based on 15+ years of experience maintaining systems across Clearfield County as well as the costs necessary to perform the 5-10 year rehabilitation at the MR8 passive treatment system. Funding awarded for rehabilitation of the MR8 treatment system in 2025 is $230,406.

Approximate ongoing monitoring, maintenance, and rehabilitation costs associated with AMD treatment

- Annual maintenance per site: $5000 x 6 sites = $30,000 per year
- 5-10 year rehabilitation: $230,000 per site
- Biological Surveys (including collection, identification, and analysis): $250/sample
- Fishery Surveys (if services of a licensed organization cannot be secured for free or through another grant): $4,500 for a field crew for 2 business days

E. Information, Education, and Public Participation Component

Stakeholders in the watershed include the Clearfield County Conservation District (CCCD), Trout Unlimited, PA DEP, Boggs Township, Decatur Township, Susquehanna River Basin Commission, Western Pennsylvania Coalition for Abandoned Mine Reclamation, Clearfield Creek Watershed Association, Clearfield County

Recreation and Tourism Authority (Visit Clearfield County), Clearfield County Planning Commission, Clearly Ahead (Clearfield County Economic Development), Clearfield County Commissioners, Pennsylvania Game Commission, US Office of Surface Mining, US Environmental Protection Agency, private consultants, residents and landowners along Morgan Run, and other local government and development interests. Engaging these stakeholders can be done through local news media, social media, websites, community events, and attendance at meetings. Some of these avenues are detailed below:

Monthly meetings of the CCCD, Boggs Township, Decatur Township, Clearfield Creek Watershed Association, Clearfield Co Planning Commission, or the Clearfield County Commissioners could be forums for restoration updates to be shared with the public on an annual basis, at minimum. The Watershed Specialist with the CCCD provides a monthly report at the District Meetings that includes current project updates. Projects will include ongoing work in the Morgan Run watershed.

The CCCD has ties with all the local news outlets that will also be used to inform the residents of Clearfield County about restoration progress. These include the Progress newspaper, GantDaily online paper, the Courier Express newspaper, or the local radio station WOKW 102.9. News items can be shared at any point during a project, for example when funding is awarded, when a project is completed, or improvements resulting from treatment are documented.

Additionally, the CCCD maintains a website and an active Facebook page with 500+ followers where annual (at minimum) updates can also be shared. Our partners, stakeholders listed in this section, and others can share these posts to an even broader audience.

Lastly, the CCCD already participates in several annual educational events in the county including the Conservation Celebration (in the fall), Clearfield Elementary Conservation Day (in the winter), Curwensville Elementary Environmental Day (in the spring), and numerous Earth Day celebrations (April every year). These events may not specifically focus on Morgan Run, but the watershed education provided helps garner additional support for watershed restoration and protection through greater appreciation of this natural resource.

The CCCD has a long history of AMD restoration activities in the watershed and the property owners where the priority discharges are located have already been engaged and are deeply involved in their respective projects. Because of this, there is no more outreach necessary to get landowner involvement. The private landowners of the Steve's Spring and MR7 Prime sites have been working with the District for more than 15 years and have signed landowner agreements. They have been involved in numerous on-site meetings regarding everything from initial monitoring activities to current construction oversight activities so they understand what the AMD discharges are, how they impact water quality, why they need to be treated, and what to expect from a passive treatment system. The Pennsylvania Game Commission owns State Game Lands 98 where the MRSGL98 discharges are located. They have also been working with the District for more than 15 years and have provided a landowner letter of commitment. They are very familiar with the impacts of, and treatment required for AMD and AML and are known statewide for their efforts to restore AMD and AML on State Game Lands across Pennsylvania. The same can be said of the landowners where treatment systems already exist and are being maintained. They are aware of the ongoing maintenance activities the District performs at the systems located on their properties. These landowners have all provided signed landowner agreements as well. If we need to conduct either maintenance or rehabilitation of a system, we meet with them in person and thoroughly explain what needs to be done and what to expect, and they have been shown what is a normal functioning condition for a treatment system and have been instructed to call us if they notice anything that doesn't seem to be working right such as pipes being clogged or water levels seeming to be excessively high, etc.

F. Schedule

The implementation schedule for the priority management measures and the order in which to complete them is based on the remaining sources of metal and acidity loadings in Morgan Run as well as projects currently underway. The schedule identified below also includes tasks and milestones related to the documentation of the chemical and biological recovery of Morgan Run.

Table 35 Implementation Schedule

	2023	2024	2025	2026	2027	2028	2029+
MR7 Prime and Steve's Spring Funded	■						
MR7 Prime and Steve's Spring Construction Underway		■	■				
Post Construction Monitoring & Evaluation of MR7 Prime and Steve's Spring			■	■			
Interim Water Quality and Biological Improvements from MR7 Prime and Steve's Spring Achieved				■			
Secure funding for Construction of MRSGL98			■	■			
MRSGL98 Construction Underway				■	■		
Post Construction Monitoring & Evaluation of MRSGL98					■	■	
Assess rehabilitation needs at MRROSS and MRGROG; develop rehab plans				■			
Secure funding for rehabilitation of MRROSS and MRFROG					■		
Rehabilitate MRROSS and MRFROG						■	
In-Depth Study to Reassess Morgan Run Chemical and Biological Recovery						■	■
Ongoing System Monitoring, Maintenance, and Rehabilitation	■	■	■	■	■	■	■

G. Milestones

The implementation schedule for the remaining necessary remediation projects in the Morgan Run watershed was developed to achieve restoration in an efficient logical manner. Measurable milestones toward this goal include:

Interim Goals

- Achieve at least 50% of the expected loading reductions identified in Table 15, Table 27, and Table 28 following implementation of each project
    - From MR7 Prime and Steve's Spring Treatment –2026

- Gradual water quality improvement in the mainstem of Morgan Run; achieve 40% reduction in acidity and metal loadings and 40% increase in alkalinity as compared to the values in Table 3 in Section A, Table 30, Table 31, and Table 32
    - From MR7 Prime and Steve's Spring Treatment –2026

- Initial increase in Total Taxa Richness and EPT Taxa Richness
    - 25% increase in indices compared to data in Table 3, Appendix C downstream of all passive treatment systems at MRPOWER, MR153, and MRMOUTH – 2026

- Increased number and diversity of fish in the mainstem of Morgan Run
    - Though difficult to quantify given the factors that affect fish populations outlined in Section H below, we hope to see a 25% increase in number and diversity of fish compared to Table 5, Appendix C downstream of all passive treatment systems at MRPOWER, MR153, and MRMOUTH - 2026

Overall

- Successful implementation of projects identified in this WIP
    - MR7 Prime and Steve's Spring Treatment – 2028
    - MRSGL98 Treatment – 2028
    - Rehabilitation of MRROSS and MRFROG East - 2028
- Achieve 99 % of the loading reductions identified in Table 15, Table 16, Table 27, and Table 28 following implementation of each project
    - MR7 Prime and Steve's Spring Treatment – 2028
    - MRSGL98 Treatment – 2028
    - Rehabilitation of MRROSS and MRFROG East - 2028
- Water quality improvement in the mainstem of Morgan Run; achieve 80% reduction in acidity and metal loading and 80% increase in alkalinity compared to the values in Table 3, Table 30, Table 31, and Table 32
    - MR7 Prime and Steve's Spring Treatment – 2028
    - MRSGL98 Treatment – 2028
    - Rehabilitation of MRROSS and MRFROG East - 2028
- Greater increase in in Total Taxa Richness and EPT Taxa Richness
    - 50% increase in indices compared to data in Table 3, Appendix C downstream of all passive treatment systems at MRPOWER, D53, and MRMOUTH – 2028
- Increased number and diversity of fish in the mainstem of Morgan Run
    - Again, difficult to quantify given the factors that affect fish populations outlined in Section H below, we hope to see a 50% increase in number and diversity of fish compared to Table 5, Appendix C downstream of all passive treatment systems at MRPOWER, MR153, and MRMOUTH – 2028

Once the recommendations in this WIP are implemented, a more extensive study of the water chemistry and biological conditions in the watershed should be completed to ensure the necessary loading reductions are being achieved and to identify additional projects if needed.

H. Load Reduction Evaluation

To ensure the expected loading reductions are achieved, post construction monitoring following implementation of each project identified as a priority will be key. Water quality improvements will be documented by monitoring the influent and effluent data from the MR7 Prime, Steve's Spring, and MRSGL98 systems once constructed and the influent and effluent data from the existing passive treatment systems. This will be compared to the calculated Allowable Load from each site and will tell us how effectively all the systems are treating the discharges.

Water quality at the MRPOWER, MR153, and MRMOUTH in-stream sample locations following construction of the MR7 Prime, Steve's Spring, and MRSGL98 systems will show the progress made toward loading reductions in the watershed.

Improvement in the biological community as a response to treatment is difficult to accurately predict given the numerous factors at play. Benthic macroinvertebrate and fishery communities were documented as a part of this study to show the status of recovery thus far and provide a benchmark for comparison once the final treatment systems are constructed. Biological surveys should be completed on an annual basis after the MR7 Prime, Steve's Spring, and MRSGL98 treatment systems are constructed. Several tributaries to Morgan Run support naturally reproducing brook trout and will be the source population for recolonization. The target metric for the fish community should be an increase in the abundance and diversity of fish in the mainstem of Morgan Run at the MRPOWER, MR153, and MRMOUTH in-stream sample points as detailed in Section G. Given the number of variables beyond water quality that drive fish populations (for example droughts or flooding), a timeline to meet this goal though included, could be difficult to attain and should be given careful consideration when monitoring to document fishery recovery. For benthic macroinvertebrate communities, biological metrics such as Total Taxa Richness, Index of Biological Integrity, Beck's Index, Hilsenhoff Biotic Index, Shannon Diversity Index, EPT Taxa Richness, and the percent sensitive individuals will be used to quantify the response to AMD projects. We would expect a statistically significant increase in each of those metrics (except for Hilsenhoff Biotic index, which would be expected to decrease) following project implementation. Previous studies on Twomile Run suggest that a quantifiable response in benthic macroinvertebrate metrics should be realized within five years following project implementation.

As observed during Trout Unlimited studies of Twomile Run, the specific metrics that responded most significantly to restoration efforts are Total Taxa Richness and EPT Taxa Richness. Given the nature of AMD restoration, typically we wouldn't expect to see improvement in these metrics until all the major sources of impairment are corrected. However, Sections F and G outline approximate target dates and benchmarks for the interim and overall milestones for water quality as well as biological improvement.

In addition to loading reductions and biological community improvements, as more projects are successfully implemented in the watershed, we may also see increased grassroots public involvement. There was an informal watershed group formed for the Morgan Run watershed that has been dormant for more than 5 years. This group could be restarted to aid with monitoring and system operation and maintenance. Or a local sportsman's organization could be asked to fulfill this role. Morgan Run has been utilized in the past as an outdoor classroom for Penn State students who could also help monitor the systems as well. Treatment systems within the watershed have been used for both classes and demonstrations by DEP BAMR as well and it is hoped that this can continue, especially as we see biological improvement. Additionally, we should also see increased recreational use primarily in the form of fishing as trout and other fish species increase in the watershed.

Adaptive Management

As indicated in Priority Management Measure 3, regularly monitoring the raw and treated effluent of each system as well as the water quality of each stream sample site will be key and will indicate when the adaptive management thresholds discussed in this section are triggered. As mentioned earlier, achieving the loading reductions identified for the MRMOUTH sample site is the ultimate determination of success in the restoration of the Morgan Run watershed. In an AMD impaired watershed, the only way to achieve loading reductions is to treat the AMD discharges and keep these systems functioning properly. Restoration of a watershed caused by AMD using passive treatment systems is known as "treatment dependent restoration" meaning the treatment systems will always need to be kept functioning to maintain restoration. There is no other activity that will remediate the AMD parameters causing the impairment. As such, there are 2 thresholds that if triggered, will indicate it's time to take action to protect the restored water quality in Morgan Run:

- Threshold 1: If the calculated Allowable Load at any of the treatment systems is exceeded
- Threshold 2: If the calculated Allowable Load at the MRMOUTH site is exceeded

Section B of this plan explains and identifies the Allowable Load for each discharge and stream sampling site. Making sure the water quality of the treated effluent stays below the calculated Allowable Load is the threshold we will use to determine when each system needs to be maintained. Once constructed, each system will be visited quarterly at minimum and part of the visit will include a check of basic water chemistry. If the water chemistry of the treated effluent exceeds the calculated Allowable Load, we will need to rehabilitate each system as explained in Section C, pages 27-28.

Sampling and maintenance of the treatment systems will be done more frequently than sampling of the stream sites and will be the primary indicator that we need to initiate these adaptive management measures. However, since the ultimate success of this WIP relies on meeting the loading reductions identified at the MRMOUTH stream site, then ensuring the Allowable Loading at the MRMOUTH stream site is not exceeded will be the secondary indicator that there is an issue with one of the treatment systems in the watershed. If the threshold at MRMROUTH is triggered, we will likely already know which system isn't functioning as designed based on the regular maintenance visits and we will need to rehabilitate the failing system according to Section C, pages 27-28.

I. Monitoring Component

Water quality monitoring associated with the remediation projects will take place following project completion to document improvements and load reductions. Projects will be evaluated by monitoring water quality and flow at the influent, effluent, and mainstem of Morgan Run. Restoring the mainstem of Morgan Run is the focus of this restoration plan so monitoring of the stream sample locations downstream of all the passive treatment systems, in particular at MRMOUTH, will be important to gauge whether treatment of MR7 Prime, Steve's Spring, and MRSGL98, rehabilitation of the MRROSS as well as all the existing systems are successful or not on the overall watershed scale. Sampling will include standard mine drainage parameters (pH, alkalinity, acidity, Fe, Al, Mn, sulfate, total suspended solids) and flow rates. Frequency of monitoring after the construction of each project and of the existing passive treatment systems will be done on a quarterly basis at minimum. The monitoring data will be evaluated by comparing it to pre-project conditions and calculated Allowable Loads, documented in this WIP.

Biological monitoring will take place once all construction and rehabilitation of MRROSS and MRFROG have been implemented. Monitoring should be done at the same locations that were sampled for the development of this WIP so data can be comparable. Protocols and sampling methodology will be the same as explained in the Biological Report in Appendix C unless the DEP Instream Comprehensive Evaluation (ICE) protocol for macroinvertebrates or the PFBC protocol for fisheries surveys are updated. Ideally, macroinvertebrates would be sampled annually. However, the analysis of macroinvertebrates is expensive, and cost may prohibit annual sampling after the initial post construction study if monitoring funds are not available.

APPENDIX A: Raw data for each sampling location

Note, values highlighted in the tables in this appendix were below the Limit of Detection and adjusted according to the following EPA protocol: < LOD values were corrected to LOD/Square root of 2 or LOD/1.414214 per the most frequently referenced scholarly article on the subject: *https://ntrl.ntis.gov/NTRL/dashboard/searchResults.xhtml?searchQuery=PB2004-100886*

STREAM RESULTS

MRSAN (at Sanborn Road)

Date Sample	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/24/2023	207.2	6.8	193	14.8	6.63	14.5	0.56	0.29	0.07	57	3.5	16.48	36.05	1.39	0.72	0.18	141.72
6/13/2023	156.3	6.56	195	18.5	16.46	0.98	1.39	1.33	0.07	64.2	3.5	30.87	1.84	2.61	2.49	0.13	120.41
7/24/2023	169.3	6.33	237	26.6	11.46	-3.92	1.09	0.83	0.07	72.7	3.5	23.28	-7.96	2.21	1.69	0.14	147.70
8/28/2023	98.53	6.08	226	21.3	20.86	-9.4	1.4	0.78	0.15	90.6	3.5	24.66	-11.11	1.66	0.92	0.18	107.12
9/18/2023	76.47	6.49	265	17.9	17.15	-2.35	1.58	0.71	0.5	190.3	3.5	15.74	-2.16	1.45	0.65	0.46	174.63
10/18/2023	145.3	6.16	299	10.2	14.03	-12.34	0.56	0.41	0.07	103.3	3.5	24.46	-21.52	0.98	0.71	0.12	180.11
Average	**142.18**	**6.40**	**235.83**	**18.22**	**14.43**	**-2.09**	**1.10**	**0.73**	**0.16**	**96.35**	**3.54**	**24.62**	**-3.56**	**1.87**	**1.24**	**0.27**	**164.39**

MRPOWER (at the Powerline below MR7 and MRROSS)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/25/2023	1039	4.5	366	12.6	0.07	29.79	0.26	1.99	2.21	133.9	5	0.88	371.42	3.24	24.81	27.55	1669.47
6/13/2023	862.4	3.61	605	15.6	0.07	95.4	0.92	4.4	3.23	238.8	3.5	0.73	987.28	9.52	45.53	33.43	2471.29
7/25/2023	1443	4.96	358	19.2	0.22	18.22	0.5	2.58	1.21	149.5	3.5	3.81	315.50	8.66	44.68	20.95	2588.74
8/28/2023	667.2	4.9	417	18.3	1.33	8.62	0.6	2.83	0.68	22.7	3.5						
9/18/2023	551.8	6.45	453	14.8	2.68	11.95	0.64	3.32	0.94	259	5	17.75	79.13	4.24	21.98	6.22	1714.99
10/18/2023	687.3	6.28	399	10.7	2.66	27.24	0.42	2.15	0.23	162.1	3.5	21.94	224.66	3.46	17.73	1.90	1336.94
Average	**875.117**	**5.12**	**433**	**15.20**	**1.1719**	**31.87**	**0.56**	**2.88**	**1.42**	**161.00**	**4.02**	**12.31**	**334.68**	**5.85**	**30.23**	**14.88**	**1690.73**

MR153 (at the SR153 Crossing, just upstream of Crooked Sewer Run tributary)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/24/2023	2733	5.97	403	11.9	0.07	27.83	0.25	3.76	1.91	154.5	6	2.32	912.71	8.20	123.31	62.64	5066.98
6/15/2023	2280	6.84	523	11.7	0.07	83.1	0.42	5.96	2.76	229.8	3.5	1.93	2273.62	11.49	163.07	75.51	6287.33
7/24/2023	2928	4.91	350	19.6	0.91	18.03	1.15	4.06	1.22	115.7	9	31.97	633.50	40.41	142.65	42.87	4065.24
8/28/2023	1818	4.65	452	17.5	0.07	18.22	0.07	5.57	1	242.5	3.5	1.54	397.49	1.54	121.52	21.82	5290.38
9/18/2023	1045	5.01	519	15	0.07	20.97	0.52	5.78	1.89	295.8	3.5	0.89	262.96	6.52	72.48	23.70	3709.33
10/18/2023	1888	4.77	474	10.1	0.07	31.75	0.29	5.29	1.81	209.1	3.5	1.60	719.33	6.57	119.85	41.01	4737.37
Average	**2115.333**	**5.35833**	**453.5**	**14.3**	**0.2**	**33.3**	**0.45**	**5.07**	**1.77**	**207.9**	**4.85702**	**5.35**	**845.71**	**11.43**	**128.70**	**44.80**	**5277.33**

MRMOUTH

Date Sampled	Flow	pH-Field	Cond	Temp-Fie	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	TSS	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	3199	5.59	335	13	0.12	81.53	0.25	3.19	1.38	126	7	4.61	3129.77	9.60	122.46	52.98	4836.89
6/15/2023	2788	4.27	473	12.1	0.07	72.82	0.46	5.09	2.98	199.5	3.5	2.37	2436.27	15.39	170.29	99.70	6674.47
7/25/2023	4341	5.94	304	18.2	0.32	15.68	0.76	3.16	1.21	104.1	10	16.67	816.80	39.59	164.61	63.03	5422.78
8/28/2023	1821	5.61	383	18.5	1.58	8.82	0.44	3.67	0.94	186.7	3.5	34.53	192.73	9.61	80.20	20.54	4079.77
9/18/2023	1334	5.17	442	16.2	0.43	11.36	0.74	4.33	1.43	257.6	3.5	6.88	181.85	11.85	69.31	22.89	4123.66
10/18/2023	2564	5.12	421	11	2.39	34.69	0.46	3.63	0.82	179.9	3.5	73.54	1067.34	14.15	111.69	25.23	5535.16
Average	**2674.50**	**5.28**	**393.0**	**14.8**	**0.8**	**37.5**	**0.52**	**3.85**	**1.46**	**175.63**	**5.19**	**26.27**	**1202.99**	**16.64**	**123.40**	**46.86**	**5636.78**

TREATMENT SYSTEM RESULTS

MRTUFF A1 IN (Raw)

Sample Point	Date Sampled	Flow	pH-Field	Cond	Temp-Fie	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
		GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
7Q in 5 sec	5/17/2023	21	3.78	835	14.8	0.07	62.48	0.67	9.83	1.23	316.7	3.5	0.02	15.74	0.17	2.48	0.31	79.81
5Q in 5 sec	6/13/2023	15	4.5	885	15.6	0.07	72.3	0.87	10.35	1.12	389.5	3.5	0.01	13.01	0.16	1.86	0.20	70.11
3Q in 5sec	7/26/2023	9	4.33	746	20.9	0.07	20.77	1.59	8.91	0.28	300.4	3.5	0.01	2.24	0.17	0.96	0.03	32.44
2Q 5sec	8/30/2023	6	5.54	739	19.2	0.07	24.5	2.95	6.99	0.15	530.7	3.5	0.01	1.76	0.21	0.50	0.01	38.21
2Q 5sec	9/19/2023	6	6.08	716	14.6	3.66	22.93	6.01	7.68	0.82	317.7	7	0.26	1.65	0.43	0.55	0.06	22.87
2Q 5sec	10/19/2023	6	6.25	700	10.6	6.52	49.78	1.59	6.64	0.16	332.1	3.5	0.47	3.58	0.11	0.48	0.01	23.91
	Average	**10.5**	**5.08**	**770.17**	**15.95**	**1.74**	**42.13**	**2.28**	**8.4**	**0.72**	**364.5**	**4.1**	**0.22**	**5.31**	**0.29**	**1.06**	**0.09**	**45.93**

MRTUFF A1 Out (Treated)

Date Sampled	Flow	pH-Field	Cond	Temp-Fie	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	18	6.42	818	16.2	31.86	-18.62	0.07	0.81	0.13	308.4	3.5	6.88	-4.02	0.02	0.17	0.03	66.61
6/13/2023	24	6.48	870	16.7	39.56	-31.16	0.07	0.91	0.07	369.8	3.5	11.39	-8.97	0.02	0.26	0.02	106.50
7/26/2023	6	6.56	663	22	34.15	-21.36	0.07	0.46	0.07	252.6	3.5	2.46	-1.54	0.01	0.03	0.01	18.19
8/30/2023	12	6.73	705	20.5	62.25	-43.7	0.07	1	0.07	343	3.5	8.96	-6.29	0.01	0.14	0.01	49.39
9/19/2023	9	6.88	693	15.8	63.19	-44.68	0.11	0.8	1	346	3.5	6.82	-4.83	0.01	0.09	0.11	37.37
10/19/2023	9	6.52	645	10.6	55.32	-33.32	0.16	1.06	0.07	253.6	3.5	5.97	-3.60	0.02	0.11	0.01	27.39
Average	**13.00**	**6.60**	**732.33**	**16.97**	**47.72**	**-32.14**	**0.09**	**0.84**	**0.24**	**312.23**	**3.54**	**7.44**	**-5.01**	**0.01**	**0.13**	**0.04**	**48.71**

MRTUFF A2 IN (Raw)

Sample Point	Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminun	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminun	Sulfate
		GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
3.5Q in 5 sec	5/17/2023	10.5	3.78	835	14.8	0.07	62.48	0.67	9.83	1.23	316.7	3.5	0.01	7.87	0.08	1.24	0.15	39.90
3.5Q in 5 sec	6/13/2023	10.5	4.5	885	15.6	0.07	72.3	0.87	10.35	1.12	389.5	3.5	0.01	9.11	0.11	1.30	0.14	49.08
2Q 2sec	7/26/2023	15	4.33	746	20.9	0.07	20.77	1.59	8.91	0.28	300.4	3.5	0.01	3.74	0.29	1.60	0.05	54.07
5Q 5 sec	8/30/2023	15	5.54	739	19.2	0.07	24.5	2.95	6.99	0.15	530.7	3.5	0.01	4.41	0.53	1.26	0.03	95.53
3Q 5 sec	9/19/2023	9	6.08	716	14.6	3.66	22.93	6.01	7.68	0.82	317.7	7	0.40	2.48	0.65	0.83	0.09	34.31
1.5G in 5 sec	10/19/2023	13.5	6.25	700	10.6	6.52	49.78	1.59	6.64	0.16	332.1	3.5	1.06	8.06	0.26	1.08	0.03	53.80
	Average	**12.25**	**5.08**	**770.17**	**15.95**	**1.74**	**42.13**	**2.28**	**8.4**	**0.72**	**364.5**	**4.1**	**0.26**	**6.19**	**0.34**	**1.23**	**0.11**	**53.58**

MRTUFF A2 OUT (Treated)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminun	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	3	7.76	757	17.4	58.32	-40.37	0.26	1.93	0.4	263	21	2.10	-1.45	0.01	0.07	0.01	9.47
6/13/2023	10.5	6.76	898	17.2	76.72	-71.14	0.07	0.46	0.07	309.4	3.5	9.67	-8.96	0.01	0.06	0.01	38.98
7/26/2023	15	7.92	627	24.1	40.15	-28.61	0.07	0.11	0.07	247.5	3.5	7.23	-5.15	0.01	0.02	0.01	44.55
8/30/2023	6	7.47	737	21.2	52.53	-37.24	0.07	0.04	0.07	386.6	3.5	3.78	-2.68	0.01	0.00	0.01	27.84
9/19/2023	7.5	7.44	694	16.4	55.27	-39	0.07	0.04	0.07	362.1	3.5	4.97	-3.51	0.01	0.00	0.01	32.59
10/19/2023	13.5	7	651	10.8	43.2	-32.73	0.16	0.04	0.07	270.3	3.5	7.00	-5.30	0.03	0.01	0.01	43.79
Average	**9.25**	**7.39**	**727.33**	**17.85**	**54.37**	**-41.52**	**0.12**	**0.43**	**0.13**	**306.48**	**6.45**	**6.03**	**-4.61**	**0.01**	**0.05**	**0.01**	**34.02**

MRTUFF B IN (Raw)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	1.5	4.52	690	12.1	0.07	35.8	1.05	7.52	0.07	277.9	3.5	0.00	0.64	0.02	0.14	0.00	5.00
6/13/2023	3	5.94	804	12.6	0.07	55.36	5.35	7.3	0.84	303	6	0.00	1.99	0.19	0.26	0.03	10.91
7/26/2023	1.5	6.48	533	18.2	6.14	11.56	14.52	5.6	0.07	240.5	15	0.11	0.21	0.26	0.10	0.00	4.33
8/30/2023	3	6.42	541	18.1	17.14	-1.37	18.17	5.53	0.07	588.4	3.5	0.62	-0.05	0.65	0.20	0.00	21.18
9/19/2023	3	6.37	587	12.9	10.76	-10.38	11.86	8.13	0.66	359.6	10	0.39	-0.37	0.43	0.29	0.02	12.95
10/19/2023	1.5	6.32	485	7.8	30.47	-18.03	12.21	4.76	0.07	184.7	3.5	0.55	-0.32	0.22	0.09	0.00	3.32
Average	**2.3**	**6.01**	**606.67**	**13.62**	**10.78**	**12.16**	**10.53**	**6.47**	**0.30**	**325.68**	**6.93**	**0.29**	**0.33**	**0.28**	**0.17**	**0.01**	**8.79**

MRTUFF B OUT (Treated)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	2	6.6	685	16.1	57.2	-38.61	0.07	0.18	0.07	246.7	3.5	1.37	-0.93	0.00	0.00	0.00	5.92
6/13/2023	3	6.98	742	17.1	83.6	-74.4	0.29	0.25	0.07	280.7	3.5	3.01	-2.68	0.01	0.01	0.00	10.11
7/26/2023	5.4	7.2	533	23	58.7	-45.66	0.07	0.05	0.07	178.8	3.5	3.80	-2.96	0.00	0.00	0.00	11.59
8/30/2023	3	6.89	521	20.5	72.5	-47.62	0.07	0.06	0.07	226.5	3.5	2.61	-1.71	0.00	0.00	0.00	8.15
9/19/2023	3	6.8	540	16.5	68.35	-48.02	0.07	0.04	0.07	245.9	3.5	2.46	-1.73	0.00	0.00	0.00	8.85
10/19/2023	1.5	6.74	499	11.6	65.22	-15.87	0.07	0.04	0.07	168.5	3.5	1.17	-0.29	0.00	0.00	0.00	3.03
Average	**2.98**	**6.87**	**586.67**	**17.47**	**67.60**	**-45.03**	**0.11**	**0.10**	**0.07**	**224.52**	**3.54**	**2.42**	**-1.61**	**0.00**	**0.00**	**0.00**	**8.04**

MRFROG E IN (Raw)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	15	3.16	331	10.4	0.07	109.2	0.19	3.06	8.33	117.2	3.5	0.01	19.66	0.03	0.55	1.50	21.10
6/13/2023	8	4.03	352	14.7	0.07	145.08	0.5	3.37	7.94	135.8	3.5	0.01	13.93	0.05	0.32	0.76	13.04
7/25/2023	3.4	3.67	360	17.6	0.07	118.18	1.27	2.88	3.93	99.5	3.5	0.00	4.82	0.05	0.12	0.16	4.06
8/30/2023	0.3	3.62	428	19.6	0.07	97.6	7.16	2.42	1.84	143	284.00	0.00	0.35	0.03	0.01	0.01	0.51
9/19/2023	0.2	3.9	365	16.5	0.07	72.91	6	2.6	2.09	135.3	110	0.00	0.17	0.01	0.01	0.01	0.32
No Sample = Dry																	
Average	**5.38**	**3.676**	**367.2**	**15.76**	**0.07**	**108.59**	**3.02**	**2.87**	**4.83**	**126.16**	**80.92**	**0.00**	**7.01**	**0.20**	**0.19**	**0.31**	**8.14**

MRFROG E OUT (Treated)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	3	4.1	312	13.3	0.07	105.52	5.61	3.12	9.39	107.9	11	0.00	3.80	0.20	0.11	0.34	3.88
6/13/2023	2.6	4.28	328	15.6	0.07	106.76	4.16	3.29	7.59	136.7	3.54	0.00	3.33	0.13	0.10	0.24	4.27
7/25/2023	3	4.36	290	20.6	0.07	26.46	0.35	3	3.66	108.3	3.54	0.00	0.95	0.01	0.11	0.13	3.90
8/28/2023	0.2	4.62	275	19.5	0.47	135.43	133.05	2.47	14.44	147.6	536.00	0.00	0.33	0.32	0.01	0.03	0.35
9/19/2023	0.2	4.42	204	14.1	0.07	18.22	2.43	1.63	2.28	95.5	30	0.00	0.04	0.01	0.00	0.01	0.23
No Sample = DRY																	
Average	**1.8**	**4.36**	**281.8**	**16.62**	**0.15**	**78.48**	**29.12**	**2.70**	**7.47**	**119.2**	**116.81**	**0.00**	**1.70**	**0.63**	**0.06**	**0.16**	**2.57**

MRFROG W IN (Raw)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	3	3.47	219	10.2	0.07	64.56	0.11	2.03	2.38	59.9	3.5	0.002546	2.32416	0.00396	0.07308	0.08568	2.1564
6/13/2023	12	3.62	213	11	0.07	71.72	0.15	1.93	2.74	67.4	3.5	0.01	10.33	0.02	0.28	0.39	9.71
7/25/2023	6	4.15	221	13.9	0.07	81.53	0.1	2.44	2.38	64.1	3.5	0.01	5.87	0.01	0.18	0.17	4.62
8/28/2023	0.3	3.9	216	13.4	0.07	33.51	0.07	1.96	2.1	87.8	3.5	0.00	0.12	0.00	0.01	0.01	0.32
9/19/2023	1.5	3.9	215	12.1	0.07	40.37	0.11	1.92	2.28	88.8	6	0.00	0.73	0.00	0.03	0.04	1.60
11/6/2023	26.3	4.78	222	13.2	0.07	47.23	0.19	1.92	1.45	59.8	3.5	0.02	14.91	0.06	0.61	0.46	18.87
Average	**8.18**	**3.97**	**217.67**	**12.3**	**0.07**	**56.49**	**0.12**	**2.03**	**2.38**	**71.3**	**3.9**	**0.01**	**5.55**	**0.01**	**0.20**	**0.23**	**7.00**

MRFROG W OUT (Treated)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	3	6.36	311	15.6	75.94	-48.82	0.07	0.11	0.13	65.9	3.5	2.73	-1.76	0.00	0.00	0.00	2.37
6/13/2023	2.5	6.76	306	17.1	82.92	-70.48	0.07	0.14	0.07	69.6	3.5	2.49	-2.11	0.00	0.00	0.00	2.09
7/25/2023	6	6.55	326	21.2	84.87	-88.98	0.07	0.51	0.1	58.7	3.5	6.11	-6.41	0.01	0.04	0.01	4.23
8/30/2023	0.3	6.72	316	21.2	77.69	-70.36	0.07	0.04	0.07	79.1	3.5	0.28	-0.25	0.00	0.00	0.00	0.28
9/19/2023	1.5	6.53	297	17.5	65.51	-48.21	0.07	0.04	0.07	78.8	3.5	1.18	-0.87	0.00	0.00	0.00	1.42
11/6/2023	26.3	6.49	278	11.1	65.51	-51.74	0.07	0.04	0.07	53.3	3.5	20.67	-16.33	0.02	0.01	0.02	16.82
Average	**6.60**	**6.57**	**305.67**	**17.28**	**75.41**	**-63.10**	**0.07**	**0.14**	**0.09**	**67.57**	**3.54**	**5.97**	**-5.00**	**0.01**	**0.01**	**0.01**	**5.35**

MR8 A1 (Raw flow into both VFPs)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	30	5.3	384	12.2	0.07	50.54	0.43	2.65	1.63	111.6	3.5	0.03	18.19	0.15	0.95	0.59	40.18
6/13/2023	8.3	4.46	368	14.3	0.07	70.14	0.86	3.34	2.53	130.2	3.5	0.01	6.99	0.09	0.33	0.25	12.97
7/25/2023	40.5	4.64	387	19.6	0.07	28.61	0.66	2.93	1.06	116.8	3.5	0.03	13.90	0.32	1.42	0.52	56.76
8/28/2023	6.75	5.8	415	18.1	0.07	26.26	1.33	3.77	1.79	187	3.5	0.01	2.13	0.11	0.31	0.14	15.15
9/18/2023	6.75	4.02	411	14.6	0.07	38.41	1.73	4.28	2.77	201.1	3.5	0.01	3.11	0.14	0.35	0.22	16.29
10/18/2023	12	4.12	403	10.4	0.07	24.3	1.17	3.24	2.11	146.4	3.5	0.01	3.50	0.17	0.47	0.30	21.08
Average	**17.38**	**4.72**	**394.67**	**14.87**	**0.07**	**39.71**	**1.03**	**3.37**	**1.98**	**148.85**	**3.54**	**0.01**	**8.28**	**0.21**	**0.70**	**0.41**	**31.05**

MR8 C1 (Raw flow into DLB)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	18	4.13	514	12.3	0.07	146.02	1.04	7.17	10.29	184.6	3.5	0.02	31.54	0.22	1.55	2.22	39.87
6/13/2023	10.5	3.72	547	14.2	0.07	179.18	1.96	6.85	11.17	230.1	3.5	0.01	22.58	0.25	0.86	1.41	28.99
7/25/2023	21	3.6	543	20	0.07	183.45	3.26	7.02	8.29	191.3	3.5	0.02	46.23	0.82	1.77	2.09	48.21
8/28/2023	9	3.69	577	17.8	0.07	125.44	5.39	7.67	8.58	269.8	3.5	0.01	13.55	0.58	0.83	0.93	29.14
9/18/2023	9	3.59	550	14.7	0.07	118.18	4.43	6.56	6.41	281.7	3.5	0.01	12.76	0.48	0.71	0.69	30.42
10/18/2023	7.6	3.45	517	10	0.07	100.74	2.83	6.41	10.46	213.4	3.5	0.01	9.19	0.26	0.58	0.95	19.46
Average	**12.52**	**3.70**	**541.33**	**14.83**	**0.07**	**142.17**	**3.15**	**6.95**	**9.20**	**228.48**	**3.54**	**0.01**	**21.35**	**0.47**	**1.04**	**1.38**	**34.32**

MR8 E1 (Treated, final system effluent)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	46	6.98	478	18.1	42	-33.51	0.07	1.16	0.17	149.1	3.5	23.18	-18.50	0.04	0.64	0.09	82.30
6/13/2023	17	6.71	539	17.5	27.68	-23.68	0.07	0.46	0.45	230	3.5	5.65	-4.83	0.01	0.09	0.09	46.92
7/25/2023	59	6.52	504	23.5	70.27	-63.7	0.07	0.21	0.07	146.8	3.5	49.75	-45.10	0.05	0.15	0.05	103.93
8/28/2023	15	6.25	549	19	87.63	-71.34	0.07	0.47	0.23	317.1	3.5	15.77	-12.84	0.01	0.08	0.04	57.08
9/18/2023	14	6.24	563	17.5	73.44	-57.23	0.54	1.04	2.11	257.2	15	12.34	-9.61	0.09	0.17	0.35	43.21
10/18/2023	15	6.05	475	10.35	68.56	-56.84	0.07	0.12	0.07	132.8	3.5	12.34	-10.23	0.01	0.02	0.01	23.90
Average	**27.67**	**6.46**	**518.00**	**17.66**	**61.60**	**-51.05**	**0.15**	**0.58**	**0.52**	**205.50**	**5.45**	**20.45**	**-16.95**	**0.05**	**0.19**	**0.17**	**68.23**

MR7: Steve's Spring Discharge (Raw)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	29.9	4.02	292	9.9	0.07	97.06	0.07	1.91	6.65	76.4	3.5	0.03	34.83	0.03	0.69	2.39	27.41
6/13/2023	17.4	3.67	416	11.6	0.07	178.66	0.19	3.32	12.08	146.8	3.5	0.01	37.30	0.04	0.69	2.52	30.65
7/27/2023	11.2	4.22	337	14.5	0.07	62.32	0.07	2.36	8.22	94.2	3.5	0.01	8.38	0.01	0.32	1.10	12.66
8/28/2023	9.43	4.02	437	13.8	0.07	97.41	0.07	2.88	11.78	195	3.5	0.01	11.02	0.01	0.33	1.33	22.07
9/18/2023	23	4.05	474	12.6	0.07	110.54	0.07	3.07	10.21	231.9	3.5	0.02	30.51	0.02	0.85	2.82	64.00
10/18/2023	37	3.73	465	11.1	0.07	103.68	0.12	2.71	16.65	162.1	3.5	0.03	46.03	0.05	1.20	7.39	71.97
Average	**21.32**	**3.95**	**403.5**	**12.25**	**0.07**	**108.28**	**0.10**	**2.71**	**10.93**	**151.07**	**3.54**	**0.02**	**27.70**	**0.03**	**0.69**	**2.80**	**38.65**

MR7 Prime Discharge (Raw)

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	324.8	4	1593	17.4	0.07	217	41.12	14.55	0.94	549.5	6	0.28	845.78	160.27	56.71	3.66	2141.73
6/13/2023	178.1	3.45	1399	17.4	0.07	340.76	46.28	14.45	5.76	626.4	3.5	0.15	728.27	98.91	30.88	12.31	1338.74
7/26/2023	303.2	3.61	1361	22.5	0.07	133.28	39.7	12.86	3.17	540	3.5	0.26	484.93	144.44	46.79	11.53	1964.74
8/28/2023	93.2	3.45	1392	19.5	0.07	176	37.28	11.92	2.6	710	3.5	0.08	196.84	41.69	13.33	2.91	794.06
9/18/2023	128.9	3.66	1374	17.3	0.07	173.06	40.94	11.65	2.42	817.3	3.5	0.11	267.69	63.33	18.02	3.74	1264.20
10/18/2023	93.6	3.28	1355	10.5	0.07	126.22	30.88	10.95	2.3	562.7	3.5	0.08	141.77	34.68	12.30	2.58	632.02
Average	**186.97**	**3.58**	**1412.33**	**17.43**	**0.07**	**194.39**	**39.37**	**12.73**	**2.87**	**634.32**	**3.95**	**0.16**	**436.13**	**88.32**	**28.56**	**6.43**	**1423.15**

MR7: Pit Spring Discharge (Raw)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	38.9	4.46	287	8.2	0.07	103.66	0.07	2.14	7.72	79	18	0.03	48.39	0.03	1.00	3.60	36.88
6/13/2023	23.4	3.8	317	10.6	0.07	142.12	0.07	2.45	9.76	111.6	3.5	0.02	39.91	0.02	0.69	2.74	31.34
7/28/2023	55.7	3.9	302	15	0.07	68.99	0.07	2.48	10.12	94.3	3.5	0.05	46.11	0.05	1.66	6.76	63.03
8/28/2023	37.5	4.21	313	12.8	0.07	78.59	0.07	2.4	7.81	136.5	3.5	0.03	35.37	0.03	1.08	3.51	61.43
9/18/2023	30	3.78	329	12.8	0.07	75.65	0.07	2.45	6.59	147.1	3.5	0.03	27.23	0.03	0.88	2.37	52.96
10/18/2023	12	4.02	347	11.3	0.07	76.44	0.07	2.55	11.22	114.5	3.5	0.01	11.01	0.01	0.37	1.62	16.49
Average	**32.92**	**4.03**	**315.8**	**11.78**	**0.07**	**90.91**	**0.07**	**2.41**	**8.87**	**113.83**	**5.95**	**0.03**	**35.91**	**0.03**	**0.95**	**3.50**	**44.96**

MR7: Pit Spring Treated Effluent

Date Sampled	Flow	pH-Field	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
8/28/2023	37.5	6.35	504	17.4	104.42	-85.65	0.07	0.04	0.07	142.1	3.5	46.99	-38.54	0.03	0.02	0.03	63.95
9/18/2023	30	6.45	509	15.2	111.28	-88.39	0.15	0.04	0.07	155.9	3.5	40.06	-31.82	0.05	0.01	0.03	56.12
10/18/2023	12	6.15	481	10.7	107.51	-87.8	0.07	0.04	0.07	111.2	3.5	15.48	-12.64	0.01	0.01	0.01	16.01
Average	**26.5**	**6.32**	**498**	**14.43**	**107.74**	**-87.28**	**0.10**	**0.04**	**0.07**	**136.40**	**3.54**	**34.26**	**-27.76**	**0.03**	**0.01**	**0.02**	**43.38**

MR7: North Culvert Discharge (Raw)

Date Sampled	Flow	pH-Field	Cond	Temp-Field	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganese	Aluminum	Sulfate
	GPM		µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	21.2	4.3	348	11.3	0.07	143.32	0.14	2.32	12.01	113.8	3.5	0.02	36.46	0.04	0.59	3.06	28.95
6/13/2023	5.4	3.67	350	13.6	0.07	173.9	0.25	2.45	13.17	132.8	3.5	0.00	11.27	0.02	0.16	0.85	8.61
7/26/2023	22.5	3.91	306	18.5	0.07	104.46	0.3	2.04	9.93	101.2	3.5	0.02	28.20	0.08	0.55	2.68	27.32
8/28/2023	6.7	3.87	306	18.6	0.07	93.88	0.63	2.04	8.37	143.1	3.5	0.01	7.55	0.05	0.16	0.67	11.51
9/18/2023	6.9	3.96	329	14.5	0.07	88.39	0.74	2.17	7.62	142.6	3.5	0.01	7.32	0.06	0.18	0.63	11.81
10/18/2023	5.2	4.05	305	10.3	0.07	102.11	0.48	1.88	11.79	103.7	3.5	0.00	6.37	0.03	0.12	0.74	6.47
Average	**11.32**	**3.96**	**324**	**14.47**	**0.07**	**117.68**	**0.42**	**2.15**	**10.48**	**122.87**	**3.54**	**0.01**	**15.98**	**0.06**	**0.29**	**1.42**	**16.69**

MRROSS: (Treated, final system effluent)

Date Sampled	Flow	pH-Field	pH-Lab	Cond	Temp-Fiel	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate	SSP	Alkalinity	Acidity	Iron	Manganes	Aluminum	Sulfate
	GPM			µS/cm	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	PPD	PPD	PPD	PPD	PPD	PPD
5/17/2023	125	7.02	6.79	167	19.4	29.26	-13.13	5.25	10.33	0.18	437.4	10	73.15	-19.70	7.88	15.50	0.27	656.10
6/13/2023	75	5.83	6.57	1200	19.7	18.34	-13.13	5.17	14.66	0.07	596.2	3.5	27.51	-11.82	4.65	13.19	0.06	536.58
7/25/2023	192.75	6.11	6.74	1064	20.8	25.94	-19.4	4.16	20.14	0.38	505.9	10	100.00	-44.87	9.62	46.58	0.88	1170.15
8/28/2023	154.4	6.13	6.47	1151	21.1	22.13	-11.95	2.02	18.19	0.53	751.5	3.535534	68.34	-22.14	3.74	33.70	0.98	1392.38
9/18/2023	83.2	6.23	6.43	1191	19.1	16.91	-1.76	1.96	15.57	0.9	626.6	6	28.14	-1.76	1.96	15.55	0.90	625.60
10/18/2023	91.2	5.66	5.57	1159	11.2	3.81	11.95	4.82	16.77	0.43	629.1	7	6.95	13.08	5.28	18.35	0.47	688.49
Average	**120.258**	**6.16333**	**6.4**	**988.7**	**18.6**	**19.4**	**-7.9**	**3.90**	**15.94**	**0.42**	**591.12**	**6.68**	**46.66**	**-11.41**	**5.62**	**23.01**	**0.60**	**853.04**

APPENDIX B: Pictures

MRTUFF B DLB

MRFROG West DLB

MR8 VFP

MR7 Prime (this pond was created by the installation of a berm for the 2012 pilot scale project described above)

MR7 North Culvert DLB

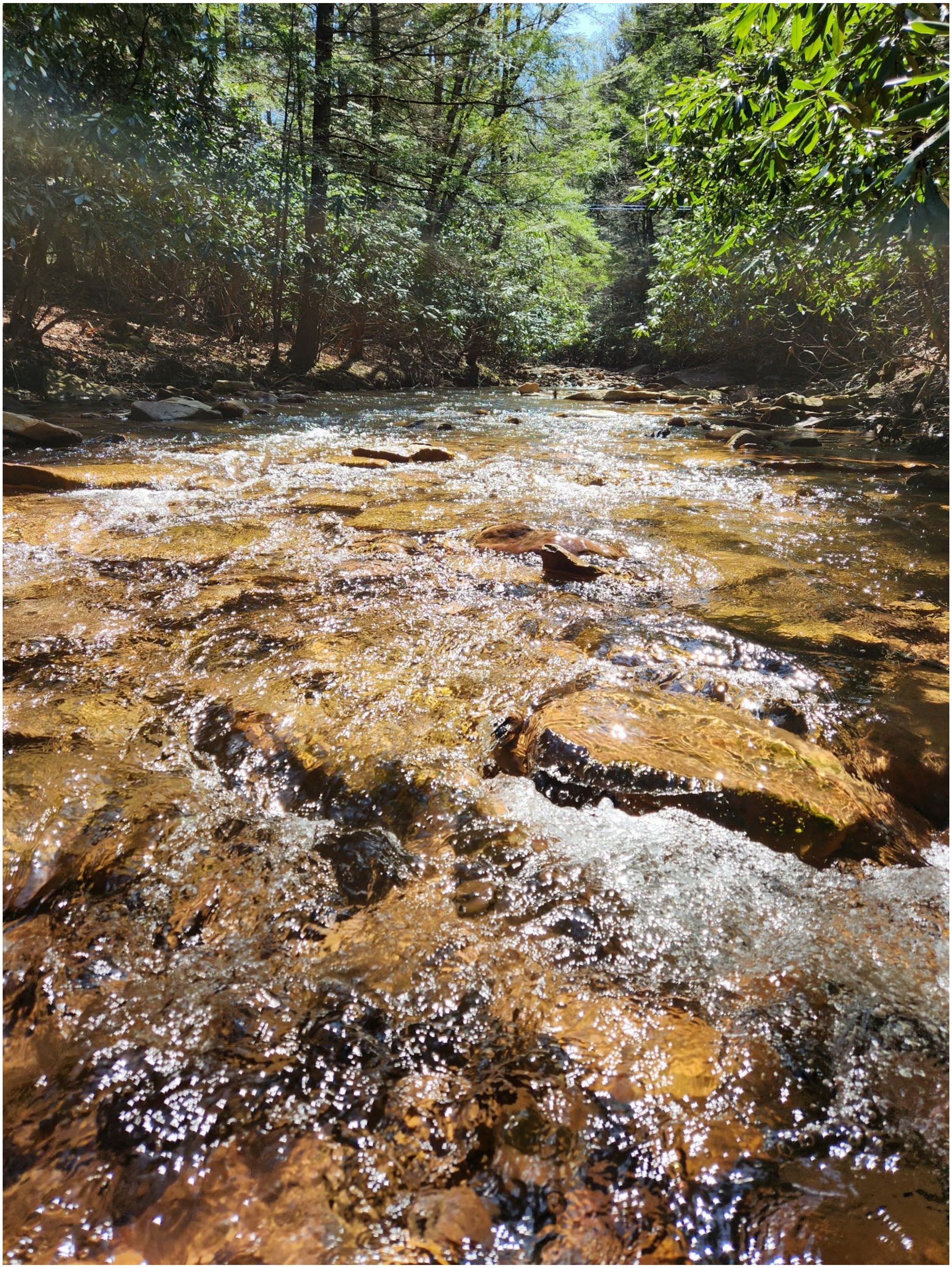
MR7 Pit Spring DLB

MRROSS VFP

MRPOWER Stream Site

MR153 Stream Site

MRMOUTH Stream Site



APPENDIX C: TU Biological Report

Biological Assessment of Morgan Run
Clearfield County, PA

December 2023

Background

The Clearfield County Conservation District (CCCD) had funding available for Trout Unlimited (TU) to assist with monitoring biological conditions in Morgan Run, Clearfield County. Morgan Run is a tributary to Clearfield Creek, the confluence is upstream of the USGS gaging station at Dimeling, PA. CCCD installed five passive treatment systems on the tributary from 2008-2022. Continuing to monitor biological communities in Morgan Run helps to track the recovery of these streams as well as assist in monitoring effectiveness of the treatment system to predict when maintenance or rehabilitation may be needed. Macroinvertebrate and fishery surveys were planned originally at five sites. However, due to beaver activity, MR05 had to be removed from macroinvertebrate and electrofishing sampling and MR06 had to be removed from macroinvertebrate sampling.

Table 1. Biological monitoring locations on Morgan Run.

Site ID	Site Description	Latitude	Longitude
MR01	Mouth of Morgan Run	40.95885	-78.40307
MR02	Upstream of the Singing Bridge at SR153 (downstream of all identified discharges)	40.95401	-78.37379
MR04	Upstream of SGL98/downstream of ROSS, MR7, MR8, MRTUFF, MRFROG	40.92021	-78.35927
MR05	Upstream of ROSS/downstream of MR 7&8	40.91917	-78.35975
MR06	Upstream of MR7&8/downstream of TUFF &FROG	40.89485	-78.36887

Table 2. Treatment system locations along Morgan Run.

Site	Site Description	Latitude	Longitude
MRTUFF	The MR TUFF system is in the very headwaters of Morgan Run. This project was built in 2009 and rehabilitated in 2017. Water from Morgan Run is diverted into 3 treatment areas, each consisting of a limestone cell followed by a settling basin.	40.88117	-78.35492
MR FROG	MR Frog was built at the same time as the MR TUFF system in 2009 and also rehabilitated at the same time in 2017. There are two discharges on site that are treated separately. Each discharge flows into a limestone cell, settling basin, and a final polishing wetland before flowing into Morgan Run.	40.88862	-78.35869
MR 8	The MR 8 passive treatment system was built in 2016 on an unnamed tributary to Morgan Run	40.90001	-78.36118
MR7	A series of 4 separate discharges make up the MR7 point (MR7 Prime, Steve's Spring, North Culvert, and Pit Spring). A pilot scale system was constructed on MR7 Prime in 2011 to prove passive technology could work. Drainable Limestone Beds were constructed in 2023 on the North Culvert and Pit Spring discharges. Treatment of the MR7 Prime and Steve's Spring discharges will be constructed in 2025.	40.90404	-78.35813
MR ROSS	The MR ROSS treatment system was installed in 2011 and consists of a vertical flow pond, settling basin, a limestone cell, and a final settling basin.	40.91439	-78.34937
MR SGL98	The MR SGL98 discharges are a series of toe of slope discharges emanating from an abandoned mine site on State Gamelands 98, passive treatment system at this location is currently under design.	40.9324	-78.36275

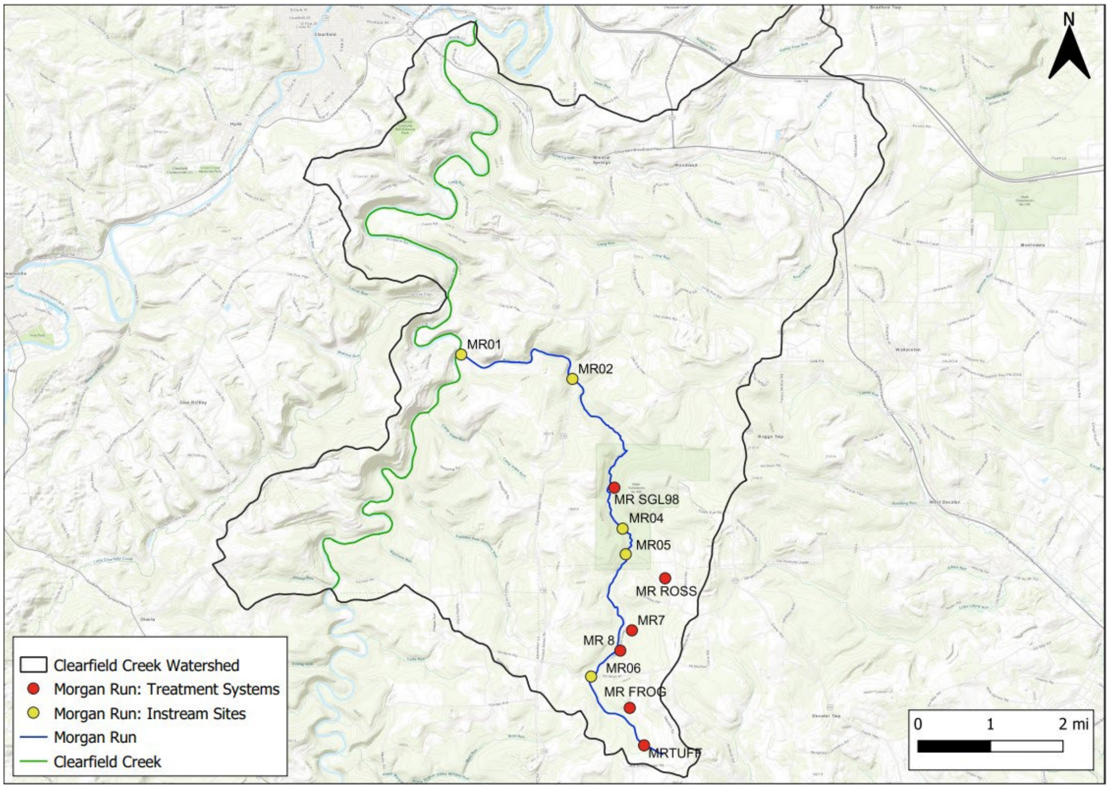


Figure 1. Stream sampling locations in relation to treatments systems in Morgan Run.

Methods

Benthic macroinvertebrates

Benthic macroinvertebrates were sampled at three of the five site locations, MR01, MR02, and MR04 on May 25th, 2023. Macroinvertebrate samples were not collected at MR05 and MR06 due to no suitable habitat upstream or downstream of the listed site coordinates. Benthic macroinvertebrate collections were made according to DEP's Instream Comprehensive Evaluation (ICE) protocol (section C.1.b. Antidegradation Surveys; Barbour et al. 1999; Shull and Lookenbill 2021). Benthic macroinvertebrate samples consisted of six D-frame kicks within a 100-meter stream section. The kicks were spread out within the best riffle habitats at varying water depths. Each kick consisted of an area of 1 m^2 to a depth of at least 4 inches as substrate allowed; all were completed with a 500-micron mesh 12-inch diameter D-frame kick net.

The six individual efforts were composited and preserved with ethanol for processing in the laboratory. Individuals were identified by taxonomists certified by the North American Benthological Society to genus or to the next highest possible taxonomic level. Samples containing 160 to 240 individuals were evaluated according to the six metrics comprising the DEP's Index of Biological Integrity (IBI) (Total Taxa Richness, EPT Taxa Richness, Beck's Index V.3, Shannon Diversity, Hilsenhoff Biotic Index, and Percent Sensitive Individuals). These metrics were standardized and used to determine if the stream met the Aquatic Life Use

(ALU) threshold for coldwater fishes, warmwater fishes and stocked trout fishes (Figure 2). Appendix A contains a description of each metric.

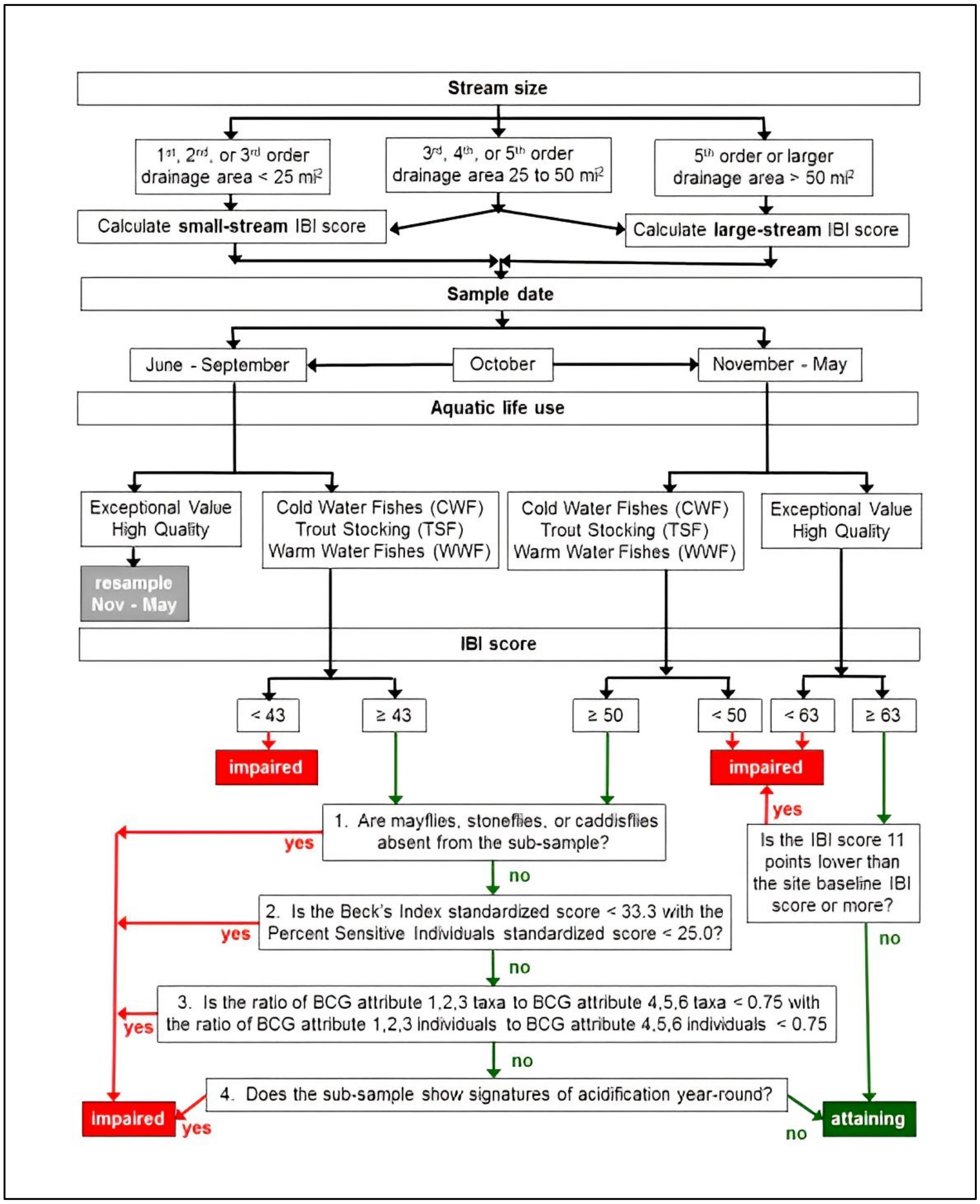


Figure 2. Aquatic Life Attainment chart to determine if benthic macroinvertebrate communities are attaining their aquatic life use (ALU).

Fishery Assessments

Fishery data were collected using backpack electrofishing gear. Specifically, all surveys were completed using the Smith-Root, LR-24 backpack electrofisher. Pulsed DC was used at all sites.

Electrofishing proceeded upstream from the beginning of each sample site and covered approximately 100 meters in length. Pennsylvania Fish and Boat Commission's Unassessed Waters Protocol (PFBC 2021) was followed for all fishery surveys where trout were not present. In short, a 100 meter reach was determined and electrofishing proceeded upstream ending at a natural break in the stream to prevent aquatic life from exiting the sample reach. All species were identified and then returned to the stream. Basic field chemistry (pH, temperature, conductivity, alkalinity) was collected at all sites.

Results

Macroinvertebrates

Macroinvertebrate sampling was performed at three of the five sampling locations: MR01, MR02, and MR04. Biological metrics that were calculated are shown in Table 3, and a complete list of taxa can be found in Appendix B. MR01 and MR04 immediately failed to attain ALU due to low abundance of individuals (78 and 47 respectively). Due to the low number of individuals (<160 individuals), IBI scores could not be accurately calculated for MR01 and MR04. Site MR02 did not attain ALU due to to an IBI score of less than 50.

Figure 3 shows the total taxa richness and EPT taxa richness for sites MR01, MR02, and MR04. Taxa richness was the same for MR01 and MR02 (8 taxa), with MR04 having nearly half the total taxa richness (5 taxa). EPT taxa richness was nearly identical in value between MR01 and MR02 (2 taxa vs 3 taxa), with MR04 again having less taxa richness than the other two sites (1 taxa). Table 3 shows MR04 had smaller Shannon's Diversity and Beck's Index values compared to MR01 and MR02 and a far lower percentage of pollution sensitive individuals, potentially indicating more anthropogenic stress at MR04 compared to the other two sites.

Functional feeding groups (FFG) were assigned to all taxa, and percent composition was calculated for all three macroinvertebrate sites (Table 4, Figure 4). MR01 and MR02 had similar percentages of Collector-Gatherers (CG) (73.1% and 68.1% respectively), while MR04's percentage was nearly half of the other sites for Collector-Gatherers (33.3%). Collector-Filterers (FC) were all found in similar, low percentages across all sites, all being less than three percent of the total count. Over double the percentage of shredders (SH) were found at MR02 compared to MR01 (34.7% vs 15.4%), while no shredders were found at MR04. Predators (PR) were more common at MR02 and MR04, making up approximately a third of the total sample size at both sites (30.5% and 29.8% respectively), while far less predators were found at MR01, making up less than a tenth of the total sample size (8.9%).

Table 3. Biological metrics calculated for each of the three sample sites.

Metric	MR01	MR02	MR04
Total Abundance	78	213	47
Total Taxa Richness	8	8	5
EPT Taxa Richness	2	3	1
Beck's Index	7	7	3
Hilsenhoff Index	5	4.19	5.87
Shannon Diversity Index	0.98	1.46	0.86
% Sensitive Individuals	17.9	36.6	2.1
IBI Score	28.4	37.4	18.6

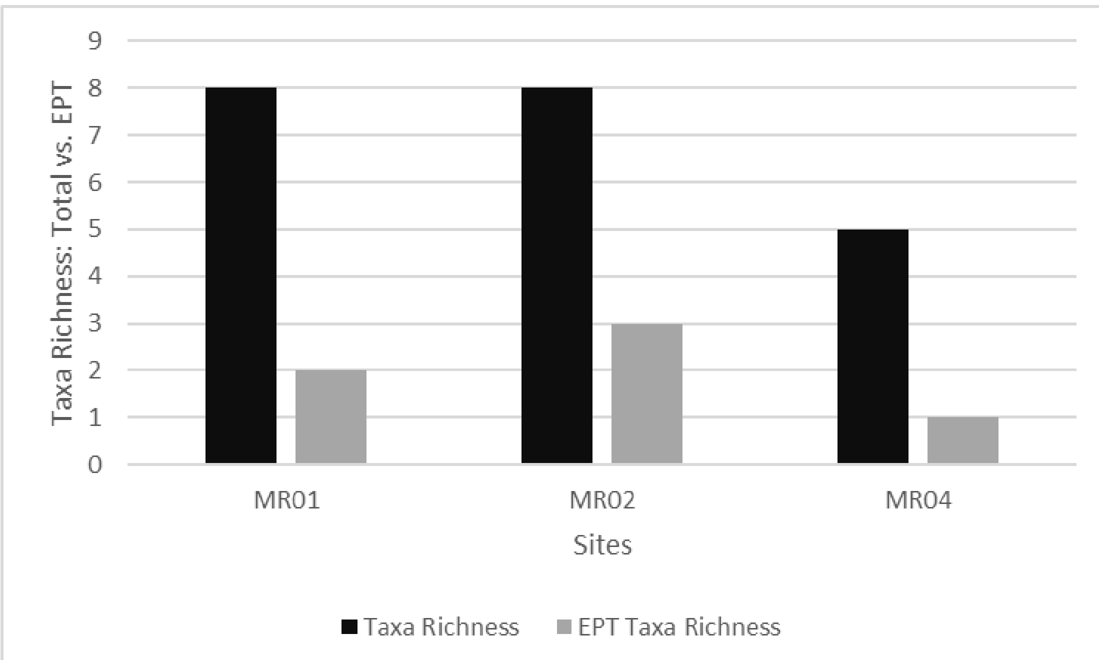


Figure 3. Total and EPT taxa richness across all macroinvertebrate sites

Table 4. Percentage of each functional feeding group, including Collector Gatherer (CG), Collector Filterer (FC), Predator (PR), Scraper (SC), Shredder (SH), and Piercer (PI) by site.

Site	% SH	% CG	% FC	% PR
MR01	15.4	73.1	2.6	8.9
MR02	34.7	33.3	1.4	30.5
MR04	0.0	68.1	2.1	29.8

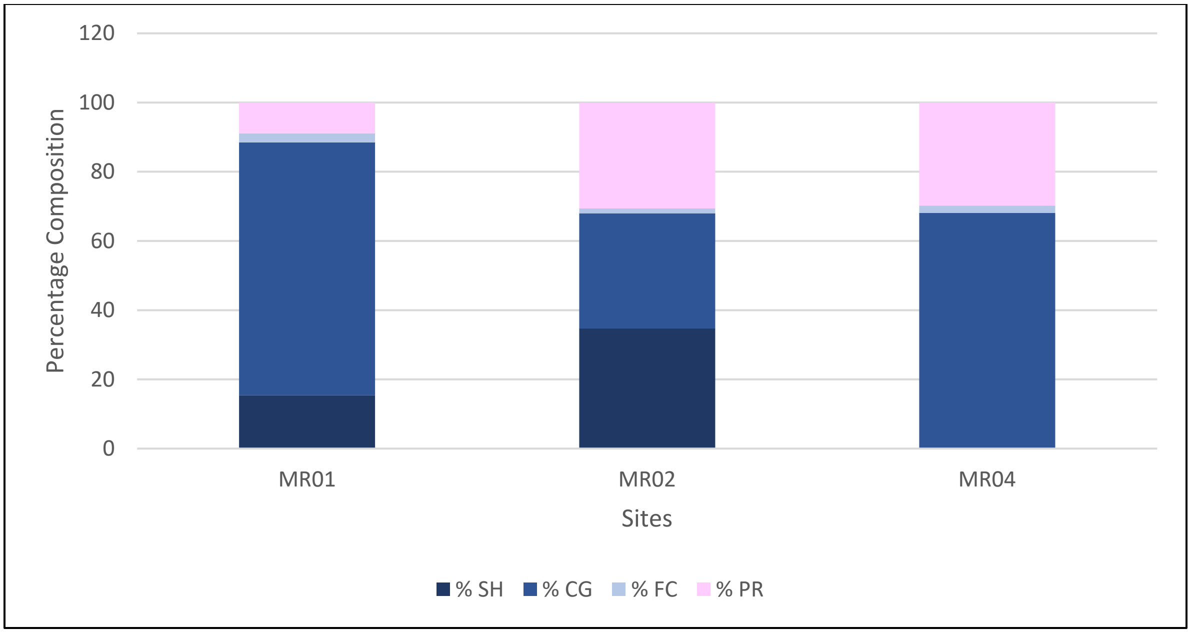


Figure 4. Percent composition of macroinvertebrate functional feeding groups by site.

Fishery Surveys

Fishery Surveys were performed at four of the five sampling locations. Site MR05 did not have a suitable location for an electrofishing survey due to heavy beaver activity. Four species were found across all sites: margined madtom (*Noturus insignis*), bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), and golden shiner (*Notemigonus crysoleucas*). Each species was assigned a presence or absence value for each species, specific abundances of species were not listed due to low individual counts (1-8 individuals) being found for each species across all sites. (Table 5). No salmonoid species were found at any of the sampling sites, with MR04 not having fish of any species. A low abundance of fish species across all sites is potentially an indicator of poor water quality, habitat availability, or food availability.

Table 5. Fish species captured at each site; X represents presence of the species, and no X represents absence of the species.

Fish Species	MR01	MR02	MR04	MR06
Margined Madtom	X			X
Bluegill		X		
Brown Bullhead				X
Golden Shiner				X

Conclusions

Overall, the benthic macroinvertebrate community at MR01 and MR04 did not have enough individuals to calculate an accurate IBI score and should be considered impaired. MR02 had enough individuals to calculate an IBI score, however it still was too low to attain ALU. Low

EPT taxa richness and percent-sensitive individuals across all sites show that there are few pollution-sensitive taxa present and that the sites are likely impaired by anthropogenic pollution. The low abundance or lack of fish species across all sampling sites further supports the macroinvertebrate results and likely impairment by anthropogenic pollution. Continued biological monitoring is needed to provide insight into improvements or changes on Morgan Run, along with continued maintenance and construction of present and future treatment systems.

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APPENDIX A: Description of Instream Comprehensive Evaluation biological metrics that were used in this project.

Total Abundance
The total abundance is the total number of organisms collected in a sample or sub-sample.

Dominant Taxa Abundance
This metric is the total number of individual organisms collected in a sample or sub-subsample that belong to the taxa containing the greatest numbers of individuals.

Taxa Richness
This is a count of the total number of taxa in a sample or sub-sample. 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.

% EPT Taxa
This metric is the percentage of the sample that is comprised of the number of taxa belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). 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, pollution (Lenat and Penrose 1996). 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.

Shannon Diversity Index
The Shannon Diversity Index is a community composition metric that takes into account both taxonomic richness and evenness of individuals across taxa of a sample or sub-sample. In general, 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.

Hilsenhoff Biotic Index
This community composition and tolerance metric is calculated as an average of the number of individuals in a sample or sub-sample, weighted by pollution tolerance values. The Hilsenhoff Biotic Index was developed by William Hilsenhoff (Hilsenhoff 1977, 1987; Klemm et al. 1990) and generally increases with increasing ecosystem stress, reflecting dominance of pollution-tolerant organisms. Pollution tolerance values used to calculate this metric are largely based on organic nutrient pollution. Therefore, care should be given when interpreting this metric for stream ecosystems that are largely impacted by acidic pollution from abandoned mine drainage or acid deposition.

Beck's Biotic Index
This metric combines taxonomic richness and pollution tolerance. It is a weighted count of taxa with PTVs of 0, 1, or 2. It is based on the work of William H. Beck in 1955 (Beck 1955). The metric is expected to decrease in value with increasing anthropogenic stress to a stream ecosystem, reflecting the loss of pollution-sensitive taxa.

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

APPENIX B: List of macroinvertebrate taxa

Order	Family	PA Taxon	MR01	MR02	MR04
Diptera	Ceratopogonidae	Ceratopogonidae		1	1
	Chironomidae	Chironomidae	56	54	32
	Empididae	Hemerodromia	5	63	12
Plecoptera	Perlidae	Amphinemura		4	
	Leuctridae	Leuctra	12	70	
Megaloptera	Corydalidae	Nigronia	1	1	
	Sialidae	Sialis	1		1
Tricoptera	Hydropsychidae	Diplectrona	1	3	1
	Polycentropodidae	Polycentropodidae	1		
		Oligochaeta	1	17	