QUALIFIED HYDROLOGIC UNIT PLAN (QHUP) FOR THE MILL CREEK AND LITTLE MILL CREEK WATERSHEDS IN JEFFERSON AND CLARION COUNTIES, PENNSYLVANIA

PRESENTED TO

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1.0 INTRODUCTION

Since the early 1990's, the Mill Creek Coalition (MCC) and their various supporting partner organizations and agencies have been working to address non-point sources of Acid Mine Drainage (AMD) within the Mill Creek & Little Mill Creek watersheds. The watersheds have a long history of mining which has left over 60 areas of identifiable AMD pollution to Mill Creek, Little Mill Creek, and its tributaries. As a result of this past mining and close proximity of Clarion University, the Mill Creek watershed was one of the first test grounds for developing passive and active AMD treatment technologies as well as development of a grass roots watershed group. Treatment efforts, such as the "Howe Bridge" ALD and SAPS passive treatment system and the Orcutt-Smail lime slurry active treatment system, were developed using cooperative partnerships, grass-roots volunteerism, and unique treatment ideas. Many of the first passive systems were constructed as experimental efforts without the sizing guidance and design approaches that have developed since these early efforts.

In 1999, the Mill Creek PL-566 Watershed Plan was created to identify and prioritize the major AMD sites within the Mill Creek and Little Mill Creek watersheds. The initial Watershed Plan identified 58 sites for treatment. A number of treatment systems were constructed by the MCC and additional efforts were initiated including alkaline addition "land liming" and well plugging prior to development of the 1999 Watershed Plan. Since completion of the initial Watershed Plan, the MCC and the Pennsylvania Department of Environmental Protection (DEP), Bureau of Abandoned Mine Reclamation (BAMR) have constructed a number of several passive treatment systems within the watersheds. In addition, the DEP, Bureau of Mining and Reclamation (BMR) constructed and oversees operation of a number of active treatment systems in the watersheds at bond forfeiture sites including the Orcutt-Smail lime slurry active treatment system.

In 2006, an Operation, Maintenance & Replacement (OMR) Plan was developed by The EADS Group for the HCT/MCC. This plan evaluated the existing passive treatment system constructed by the MCC, assessing current conditions, and providing recommendations for maintenance or replacement depending on the conditions of the passive treatment system. Efforts by the MCC and HCT in the past decade have implemented most of the recommendations in the OMR Plan ranging from maintenance efforts to remove iron solids at Filson 5/6 to complete reconstruction and replacement of the SAPS at Filson 1/2 with AVFW.

This Qualified Hydraulic Unit Plan (QHUP) has been developed to assess current water quality conditions throughout the Mill Creek and Little Mill Creek watersheds and identify areas and stream sections that have been restored, and areas and sections that need additional focused efforts either through additional improvements to existing systems or new systems and approaches in the focus areas. The following summarizes:1) the locations of current passive and active treatment systems and the responsible entity(s); 2) water quality in the Mill Creek and Little Mill Creek watersheds; 3) aquatic biota within the two watersheds; 4) water quality objectives to be met in the two watersheds and sections or focus areas where water quality objectives are not met; 5) current pollutant loads in the identified sections and required reductions to meet water quality objectives; 6) evaluation of water quality with the required pollutant load reductions; and 7) conceptual approaches and designs to achieve the load reductions and meet the water quality objectives.

2.0 TREATMENT SYSTEMS AND LOCATIONS

As indicated in the introduction, MCC, BAMR and BOM have responsibility for the passive and active treatment systems in the Mill Creek and Little Mill Creek watersheds. The locations of the treatment systems are shown on Figure 2-1 with the sites color coded and keyed to the tables that follow. There are 26 systems in the Mill Creek and Little Mill Creek watersheds with: 1) the MCC having responsibility for twenty (20) passive treatment systems; 2) BAMR responsible for two (2) passive treatment systems; and 3) BOM responsible for four (4) active treatment systems. Table 2-1 through Table 2-3 provides information on the original systems constructed and reconstruction where this has occurred.

The water quality in the evaluation below reflects the current performance of all the treatment systems and the impacts/benefits of these systems on the water quality in Mill Creek and Little Mill Creek. As such, the evaluation provides an overall review of satisfactory treatment and where additional treatment and improvements are necessary to provide restoration in the watersheds and sections or focus areas of the watersheds.

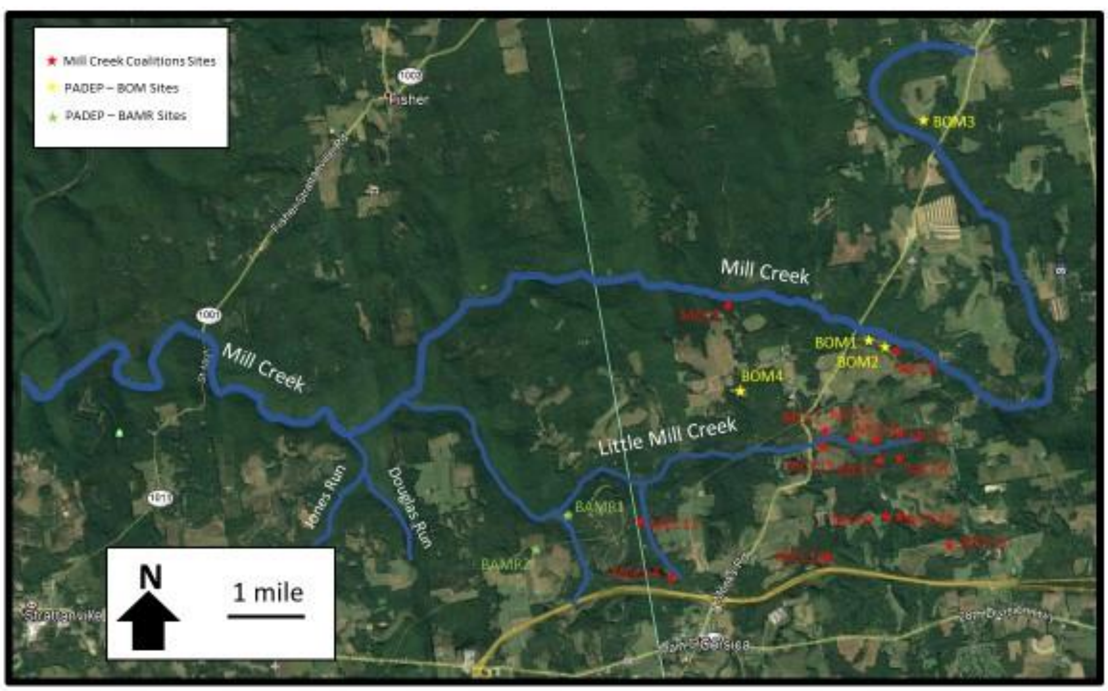

Figure 2-1. Treatment System Locations in the Mill Creek and Little Mill Creek watersheds.

Table 2-1. Mill Creek Coalition Passive Treatment Systems in the Mill Creek and Little Mill Creek Watersheds.

Site Name	Year Built	Map Code	System Description
Howe Bridge	1991 Modified in 2002 Rebuilt 2020	MCC2	ALD/Aerobic Pond/SAPS Settling Pond converted to SAPS ALD Replaced & Solids Removed
Schnepp Road 1/2	1992	MCC6	ALD/Settling Ponds/SAPS
Filson 1/2/3	1995-2001 Filson1/2 Rebuilt 2019	MCC4	Multiple SAPS/Settling Ponds SAPS Replaced with AVFW
Filson 4	1994 Renovated 2012	MCC3	ALDs/Aerobic Ponds/SAPS SAPS Replaced with AVFW
Filson 5/6	2000 Renovated 2011	MCC1	ALD/Settling Ponds/SAPS Pond/Channel Cleanout & Standpipe Install
McKinley 1	1996 Renovated 2014	MCC9	SAPS/Aerobic Pond SAPS Replaced with AVFW
Beagle Site	1998 Renovated 2015	MCC5	Aluminator ® ALD & Settling Pond Installed
Morrow 1	1998 Renovated 2011	MCC8	ALD/Aerobic Pond Installed Channel
McKinley 2	1999 Renovated 2015	MCC10	SAPS/Aerobic Pond SAPS Replaced with AVFW
Bog Site	1999 Renovated 2011	MCC7	SAPS Installed Baffles & Outlet Orifices
Daiva	2001	MCC12	ALD/Aerobic Pond
Simpson 1	2000	MCC11	ALD/Aerobic Pond
Glenn 19	2012 2019	MCC14	ULW Installed Autoflushing System
Glenn 17	2012 2017	MCC13	Upflow ALD/Settling Pond/Limestone Bed Replace Limestone/Turned over Limestone

Table 2-2. DEP-BAMR Passive Treatment Systems in the Mill Creek and Little Mill Creek Watersheds.

Site Name	Year Built	Map Code	System Description
Markle-Kotchey	2000	BAMR1	ALD/Aerobic Pond
Hanlon	2003	BAMR2	ALD/Settling Ponds/SAPS

Table 2-3. DEP-BOM Active Treatment Systems in the Mill Creek and Little Mill Creek Watersheds.

Site Name	Year Built	Map Code	System Description
Songer-Schnepp (C&K)	*Pre-2000*	BOM1	NaOH Feed/Settling Ponds
Schnepp Road (C&K)	*Pre-2000*	BOM2	NaOH Feed/Settling Ponds
Kunselmann (C&K)	*Pre-2000*	BOM3	NaOH Feed/Settling Ponds
Orcutt-Smail (REM)	2005 2014	BOM4	SAPS/Settling/Flushing Ponds Lime Slurry/Reactor/Settling Ponds

3.0 WATER QUALITY ASSESSMENT

The Mill Creek and Little Mill Creek water quality assessment was conducted to provide a snapshot of current water quality and to identify areas and stream sections of the watersheds where water quality objectives are met and where additional treatment and improvements are needed to restore the watersheds. The following sections provide the approach to sampling and results.

3.1 SAMPLING PROGRAM

Stream and tributary water quality sampling were conducted in the Mill Creek and Little Mill Creek watersheds at twenty-one (21) sampling locations consistent with past sampling efforts. The sampling locations are shown on Figure 3-1. Sampling was conducted in September 2019, which was delayed from the expected sampling in late summer of 2018. This was due to the abnormally high precipitation and stream flows in 2018 and was necessary to capture a baseflow and seasonal low flow condition where AMD impacts would be at their greatest.

Figure 3-1 . Sampling Locations in the Mill Creek and Little Mill Creek watersheds.

Water quality parameters related to AMD impacts were measured at each sampling location including pH, alkalinity, conductivity, and total and dissolved iron, manganese, and aluminum. Table 3-1 summarizes the water quality parameters and methods of determination. pH, alkalinity, and conductivity were measured in the field due to potential instability of the parameters during transport and laboratory handling. Total and dissolved metals were field collected and acidified for laboratory determination by G&C Coal Analysis Lab, Inc. (Summerville, PA). Dissolved metals were determined on a 0.2 µM field filtered sample.

Table 3-1. Sampling Location Water Quality Analysis.

Parameter	Units	Method
pH	s.u.	Oakton pHTestr 30/Oakton 300 Series
Conductivity	µS/cm	Oakton Conductivity Testr
Alkalinity	mg/L (as $CaCO_3$)	Hach Digital Titrator (0.1600 N H_2SO_4)
Iron	mg/L	EPA 200.7
Manganese	mg/L	EPA 200.7
Aluminum	mg/L	EPA 200.7

There was one parameter that was calculated based on the sampling results, which was net acidity (or net alkalinity). Net acidity was calculated using the following equation:

$$\textit{Net Acidity} = \textit{Alkalinity} - (50{,}000 \times 10^{-pH}) - (1.8 \times \textit{Diss. Fe}) - (1.8 \times \textit{Diss. Mn}) - (5.6 \times \textit{Diss. Al})$$

All metals in the above equation were dissolved concentrations and units are in mg/L. Alkalinity and acidity units are in mg/L as $CaCO_3$. This calculated net acidity also represents the net alkalinity and is a value that would equate to an equilibrium pH greater than 6 where net alkalinity is greater than 5 mg/L.

In addition to water quality, stream flows were measured at a number of locations. This differs from past sampling efforts in the watersheds where flow was not collected. Collection of flows enables calculation of pollutant loadings and levels of reductions needed to achieve water quality objectives. Flow was determined using the USGS stream flow cross-section method with stream velocities measured using a Marsh-McBirney FloMate 2000 velocity meter.

The watersheds were sampled over a two-day period, September 25 and 26, 2019, during which no precipitation had occurred in the previous 7 to 10 days nor during the sampling dates. This was needed to provide a consistent snapshot under relatively constant stream flow and AMD discharge flow. The data from the sampling is provided in Appendix A.

3.2 WATER QUALITY OBJECTIVES

The water quality objectives established for the restoration of Mill Creek and Little Mill Creek focus on the needed water quality to restore aquatic life to the surface waters. As such, the water quality standards in the Pennsylvania Code, Title 25, Chapter 93 were used for developing the water quality objectives. Table 3-2 summarizes the water quality objectives. The net acidity contained in Table 3-2 is based on the relationship between alkalinity and pH that shows greater than 5 mg/L of alkalinity (or -5 mg/L net acidity) is needed to maintain a pH greater than 6.0. While manganese is listed, the MCC has determined this objective is not a primary concern as manganese typically shows minimal toxicity to aquatic life at concentrations well above the 1.0 mg/L water quality standard, which is intended for the protection of drinking water supplies (neither Mill Creek or Little Mill Creek are drinking water supplies). The concentration of manganese is more of a concern as it relates to net acidity and the release of acidity when the dissolved manganese is oxidized and precipitated.

Table 3-2. Mill Creek and Little Mill Creek Water Quality Objectives.

Parameter	Unit	Objective	Source
pH	s.u.	>6.0	PA Code, Title 25, Chapter 93
Net Acidity	mg/L as $CaCO_3$	<-5	pH relationship
Total Iron	mg/L	<1.5	PA Code, Title 25, Chapter 93
Total Aluminum	mg/L	<0.75	PA Code, Title 25, Chapter 93
Total Manganese[1]	mg/L	1.0	PA Code, Title 25, Chapter 93

[1] *the value listed is for the protection of drinking water supplies and does not relate to aquatic life restoration. Actual aquatic life toxicity is well above this value.*

3.3 WATER QUALITY EVALUATION RESULTS

The following figures provide the water quality throughout the stream lengths in the Mill Creek and Little Mill Creek watersheds. The approach was to use the water quality data to determine stream segment water quality; that is, the water quality between two sampling locations was the water quality in the segment. Figures provided include the water quality parameters listed in Table 3-2 where categories for each parameter were developed with one or more of categories representing compliance with the water quality objectives provided in Table 3-2. Other categories are provided to show the severity of the degradation from the AMD inputs.

Figure 3-2 provides the pH found in the Mill Creek and Little Mill Creek watersheds. The vast majority of stream lengths have a pH greater than 6 and meet the water quality objective. However, the lower stream section of Mill Creek, downstream of Jones/Douglas Run and to its confluence with Piney Dam, has a pH between 4 and 5 and does not meet the water quality objective. Jones Run is the source of

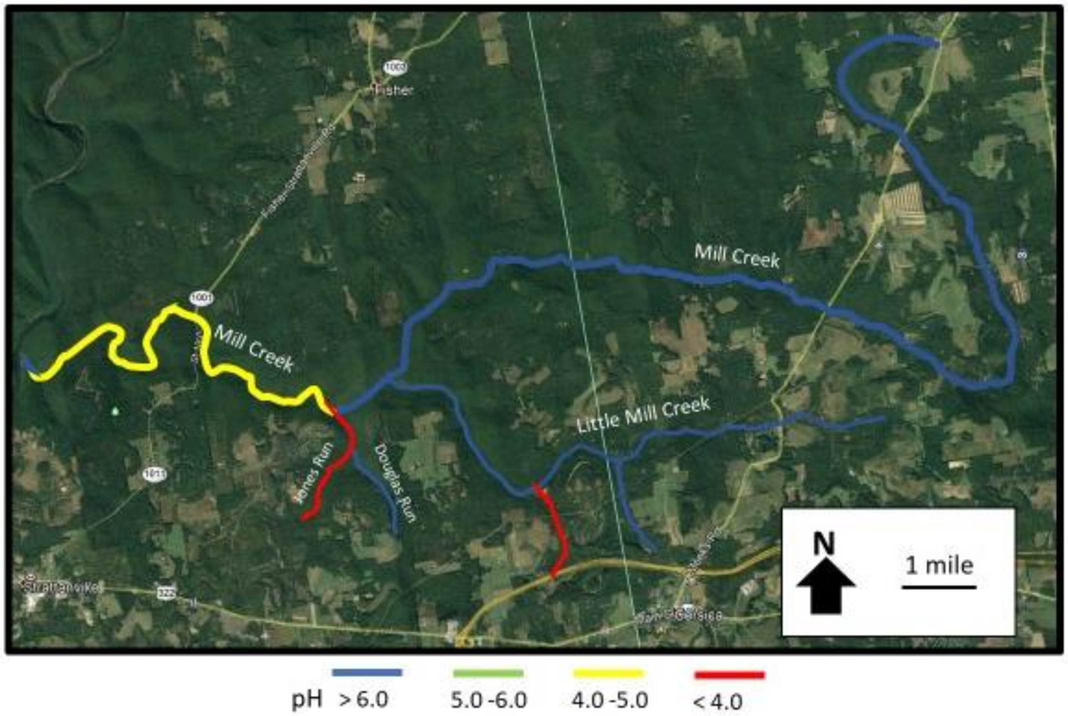

Figure 3-2. pH conditions in the Mill Creek and Little Mill Creek watersheds.

this lowered pH with a pH for this tributary approaching 3. A tributary (Asbury Road) in the lower reaches of Little Mill Creek also has a lower pH but does not cause the Little Mill Creek downstream of this tributary to decrease below 6.

Net acidity in the watersheds is provided in Figure 3-3 for various categories. In this figure both the blue (< -10 mg/L) and green (-10 to 0 mg/L) achieve the water quality objectives. Similar to pH, most of the stream sections meet the objective and also similar to pH the lower reaches of Mill Creek have elevated net acidity between +10 and +20 mg/L. This is downstream of Jones/Douglas Run and similar to pH is from AMD inputs associated with Jones Run where the net acidity of this tributary is greater than 20 mg/L (~100 mg/L at the time of the sampling). The lower section of Little Mill Creek also shows an increase in acidity from upstream water quality downstream of the Asbury Road tributary that has an acidity greater than +20 mg/L (+35 mg/L at the time of the sampling).

Total iron in the watersheds is displayed on Figure 3-4 for various categories. As can bee seen much larger sections of Mill Creek and Little Mill Creek exceed the total iron water quality objective of 1.5 mg/L. *Note the sampling was conducted at low flow where TSS from other stormwater runoff that may contribute to total iron is negligible.* In Mill Creek the lower section downstream of Jones/Douglas Run is consistent with the pH and acidity evaluation indicating Jones Run is the major contribution to this elevated iron. However, there is also a section of Mill Creek downstream of SR 949 sampling location with elevated total iron in excess of 3

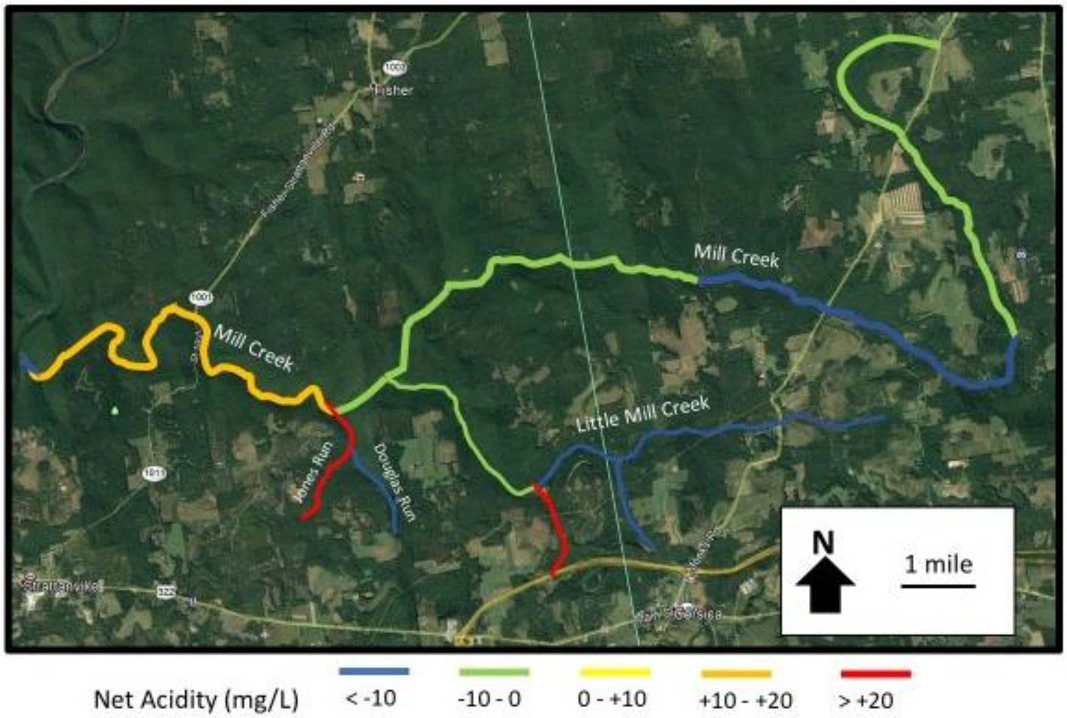

Figure 3-3. Net acidity conditions in the Mill Creek and Little Mill Creek watersheds.

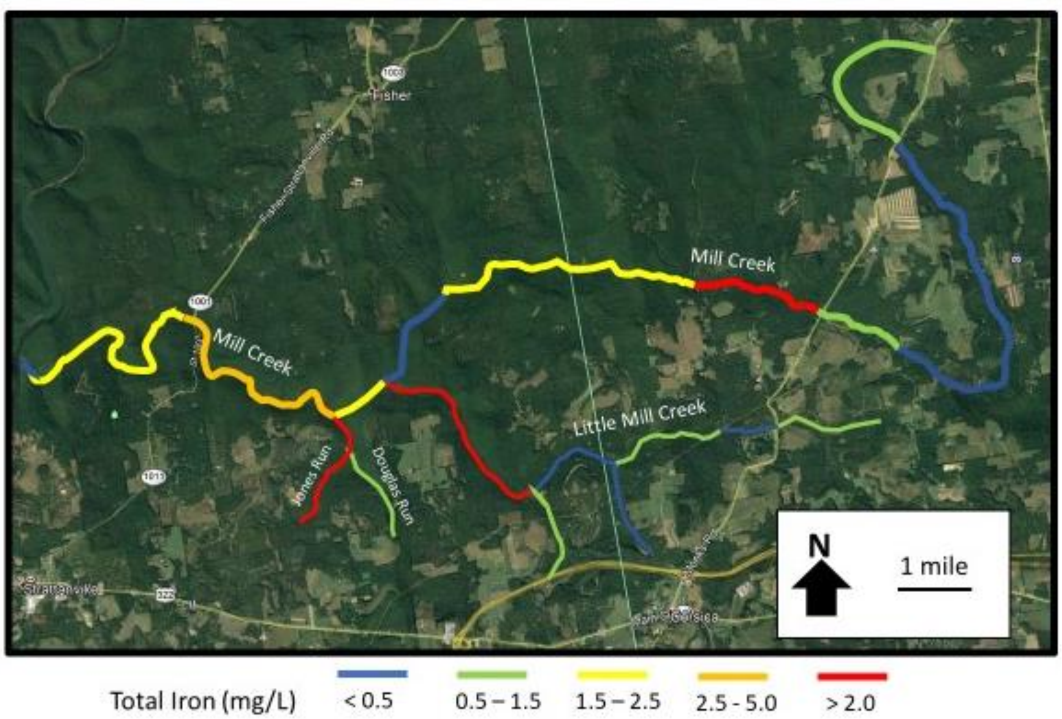

Figure 3-4. Total iron conditions in the Mill Creek and Little Mill Creek watersheds.

mg/L. Section evaluation identified possible sources of this total iron that will be discussed in the sections that follow. In Little Mill Creek the majority of the stream meets the water quality objective for total iron. However, the lower section of Little Mill Creek has elevated total iron approaching 10 mg/L. This section is downstream of the Markle-Kotchey passive treatment system where iron removal is inadequate. Additionally, Mill Creek downstream of the confluence with Little Mill Creek shows elevated total iron indicated this poorly performing passive treatment system affect Mill Creek as well.

Total aluminum in the watersheds is shown in Figure 3-5. As shown, total aluminum is less than the 0.75 mg/L objective except for two tributaries including Jones Run in Mill Creek and the Asbury Road tributary to Little Mill Creek. However, total aluminum in the lower section of Mill Creek approached the 0.75 mg/L with concentrations of 0.67 mg/L and 0.75 mg/L at the two sampling locations in the stream section. Aluminum is known to be more toxic to aquatic life, as low as 0.050 mg/L, at low pH (< 5) found in the tributaries and this lower section of Mill Creek.

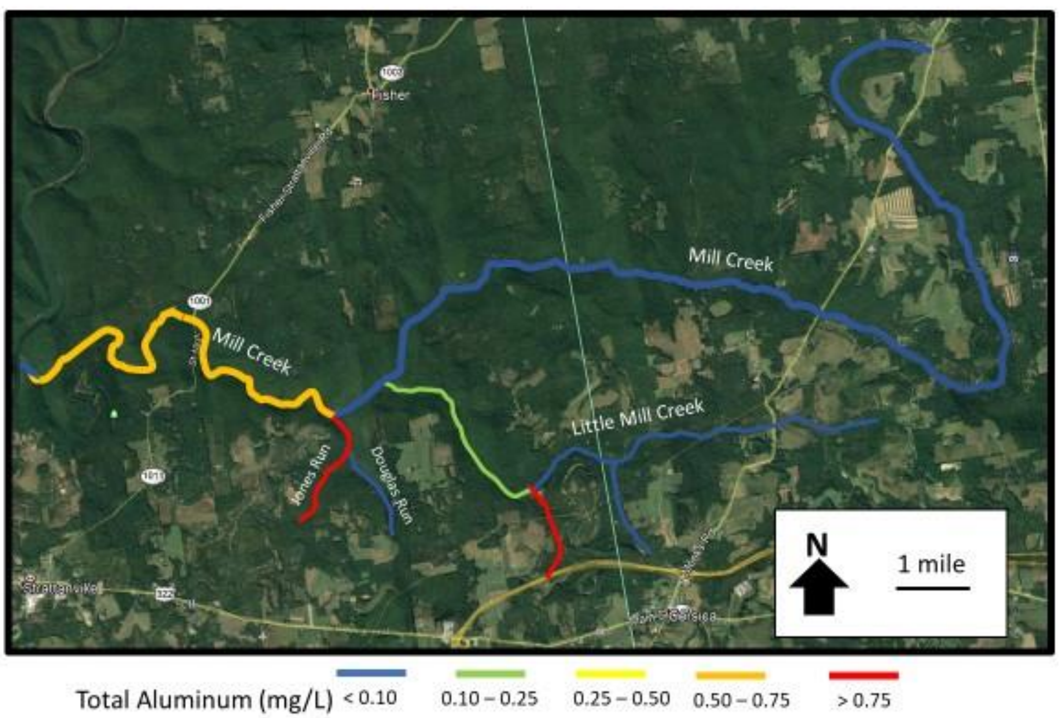

Figure 3-5. Total aluminum conditions in the Mill Creek and Little Mill Creek watersheds.

Total manganese in the watersheds is shown in Figure 3-6. As can be seen, most of the Mill Creek watershed exceeds the 1.0 mg/L water quality standard and all of the Little Mill Creek watershed exceeds this benchmark. Stream sections in both watersheds exceed 2.0 mg/L. As previously stated, the 1.0 mg/L water quality standard is for the protection of drinking water supplies and aquatic life toxicity is well above this concentration. As a result, low manganese (<1 mg/L) is not particularly relevant to restoration in these two watersheds. MCC is more concerned about the contribution of manganese to acidity.

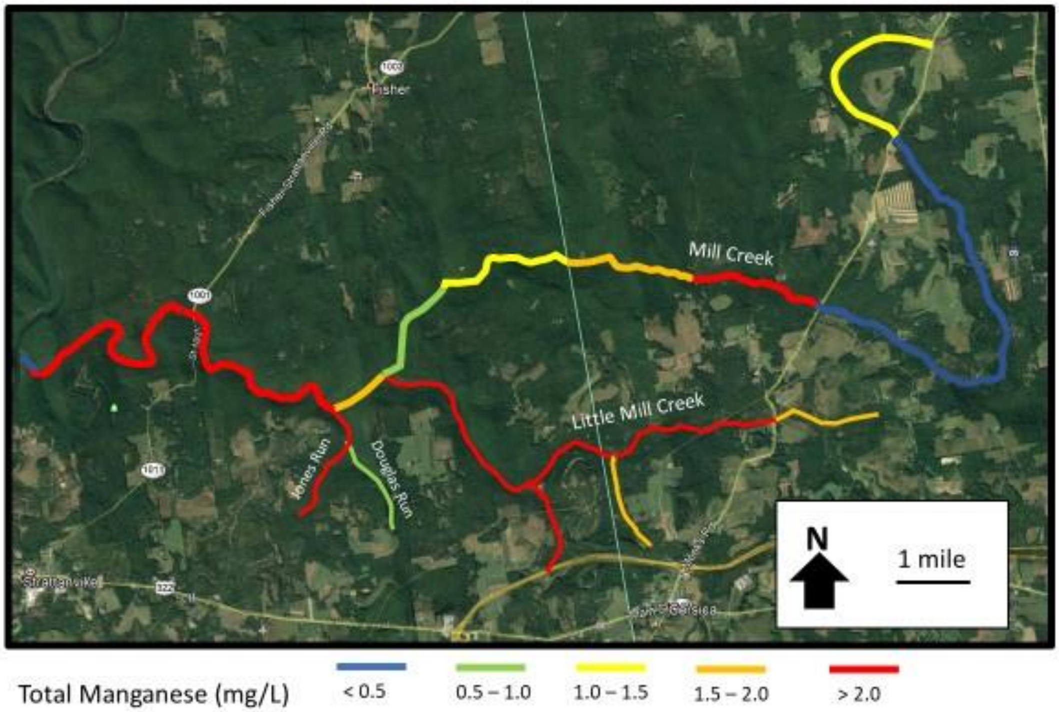

Figure 3-6. Total manganese conditions in the Mill Creek and Little Mill Creek watersheds.

3.4 WATER QUALITY EVALUATION SUMMARY

The water quality evaluation of the Mill Creek and Little Mill Creek watersheds identified stream sections within each watershed that meet and do not meet the water quality objectives. With respect to sections that do not meet the water quality objectives the following summarizes the results of this evaluation:

- pH and acidity objectives are not met in the lower section of Mill Creek downstream of the Jones/Douglas Run confluence. Jones Run is the source of the pH and acidity condition in Mill Creek.
- In addition to this section the Asbury Road tributary in Little Mill Creek affects acidity downstream of its confluence.
- The total iron objective is exceeded in the lower section of Mill Creek and similar to above occurs downstream of the Jones/Douglas Run confluence.

- The total iron objective is also exceeded in Mill Creek downstream of S.R. 949, but meets the objective just upstream of S.R. 949 to the headwaters.
- The lower section of Little Mill Creek similarly exceeds the total iron downstream of the confluence of the Asbury Road tributary, but this exceedance is due to the inflow from the Markle-Kotchey discharge and poorly performing passive treatment system.
- The total aluminum objective is met throughout the two watersheds but is near exceedance of the objective in the lower section of Mill Creek downstream of the Jones/Douglas Run confluence.
- The total manganese objective is exceeded throughout both watersheds except for a section in the headwaters of Mill Creek upstream of S.R. 949. *Note the manganese relates to potable water use and this objective is not necessary for the restoration of aquatic life, the primary objective of MCC.*

Based on the evaluation and the above, three focus areas for additional restoration in the Mill Creek and Little Mill Creek watershed are identified including:

1. The Lower Mill Creek sections downstream of Jones/Douglas Run confluence where the source of the acidity and iron are from the Jones Run tributary.
2. The section of Mill Creek immediately downstream of S.R. 949 road crossing where total iron concentrations increase but gradually decrease over the next 2 to 3 miles of stream length.
3. The section of Little Mill Creek downstream of the Asbury Road tributary and the Markle-Kotchey AMD discharge and passive treatment system where acidity inputs decrease alkalinity and total iron concentrations increase. The focus would be acidity contributed by the tributary and total iron contributed by the Markle-Kotchey AMD discharge and poorly performing passive treatment system.

There should also be consideration to the operation and maintenance of all the passive and active treatment systems in the watershed that have been installed, and in many cases, rehabilitated in order to improve and maintain water quality throughout the watersheds and stream sections. These systems are listed in Table 2-1 through Table 2-3.

4.0 MACROINVERTEBRATE EVALUATION

Macroinvertebrates in the two watersheds were collected by the Western Pennsylvania Conservancy (WPC) and summarized in a 2015 report titled "Mill Creek and Little Mill Creek of Clarion and Jefferson Counties Macroinvertebrate Assessment" prepared by Mr. Eric Chapman, Director of Aquatic Science for the WPC. Macroinvertebrate samples were collected at nine (9) locations with locations matching water quality sampling locations. The samples were collected in the headwaters and in mid-section locations of each stream.

Table 4-1 summarizes the invertebrate sample results for Mill Creek. The analyses indicated a range in the quality of the macroinvertebrate communities with excellent communities found in headwaters, deterioration of the community downstream of S.R. 949 to fair/good, improvement and return to excellent in the middle section, followed by a deterioration to fair downstream of the Little Mill Creek confluence. Although not sampled, the lower section of Mill Creek downstream of Jones/Douglas Run has low pH, elevated acidity, and high iron, which would likely result in a continued deterioration of the macroinvertebrate communities to poor.

Table 4-1. Various metrics for macroinvertebrate assessment for Mill Creek.

Parameter	Sampling Location					
	MC-01	MC-03	MC-07	MC-07B	MC-08A	MC-08B
Total Individuals	177	233	67	83	211	29
Richness	18	15	8	8	22	8
Evenness	0.77	0.74	0.71	0.55	0.68	0.82
Shannon Diversity	2.22	2.01	1.47	1.14	2.10	1.70
Hilsenhoff Index	3.64	4.03	3.51	3.98	4.15	4.45
% Ephemeroptera	4.52	2.57	0.00	0.00	30.7	3.44
% Plecoptera	33.0	23.0	30.0	12.0	3.0	0.0
% Trichoptera	8.0	29.0	51.0	66.0	35.0	34.0
% EPT	45.0	55.0	81.0	78.0	69.0	38.0
% Chironomidae	29.0	35.0	16.0	19.0	19.0	28.0
# Intolerant Taxa	7	5	4	3	8	0
PTI Index Score	31	28	16	21	29	15
PTI Rank	Excellent	Excellent	Fair	Good	Excellent	Fair

Little Mill Creek macroinvertebrate sample results are summarized in Table 4-2. Similar to Mill Creek the samples show an excellent macroinvertebrate community in the headwaters. The sampling also shows an excellent macroinvertebrate community in the mid-section, which is downstream of a large number of passive and active treatment systems to the east of S.R. 949 in the Little Mill Creek watershed (see Figure 2-1). This indicates treatment efforts have been effective in restoring Little Mill Creek in this section. The data indicates the macroinvertebrate communities deteriorate in the lower section of Little Mill Creek downstream of the Asbury Road tributary and the Markle-Kotchey passive treatment system due to the influx of acidity and high iron concentrations.

Table 4-2. Various metrics for macroinvertebrate assessment for Little Mill Creek.

Parameter	Sampling Location		
	LMC-01A	LMC-04	LMC-06
Total Individuals	227	37	23
Richness	17	12	6
Evenness	0.67	0.76	0.84
Shannon Diversity	1.89	1.89	1.50
Hilsenhoff Index	2.99	4.03	3.70
% Ephemeroptera	1.76	2.70	34.8
% Plecoptera	37.0	16.0	0.0
% Trichoptera	43.0	43.0	48.0
% EPT	82.0	62.0	83.0
% Chironomidae	5.0	22.0	0.00
# Intolerant Taxa	9	3	1
PTI Index Score	28	28	10
PTI Rank	Excellent	Excellent	Poor

The macroinvertebrate sample PTI scores are shown on Figure 4-1. Comparing this figure to Figure 3-2 through Figure 3-4 shows the water quality and macroinvertebrate community results are consistent and provides additional support for the three focus areas identified, based on the water quality data, where water quality improvements are needed.

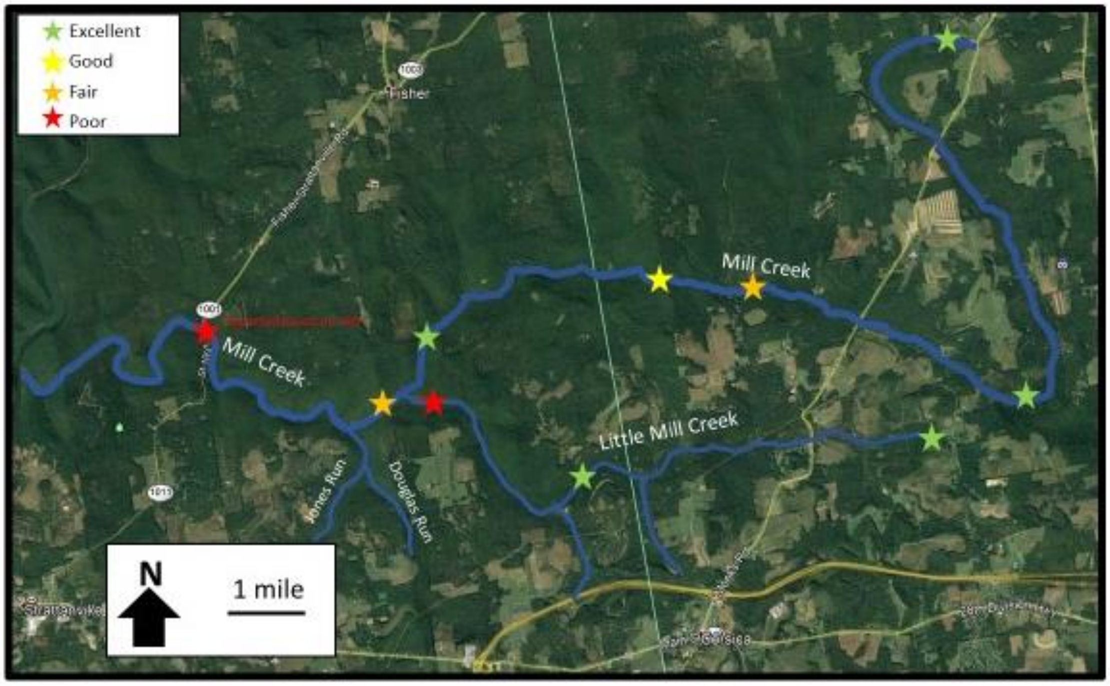

Figure 4-1. Macroinvertebrate Sampling Locations and PTI Rank (WPC 2015).

5.0 FOCUS AREAS

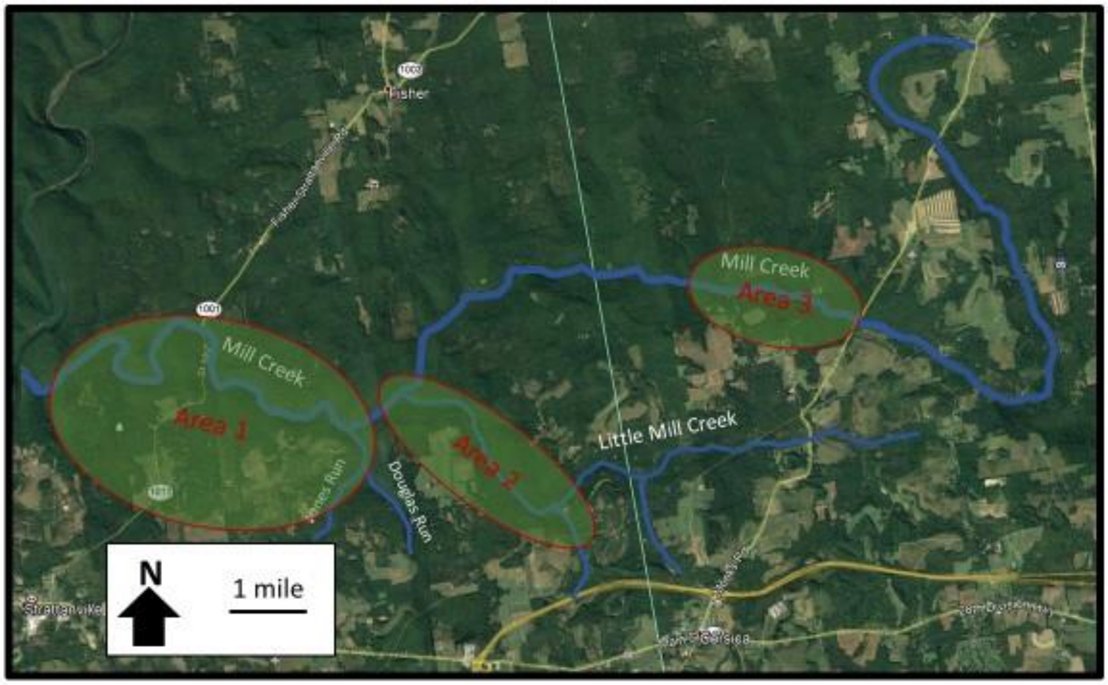

Figure 5-1. Focus Areas for Pollutant Loading Assessment in Mill Creek and Little Mill Creek watersheds.

Three focus areas were identified where streams segment water quality did not meet the water quality objectives. The three target areas are shown on Figure 5-1 and include:

Area 1 – The lower section of Mill Creek from Piney Dam upstream to its confluence of Jones/Douglas Run where the water quality objectives for pH, acidity, and total iron are not met. Total aluminum approaches and likely does not meet the objective at times. Jones Run is included in Area 1 as it is the source of the low pH, and elevated acidity, iron and aluminum.

Area 2 – The lower section of Little Mill Creek from the confluence of the Asbury Road tributary and inflow of the Markle-Kotchey passive treatment system downstream to its confluence with Mill Creek where total iron does not meet the water quality objective and acidity is affected. The Markle-Kotchey AMD discharge is the source of the iron and the Asbury Road tributary is the source of the acidity.

Area 3 – The section of Mill Creek downstream of S.R. 949 to the stream section just below Howe Road Bridge and the Howe Bridge passive treatment system where total iron does not meet the water quality objective. There is no definitive point source of this iron and preliminary site reconnaissance was conducted but additional effort is needed.

The following sections summarize the pollutant loadings in each section and an analysis of the pollutant load reductions needed to meet the water quality objectives currently exceeded. Achieving pH is based on net alkalinity and pH relationships and therefore focuses on acidity removed and not hydrogen ion (H^+) removal.

5.1 POLLUTANT LOAD EVALUATION

Streams flows were collected at the various locations during the sampling program, which when combined with the measured pollutant concentrations allow for determination of the pollutant loads at each sampling location.

Table 5-1 provides the pollutant loadings calculated for Area 1 including Mill Creek and the source of the pollutant loading, which is Jones Run. The table shows the pollutant loading calculated in Mill Creek are about twice the loading calculated from the Jones Run location. This is actually in reasonable agreement given the upstream location the Jones Run sample was taken and the presence of additional downstream inputs, and that the flow measurement in the channel may underestimate the actual flow from Jones Run because of the likelihood of contaminated interflow and groundwater flow.

Table 5-1. Area 1 Pollutant Loading Determined from Sampling.

Location	Flow (cfs)	Acidity		Total Iron		Total Aluminum	
		mg/L	lbs/day	mg/L	lbs/day	mg/L	lbs/day
	Measured/Average Baseflow						
MC09	13.2	14.8	1,055	3.7	264	0.65	47.6
MC10	13.2	14.3	1,020	1.8	133	0.69	52.5
JR1	0.78	106	450	18.2	77.0	6.4	27.1

Overall, the calculated loadings from the sampling period likely represent an average baseflow condition of AMD input. Applying a 2.5X multiplier to this value should approximate the maximum pollutant loading that needs to be addressed with treatment/restoration. This results in an acidity, iron and aluminum loading for Area 1 of 2,600 lbs/day, 660 lbs/day, and 130 lbs/day, respectively.

Table 5-2 provides the pollutant loadings calculated for Area 2 including Little Mill Creek downstream (LMC05) of the Markle-Kotchey AMD discharge and passive treatment system. The Markle-Kotchey passive treatment effluent quality from a 2007 Hedin Environmental TAG report is also provided and has an iron loading of 240 lbs/day, which is similar to the iron load of 188 lbs/day in Little Mill Creek immediately downstream (LMC05). This shows that the iron loading in Little Mill Creek in this focus area is from the Markle-Kotchey AMD discharge and poorly performing passive treatment system.

Table 5-2. Area 2 Pollutant Loading Determined from Sampling.

Location	Flow (cfs)	Acidity		Total Iron	
		mg/L	lbs/day	mg/L	lbs/day
Measured/Average Baseflow					
LMC04	3.2	-9.8	-168	NA	NA
LMC05	3.5	-3.0	-55	9.9	188
KT1	0.12	35.1	166	NA	NA
M-K AMD[1]	0.5	NA	NA	90	240

[1] *Effluent from Markle-Kotchey passive treatment system*

An upstream location in Little Mill Creek (LMC04) is also provided to show the increase in acidity, as reflected in a lower negative value, from the Asbury Road Tributary (KT1) on Little Mill Creek. The difference between the two Little Mill Creek sampling locations is about 110 lbs/day and would reflect the acidity loading impact of the tributary on Little Mill Creek. While still net alkaline this decrease in buffering will affect pH, as well as the ability of the stream to buffer other sources of acidity.

Overall, the calculated loadings from the sampling period likely represent an average baseflow condition from the AMD. Applying a 2.5X multiplier to this value should approximate the maximum pollutant loading that needs to be addressed with treatment/restoration. This results in an iron and acidity loading for Area 2 of 470 lbs/day, and 275 lbs/day, respectively.

Table 5-3 provides the pollutant loadings calculated for Area 3 for several Mill Creek locations in the stream section. Total iron was the pollutant exceeding the water quality objective and the sampling showed an instream concentration of 3.6 mg/L at the S.R. 949 sampling location (MC05) that decreased to 1.7 mg/L at the downstream sampling location (MC07) in the focus area. The iron loading at the S.R. 949 was 50 lbs/day.

Acidity is also provided in Table 5-3 for the three sampling locations. This is provided to determine whether the input was net acidic and the data shows an increasing acidity in the downstream direction, represented by lower negative values. Therefore, the elevated iron AMD input(s) in this section are also acidic. In addition, the increasing acidity values in the downstream direction indicates the AMD input is throughout the stream section, despite a decreasing iron concentration. The decreasing iron concentration is due to oxidation and precipitation of the iron inputs while the acidity is conserved.

Table 5-3. Area 3 Pollutant Loading Determined from Sampling.

Location	Flow (cfs)	Acidity		Total Iron	
		mg/L	lbs/day	mg/L	lbs/day
Measured/Average Baseflow					
MC05	2.6	-17.2	-240	3.6	50.1
MC06	--	-14.1	--	2.1	--
MC07	--	-9.8	--	1.7	--

Applying the 2.5X multiplier to this value should approximate the maximum pollutant loading that needs to be addressed with treatment/restoration. This results in an iron loading for Area 3 of 125 lbs/day. Acidity loading can be estimated from the increase in acidity from MC05 to MC07 (+7.4 mg/L), which equates to an acidity loading in Area 3 of approximately 100 lbs/day under average conditions and 250 lbs/day for the estimated maximum pollutant loading.

While no specific source was identified in Area 3, it was evident the appearance of iron oxide on the benthic substrate started in the vicinity of the S.R. 949 Bridge. Further investigation revealed upwellings along the bridge support on the north side abutment of the bridge. Samples were collected and the results indicate the upwelling has an iron concentration of 42.4 mg/L, manganese of 18.3 mg/L, and an acidity of 42 mg/L. This upwelling may be representative of groundwater in this area that may be infiltrating into the stream throughout this stream section (Area 3) of Mill Creek. This is supported by the gradual increase in acidity in the downstream direction in Area 3 for the three sampling stations.

5.2 POLLUTANT LOAD REDUCTION

Based on the pollutant loads in each of the focus areas, reductions in the pollutant loads were evaluated using a modeling analysis. The modeling analysis used a mass balance model to determine the pollutant load reductions to achieve the water quality objectives in Mill Creek and Little Mill Creek. The model is of the form:

$$PL_{WQ} = AF \times (Q_S C_S - Q_S C_{WQ})$$

where PL_{WQ} is the Pollutant Load at the Water Quality objective, Q_S is the stream flow, C_S is the stream concentration, and C_{WQ} is the water quality objective concentration (see Table 3-2). The AF is the adjustment factor to obtain an average from the stream flow condition, which was 2.5 for the summer baseflow sampling condition.

Based on this equation, pollutant loading reductions were calculated for each section, which are summarized in Table 5-4. Note, pH and total aluminum are not contained in Table 5-4 because they are both addressed by the reduction of the acidity pollutant load.

Table 5-4. Area 1 Pollutant Loading (PL) Reductions Needed to Achieve Water Quality objectives (WQ_{obj}).

Focus Area	Description	Acidity lbs/day	Total Iron lbs/day
Area 1	Lower Mill Creek downstream of Jones/Douglas Run	3,522	394
Area 2	Lower Little Mill Creek downstream of Markle-Kotchey AMD and Asbury Tributary	0 (235)[1]	399
Area 3	Mill Creek Section downstream of S.R. 949 to Howe Road Bridge	0 (288)[1]	73.0

[1] The value in () is the acidity load reduction needed to maintain upstream alkalinity in the stream section.

As can be seen in Table 5-4, Area 1 has the largest required acidity reduction of approximately 3,500 lbs/day. The source of the acidity is multiple AMD sources in Jones Run. Area 2 and Area 3 do not have specific acidity load reductions to meet the water quality objects. However, the value in the parentheses represents the acidity load reduction to minimize decreases in alkalinity from upstream sources and are 235 and 288 lbs/day, respectively. The source of the acidity in Area 2 (Little Mill Creek) is the Asbury Road tributary that has several AMD discharges including Hanlon (BAMR2 on Figure 2-1), a location where there is a passive treatment system, and Shofestall-Zerbe, a site of a BAMR abandoned surface mine and highwall reclamation adjacent to U.S. 80 in the headwaters of the tributary.

Iron load reductions are needed in all three sections. Area 2 has the largest iron load reduction of approximately 400 lbs/day. The Markle-Kotchey AMD discharge and passive treatment system (BAMR1 on Figure 2-1) is the location of this iron load reduction needed to meet the water quality objective in Little Mill Creek and Mill Creek downstream of the Little Mill Creek confluence. Iron loading reductions for Area 1 also approach 400 lbs per day and similar to acidity for this area are related to multiple AMD sources in Jones Run. Area 3 requires modest reduction of iron equaling approximately 75 lbs/day to achieve the water quality objective. However, as discussed in this section there is not an identifiable AMD discharge source of this iron, based on the observed upwelling at the S.R 949 bridge abutment.

5.3 PREDICTED WATER QUALITY

Predicted Mill Creek and Little Mill Creek with pollutant load reductions for pH, acidity/alkalinity, total iron, and total aluminum is provided in Figure 5-2 through Figure 5-5. The figures assume the pollutant loadings reductions can be achieved through treatment, site reclamation, or some other remediation measure. As previously discussed, this pollutant removal may not be possible in Area 3 due to the groundwater source and its upwelling directly into the stream channel.

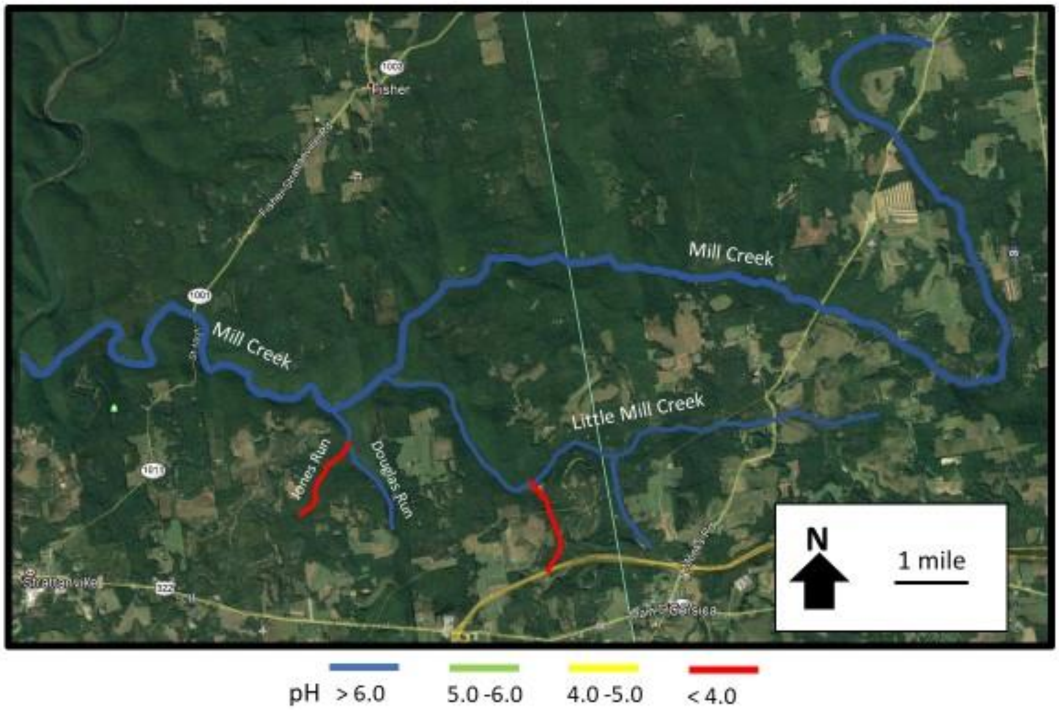

Figure 5-2. Predicted pH conditions in the Mill Creek and Little Mill Creek watersheds.

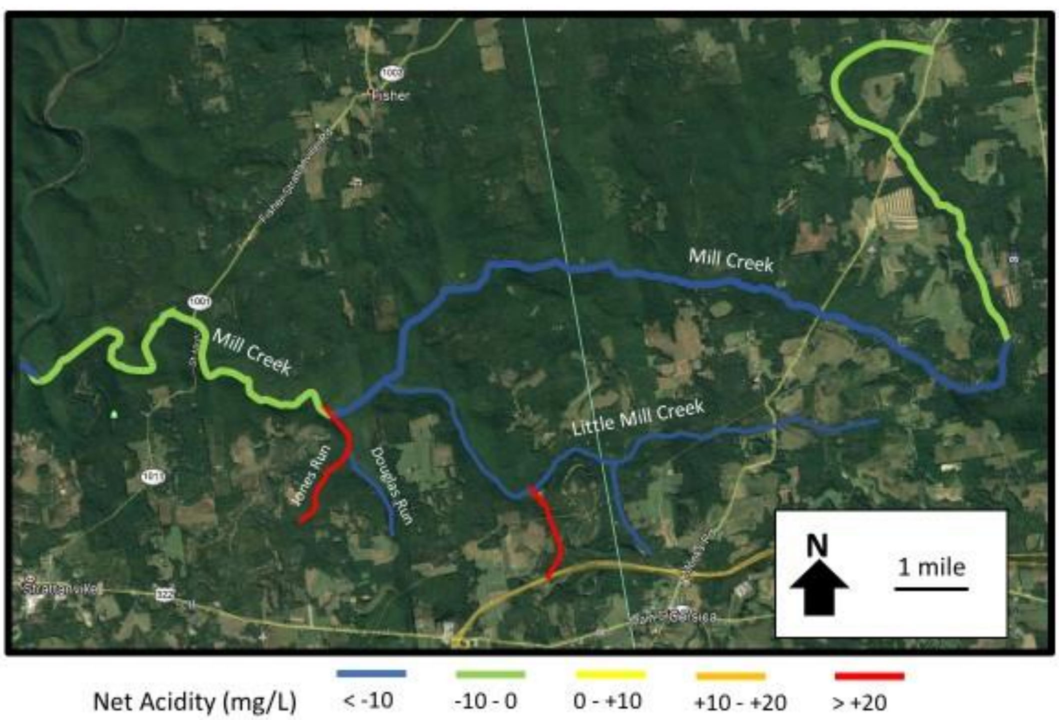

Figure 5-3. Predicted net acidity conditions in the Mill Creek and Little Mill Creek watersheds.

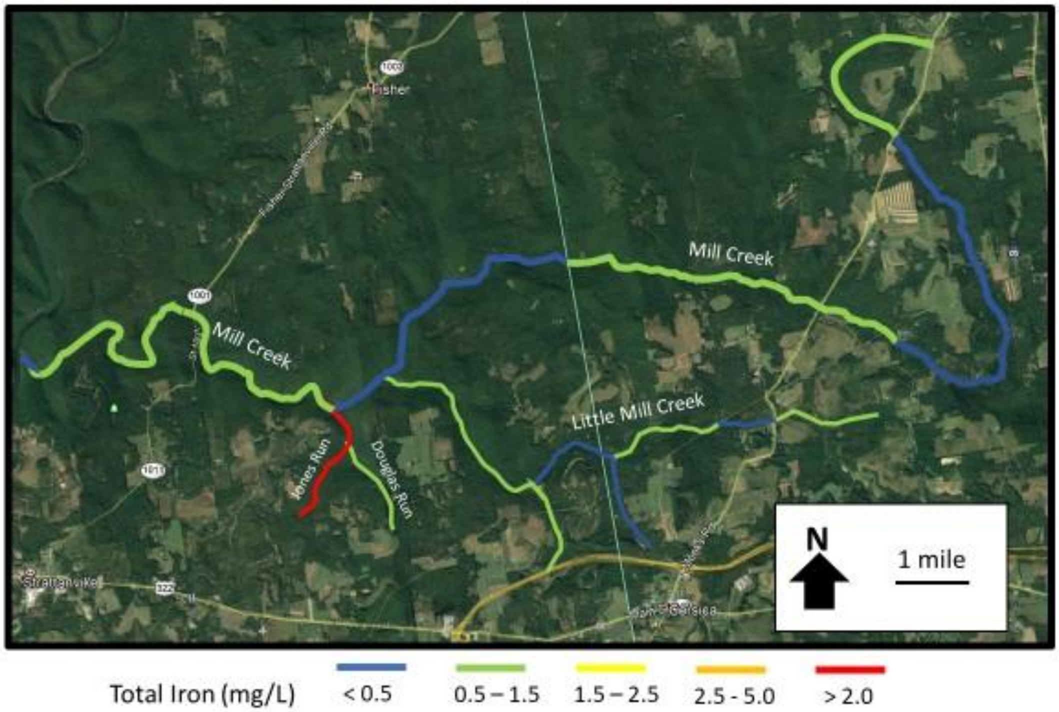

Figure 5-4. Predicted total iron conditions in the Mill Creek and Little Mill Creek watersheds.

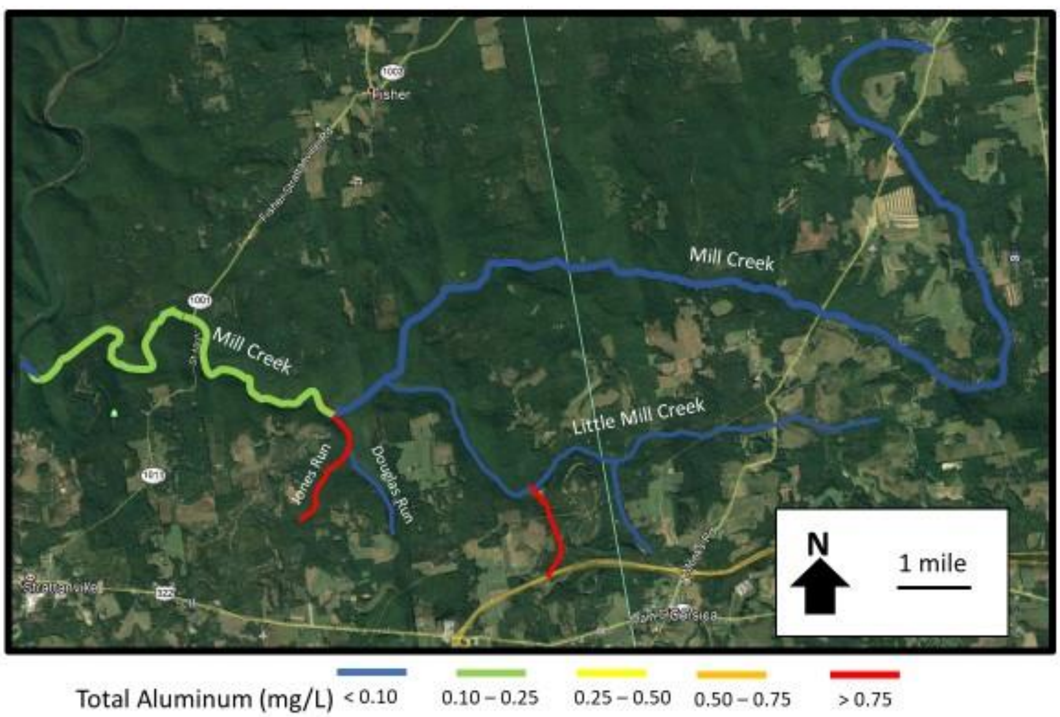

Figure 5-5. Predicted total aluminum conditions in the Mill Creek and Little Mill Creek watersheds.

6.0 SPECIFIC PROJECTS

The following provides discussion of specific projects to achieve the pollutant load reductions in each of the areas identified. Projects are discussed by the focus area.

6.1 AREA 1 PROJECT(S)

Projects in Area 1 relate primarily to acidity load decreases to remove acidity and add alkalinity. Aluminum has pH dependent solubility and is addressed with acidity removal treatment. Iron can have a required oxidation step, but similar to aluminum is likely addressed with acidity removal.

6.1.2 Alternative Evaluation

Based on primarily survey and review of past reports and efforts the focus of the remediation and treatment efforts is Jones Run, which was identified as the major source, if not the only source, of the acidity in Area 1. Jones Run and Douglas Run water quality, which comprise the major tributaries to Jones/Douglas Run are provided in Table 6-1. As can be seen, Jones Run is the source of acidity and metals with over 100 mg/L of acidity in the tributary and elevated iron, aluminum, and manganese. In comparison, Douglas Run has a circumneutral pH, some alkalinity and low metals, particularly dissolved metals.

Table 6-1. Summary of Water Quality in Major Tributaries to Jones/Douglas Run in Area 1.

Stream	Unit	Jones Run	Douglas Run
Station		JR1	DR1
Flow	gpm	352	155
pH	s.u.	3.29	6.65
Temperature	°C	14.5	15.3
Conductance	µS	930	270
Alkalinity	mg/L	0	5.2
Acidity	mg/L	106	2.7
Net Acidity	mg/L	106	-2.5
Total Iron	mg/L	18.2	0.88
Dissolved Iron	mg/L	17.7	0.08
Total Aluminum	mg/L	6.4	0.05
Dissolved Aluminum	mg/L	6.1	0.05
Total Manganese	mg/L	8.4	0.56
Dissolved Manganese	mg/L	8.2	0.52

Figure 6-1 shows the location of seep areas in Jones Run that have been identified as sources of AMD. The seep areas are on both sides of the stream. Figure 6-2 shows one of these seep areas. As can be seen, the area is large and there are a number of upwellings throughout the area. This seep areas outbreaks pose a number of collection and construction challenges.

Figure 6-1. Jones Run Area Assessment in Focus Area 1.

Figure 6-2. Jones Run AMD Seep Area.

There are several options to address the AMD sources including passive treatment, active treatment, and stream neutralization. Passive treatment would involve multiple systems with large basins where alkalinity is generated from AVFW (anaerobic vertical flow wetland), which are also known as SAPS and RAPS. However, the potential to successfully implement passive treatment is suspect given the stream has iron and aluminum concentrations that total over 25 mg/L. It is likely the discharges, without dilution and reaction, would likely result in a risk based on the concentrations/flows established by the BAMR's risk matrix table provided in Table 6-2 for passive treatment systems (Category 4). The high risk indicates passive treatment would likely be unsuitable.

Table 6-2. Risk Analysis Matrix for Category 4 Passive Treatment Systems.

Risk Analysis Matrix				
Summation of Fe and Al Concentration	Design Flow Rate for each treatment cell			
	< 25 gpm	≥ 25 < 50 gpm	≥ 50 < 100 gpm	≥ 100 < 200 gpm
< 5 mg/L	Low	Low	Low	Low
≥ 5 but < 15 mg/L	Low	Medium	Medium	Medium
≥ 15 < 25 mg/L	Low	Medium	Medium	Medium
≥ 25 < 50 mg/L	Medium	Medium	Medium	High
≥ 50 mg/L	High	High	High	High
Summation of Fe and Al Concentration	Design Flow Rate for each treatment cell			
	≥ 200 < 400 gpm	≥ 400 < 800 gpm	≥ 800 < 1600 gpm	≥ 1600 gpm
< 5 mg/L	Medium	Medium	Medium	High
≥ 5 but < 15 mg/L	Medium	High	High	High
≥ 15 < 25 mg/L	High	High	High	High
≥ 25 < 50 mg/L	High	High	High	High
≥ 50 mg/L	High	High	High	High

From the Bureau of Abandoned Mine Reclamation Acid Mine Drainage Set-A-Side Program: Program Implementation Guideline

Even if the discharge characteristics meet the matrix table there are three factors that may be prohibitive to construction of passive treatment systems. First is land area required for passive treatment, which would be over 15 acres of AVFW treatment area based on the required acidity loading removal (or alkalinity generation require) of 3,500 lbs/day (see Section 5.1) and a surficial sizing criteria of 25 grams per day per square meter (220 lbs/acre) contained in AMDTreat 5.0 (OSMRE 2006). Actual needed land area could easily be double this acreage for access roads, embankments, settling ponds, channels, construction staging, etc.. Secondly is the land availability. As can be seen in Figure 6-1, the locations of several seep areas are in steeply sloped sections of Jones Run and adjacent to the stream channel, which would be prohibitive for large footprint passive treatment systems. Thirdly is the cost, which based on recent construction costs for AVFW (with no liner) only is about $10.50 per square feet and would bring the cost to well over $7 million. This does not include access roads, settling ponds, channels, etc.

that would likely increase the overall passive treatment construction costs to in excess of $10 million.

Active treatment would also pose a number of challenges. For a single active treatment system, the major issue is related to collection and conveyance of all the disperse (over 1 mile apart) AMD seeps in Jones Run. Discrete active treatment systems would have similar issues as passive treatment related to available area at each site for reactor systems, clarifiers or ponds, and sludge holding & handling facilities. Costs for multiple active treatment systems would likely approach the costs for passive treatment. In addition, active systems require substantial operation and maintenance to for chemicals, equipment, sludge management, and operation personnel.

An alternative approach is direct alkaline addition to the stream (i.e., Jones Run). The MD Bureau of Mines has successfully used this approach in the upper Potomac River in Maryland and uses direct lime addition at over eight AMD impacted tributaries. The approach has been very successful at restoring and maintaining water quality in the Potomac River. It should be noted the goal of this alkaline addition is not to restore the tributary but is focused on the water quality and socioeconomic benefits of the larger downstream stream/river. In this approach the tributary becomes the sacrificial water for the benefit and protection of the downstream resource. In the case of Area 1,Jones/Douglas Run is sacrificed to benefit the much larger and more valuable Mill Creek resource.

6.1.3 Area 1 Conceptual Alkaline Addition Approach

The treatment concept for removal of acidity and metals for Mill Creek involves direct alkaline addition to Jones Run to address the various AMD inputs located throughout the tributary. A conceptual alkaline addition approach is depicted in Figure 6-3 and is located along the township road (T-567) that crosses Jones Run downstream, near, and upstream of the AMD inputs. The treatment approach would include:

1. Lime Slurry Storage Tank – a storage tank for holding and mixing pre-made lime slurry.
2. Lime Slurry Feed Pumps - operating and backup lime slurry feed pumps.
3. Reactor Mix Tank – a mixing reactor tank to dissolve the lime slurry with diverted stream water.
4. Control System – control systems for the mixers, pumps, and flow paced alkaline addition.

In addition to the above, site development would require:

1. Site development including access road, gravel pad, concrete pads, and perimeter fencing.
2. Stream channel structure for flow measurement and intake to divert a portion of stream flow to the mixing tank.
3. Utility installation including approximately 500 feet of power lines and tap into nearby potable water source.

Figure 6-3. Area 1 Jones Run Conceptual Alkaline Addition Treatment System.

Table 6-3 provides a treatment system installation cost estimate and Table 6-4 provides an annual operating cost estimate. As can be seen this approach is much lower in capital cost than the passive (or active) treatment approaches generally discussed above. Operating costs are also provided with lime costs based on the provided estimate of average acidity load to be removed.

Table 6-3. Area 1 Jones Run Alkaline Addition Lime Slurry System.

Item No.	Description	Quantity	Sub-Total
1	**Stream Structure & Piping**	**1**	$55,000
	a. Collection/Pipeline	1	
	b. Piping	1	
2	**Lime Slurry System**	**1**	$115,000
	a. 8,800-gal Lime Slurry Storage Tank	1	
	b. 3 H.P. Lime Slurry Tank Mixer	1	
	c. Slurry Level Indicator & Controls	1	
	d. Lime Slurry Pumps	2	
3	**Mixing Reactor**	**1**	$35,000
	a. 5,000 gallon Mixing Reactor	1	
	b. 1 H.P Top Mounted Mixers	1	
4	**Control System**	**1**	$25,000
	a. PLC System	1	
	b. pH/Flow Monitor	1	
	c. Remote Monitoring/Alarm System	2	
5	**Facilities**	**1**	$175,000
	a. Access/Parking	1	
	b. Gravel & Concrete Pads	1/3	
	c. Electrical	1	
	d. Water	1	
	e. Fencing	1	
7	**Engineering Services**	**1**	$105,000
	a. Permitting	1	
	b. Design	1	
	c. Construction	1	
TOTAL SYSTEM COST ESTIMATE			**$510,000**

Table 6-4. Area 1 Jones Run Alkaline Addition Lime Slurry System Estimated Annual Operating Costs.

Item	**Annual**		**Cost Estimate $/yr**
	Unit	**Quantity**	
Lime Slurry	Tons as $Ca(OH)_2$	475	$152,000
Electricity	KwHr	15	$3,500
Monitoring Service	per year	lump sum	$300
Routine Maint. Materials	per year	lump sum	$1,000
Labor	per year	lump sum	$25,000
ANNUAL O&M TOTAL			**$125,000**

6.2 AREA 2 PROJECT(S)

Projects in the Area 2 focus area include primarily iron load decreases in the lower Little Mill Creek associated with the Markle-Kotchey AMD discharge and acidity load from the Asbury Road Tributary. The following summarizes potential projects in Area 2.

6.2.2 Alternative Evaluation

Based on primarily survey and review of past reports and efforts the focus of the remediation and treatment efforts for iron loading reduction is the Markle-Kotchey AMD discharge and associated passive treatment system. Table 6-5 summarizes the AMD discharge but with anoxic limestone drain (ALD) pre-treatment for alkalinity generation. As can be seen, the discharge is high iron and remains net acidic despite the use of an ALD for alkalinity generation.

Table 6-5. Summary of AMD Chemistry for Markle-Kotchey ALD Outlet.

Date	Source	pH	Alkalinity mg/L as $CaCO_3$	Acidity mg/L as $CaCO_3$	Total Iron mg/L	Total Manganese mg/L
8/11/2004	BAMR	6.4	155	58	114	19
6/1/2007	HE	6.4	158	37	123	18
7/16/2019	Tetra Tech	6.3	141	62	81.6	14.0

The existing Markle-Kotchey passive treatment system consists of a large aerobic pond following the buried ALD. The passive treatment system was installed by BAMR in 2000. However, this passive treatment system has removed less than ½ of the iron since it was constructed, and this was documented by Hedin Environmental in a 2007 TAG study. A number of efforts were attempted to improve iron removal including aeration of the water prior to the aerobic pond but with little overall success in improving impacts of the discharge on Little Mill Creek. In simple terms, a much larger passive treatment area, larger than available, is needed to remove the iron and minimize the impact of this discharge on Little Mill Creek.

Active treatment of the discharge is an alternative that has merit for this discharge and a proposed active treatment system approach was developed and submitted to the Pilot Program by HCT/MCC in 2019. The project was selected but funding issues could not be resolved for the project. An active treatment approach would decrease the footprint of the treatment system, thereby allowing for treatment of the Markle-Kotchey AMD discharge in the available land area adjacent to the aerobic pond.

In addition to iron loading, acidity loading from the Asbury Road tributary was identified in Area 1 as impacting Little Mill Creek water quality through the reduction of stream alkalinity. Site assessment identified several sources in the tributary including the Hanlon AMD discharge and the Shofestall-Zerbe AMD discharge. Figure 6.4 shows the two discharges. The Hanlon AMD discharge is treated by a passive treatment system constructed by BAMR in 2003. However, recent data from the outlet indicates the passive treatment system is discharging considerable acidity and is likely in need of a rehabilitation, particularly given the system is now over 15 years in operation. The Shofestall-Zerbe AMD discharge emanates from a BAMR reclaimed high wall in the headwaters of the tributary. Both projects may be necessary to address the acidity loading of the Asbury Road tributary but the Hanlon AMD discharge should take precedent as the existing passive treatment system can be rehabilitated at a much lower cost than building a new passive system for the Shofestall-Zerbe AMD discharge.

Figure 6-4. Location of Asbury Road Tributary AMD discharges.

6.2.3 Area 2 Markle-Kotchey Conceptual Approach

The treatment concept for removal of iron from the Markle-Kotchey AMD for Little Mill Creek involves an active treatment system to adjust pH, oxidize/precipitate iron, remove particulate iron, and collect and manage sludge. Figure 6-5 shows a conceptual layout of the active treatment system, as well as modification to the existing pond for polishing and use as a recreational fishery. The active treatment system would include:

1. Lime Slurry Storage Tank – a storage tank for holding and mixing pre-made lime slurry.

2. Lime Slurry Feed Pumps - operating and backup lime slurry feed pumps.
3. Reactor Tank System – an aeration (with blower) and mixing reactor tank to oxidize and precipitate iron.
4. Clarifier System – a flocculation and clarifier (lamella type) to remove suspended solids and collect sludge.
5. Sludge Handling/Dewatering System – a system to collect, convey and dewater sludge using Geotubes©.
6. Control System – control systems for the mixers, blowers, pumps, and with remote monitoring systems.

Figure 6-5. Conceptual Design of the Markel-Kotchey Active Treatment Plant & Recreational and Enhancement.

In addition to the above, site development will include:

1. Collection and pumping system to convey AMD to the treatment system.
2. Site development including access road, gravel pad, concrete pads, and perimeter fencing.
3. Installation of a building to house the treatment system.
4. Modification in and around the existing aerobic pond.
5. Utility installation including approximately 200-500 feet of power lines.

Table 6-6 and Table 6-7 provides a treatment system installation cost estimate and a cost estimate for the aerobic pond modifications. Table 6-8 provides an annual operating cost estimate. Operating costs are also provided with lime costs based on the expected Markle-Kotchey AMD prior to the existing ALD.

Table 6-6. Markle-Kotchey Active Treatment System Estimated Installed Costs.

Item No.	Description	Quantity	Sub-Total
1	**Collection & Pumping**		
	a. Collection/Pipeline	**1**	$75,000
	b. Pumping System	**1**	
2	**Lime Slurry System**	**1**	$105,000
	a. 5,000 gallon Lime Slurry Storage Tank	1	
	b. 3 H.P. Lime Slurry Tank Mixer	1	
	c. Slurry Level Indicator & Controls	1	
	d. Lime Slurry Pumps	2	
3	**Aeration/Mixing Reactor**	**1**	$385,000
	a. 30,000 gallon Mixing Reactor	1	
	b. 3,000 gallon Flocculation Reactor	1	
	c. 1-3 H.P Top Mounted Mixers	4	
	d. 5 H.P. Blower Unit	1	
4	**Clarification System**	**1**	$495,000
	a. Polymer Makedown/Feed System	1	
	b. 1,400 SF Inclined Plate Clarifier	1	
	c. 7.5 H.P. Sludge Pump	2	
5	**Sludge Dewatering**	**1**	$65,000
	a. Concrete Pad	1	
	b. Geotubes®	4	
6	**Control System**	**1**	$55,000
	a. PLC System	1	
	b. pH/Flow Monitor	2	
	c. Remote Monitoring/Alarm System	1	
7	**Building Facilities**	**1**	$325,000
	a. Building	1	
	b. Access/Parking	1	
	c. Electrical	1	
TOTAL SYSTEM COST ESTIMATE			**$1,505,000**

Table 6-7. Markle-Kotchey Recreational Facilities Estimated Costs.

Item No.	Description	Quantity	Sub-Total
1	**Trail Head Facilities**	**1**	$30,000
	a. Parking	1	
	b. Outdoor Restroom	1	
	c. Trail Head	1	
	d. Signage	1	
2	**Perimeter Trail**	**1**	$95,000
	a. Trail	1	
	b. Benches	3	
	c. Shoreline Access	1	
	d. Fishing Pier	1	
3	**Pavilion Facilities**	**1**	$30,000
	a. Pavilion	1	
	b. Picnic Tables	4	
4	**Pond Rehabilitation**	**1**	$120,000
	a. Sludge Removal/Disposal	1	
	b. Liner Removal Disposal	4	
	c. Habitat Enhancement	1	
TOTAL SYSTEM COST ESTIMATE			**$275,000**

Table 6-8. Markle-Kotchey Treatment Plant Estimated Annual Operating Costs.

Item	Annual		Cost Estimate $/yr
	Unit	Quantity	
Lime Slurry	Tons as $Ca(OH)_2$	135	$26,000
Electricity	KwHr	15	$18,000
Polymer	lbs/year	220	$700
Monitoring Service	per year	lump sum	$300
Routine Maint. Materials	per year	lump sum	$1,000
Sludge Handling	CY per year	675	$24,000
Labor	per year	lump sum	$55,000
ANNUAL O&M TOTAL			**$125,000**

6.2.4 Area 2 Hanlon Conceptual Approach

The treatment concept for removal of acidity load contribution from the Asbury Road tributary will involve rehabilitation of the Hanlon AMD passive treatment system. The Shofestall-Zerbe site should only be considered after it is determined whether the rehabilitation of the Hanlon passive treatment system addresses the acidity load from this tributary.

Water quality sampled from the effluent channel of the Hanlon passive treatment system is provided in Table 6-9. The results show the effluent from the passive system contains considerable acidity and the passive system is in need of rehabilitation, which is not unexpected given the nearly 20 years of operation.

Table 6-9. Summary of Water Quality from the Hanlon passive treatment system.

Stream	Unit	Hanlon Outlet	Asbury Trib.
Station		HD01	DR1
Flow	gpm	5	52
pH	s.u.	3.65	4.03
Temperature	°C	16.4	15.3
Conductance	µS	780	940
Acidity	mg/L	55	35
Total Iron	mg/L	0.7	0.58
Total Aluminum	mg/L	6.3	3.2
Total Manganese	mg/L	4.5	7.2

Figure 6-6 shows the Hanlon passive treatment system, along with recommended rehabilitation measures to convert a number of the basins to AVFW. AVFW were selected for the rehabilitation based on success of this passive treatment technology at numerous other passive rehabilitation locations in the watershed including Filson 4, Filson 1/2, McKinley 1 and McKinley 2. The overall converted to AVFW treatment area is approximately 19,500 ft^2. Based on this area acidity removal should be approximately 100 lbs/day. In addition, the AVFW will generate excess alkalinity in an amount of 75 lbs/day for a total acidity removal of 175 lbs/day, which is about 75% of the 235 lbs/day acidity load computed for this section of Little Mill Creek (see Table 5-4). In addition, there will be excess alkalinity added by the above Markle-Kotchey active treatment system, which in conjunction with the Hanlon passive treatment rehabilitation should address the acidity loading to this section of Little Mill Creek.

The estimated costs for the Hanlon passive treatment system rehabilitation are contained in Table 6-10. The total costs including engineering servicers total $300,000 with the primary costs for limestone and compost.

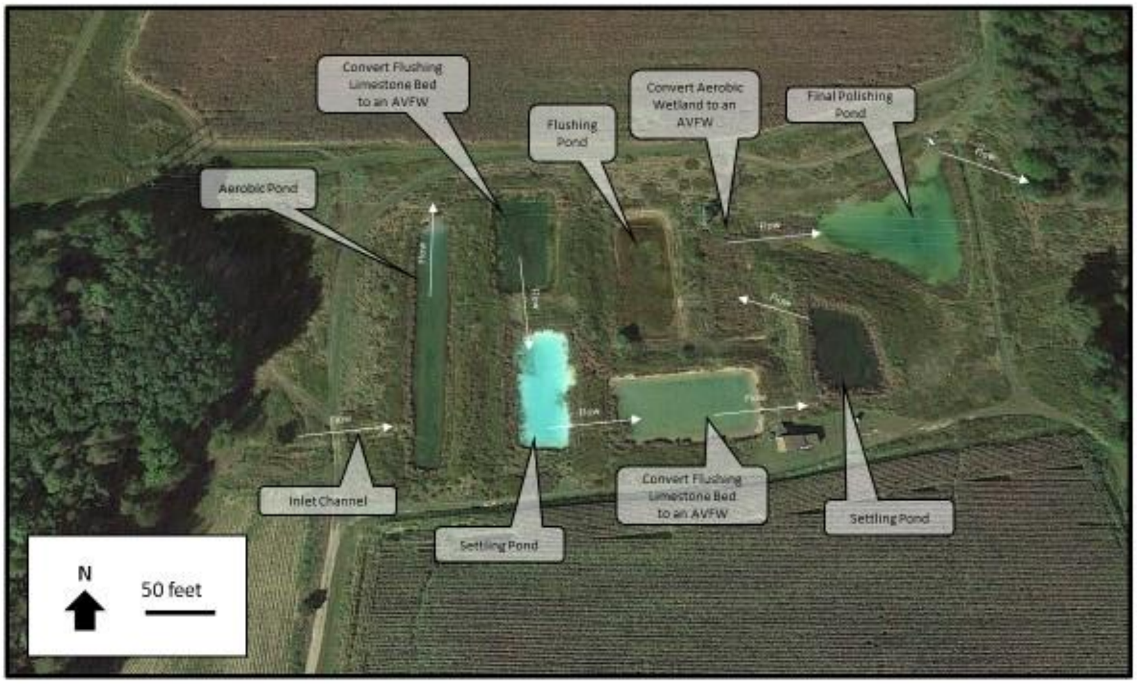

Figure 6-6. Conceptual Design for the Hanlon Passive Treatment System Rehabilitation.

Table 6-10. Preliminary Cost Estimate for the Hanlon Passive Treatment System Rehabilitation.

Item No.	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$10,000.00	$ 10,000.00
2	Clearing and Grubbing	1	LS	$ 2,000.00	$ 2,000.00
3	E&S Control	1	LS	$ 1,500.00	$ 1,500.00
4	Access Road	1	LS	$ 5,000.00	$ 5,000.00
5	Excavation & Handling	1	LS	$10,000.00	$ 4,000.00
6	Geotextile Liner	3	EA	$ 7,500.00	$ 22,500.00
7	Straw Layer	2,200	SY	$ 2.00	$ 4,400.00
8	High Quality Limestone	2,200	Ton	$ 40.00	$ 88,000.00
9	Mushroom Compost Substrate	1,800	CY	$ 38.00	$ 68,400.00
10	Piping (SCH 40 PVC) installed	3	EA	$ 8,500.00	$ 25,500.00
11	Wetland Planting	2,000	EA	$ 2.50	$ 5,000.00
12	Rock Lining / Rock Channel	500	SY	$ 20.00	$ 10,000.00
13	Seeding/Restoration	1	Acre	$ 2,000.00	$ 2,000.00
14	Engineering Services	1	LS	$50,000.00	$ 50,000.00
	PROJECT COST ESTIMATE				**$ 300,300.00**

6.3 AREA 3 PROJECT(S)

Area 2 requires primarily iron load decreases and secondarily acidity load decrease. However, based on reconnaissance of the area, there is not a defined AMD discharge that can be identified in Area 1. Figure 6-6 shows the S.R. bridge and noticeable iron seeps in around the bridge abutment. This is supported by the sampling of upwelling at the S.R 949 bridge abutment (discussed in section 5.1). The stream sampling and upwelling sample suggest the likely AMD source is groundwater that permeates through the stream bottom, causing the increases in iron and decreases in alkalinity in this section.

Figure 6-7. Mill Creek at the S.R. 949 Bridge.

Additional survey, testing and analysis is recommended for Area 3 to better understand the source of the AMD and approaches to remediate the impacts on Mill Creek.

7.0 SUMMARY

This Qualified Hydrologic Unit Plan (QHUP) was developed for the Mill Creek and Little Mill Creek watersheds to assess current conditions, based on the current levels of passive and active treatment and to identify sections and areas within the two watersheds that meet and do not meet the water quality objectives. Water quality sampling was conducted in 2019 for the two watersheds and recent macroinvertebrate data was evaluated.

The results of the water quality and macroinvertebrate assessment indicate large sections of both Little Mill Creek and Mill Creek meet the water quality objectives indicating past and current treatment efforts have had considerable success in restoring the watersheds. However, three areas of concern were identified that included:

1. **Area 1 –** The Mill Creek section from Piney Dam upstream to the confluence with Jones/Douglas Run that does not meet pH, acidity, and total iron water quality objectives. The total aluminum objective is approached in the section of Mill Creek
2. **Area 2 –** The Little Mill Creek section from the confluence with Mill Creek upstream to the confluence of the Asbury Road tributary that does not meet the total iron objective and shows acidity impacts.
3. **Area 3 –** The Mill Creek section from S.R. 949 downstream to Howe Bridge that does that does not meet the total iron objective and shows acidity impacts.

Pollutant loading in each of the sections was evaluated and benefits of pollutant removal to meet the water quality objectives was determined for each area using mass balance modeling. Pollutant loading reductions were used to develop specific projects and remediation in each of the areas, except Area 3 where the source of the AMD did not permit development of a specific project. Conceptual designs and cost estimates were developed for the specific projects and included:

1. **Area 1 –** A stream alkaline addition system involving a lime slurry storage and flow paced pumped feed system to neutralize acidity and add alkalinity to Jones Run, which was the main source of acidity and metals to Mill Creek in this area. Jones Run would be a sacrificial stream in order to restore Mill Creek downstream of the confluence.
2. **Area 2 –**
    a. An active treatment system and associated recreational polishing pond to treat the Markle-Kotchey AMD source and replace the poorly performing passive treatment system that will remove the iron loading and restore Little Mill Creek to its confluence to Mill Creek and Mill Creek downstream of the confluence.

b. Rehabilitation of the Hanlon passive treatment system that is poorly performing. This rehabilitation would remove acidity and add alkalinity to the Asbury Road tributary thereby minimizing impacts to alkalinity in Little Mill Creek downstream of this tributary. Additional passive treatment may be needed in the tributary depending on the success of the Hanlon passive treatment system rehabilitation.

As indicated in the report, Area 3 is a problematic section of Mill Creek where AMD inputs appear to be through groundwater infiltration directly into the stream, as indicated by stream water quality sampling and samples taken at the S.R. 949 bridge abutment. Additional study of this section is needed to understand the source of the AMD and possible remediation of the AMD that contributes iron loading and negatively impacts alkalinity in this stream section.

Overall, it is expected this report will provide resource managers the needed information to continue the long term restoration efforts in Mill Creek and Little Mill Creek and return the streams to productive and valued resources for the local communities and region.

APPENDIX A

SAMPLING PROGRAM
WATER QUALITY AND FLOW DATA

APPENDIX B

SAMPLING PROGRAM STATION PHOTOGRAPHS.