Restoration Plan for Qualified Hydrologic Unit Determination
Surface Mining Control and Reclamation Act Amendments of 2006

Hydrologic Unit: Tioga River

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Description of Watershed

The area covered by this Restoration Plan for Qualified Hydrologic Unit Plan (QHUP) Development consists of the Tioga River Watershed impacted by Abandoned Mine Drainage (AMD). This includes the entire mainstem of the Tioga River that is listed as AMD-Impaired (22.46 stream miles) and all tributaries entering this stretch, including the AMD-Impaired major tributaries of Fall Brook, Morris Run, Coal Creek, Johnson Creek, and Bear Creek (Figure 1). This portion of the Tioga River Watershed requested for qualification is 240.30 square miles in size and encompasses 393.95 stream miles.

The entire 240.30 square miles covered in this Restoration Plan is classified as a Cold Water Fishery (CWF) in Chapter 93 of the Pennsylvania Code by the Pennsylvania Fish and Boat Commission (PFBC). According to an April 6, 2019, email communication with Daniel Ryan, PFBC Fisheries Biologist, once restored, the PFBC plans to manage an additional 1.5 miles of the Tioga River downstream of Morris Run as a Trout Stocked Fishery (TSF).

As mentioned, there are five major AMD impaired tributaries that impact the Tioga River mainstem. In order from upstream to downstream, these tributaries are Fall Brook, Morris Run, Coal Creek, Johnson Creek, and Bear Creek. These five tributaries enter along a very short stretch of the Tioga River near Blossburg, Tioga County. There are only 4.67 stream miles between the entrance of Fall Brook and the entry of Bear Creek. Consequently, the Tioga River is impacted abruptly and severely.

According to the Susquehanna River Basin's (SRBC's) 2003 publication *Watershed Assessment and Remediation Strategy for Abandoned Mine Drainage In the Upper Tioga River Watershed*, the vast majority of the acidity loading in the early 2000s originated in only two of the five AMD impacted tributaries: Coal Creek (44 percent) and Morris Run (26 percent). Fall Brook and Johnson Creek contributed similar amounts to each other, 13 percent and 12 percent, respectively, with Bear Creek and other smaller sources contributing the remaining small balance of 5 percent.

The high percentages of acidity originating in Coal Creek and Morris Run are even higher today than in 2019 due to Johnson Creek improving to a net-alkaline tributary owing to reclamation projects and natural attenuation, a large passive system built on Fall Brook treating its largest source, and Pennsylvania Department of Environmental Protection (PADEP) Bureau of Abandoned Mine Reclamation (BAMR) reclamation projects completed on Bear Creek. According to samples collected on the same day (October 25, 2018) hours apart, because of these improvements, acidity loading contribution from Coal Creek and Morris Run now accounts for 88 percent of the total entering the Tioga River, with Bear Creek contributing 7 percent (Appendix A). Fall Brook and other smaller sources contributed the final 5 percent. Johnson Creek was slightly net alkaline (Table 1). Consequently, treatment focus on the primary discharges that impact Coal Creek and Morris Run should restore the mainstem of the Tioga River from legacy mining impacts.

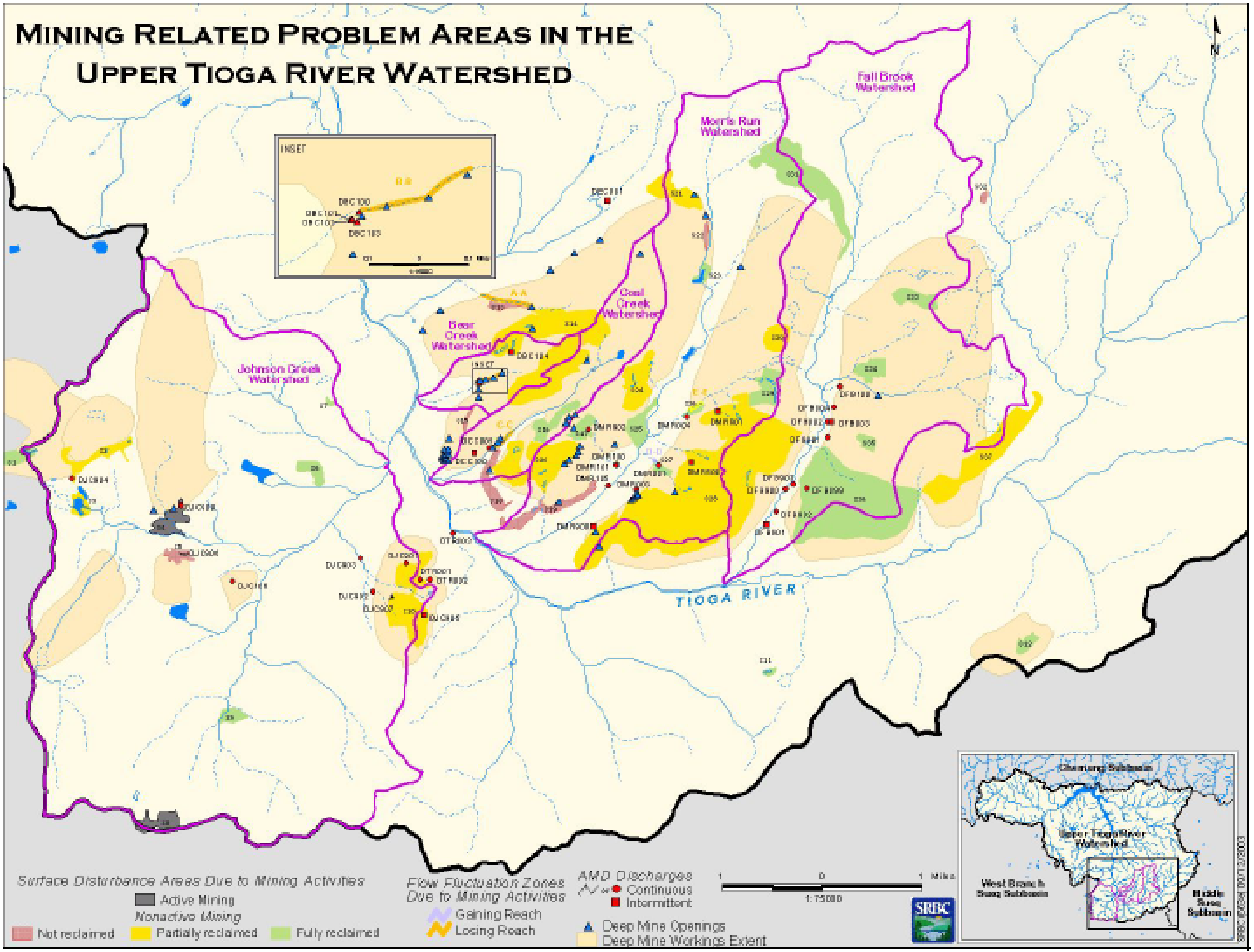

Figure 1. Map of the AMD-Impacted Streams and AMD Discharge Locations near the town of Blossburg, Tioga County, PA

Table 1. Tioga River Acidity Loading Contribution Difference from the Early 2000s to 2018

	Early 2000s Acidity Loading	2018 Acidity Loading
	%	%
Fall Brook	13	2
Morris Run	26	18
Coal Creek	44	70
Johnson Creek	12	net alkaline
Bear Creek	5	7
Other Sources	ND	3

As will be detailed further within this Restoration Plan, a vast majority of AMD pollution loading entering Coal Creek and Morris Run emanates from four sources: Morris Run Discharges 01, 03, and 04 and Coal Creek Discharge 05 (DMR01, DMR03, DMR04, and DCC05). Treatment of these four sources should restore the entirety of the Tioga Creek mainstem, possibly removing 22.46 stream miles from the Integrated List of Impaired Waters. In addition, due to the proximity of these four discharges to one another, a planned centralized active treatment plant (ATP) treating all four discharges, and with an effluent to Morris Run, has the potential of significantly improving 2.27 stream miles of Morris Run and opening up the headwaters of Morris Run to fish recolonization.

Historical Studies and Restoration Plans

Although not all comprehensive relative to the entire watershed and all mine discharges therein, historical studies and restoration plans included:

- Federal Water Pollution Control Administration – *Mine Drainage in the Susquehanna River Basin* – 1968

- Gannett Fleming Corddry and Carpenter, Inc. (Gannett Fleming) for the U.S. Department of Interior, Federal Water Pollution Control Administration – *Acid Mine Drainage Abatement Measures for Selected Areas Within the Susquehanna River Basin* – 1968

- Charles E. Weed of the Pennsylvania State University (unpublished dissertation) – *The Relationship Between Acid Mine Drainage and the Benthic Macroinvertebrate Community Structure in the Tioga River* – 1971

- U.S. Geologic Survey (USGS) – *Effects of Acid Mine Drainage on Fish and Macroinvertebrates of the Tioga River in PA and New York* – 1971

- Gannett Fleming for Pennsylvania Department of Environmental Resources (PADER) – *Mine Drainage Abatement Measures Tioga River Watershed* – 1972

- U.S. Army Corps of Engineers (USACE), Baltimore District – *Occurrence and Effects of Mine Drainage in the Tioga River Basin* – 1972

- Batelle-Columbus Laboratories – *Impact Assessment for the Tioga River Watershed, Acid Mine Feasibility Study in Tioga County, PA* – 1972

- Gannett Fleming for the United States Environmental Protection Agency (USEPA) – *Tioga River Mine Drainage Abatement Project* – 1976

- USACE, Baltimore District – *Susquehanna River Basin Mine Drainage Study: Interim Report on the Tioga River Basin* – 1977

- USEPA – *Tioga River Mine Drainage Abatement Project* – 1979

- PFBC - *Upper Tioga River Basin (404A) (Upstream from River Mile 31.50 at Mansfield), Fisheries Management Report* – 1999

- PADER - *Aquatic Biological Investigation, Tioga River Headwaters* – 1993

Though dated with recommendations and plans that are inconsistent with current water quality and watershed restoration needs, only water quality, water quantity, and biological data were utilized from these listed studies prior to 2003. Studies completed after 2003 were investigated fully for not only available data, but also for recommendations and plans for the restoration of the Tioga River from AMD impacts. Those studies included:

- PADEP – *Tioga River Watershed Total Maximum Daily Load (TMDL)* – 2003

  The Tioga River TMDL calculated the amount of load reductions needed at several stations along the Tioga River and Morris Run to meet water quality standards (Table 2). The calculations demonstrated that in 2003, only acid was an issue on the Tioga River upstream of Morris Run (Table 2). This acid issue has been mainly rectified by the Fall Brook Passive Treatment System. Downstream of Morris Run and Coal Creek, necessary loading reductions become significant on the Tioga River. Downstream of Johnson Creek and Bear Creek, only an acid loading reduction is required. Downstream of Bear Creek on the Tioga River, no additional AMD loading issues enter.

  The headwaters of Morris Run, upstream of the first major AMD impact (DMR04), required moderate metal loading reductions in 2003. As will be discussed, the headwaters of Morris Run are improved according to 2018 sampling. Downstream of the three large discharges, additional significant metal loading reductions are required, as well as reductions to acidity loading.

Table 2. Tioga River and Morris Run Pollution TMDL Loading Reduction Targets

Station	Parameter	Measured Sample Data		Allowable	lbs/day	Reduction
		mg/l	lbs/day	mg/l		%
TIOG4	Tioga River 0.5 miles upstream of Morris Run					
	Fe	0.30	88.00	0.30	88.00	0*
	Mn	1.03	302.10	0.32	93.90	0*
	Al	0.74	217.10	0.22	64.50	0*
	Acid	23.90	7010.30	21.50	630.60	84*
TIOG3	Tioga River immediately upstream of confluence with Johnson Creek					
	Fe	2.96	1330.40	0.39	175.30	28*
	Mn	3.96	1779.80	0.32	143.80	78*
	Al	5.75	2584.30	0.06	27.00	98*
	Acid	69.97	31447.50	0.35	157.30	99*
TIOG2	Tioga River at US 15 crossing upstream of Marvin Creek					
	Fe	0.74	434.30	0.74	434.30	0*
	Mn	2.56	1502.40	0.31	181.90	0*
	Al	3.75	2200.80	0.04	23.50	0*
	Acid	64.70	37971.50	0.65	381.50	92*
TIOG1	Tioga River near USGS gaging station in Mansfield					
	Fe	0.58	450.70	0.52	404.10	0*
	Mn	2.02	1569.80	0.26	202.10	0*
	Al	2.87	2230.30	0.03	23.30	0*
	Acid	47.00	36524.70	1.41	1095.70	0*
MORR2	Morris Run at SR2024					
	Fe	5.24	161.70	0.89	27.50	0*
	Mn	17,45	538.50	0.52	16.00	63*
	Al	15.85	489.10	0.16	4.90	72*
	Acid	173.17	5343.70	0.00	0.00	0*
MORR1	Morris Run at mouth					
	Fe	4.19	164.60	0.92	36.10	0*
	Mn	16.95	655.80	0.51	20.00	86*
	Al	15.55	610.80	0.16	6.30	95*
	Acid	165.57	6503.80	0.00	0.00	100*

*Percent reductions take into account reductions called for at points upstream

- SRBC – *Watershed Assessment and Remediation Strategy for Abandoned Mine Drainage in the Upper Tioga River Watershed* – 2003, and Gannett Fleming – *Acid Mine Drainage Conceptual Treatment and Restoration Plan* – 2003

  Also in 2003, the most extensive watershed assessment and remediation strategy of the Tioga River was completed by SRBC. An accompanying document by Gannett Fleming focused on conceptual treatment system design recommendations for each of the discharges quantified and qualified through the assessment. Treatment ideas for the primary discharges have changed since 2003, but Gannett Fleming's original strategy was necessary to move the needle to the treatment approach that will be described in this Restoration Plan.

Through the assessment, SRBC identified and ranked six discharges as the primary AMD loading culprits (Table 3). Four of those discharges are the focus of this Restoration Plan. DCC05 was ranked as the most severe, DMR04 as the second, DMR03 as the third, and DMR01 as the sixth. The FB099 discharge was ranked fourth and has already been treated. Bear Creek was ranked fifth, with plans to remain untreated due to the assimilating capacity of the Tioga River once the other discharges are treated.

Table 3. Loading Ranks for the Four Discharges to be Treated (SRBC documented 20 discharges total.)

Discharge	Fe Load Rank	Mn Load Rank	Al Load Rank	Acid Load Rank	Overall Rank
DCC05	1	2	1	1	1
DMR04	2	1	2	2	2
DMR03	3	4	3	3	3
DMR01	10	5	6	7	6

- Gannett Fleming and Water's Edge Hydrology – *Morris Run Acid Mine Drainage Preliminary Treatment Plan* – 2017

  The plan recommends an extensive piping system and semi-passive system (a combination of pebble-quick lime addition and drainable limestone beds) to treat just the Morris Run Discharges (DMR04, DMR03, and DMR01) on Pennsylvania Department of Conservation and Natural Resources (PADCNR) State Forest property to the east of Morris Run Road for an estimated total project cost of $4.1 million. The project also recommended stream substrate sealing to limit stream loss zones and headwater alkaline addition.

  However, with PADEP determining that conveyance of DCC05 to the centralized ATP for treatment is feasible, thus allowing for the top-three loading discharges impacting the Tioga to be treated at one system, the Gannett Fleming recommended treatment plan has become invalid.

Local Support

The Tioga County Concerned Citizens Committee Inc. (TCCCC) has been one of the strongest volunteer watershed associations in the Commonwealth for many years. Formed in 1984, their primary goals are to improve water quality in the mainstem of the Tioga River, improve the water impounded in Tioga Lake, and to improve the health and appearance of the river corridor.

TCCCC's *Save the River Campaign* is a prime example of their strength and commitment to the Tioga River. This effort solicits community donations that are to be invested exclusively for developing, operating, and maintaining AMD treatment systems in the Upper Tioga River Watershed. Funds are to be used as in-kind cash match required for government-funded grant programs or for investment in the Tioga River Trust Fund established at Woodlands Bank and managed by the Tioga County Conservation District. The Trust Fund is used to pay for the costs associated with operating and maintaining the AMD treatment systems. As of May 2019, the campaign has raised over $127,000 from 23 individuals and families, five municipalities, and 15 civic organizations (Appendix B).

In terms of restoration planning, representatives from the SRBC approached TCCCC in 2000 requesting assistance with implementing a restoration plan for the Upper Tioga River Watershed that was under development. In 2002, members of TCCCC voted to partner with the Hillside Rod & Gun Club to work together to reclaim the Upper Tioga River Watershed so that it could once again support aquatic life including stocked trout. The 2003 SRBC report *Watershed Assessment & Remediation Strategy for Abandoned Mine Drainage in the Upper Tioga River Watershed* has become the guide for the Tioga River reclamation effort. This report, as well as more recently collected discharge and stream data, will guide the recommendations found within this Restoration Plan.

In 2015, stemming from a recommendation from the SRBC restoration plan, TCCCC received a PA Department of Community and Economic Development grant through the AMD Treatment and Abatement Program to perform a comprehensive study of the Morris Run Watershed. The *Morris Run Acid Mine Drainage Preliminary Treatment Plan* was ultimately completed by Gannett Fleming and Water's Edge Hydrology in 2017. Even though the primary recommendation of this plan will not be implemented, data collected through this study were valuable to the current treatment approach detailed in this Restoration Plan: the combination of DMR01, DMR03, DMR04, and DCC05 discharges into a centralized ATP on PADCNR Tioga State Forest property northeast of the town of Morris Run (Figure 2).

Figure 2. Proposed Location of Tioga ATP (red dot) and Locations of the Four Discharges to be Treated (red triangles)

In addition to the trust fund campaign and restoration planning projects, TCCCC also guided two large passive AMD treatment system construction projects on Fall Brook in 2015, the first significant source of AMD loading to the Tioga River mainstem. These systems have not restored Fall Brook, but have improved the tributary enough to where Fall Brook is easily assimilated by the Tioga River. Consequently, the Tioga River is vastly improved between Fall Brook and Morris Run. As mentioned in the introduction, only 2 percent of Tioga River acidity loading now enters upstream of Morris Run’s entry. Other contributors to this public-private partnership project included Southwestern Energy, who funded the design and construction, and Trout Unlimited (TU) who assisted with project administration and management.

Background Data

Due to the large amount of studies and restoration plans completed for the Tioga River from the late 1960s to the present, the watershed is not without available data. Due to the focus area of this Restoration Plan being the eventual treatment of the Morris Run and Coal Creek discharges which should restore the entirety of the Tioga River mainstem, a detailed analysis of those discharges and particularly their quantity statistics and if their quality has improved over time, is essential.

DCC05 Quality

DCC05 is the largest flow and worst quality discharge to be treated (Figure 3). It is the only significant source of AMD loading to Coal Creek and often times is the only flow source due to much of Coal Creek being a losing-reach. During sampling completed on October 25, 2018, for this Restoration Plan effort, DCC05 contributed 92.5 percent of the entire Coal Creek flow.

Figure 3. The DCC05 Outfall into Coal Creek

Just like virtually all deep mine discharges, DCC05 is undergoing pyrite decay and has improved over time. While pH has stayed relatively the same for the past 50 years, acidity, iron (Fe), and aluminum (Al) concentrations have all decreased (Figures 4 and 5).

Since DCC05 is improving over time, only recent water quality data should be considered. In the last five years, DCC05 has been sampled 20 times and these samples will be used for statistical analysis (Table 4). Prior to 2014, the discharge was not significantly sampled since the early 2000s.

Table 4. Water Quality Statistics for the DCC05 Discharge since 2014

	Lab pH	**Acidity**	**Fe**	**Mn**	**Al**	**SO_4**	**TDS**
	SU	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
N	17	20	20	20	20	20	15
Min	2.66	270.00	22.44	5.33	18.88	468.00	734.00
Ave	2.80	374.80	31.50	7.66	31.12	722.31	1212.47
Med	2.80	331.50	28.50	7.12	30.52	708.00	1243.00
Max	2.90	550.00	43.15	10.23	43.64	1082.00	1720.00
STD	0.06	89.95	6.38	1.67	8.15	162.03	325.62
90 Percentile	2.90	506.80	42.57	10.10	43.36	957.90	1708.00

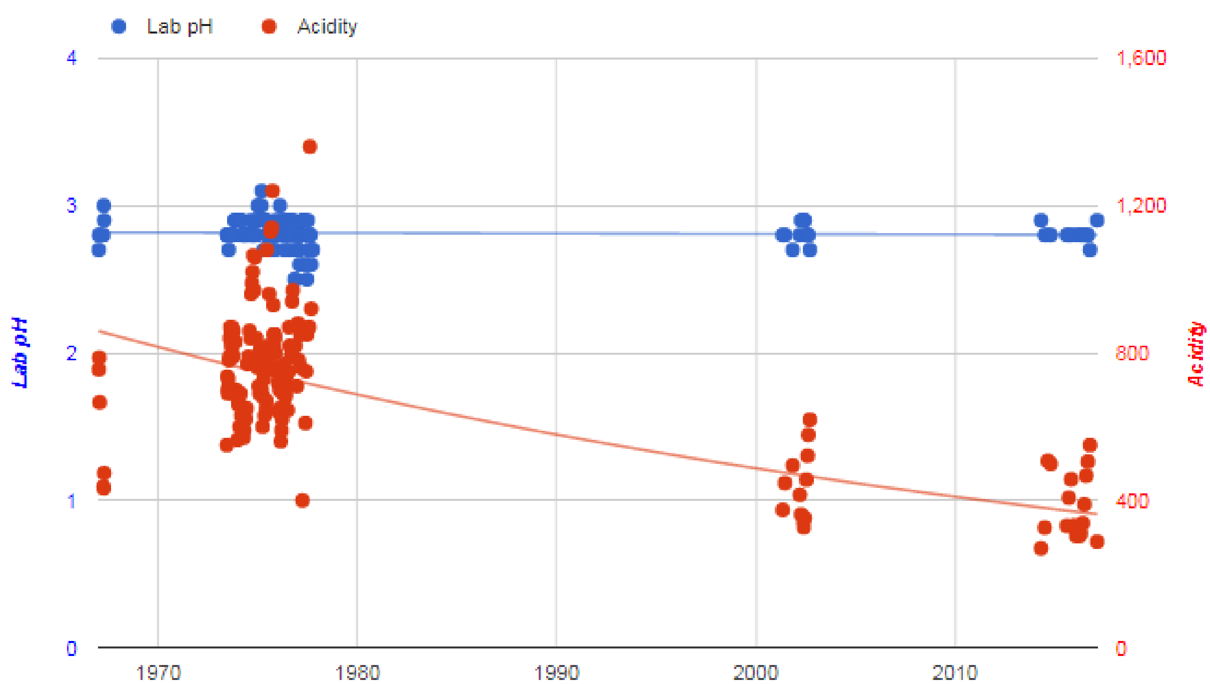

Figure 4. DCC05 pH and Acidity Concentration Trends from 1968-2018

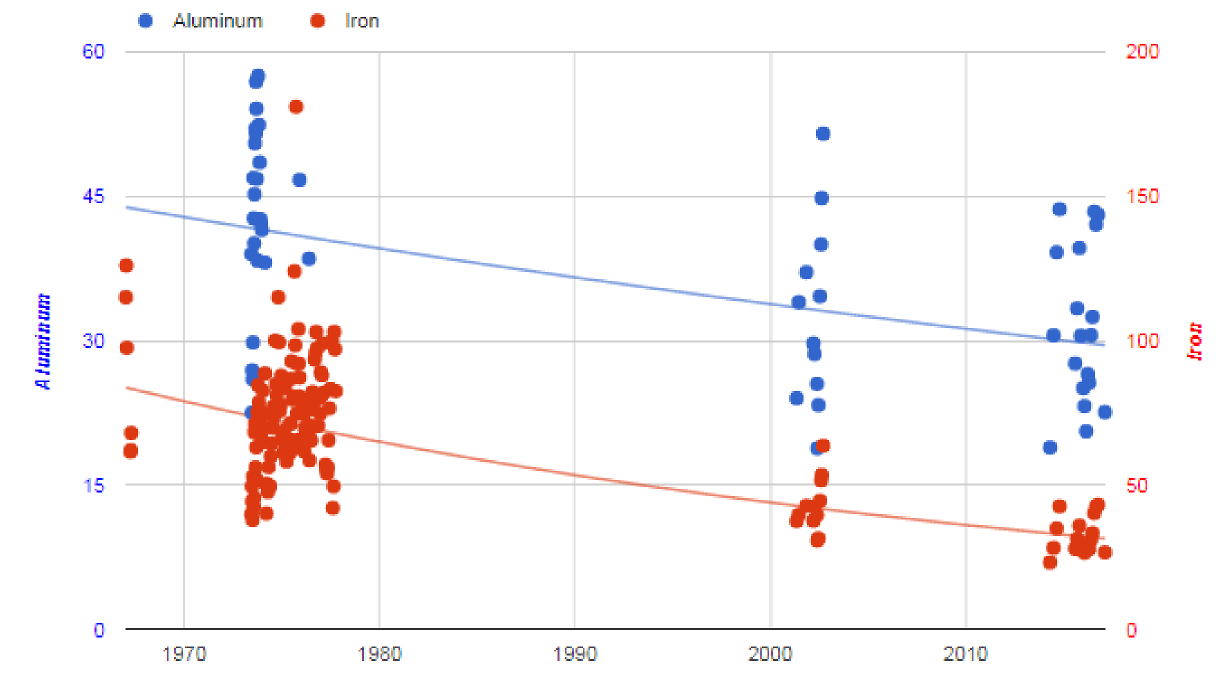

Figure 5. DCC05 Total Fe and Al Concentrations from 1968-2018

<u>*DCC05 Quantity and Loading*</u>

Surprisingly, flows exiting DCC05 seem to be decreasing over time (Figure 6). Obviously, if this trend continues, costs of operation and maintenance (O&M) at the eventual ATP could be reduced. Reasons for this trend could be reclamation projects and vegetation increases in areas of the mine pool-shed. However, with the seemingly current state of precipitation trends, continued flow decreases should not be considered a certainty. Due to this trend, we will analyze the flow of DCC05 from 1968-2018 and from 2014-2018 (Table 5).

Table 5. DCC05 Flow Statistics from 1968-2018 and 2014-2018

	1968-2018	2014-2018
	CFS	**CFS**
N	153	20
Min	0.795	0.795
Ave	5.558	3.690
Med	4.803	2.696
Max	20.500	7.351
STD	3.464	2.239
90 Percentile	9.941	7.159
95 Percentile	12.402	7.332
99 Percentile	19.137	ND

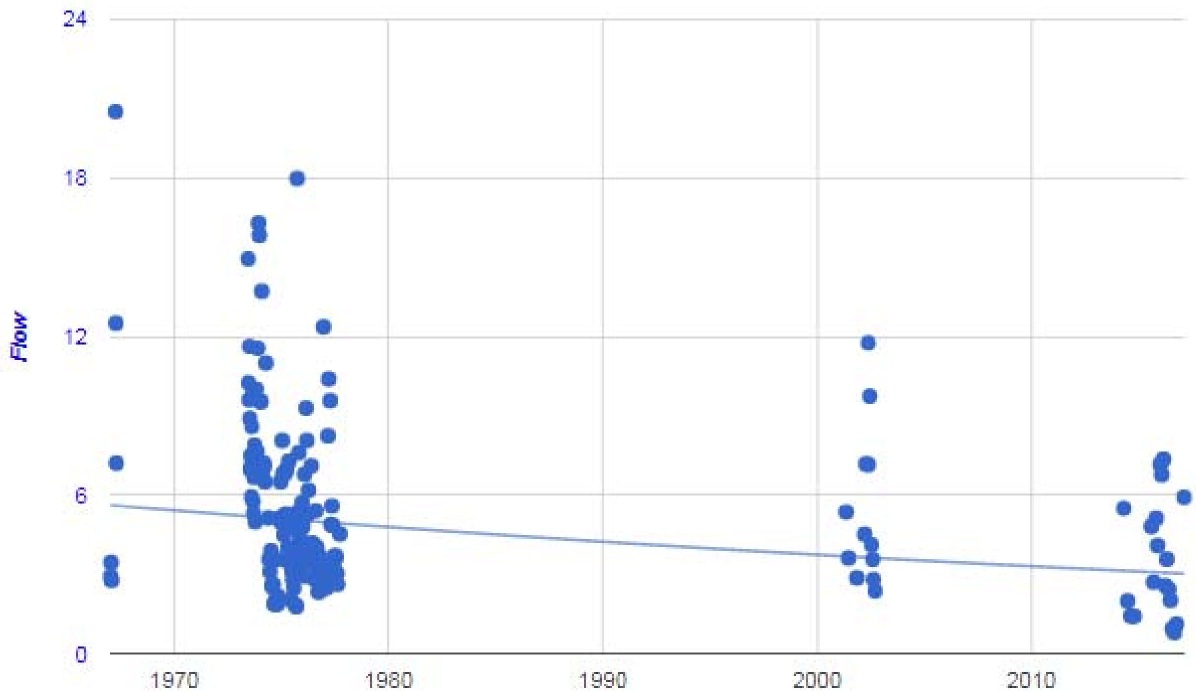

Figure 6. DCC05 Flows in CFS from 1968 to 2018

With a decreasing flow trend, when computing average AMD loading, the 2014-2018 average flows will be used (Table 6). On average, DCC05 contributes 1,362 tons per year of acidity, 114 tons per year of Fe, 28 tons per year of manganese (Mn), and 113 tons per year of Al.

Table 6. DCC05 Average AMD Loading

Ave Flow	**Ave Acidity**	**Ave Fe**	**Ave Mn**	**Ave Al**	**Ave SO_4**	**Ave TDS**
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
3.690	374.80	31.50	7.66	31.12	722.31	1212.47
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	7460.76	627.04	152.48	619.47	14378.29	24135.41

DCC05 High Flow Quality, Quantity, and Loading

Since the eventual ATP will have to be sized to accommodate the high flows from each discharge, an analysis of the high-flow quality, quantity, and loadings that could be encountered is important. Since DCC05 has improved in quality over time and seems to have reduced in flow, the 20 samples collected since 2014 are only being used for analysis. However, it should be noted that the absolute high flow encountered at DCC005 was 20.5 CFS in 1967.

Since 2014, the highest flow recorded at DCC05 was 7.351 CFS on March 2, 2016. The water quality and loading of DCC05 on that date is found in Table 7.

Table 7. DCC05 Quantity, Quality, and Loading on March 2, 2016

Flow	Acidity	Fe	Mn	Al	SO_4	TDS
CFS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
7.351	305.00	27.65	5.33	20.58	505.00	ND
	Acidity Load	Fe Load	Mn Load	Al Load	SO_4 Load	TDS Load
	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
	12094.94	1096.48	211.36	816.11	20,026.04	ND

<u>*DMR04 Quality*</u>

DMR04 is the largest flow and loading discharge to Morris Run (Figure 7). During sampling completed on October 25, 2018, for this Restoration Plan effort, DMR04 accounted for 30.5 percent of the Morris Run flow at its mouth.

Just like virtually all deep mine discharges, DMR04 is undergoing pyrite decay and has improved over time. While pH has only increased slightly over the past 50 years, acidity, Fe, and Al concentrations have all decreased (Figures 8 and 9).

Since DMR04 is improving over time, only recent water quality data should be considered. In the last five years, DMR04 has been sampled 22 times and these samples will be used for statistical analysis (Table 8). Prior to 2014, the discharge was not significantly sampled since the early 2000s.

Figure 7. DMR04 Upon Emergence Just Off the West Side of Morris Run Road

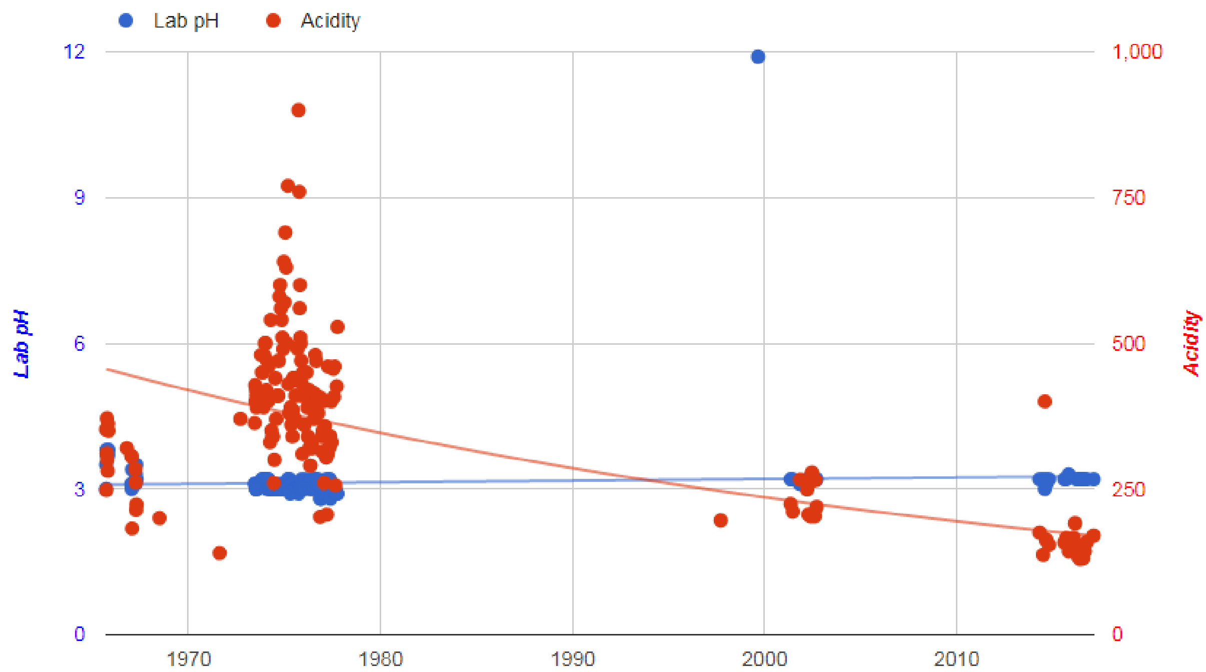

Figure 8. DMR04 pH and Acidity Concentration Trends from 1965-2018

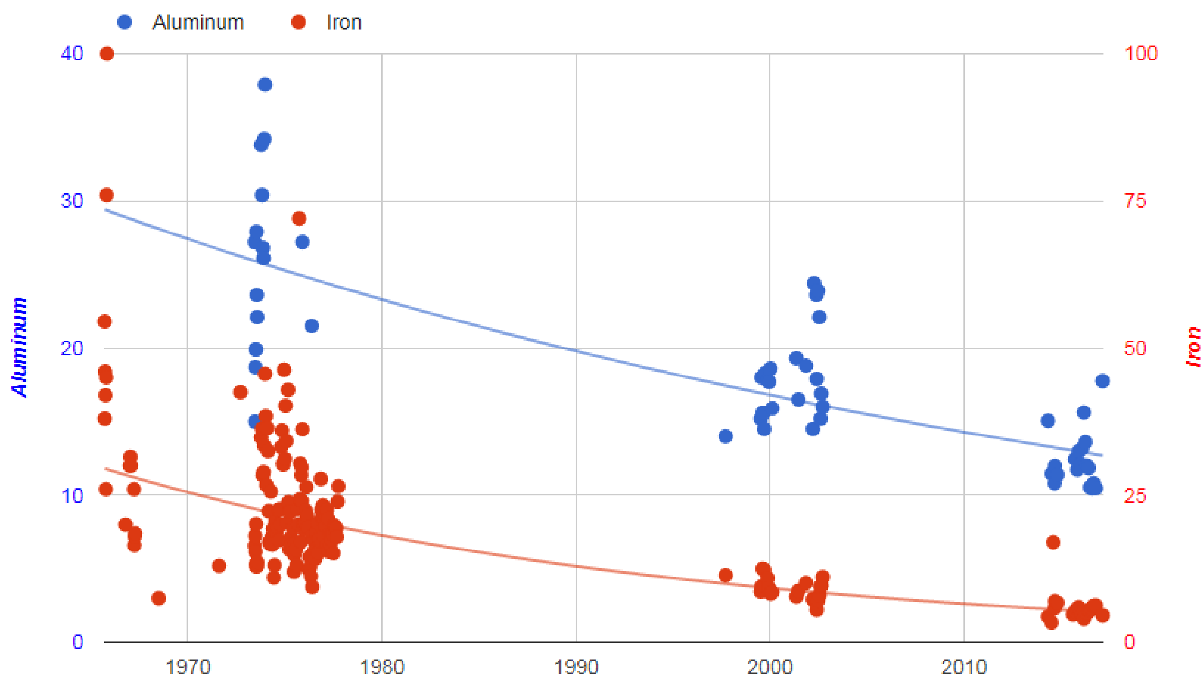

Figure 9. DMR04 Total Fe and Al Concentrations from 1965-2018

Table 8. Water Quality Statistics for the DMR004 Discharge since 2014

	Lab pH	Acidity	Fe	Mn	Al	SO_4	TDS
	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
N	18	22	22	21	20	22	16
Min	3.00	126.00	3.36	14.14	10.46	337.00	671.00
Ave	3.19	164.00	5.78	15.30	12.50	516.00	810.00
Med	3.20	154.00	5.38	15.27	12.01	500.00	810.00
Max	3.30	400.00	17.00	17.00	17.76	1170.00	940.00
STD	0.06	55.20	2.67	0.77	1.908	161.00	79.40
90 Percentile	3.21	186.00	6.92	16.42	15.56	608.00	938.00

DMR04 Quantity and Loading

Just as with DCC005, flows exiting DMR004 seem to be decreasing over time (Figure 10). Obviously, if this trend continues, costs of O&M at the eventual ATP could be reduced. Reasons for this trend could be reclamation projects and vegetation increases in areas of the mine pool-shed. However, with the seemingly current state of precipitation trends, continued flow decreases should not be considered a certainty. Due to this trend, we will analyze the flow of DMR04 from 1965-2018 and from 2014-2018 (Table 9).

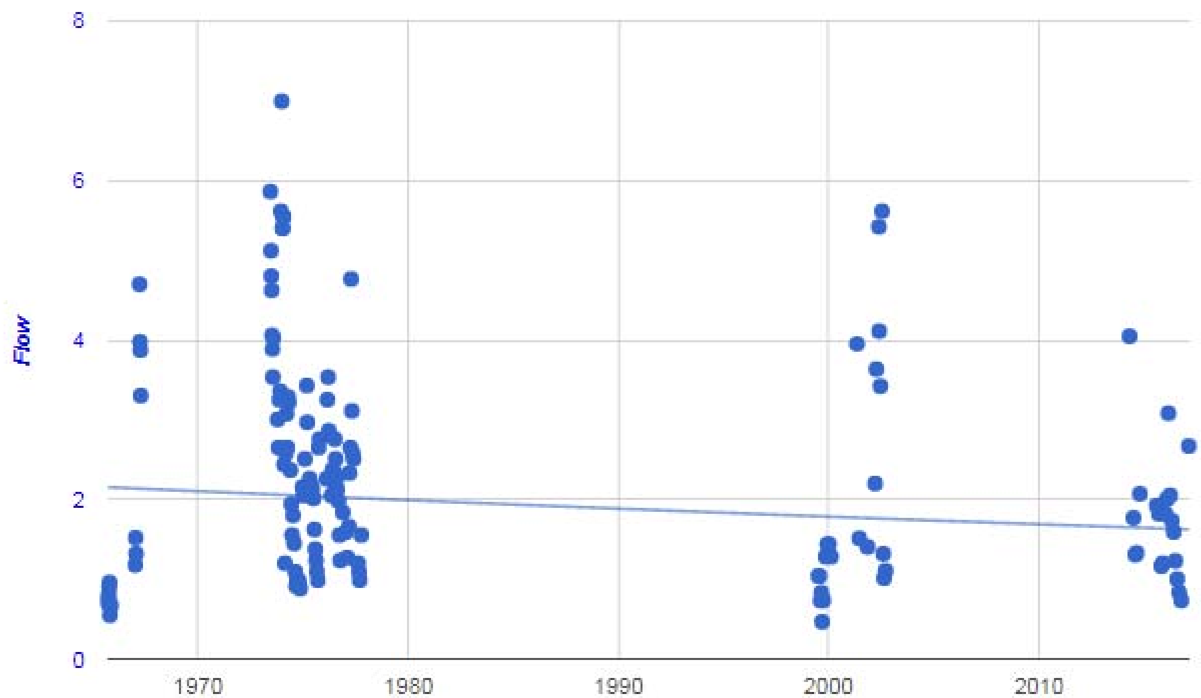

Figure 10. DMR04 Flows in CFS from 1965 to 2018

Table 9. DMR04 Flow Statistics from 1965-2018 and 2014-2018

	1965-2018	**2014-2018**
	CFS	**CFS**
N	144	21
Min	0.468	0.735
Ave	2.310	1.817
Med	2.050	1.770
Max	6.992	4.050
STD	1.368	0.803
90 Percentile	4.370	3.019
95 Percentile	5.417	3.953
99 Percentile	6.484	ND

With a decreasing flow trend, when computing average AMD loading, the 2014-2018 average flows will be used (Table 10). On average, DMR04 contributes 293 tons per year of acidity, 10 tons per year of Fe, 27 tons per year of Mn, and 22 tons per year of Al.

Table 10. DMR04 Average AMD Loading

Ave Flow	**Ave Acidity**	**Ave Fe**	**Ave Mn**	**Ave Al**	**Ave SO_4**	**Ave TDS**
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
1.817	164.00	5.78	15.30	12.50	516.00	810.00
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	1607.52	56.66	149.97	122.52	5057.80	7939.58

DMR04 High-Flow Quality, Quantity, and Loading

Since the eventual ATP will have to be sized to accommodate the high flows from each discharge, an analysis of the high-flow quality, quantity, and loadings that could be encountered is important. Since DMR04 has improved in quality over time and seems to have reduced in flow, the 22 samples collected since 2014 are only being used for analysis. However, it should be noted that the absolute high flow encountered at DMR04 was 6.992 CFS in 1973.

Since 2014, the highest flow recorded at DMR04 was 4.050 CFS on April 27, 2014. The water quality and loading of DMR04 on that date is found in Table 11.

Table 11. DMR04 Quantity, Quality, and Loading on March 2, 2016

Flow	**Acidity**	**Fe**	**Mn**	**Al**	**SO_4**	**TDS**
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
4.050	175.00	4.36	15.64	15.06	493.00	807.00
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	3823.41	95.26	341.70	329.03	10771.08	17631.36

DMR03 Quality

DMR03 is the second largest flow and loading discharge to Morris Run (Figure 11). During sampling completed on October 25, 2018, for this Restoration Plan effort, the flow of DMR03 was 0.312 CFS.

Just like virtually all deep mine discharges, DMR03 is undergoing pyrite decay and has improved over time. While pH has only increased slightly over the past 50 years, acidity, Fe, and Al concentrations have all decreased (Figures 12 and 13).

Since DMR03 is improving over time, only recent water quality data should be considered. In the last five years, DMR03 has been sampled 24 times and these samples will be used for statistical analysis (Table 12). Prior to 2014, the discharge was not significantly sampled since the early 2000s.

Table 12. Water Quality Statistics for the DMR003 Discharge since 2014

	Lab pH	Acidity	Fe	Mn	Al	SO_4	TDS
	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
N	21	24	24	24	24	24	16
Min	2.90	209.00	4.61	17.04	22.13	612.00	862.00
Ave	3.00	276.00	5.29	20.48	28.24	759.00	1285.00
Med	3.00	274.00	5.26	20.44	28.20	761.00	1289.00
Max	3.10	331.00	6.21	23.97	32.41	912.00	1680.00
STD	0.04	26.10	0.44	1.90	2.73	85.80	209.00
90 Percentile	3.00	309.00	6.03	23.81	31.82	867.00	1673.00

Figure 11. DMR03 Upon Emergence from a Pipe at Toe of Reclaimed Surface Mine

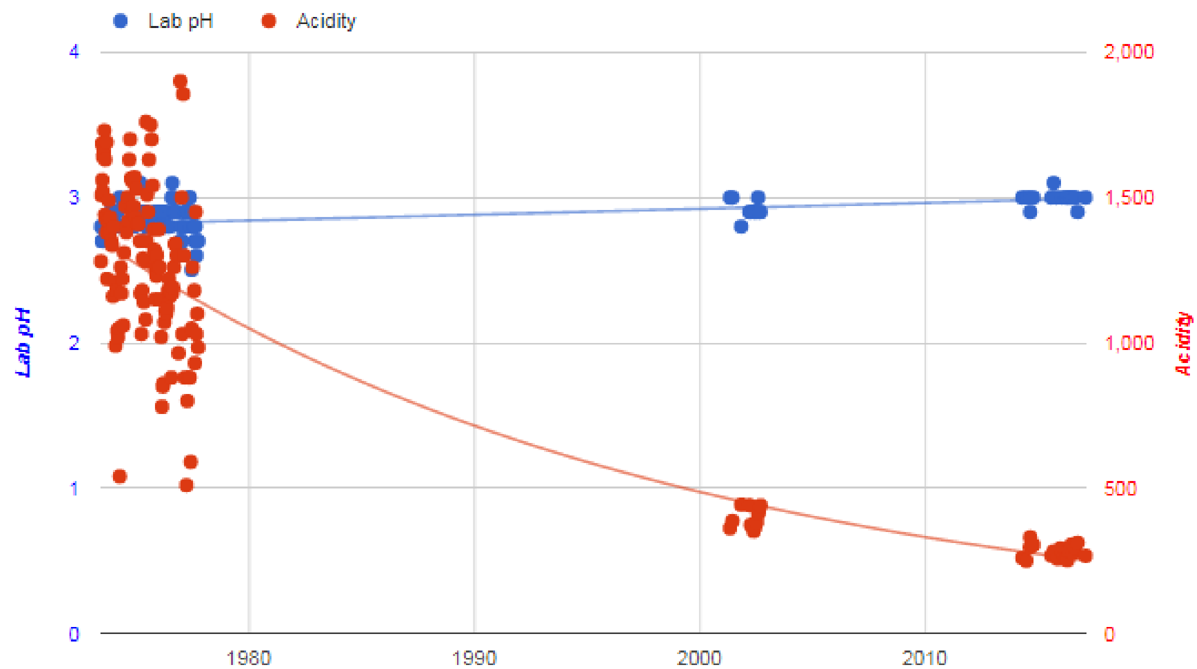

Figure 12. DMR03 pH and Acidity Concentration Trends from 1973-2018

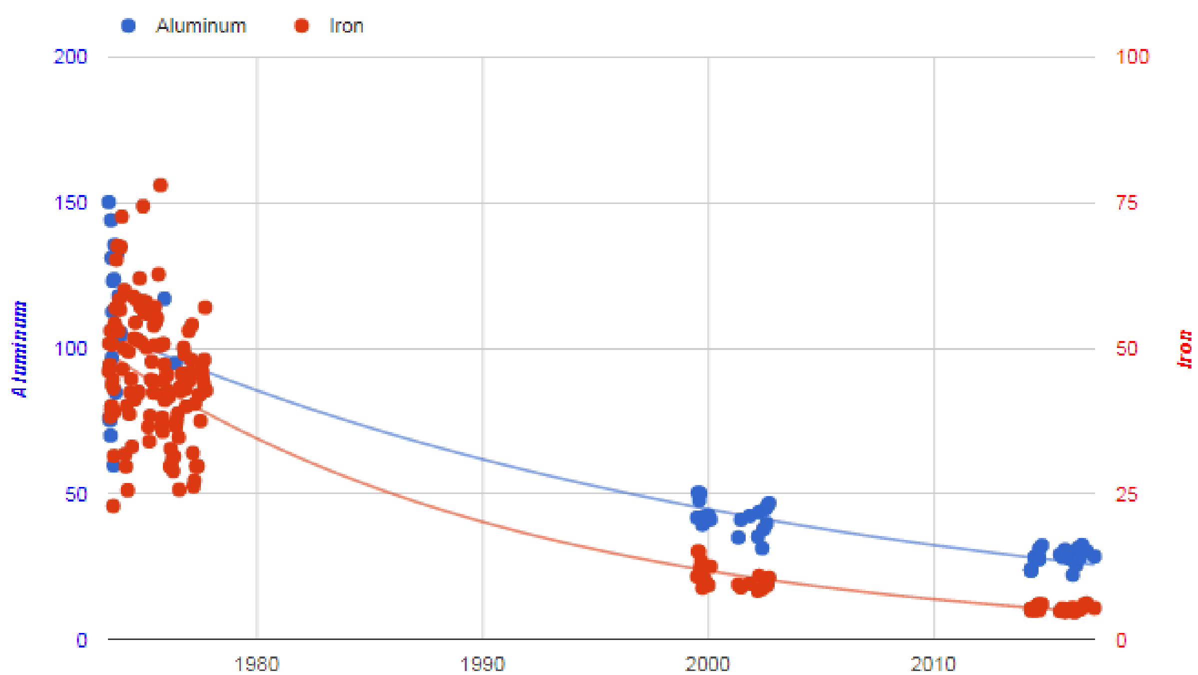

Figure 13. DMR03 Total Fe and Al Concentrations from 1973-2018

DMR03 Quantity and Loading

Just as with DCC05 and DMR04, flows exiting DMR03 seem to be decreasing over time (Figure 14). Obviously, if this trend continues, costs of O&M at the eventual ATP could be reduced. Reasons for this trend could be reclamation projects and vegetation increases in areas of the mine pool-shed. However, with the seemingly current state of precipitation trends, continued flow decreases should not be considered a certainty. Due to this trend, we will analyze the flow of DMR03 from 1973-2018 and from 2014-2018 (Table 13).

Table 13. DMR03 Flow Statistics from 1973-2018 and 2014-2018

	1965-2018	2014-2018
	CFS	CFS
N	157	23
Min	0.049	0.080
Ave	1.145	0.405
Med	0.830	0.256
Max	5.756	1.096
STD	1.038	0.329
90 Percentile	2.377	1.052
95 Percentile	3.302	1.089
99 Percentile	5.381	ND

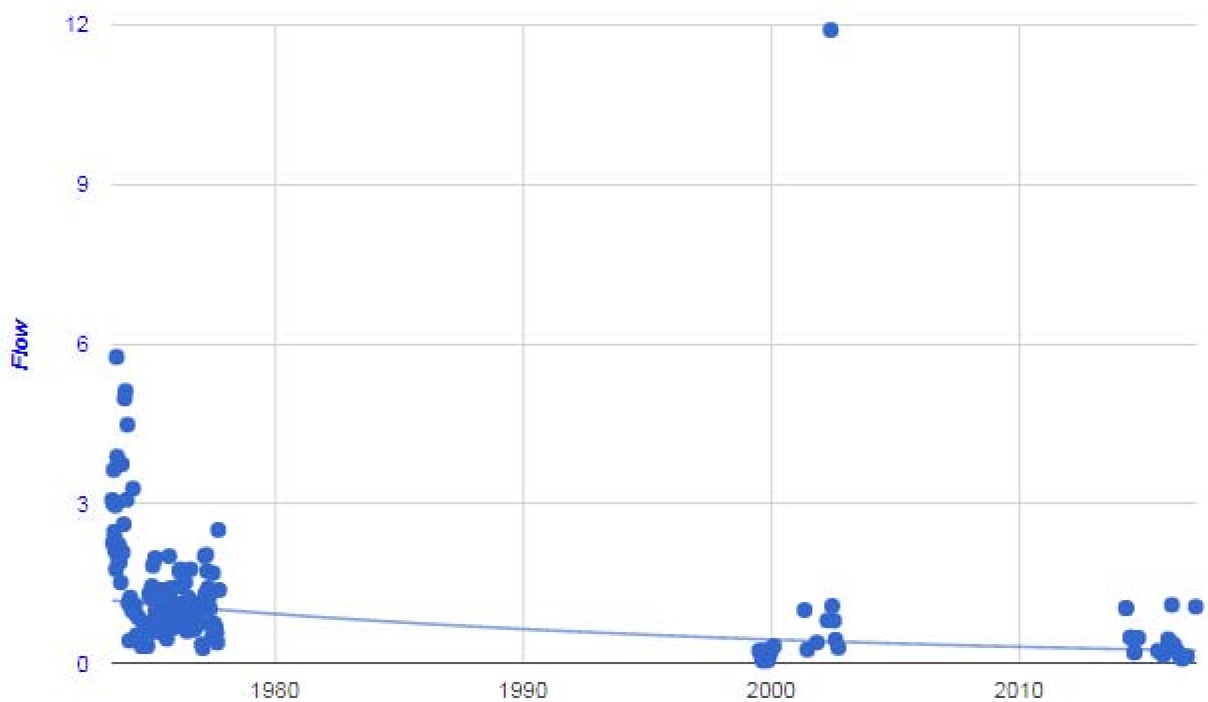

Figure 14. DMR03 Flows in CFS from 1973 to 2018

With a decreasing flow trend, when computing average AMD loading, the 2014-2018 average flows will be used (Table 14). On average, DMR03 contributes 110 tons per year of acidity, two tons per year of Fe, 8 tons per year of Mn, and 11 tons per year of Al.

Table 14. DMR03 Average AMD Loading

Ave Flow	Ave Acidity	Ave Fe	Ave Mn	Ave Al	Ave SO_4	Ave TDS
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
0.405	276.00	5.29	20.48	28.24	759.00	1285.00
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	603.01	11.56	44.74	61.70	1658.27	2807.47

DMR03 High-Flow Quality, Quantity, and Loading

Since the eventual ATP will have to be sized to accommodate the high flows from each discharge, an analysis of the high-flow quality, quantity, and loadings that could be encountered is important. Since DMR03 has improved in quality over time and seems to have reduced in flow, the 24 samples collected since 2014 are only being used for analysis. However, it should be noted that the absolute high flow encountered at DMR04 was 5.381 CFS in 1973.

Since 2014, the highest flow recorded at DMR03 was 1.096 CFS on March 2, 2016. The water quality and loading of DMR03 on that date is found in Table 15.

Table 15. DMR03 Quantity, Quality, and Loading on March 2, 2016

Flow	Acidity	Fe	Mn	Al	SO_4	TDS
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
1.096	262.00	5.44	17.75	22.13	627.00	ND
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	1549.06	32.16	104.95	130.84	3707.11	ND

DMR01 Quality

DMR01 is the smallest flow and loading discharge to be treated at the plant (Figure 15). During sampling completed on October 25, 2018, for this Restoration Plan effort, the flow of DMR01 was 0.344 CFS, actually slightly higher than MR03. Normally, flow is lower at DMR01 than at DMR03.

Just like virtually all deep mine discharges, DMR01 is undergoing pyrite decay and has improved over time. While pH has only increased slightly over the past 50 years, acidity, Fe, and Al concentrations have all decreased (Figures 16 and 17).

Figure 15. DMR01 at Its Collapsed Entry Emergence Point

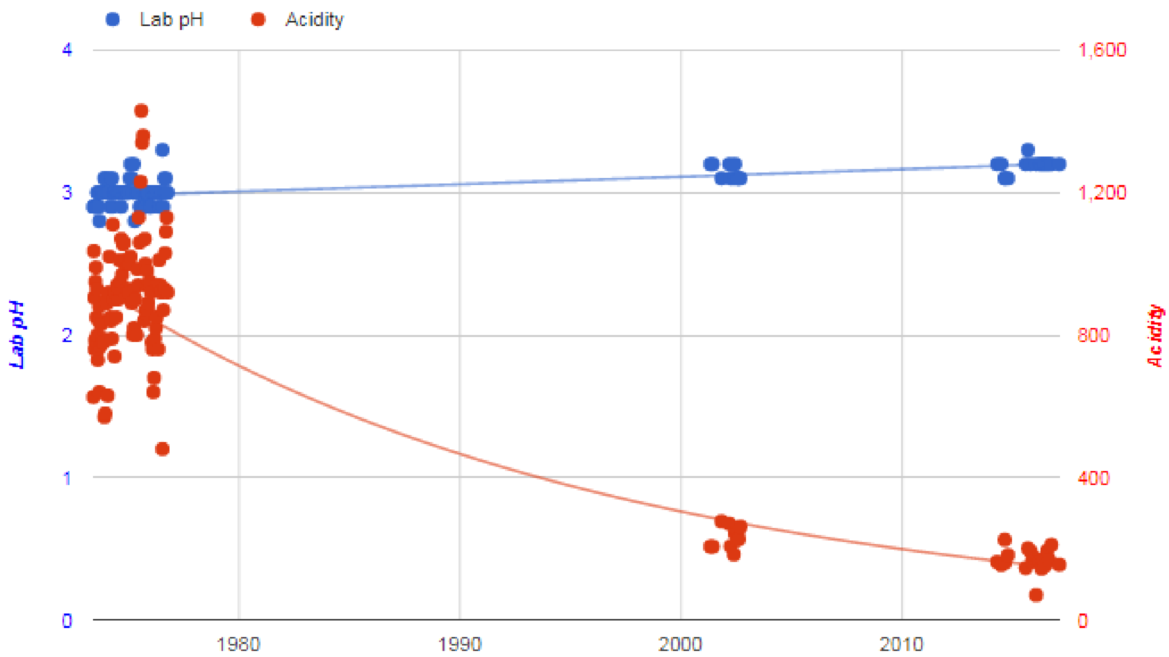

Figure 16. DMR01 pH and Acidity Concentration Trends from 1973-2018

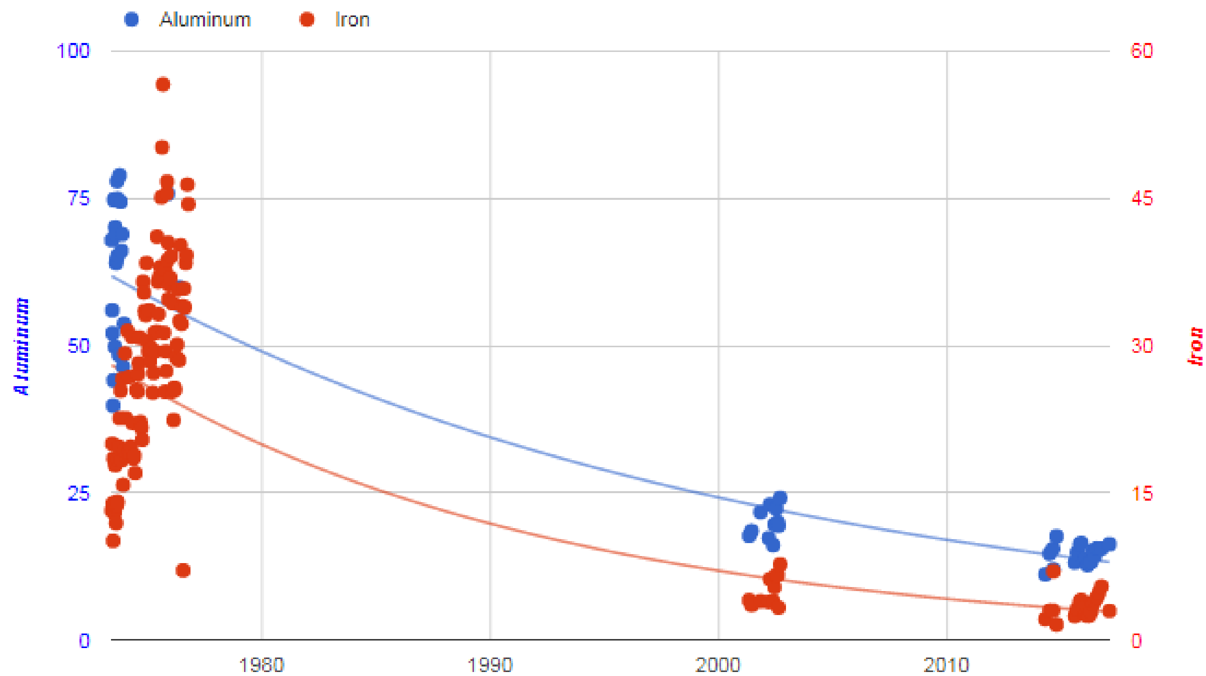

Figure 17. DMR01 Total Fe and Al Concentrations from 1973-2018

Since DMR01 is improving over time, only recent water quality data should be considered. In the last five years, DMR01 has been sampled 21 times and these samples will be used for statistical analysis (Table 16). Prior to 2014, the discharge was not significantly sampled since the early 2000s.

Table 16. Water Quality Statistics for the DMR01 Discharge since 2014

	Lab pH	Acidity	Fe	Mn	Al	SO_4	TDS
	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
N	18	21	21	21	21	21	16
Min	3.10	70.00	1.57	14.08	11.13	573.00	750.00
Ave	3.19	165.00	3.39	19.01	14.39	683.00	1136.00
Med	3.20	165.00	3.00	19.24	14.67	673.00	1145.00
Max	3.30	225.00	7.00	23.32	17.60	823.00	1408.00
STD	0.05	33.50	1.28	2.75	1.74	85.10	181.00
90 Percentile	3.21	209.00	5.33	23.15	16.45	797.00	1402.00

DMR01 Quantity and Loading

Just as with the other discharges to be treated, flows exiting DMR01 seem to be decreasing over time (Figure 18). Obviously, if this trend continues, costs of O&M at the eventual ATP could be reduced. Reasons for this trend could be reclamation projects and vegetation increases in areas of the mine pool-shed. However, with the seemingly current state of precipitation trends, continued flow decreases should not be considered a certainty. Due to this trend, we will analyze the flow of DMR01 from 1973-2018 and from 2014-2018 (Table 17).

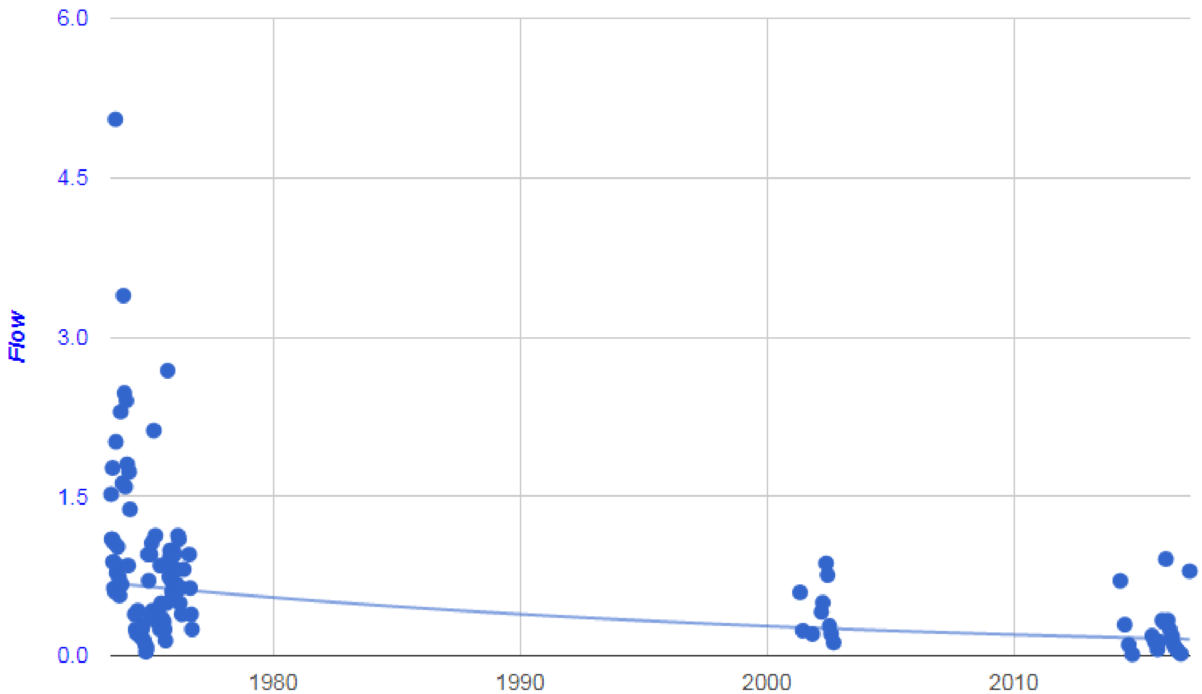

Figure 18. DMR01 Flows in CFS from 1973 to 2018

Table 17. DMR01 Flow Statistics from 1973-2018 and 2014-2018

	1965-2018 CFS	2014-2018 CFS
N	115	20
Min	0.011	0.011
Ave	0.746	0.264
Med	0.600	0.185
Max	5.050	0.909
STD	0.741	0.259
90 Percentile	1.666	0.786
95 Percentile	2.316	0.903
99 Percentile	4.784	ND

With a decreasing flow trend, when computing average AMD loading, the 2014-2018 average flows will be used (Table 18). On average, DMR01 contributes 43 tons per year of acidity, one ton per year of Fe, 5 tons per year of Mn, and 4 tons per year of Al.

Table 18. DMR01 Average AMD Loading

Ave Flow	Ave Acidity	Ave Fe	Ave Mn	Ave Al	Ave SO_4	Ave TDS
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
0.264	165.00	3.39	19.01	14.39	683.00	1136.00
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	234.99	4.83	27.07	20.49	972.71	1617.85

DMR01 High-Flow Quality, Quantity, and Loading

Since the eventual ATP will have to be sized to accommodate the high flows from each discharge, an analysis of the high-flow quality, quantity, and loadings that could be encountered is important. Since DMR01 has improved in quality over time and seems to have reduced in flow, the 21 samples collected since 2014 are only being used for analysis. However, it should be noted that the absolute high flow encountered at DMR04 was 5.050 CFS in 1973.

Since 2014, the highest flow recorded at DMR01 was 0.909 CFS on March 2, 2016. The water quality and loading of DMR01 on that date is found in Table 19.

Table 19. DMR01 Quantity, Quality, and Loading on March 2, 2016

Flow	**Acidity**	**Fe**	**Mn**	**Al**	**SO_4**	**TDS**
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
0.909	169.00	2.49	15.07	12.72	615.00	ND
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	828.72	12.21	73.90	62.37	3015.76	ND

Bear Creek Quality

Bear Creek is a small tributary to the Tioga River that is impacted by numerous small discharges through its length. Bear Creek enters in the Borough of Blossburg just upstream of Johnson Creek's entry (Figure 19). During sampling completed on October 25, 2018, for this Restoration Plan effort, the flow of Bear Creek was 1.213 CFS.

Just like virtually all streams impacted by AMD, the mines impacting Bear Creek are undergoing pyrite decay and have improved over time. While pH has only increased slightly over the past 50 years, acidity and Fe have decreased significantly (Figures 20 and 21). Al has also decreased, but less significantly.

Even though Bear Creek will not be treated by the ATP, it is important to document its historical data since mass balance projections will be utilized later to predict assimilation of the untreated Bear Creek on a restored Tioga River.

Figure 19. Bear Creek Flowing Through Blossburg Just Prior to Its Confluence with the Tioga

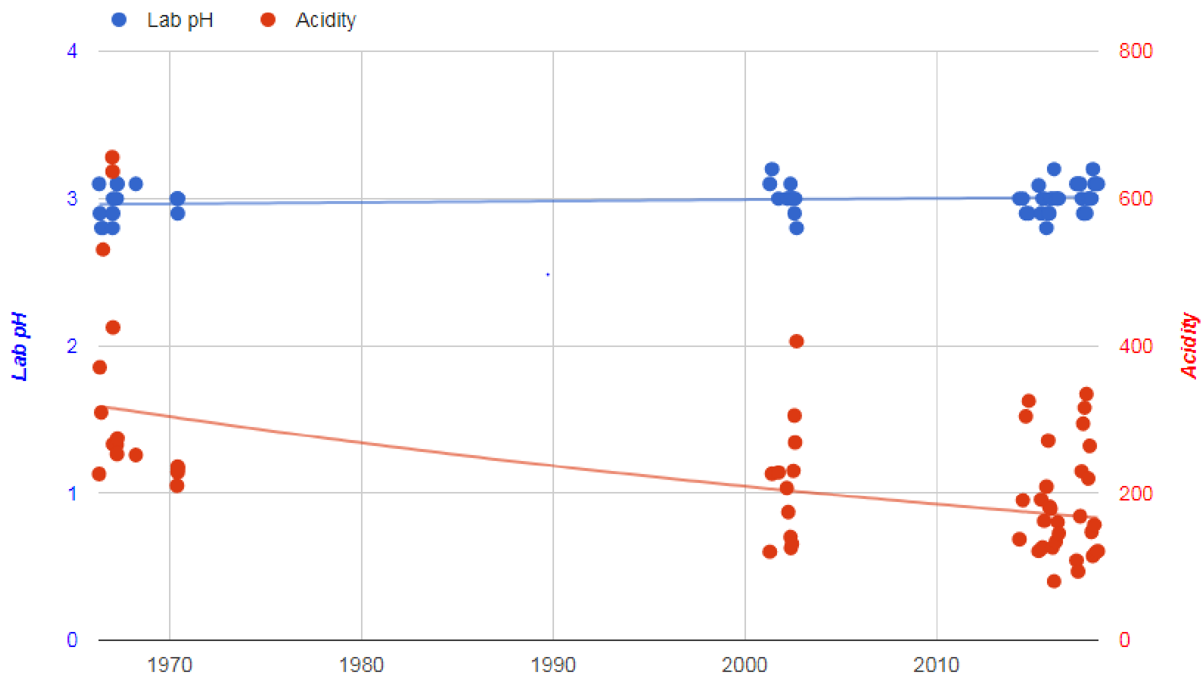

Figure 20. Bear Creek pH and Acidity Concentration Trends from 1973-2018

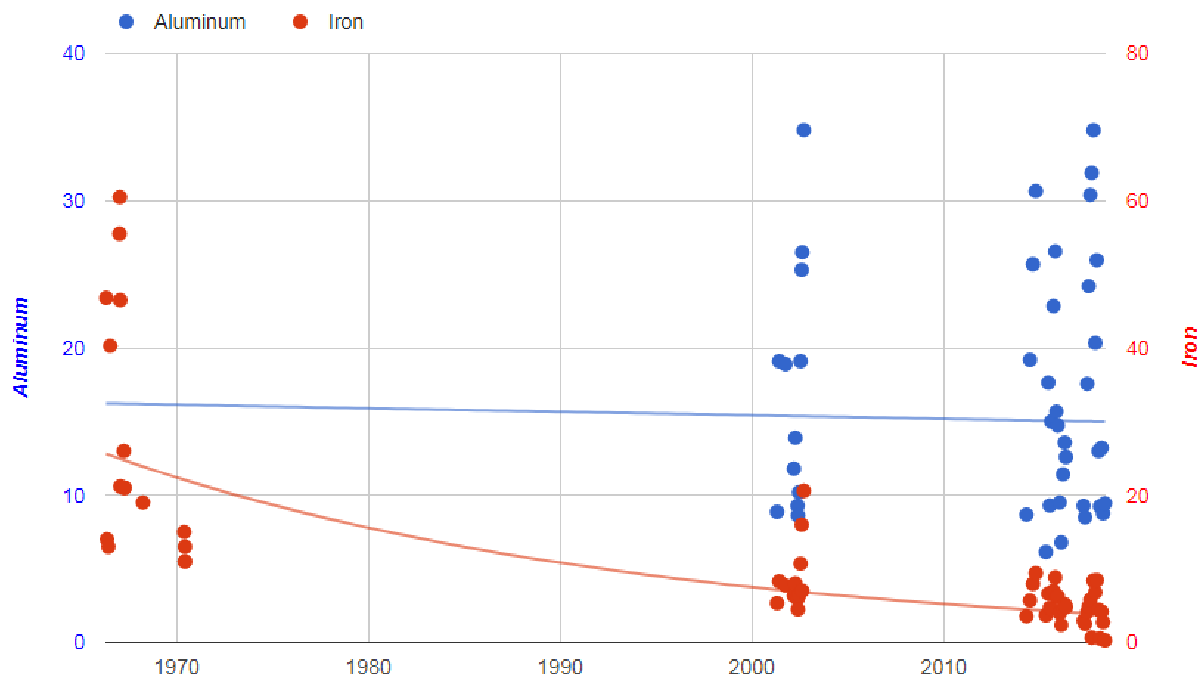

Figure 21. Bear Creek Total Fe and Al Concentrations from 1966-2018

Since Bear Creek is improving over time, only recent water quality data should be considered. In the last five years, Bear Creek has been sampled 21 times and these samples will be used for statistical analysis (Table 20). Prior to 2014, the discharge was not significantly sampled since the early 2000s.

Table 20. Water Quality Statistics for Bear Creek since 2014

	Lab pH	Acidity	Fe	Mn	Al	SO_4	TDS
	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
N	32	21	32	32	32	32	6
Min	2.80	80.00	0.28	2.66	6.15	181.80	181.00
Ave	3.00	183.40	4.92	6.37	16.79	401.41	537.00
Med	3.00	161.20	4.75	5.52	14.63	362.60	456.00
Max	3.20	334.40	9.41	12.44	34.79	744.70	1015.00
STD	0.09	72.81	2.35	3.00	8.20	178.56	311.00
90 Percentile	3.10	312.30	8.45	11.36	30.58	709.33	ND

Bear Creek Quantity and Loading

Bear Creek flows seem to be decreasing over time (Figure 22). Obviously, if this trend continues, impacts to Tioga would be reduced. Reasons for this trend could be reclamation projects and vegetation increases in the watershed. However, with the seemingly current state of precipitation trends, continued flow decreases should not be considered a certainty. Due to this trend, we will analyze the flow of Bear Creek from 1966-2018 and from 2014-2018 (Table 21).

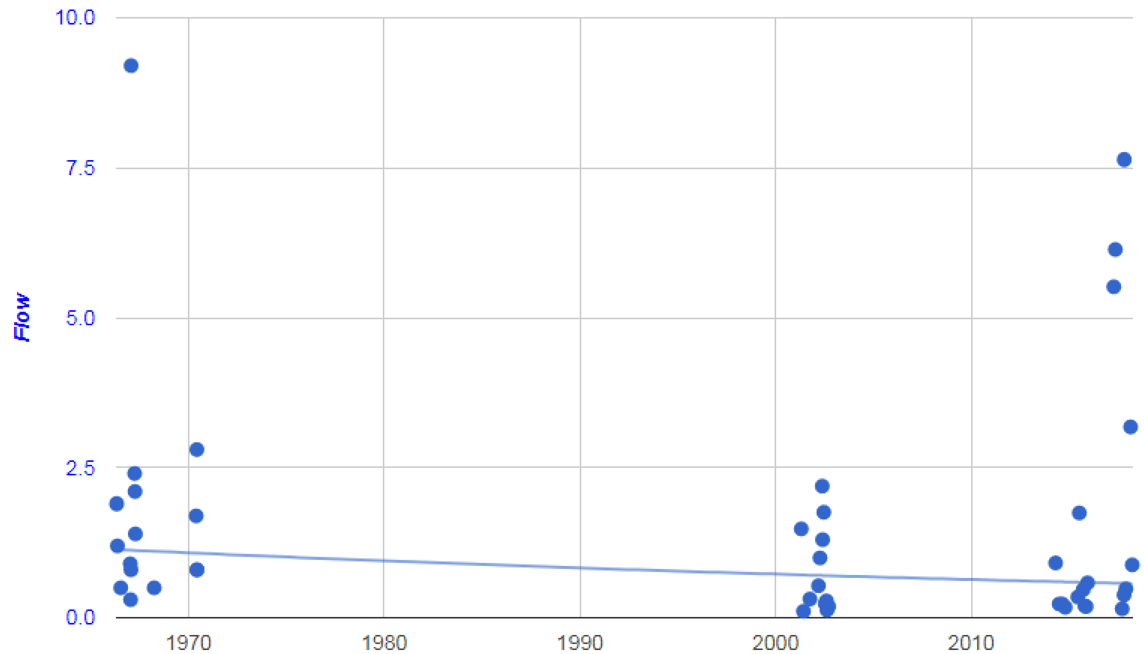

Figure 22. Bear Creek Flows in CFS from 1966 to 2018

Table 21. Bear Creek Flow Statistics from 1966-2018 and 2014-2018

	1965-2018	2014-2018
	CFS	**CFS**
N	115	19
Min	0.107	0.149
Ave	1.466	1.613
Med	0.800	0.481
Max	9.200	7.636
STD	1.968	2.291
90 Percentile	6.139	6.139
95 Percentile	7.112	7.636
99 Percentile	ND	ND

With a decreasing flow trend, when computing average AMD loading, the 2014-2018 average flows will be used (Table 22). On average, Bear Creek contributes 291 tons per year of acidity, 8 tons per year of Fe, 10 tons per year of Mn, and 27 tons per year of Al.

Table 22. Bear Creek Average AMD Loading

Ave Flow	Ave Acidity	Ave Fe	Ave Mn	Ave Al	Ave SO_4	Ave TDS
CFS	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**	**mg/l**
1.613	183.40	4.92	6.37	16.79	401.41	537.00
	Acidity Load	**Fe Load**	**Mn Load**	**Al Load**	**SO_4 Load**	**TDS Load**
	lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
	1,595.85	42.81	55.43	146.10	3,492.85	4,672.68

Since the Bear Creek flow will not be treated by the ATP, no high flow loading analysis is offered.

Treatment Plant Influent Projections

As mentioned, the proposed centralized ATP will treat the combined flows of DCC05, DMR04, DMR03, and DMR01. The average flow, quality, and loading that would be handled by the treatment plant is detailed in Table 23. The plant will have to treat, on average, 1808 tons/year of acidity and dispose of a little less than 128 tons/year of Fe, 68 tons per year of Mn, and 150 tons/year of Al, considering the effluent concentration standards of the plant. Influent to the plant will also contain on average 662 mg/l of (sulfate) SO_4 and 1096 mg/l of total dissolved solids (TDS). On average, the plant will have to treat nearly four million gallons per day (MGD) of water.

Because of the lack of storage ability within the mine pools contributing the discharge flows, the plant will have to be built to accommodate high flows and loading. The high flow quantity, quality, and loading that would have to be handled by the treatment plant is detailed in Table 24. During a high flow period, the plant will have to be able to treat around 18,296 lbs/day of acidity and dispose of a little less than 1,236 lbs/day of Fe, 732 lbs/day of Mn, and 1,338 lbs/day of Al, considering the effluent concentration standards of the plant. According to quantity data from 2014-2019, the plant will have to treat around nine MGD of water during high flow periods.

Table 23. Average Plant Combined Influent Quantity, Quality, and Loading

Station	Q	pH	Acid	Fe	Mn	Al	Acid. Load	Fe Load	Mn Load	Al Load
	CFS	SU	mg/l	mg/l	mg/l	mg/l	lbs/day	lbs/day	lbs/day	lbs/day
DCC05	3.690	2.80	374.80	31.50	7.66	31.12	7460.76	627.04	152.48	619.47
DMR04	1.817	3.19	164.00	5.78	15.30	12.50	1607.52	56.66	149.97	122.52
DMR03	0.405	3.00	276.00	5.29	20.48	28.24	603.01	11.56	44.74	61.70
DMR01	0.264	3.19	165.00	3.39	19.01	14.39	234.99	4.83	27.07	20.49
Plant Influent	6.176	~2.91	297.33	21.01	11.23	24.74	9906.28	700.08	374.27	824.19
						T/Y	1808	128	68	150

Table 24. Projected High Flow Plant Influent

Station	Q	pH	Acid	Fe	Mn	Al	Acid. Load	Fe Load	Mn Load	Al Load
	CFS	SU	mg/l	mg/l	mg/l	mg/l	lbs/day	lbs/day	lbs/day	lbs/day
DCC05	7.351	2.70	305.00	27.65	5.33	20.58	12094.94	1096.48	211.36	816.11
DMR04	4.050	3.20	175.00	4.36	15.64	15.06	3823.41	95.26	341.70	329.03
DMR03	1.096	3.10	262.00	5.44	17.75	22.13	1549.06	32.16	104.95	130.84
DMR01	0.909	3.20	169.00	2.49	15.07	12.72	828.72	12.21	73.90	62.37
Plant Influent	13.406	~2.85	252.99	17.09	10.12	18.51	18296.13	1236.11	731.91	1338.36

Current Tioga River Mainstem Quality

The Tioga River is actually a slightly net acidic watershed, even upstream of the first AMD impact of Fall Brook. This is mainly due to naturally acidic tannic tributaries, like Fellows Creek. Four samples upstream of Fall Brook in 2014 showed an average acidity of 8.25 mg/l. However, metal concentrations remain low with aluminum concentrations averaging 0.078 mg/l in 2014.

The next mainstem station significantly sampled is the Morris Run Road bridge, which is downstream of Fall Brook, the first AMD impact to Tioga, but also downstream of two good quality streams, Carpenter Run and Taylor Run. This site was sampled by SRBC on October 25, 2018, and by PADEP on March 28, 2019. Results of those two samples are shown in Table 25. Even at this station, the Tioga is slightly net acidic, but also contains very low concentrations of metals. SO_4 is also low, indicating minimal AMD impact.

Table 25. Recent Water Quality Results of Tioga at Morris Run Road

Date	pH	Cond.	Acidity	Fe	Mn	Al	SO_4	TDS
	SU	uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
10/25/2018	6.6	70.00	0.20	0.13	0.02	0.11	16.20	41.00
3/28/2019	6.6	49.00	1.40	0.10	0.20	0.13	12.80	42.00

The Tioga has also been sampled for many years by Island Park in Blossburg Borough, which is downstream of Morris Run and Coal Creek, but upstream of Johnson Creek and Bear Creek (Table 26). Water quality here shows the significant negative impact of Morris Run and Coal Creek. This station was sampled seasonally in 2014 and shows a pH drop of more than three units and a substantial increase in acidity, Fe, Mn, Al, SO_4, and TDS.

Table 26. Average 2014 Water Quality of Tioga at Island Park in Blossburg Borough

pH	Cond	Acidity	Fe	Mn	Al	SO_4	TDS
SU	uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
3.58	362.00	58.00	2.15	2.50	4.75	141.00	187.00

The North Williamstown Road Bridge has always been utilized as the station that documents the water quality downstream of all AMD impacts to the Tioga. Even though downstream of all AMD impacts, including Bear Creek, this site also receives good quality flows from East Creek and four unnamed tributaries (Table 27). Consequently, the water quality at North Williamstown Road is improved in comparison to the Island Park station, but is still significantly impacted by AMD, particularly acidity and Al.

Table 27. Average 2014-2018 Water Quality of Tioga at North Williamstown Road

pH	Cond	Acidity	Fe	Mn	Al	SO_4	TDS
SU	uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4.28	268.40	32.20	0.54	1.66	2.89	100.60	166.00

The North Williamstown Road Bridge has been sampled numerous times from 1971 to the present. Acidity trends of this station show that the Tioga is improving over time from the combination of reclamation/treatment projects and natural attenuation as pyrite decay occurs within the deep mine pools (Figure 23).

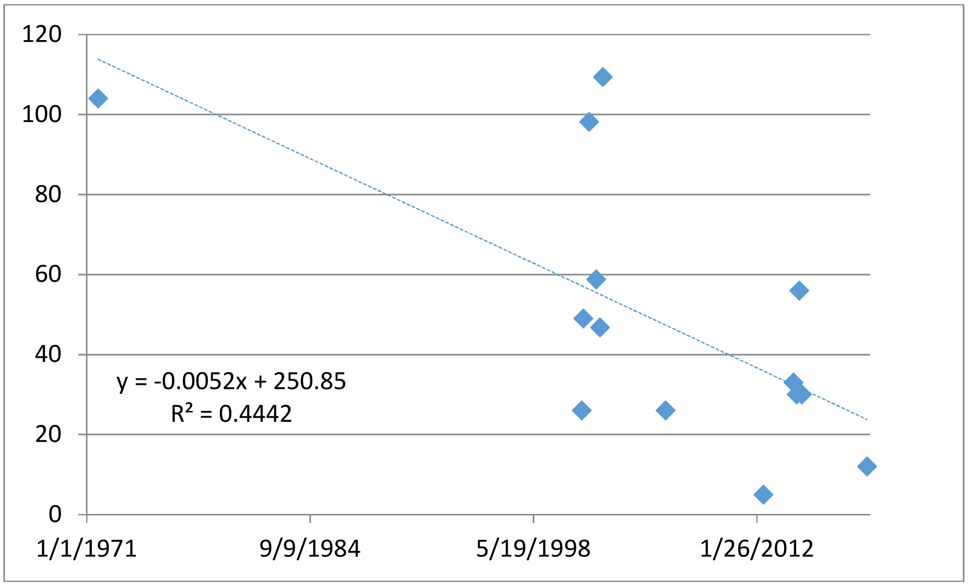

Figure 23. The Acidity Concentration Trend of the Tioga at North Williamstown Road

The final Tioga mainstem station sampled over a long period is the USGS gage near Mansfield prior to its entry into the Tioga Dam. This station is significantly improved from the North Williamstown Road station, but still does not meet water quality standards, particularly in terms of acidity and Al (Table 28). This improvement of the Tioga can also be seen when analyzing pH and conductivity readings collected by the USGS at the gage station (Figures 24 and 25).

Table 28. Average 2014-2018 Water Quality of Tioga at Mansfield USGS Gage Station

pH	Cond	Acidity	Fe	Mn	Al	SO_4	TDS
SU	uS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
5.66	251	16	0.32	1.28	1.59	80.60	160

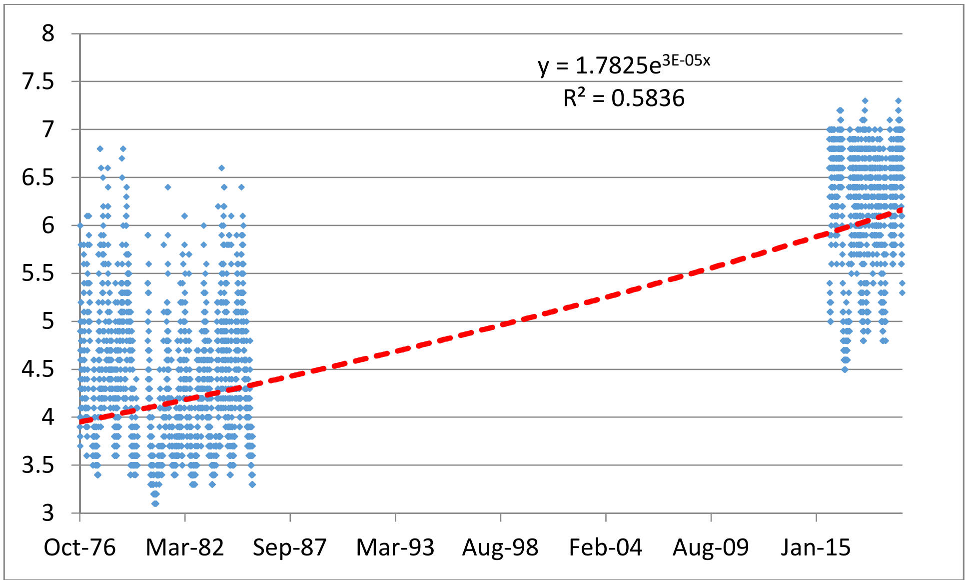

Figure 24. USGS pH Trend of the Tioga at Mansfield from 1976-2019

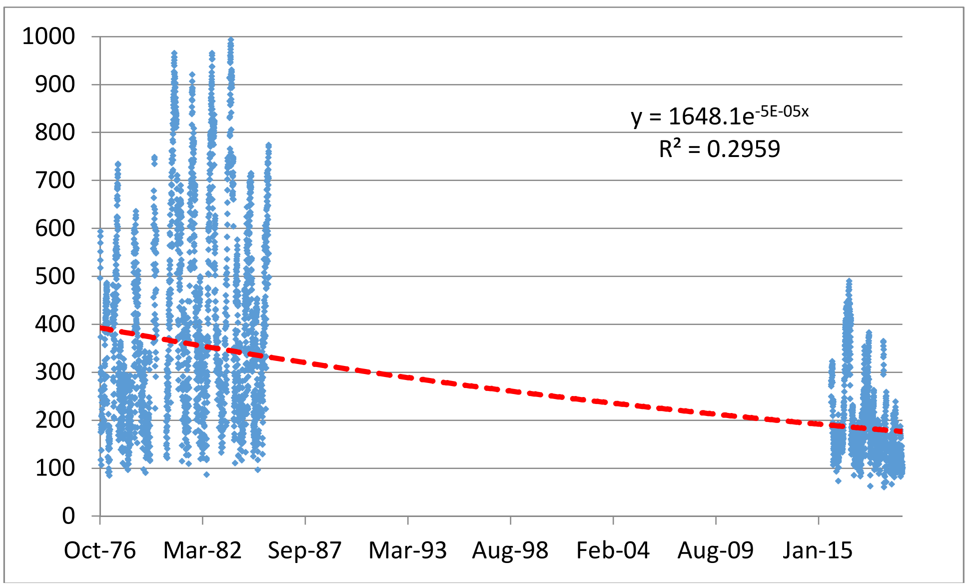

Figure 25. USGS Conductivity Trend of the Tioga at Mansfield from 1976-2019

Restoration Goals

Water Quality

The two remaining questions in terms of restoration is the predicted post-treatment Morris Run quality, and 1) if that quality will be capable of supporting a CWF; and, 2) if the Tioga River can assimilate the AMD loading from Bear Creek, which will remain untreated.

During SRBC's sampling blitz on October 25, 2018, Morris Run was found to carry 78 lbs/day of acidity upstream of DMR04 (Table 29). It was also discovered that there is an additional 1,053 lbs/day of acidity entering Morris Run that cannot be attributed to DMR01, DMR03, or DMR04. Consequently, to have a net alkaline Morris Run from the system effluent confluence to Morris Run's confluence with the Tioga River, more than 1,131 lbs/day of alkalinity would have to be produced on average beyond the quantity needed to treat the acidity loading of each discharge. Consequently, at average flow, the Tioga ATP would need to have a net alkalinity concentration of ~34 mg/l to assimilate the Morris Run acidity not attributed to the treated discharges.

Table 29. Tioga River Average Acidity Loading Not Attributed to DCC05/DMR01/DMR03/DMR04 That Will Have to be Attenuated by Excess Alkalinity Loading Effluent from the ATP

Location	Acidity lbs/day
Morris Run Upstream of DMR04	78
Morris Run Not Attributed to DMR01/DMR03/DMR04	975
Tioga River Upstream of Morris Run	101
Unnamed Trib #1	42
Coal Creek Upstream of DCC05	13
Bear Creek	929
Total	**2,138**

As Table 29 shows, even though the Tioga River is mainly restored upstream of Morris Run due to TCCCC's projects on Fall Brook, it is still a slightly net acidic water (101 lbs/day), mainly due to natural tannic acidity. In addition, smaller amounts of acidity loading enter the Tioga from the first western unnamed tributary (42 lbs/day), from Coal Creek flows upstream of DCC05 (13 lbs/day) and quite significantly from Bear Creek (929 lbs/day), totaling 1,085 lbs/day of additional acidity. This additional acidity must also be counteracted by the plant effluent to have a net alkaline flow downstream of Bear Creek. Consequently, at average flow, the Tioga ATP would need to have a net alkalinity concentration of ~64 mg/l to assimilate the acidity sources noted in Table 29 that will not be treated by the ATP.

Metal loading contributions from any of the Table 29 sources not treated should not pose an issue to the Tioga River. During the October 25, 2018, sampling blitz, the Tioga station downstream of Bear Creek met Fe concentration standards (1.073 mg/l), nearly met Mn concentration standards (1.109 mg/l), and the Al concentration was not highly elevated (1.713 mg/l). Treatment of DCC05/DMR01/DMR03/DMR04 with the ~67 mg/l of excess alkalinity exiting the plant should restore the entirety of the Tioga River under average flow conditions and could remove 22.46 miles of impairment status from the Integrated List of Impaired Waterways. To reiterate, the Tioga ATP will treat the remaining 88 percent of the acidity loading, 98 percent of the Fe loading, and 80 percent of the Al loading still impacting the Tioga River. Bear Creek only contributes 7 percent of the acidity loading, 4 percent of the Fe loading, and 7 percent of the Al loading.

Another simple mass balance analysis can be completed to show how metal concentrations entering from Bear Creek would be assimilated post treatment. On October 25, 2018, DCC05/DMR04/DMR03/DMR01 contributed 820 lbs/day of Fe, 510 lbs/day of Mn, and 1,071 lbs/day of Al. Due to the low pH of the watershed, much of that loading gets transported downstream, particularly Mn, which can act as a tracer since it needs a very high pH for increased rates of oxidation and precipitation. Subtracting this loading from the Tioga station downstream of Bear Creek allows the water quality to meet standards, even with an untreated Bear Creek (Table 30). If restored, the Tioga is large enough to assimilate the relatively low flows entering from Bear Creek. For example, on October 25, 2018, Bear Creek only contributed 0.8 percent of the flow of the Tioga. Bear Creek is just not large enough to significantly impact the Tioga on its own if all upstream sources are mitigated.

Table 30. Prediction of October 25, 2018 Metal Concentrations with the Tioga ATP Discharging Treated Flow

Station	Q	Fe	Mn	Al	Fe Load	Mn Load	Al Load
	CFS	mg/l	mg/l	mg/l	lbs/day	lbs/day	lbs/day
Tioga DS of Bear Creek Pre-Treatment	145.104	1.07	1.11	1.71	840.00	868.00	1341.00
Tioga DS of Bear Creek Post-Treatment	145.104	0.03	0.46	0.35	20.00	358.00	271.00

Restoration of this station downstream of Bear Creek is significant since every tributary downstream of Bear Creek is unimpaired by AMD with several offering very high loadings of alkalinity like Marvin Creek, Elk Run, Canoe Camp Creek, Corey Creek, and Lambs Creek. The restoration of the Tioga station downstream of Bear Creek ensures a completely restored Tioga, under average flow conditions, through Mansfield and into the Tioga-Hammond Dam Complex.

Fish and Macroinvertebrates

Detailed fish and macroinvertebrate data for the Tioga River can be found in Appendices C and D of this report. This section of the report will offer a summary and analysis of the data in Appendices C and D.

The headwaters of the Tioga River (upstream of Fall Brook) have been sampled by SRBC and PADEP five times since 2009. Sampling in the headwaters has consistently shown an unimpaired watershed with 8-11 species including native brook trout and wild brown trout. Pollution intolerant darters and sculpins were also collected in each survey (Table 31).

Table 31. Average Fish Species and Individuals at Three Sites in the Tioga River Watershed

Site	# Species	# Individuals
Tioga Headwaters	9.80	522.80
Tioga US Morris Run	4.33	62.00
Tioga DS Morris Run	0.25	0.25

Since 2015, the Tioga River immediately upstream of Morris Run has been sampled three times by SRBC and PADEP. While species numbers and individuals are significantly reduced from headwater areas, this station has improved since the TCCCC treatment system installation on Fall Brook. Native brook trout and wild brown trout have been collected, as well as sculpins, demonstrating good water quality. This site suffers from the fact that it receives no colonization of fish from downstream areas because of the mainstem AMD impacts primarily caused by Morris Run and Coal Creek.

Downstream of Morris Run, no fish community exists, even as far down as Mansfield, prior to entry to the Tioga-Hammond Dam Complex. During high flow conditions when water quality around Mansfield is less impaired, there is anecdotal evidence of fish moving into the Tioga River from Tioga Dam. However, those fish quickly retreat to the dam once water quality degrades during lower flows.

Once restored, the sections of the Tioga downstream of Morris Run should be colonized quickly by Johnson Creek, unimpaired tributaries that enter downstream of Bear Creek, and from Tioga-Hammond Dam. For example, Elk Run, a large tributary to the Tioga that enters between the towns of Covington and Canoe Camp, has been sampled twice by SRBC since 2009. On both occasions, over 1,000 fish were collected representing an average of 15 species, including game species such as bluegill, green sunfish, hatchery trout, pumpkinseed, redbreast sunfish, rock bass, and white sucker. Once the water quality block caused by Morris Run and Coal Creek is removed, fish connectivity and recolonization of the Tioga mainstem should be quick.

Even though Morris Run upstream of DMR04 is slightly impacted by AMD, a small population of blacknose dace were collected there by PADEP in 2018. The headwaters section of Morris Run is just cut off from downstream fish migration due to AMD impacts. Once remedied, fish should be able to move to the Morris Run headwaters to occupy this available habitat.

A watershed-wide macroinvertebrate survey was conducted by PADEP in 2018. Upstream of Morris Run, the macroinvertebrate communities at the two stations demonstrate a non-impaired system (Table 32). The station just upstream of Morris Run is so high in quality (96.2 IBI) that it could be considered as a high-quality stream reference point, which demonstrates the success of the TCCCC's Fall Brook treatment system. The macroinvertebrate community at this station is also a good indicator that the fish community should improve over time once the Morris Run/Coal Creek water quality block is removed and recolonization can occur from downstream sources of fish from unimpaired tributaries.

Upon the confluence of Morris Run, the macroinvertebrate community becomes heavily impacted, particularly in terms of number of individuals and taxa richness. The worst of the five stations was actually found at Mansfield, possibly because of the amount of precipitated metals in the stream substrate due to an increased stream pH in Mansfield.

Two stations were sampled on Morris Run: upstream of the Morris Run Reservoir and at its mouth (Table 33). Upstream of the Morris Run Reservoir, which is upstream of DMR04, Morris Run could be considered an unimpaired stream due to a macroinvertebrate community that just meets standards (56.7 IBI). This demonstrates that if upper reaches of Morris Run were reconnected with upper and lower reaches of the Tioga River that contain fish populations, recolonization could occur.

At Morris Run's mouth, downstream of all AMD impacts, the macroinvertebrate community is heavily impacted, having the lowest IBI score (12.5) of the seven stations collected upstream of the Tioga–Hammond Dam.

Table 32. Macroinvertebrate Statistics for Select Sites in the Tioga River Watershed in 2018

	Headwaters	**US Morris Run**	**DS Morris Run**	**DS Coal Creek**	**@ Mansfield**
Individuals	214	200	46	34	16
Taxa Richness	21	26	12	10	4
EPT Taxa	11	17	7	4	1
Becks Index	24	29	15	6	0
Hilsenhoff Index	3.35	1.86	2.61	4.82	5.06
Shannon Diversity	2.36	2.68	2.03	1.81	1.18
Percent Sensitive Individuals	42.52	75.00	71.74	29.41	18.75
IBI Score	66.60	96.20	70.30	44.40	26.60
EPT Absent	No	No	No	No	No
Becks <33% & Sens. Ind <25%	No	No	No	No	No
BCG Ratio	No	No	No	No	Yes
Acidification	No	No	No	No	No
Impaired	No	No	Yes	Yes	Yes

Table 33. Macroinvertebrate Statistics for Two Stations on Morris Run in 2018

	Headwaters	**Mouth**
Individuals	204	86
Taxa Richness	14	5
EPT Taxa	5	0
Becks Index	14	0
Hilsenhoff Index	2.72	5.98
Shannon Diversity	2.10	0.30
Percent Sensitive Individuals	60.29	0.00
IBI Score	56.70	12.50
EPT Absent	No	Yes
Becks <33% and Sensitive Ind <25%	No	Yes
BCG Ratio	No	Yes
Acidification	No	No
Impaired	No	Yes

Consequently, due to this data analysis, and the fact that PFBC plans to extend its Trout Stock Fishery designation 1.5 miles downstream of Morris Run, SRBC believes that 22.463 miles of the Tioga River will meet at least Lower Tier Restoration Goals as outlined in PADEP's *Acid Mine Drainage Set-Aside Program: Program Implementation Guidelines* document (2016).

In addition, due to the mixing and dilution of untreated loading in the Morris Run Watershed, SRBC believes that the entire impaired segments of Morris Run (7.32 stream miles) will meet Lower Tier Restoration Goals as outlined in the same.

Technology Analysis

The flows and quality of the influent to be treated eliminates any possibility of using passive technologies. Using PADEP's Risk Analysis Matrix for Passive Treatment Systems, the risk would be considered as "High" (Table 34). To even be considered of "Medium" risk, the influent to the treatment system would have to be split into at least seven separate treatment cells, which is not feasible.

Table 34. Passive Treatment System Risk Analysis Matrix

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 < 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
	> 200 < 400 GPM	**> 400 < 800 GPM**	**> 800 < 1600 GPM**	**> 1600 GPM**
< 5 mg/l	Medium	Medium	Medium	High
> 5 < 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

* Where the Tioga discharges would be ranked in the Risk Analysis Matrix if treated passively.

Over the last 10 years, PADEP has identified streams where one large ATP treating large quantities of discharge water could restore significant stream miles. The Lancashire ATP has improved about 30 miles of the West Branch Susquehanna River and has created a significant brown trout fishery near the towns of Northern Cambria and Cherry Tree. The Hollywood ATP has improved about 33 miles of the Bennett Branch of Sinnemahoning Creek to the point that sections are now being stocked with trout by the PFBC. The Cresson ATP, which has just recently come online in 2019, has the potential to restore/improve 21 miles of Clearfield Creek.

In addition to these already constructed facilities, PADEP also has plans to design and construct 1) the Wehrum ATP, which will restore/improve 25 miles of Blacklick Creek; 2) an ATP in the headwaters of Little Conemaugh River, which will restore/improve 20 miles; and, 3) the Quakake ATP, which will restore/improve 11 miles of the Lehigh River. Possible large-scale ATPs have also been planned for Chartiers Creek just outside of Pittsburgh, Shade Creek in Somerset County, and in the headwaters of Catawissa Creek west of Hazleton.

The planned Tioga ATP should be very similar to the Hollywood ATP due to the amount of infrastructure both need to convey discharge water to the centralized plant and the flow and quality of water to be treated. Consequently, the Hollywood ATP capital costs and O&M costs will be used as a starting point to estimate costs for the Tioga ATP. According to PADEP, Hollywood treats on average 2.88 MGD of water and treated 4.61 MGD in 2018, the wettest year on record. On average, the Tioga ATP would have to treat 3.99 MGD and a high of around 8.66 MGD because the Tioga mine pools are free-draining and offer no real ability for storage. Consequently, to accommodate these infrequent high flow periods, the Tioga ATP may need two clarifiers or a larger clarifier, which is the one possible difference from the Hollywood ATP.

In terms of loading between the two plants, the Tioga ATP will have to treat more acid loading on average than the Hollywood Plant, about 23 percent more than the Hollywood plant had to treat in 2018, the wettest year on record (Table 35). However, in terms of metal loading, the influent of both plants are similar. On average, the Tioga ATP would have to accommodate 11 percent more metal loading. However, if you compare the Tioga average with the metal loading that was treated at Hollywood in 2018, the Tioga ATP would have to accommodate 27 percent less.

Table 35. Comparison of Acidity and Metal Loading between the Hollywood ATP and the Planned Tioga ATP

ATP	Acid Load	Fe Load	Al Load	Metal Load
	Tons/Year	Tons/Year	Tons/Year	Tons/Year
Hollywood Average	952	170	81	251
Hollywood 2018	1467	252	129	381
Tioga Average	1808	128	150	278
Tioga % Difference (Avg)	90	-25	85	11
Tioga % Difference (2018)	23	-49	16	-27

Consequently, the costs to construct the Tioga ATP should be relatively comparable to the 2019 adjusted costs to construct the Hollywood ATP, particularly since significant discharge conveyance infrastructure is needed for both plants. The only difference, as discussed, may be the need for a larger or secondary clarifier to accommodate the high flows at Tioga due to the lack of mine pool storage potential.

The Hollywood ATP includes two ferrous Fe oxidation reactors, a 180-foot diameter clarifier, two sludge conditioning reactors, a high-density slurry system that includes sludge recirculation technology, and a 4.5-acre polishing pond (Figure 26).

According to PADEP, the 2017 adjusted cost to construct the Hollywood ATP was $15,509,262. Adjusted to 2019 costs and the need for a larger or additional clarifier (additional $368,143 according to OSM's AMDTreat software), capital construction costs for the Tioga ATP could be as high as $16,821,919. Adding in 10 percent for engineering, total design and construction could total **$18,504,111**.

Alternatives Analysis

As mentioned, with the large flow and significantly impaired water quality of the influent that is planned to be treated at the Tioga ATP, a passive treatment alternative or another type of active treatment is not feasible.

When using PADEP's Risk Analysis Matrix, a passive alternative would be considered a "High" risk. In addition, the influent water would have to be split into seven separate treatment cells to obtain even a "Medium" ranked risk passive system, which is also not feasible. A seven cell treatment system would be very large (as large as 60 acres in size according to OSM's AMDTreat software). With the land being used for treatment being PADCNR Tioga State Forest, a goal for the system should be to minimize the size of the construction footprint. According to PADEP, the Hollywood ATP has a project area of 41 acres.

Figure 26. Aerial Photo of the Hollywood ATP

SRBC agrees with PADEP that the only cost and size feasible method for treatment of the proposed influent is a hydrated lime/clarifier plant, which would be very similar to the Hollywood ATP that treats a very similar quantity and quality of water.

Operation and Maintenance

O&M at the Tioga ATP should be slightly more than the annual O&M costs at the Hollywood ATP due to the influent containing a higher acid load. According to OSM's AMDTreat software, the chemical cost of the Tioga ATP could be as high as $347,601 per year (Appendix K). Adding in normal electrical and labor costs of other similar ATPs that include pumping of water and sludge, total yearly O&M costs of the Tioga ATP could be as high as **$715,601**.

Benefit/Cost Analysis

To determine the value of the benefits of restoring the Tioga River, five distinctive benefits were calculated:

1. PFBC Recreational Use Loss Estimates for PA Streams Degraded by AMD – for base year 1989 adjusted to 2019 using the Bureau of Labor Statistics Consumer Price Index (CPI) Inflation Calculator. It is important to note that the CPI changes 12-times per year and therefore results may differ each time the data are checked.
2. SRBC calculation on the worth of Tioga-Hammond Dam water storage that could be utilized for consumptive use mitigation. SRBC would fund this amount if storage water at Tioga-Hammond could be utilized for this low flow augmentation.
3. Property value increases with a restored Tioga River and improved Morris Run, utilizing calculations offered by *An Economic Benefit Analysis for Abandoned Mine Drainage Remediation in the West Branch Susquehanna River Watershed, Pennsylvania* (2008) by TU and Downstream Strategies, LLC.
4. Tioga-Hammond Dam recreational use revenue increases, extrapolating a calculation completed for the East Branch Dam in the Clarion River Restoration Plan QHUP.
5. Funds from TCCCC's *Save the River Campaign.*

PFBC Use Loss Benefit

Stream Segment #1 – Tioga River Impaired Section Upstream of Fall Brook to Morris Run
Chapter 93 Designation: Cold Water Fishery (CWF)
Projected Use: Wild Trout (WT)
Miles Restored (Lower Tier): 4.790
Use Rate: 500 trips/year/mile
Valuation in 2019 dollars: $83.94/trip
Lost Value: $201,036.30

Stream Segment #2 – Tioga River Impaired Section from Morris Run to Bear Creek
Chapter 93 Designation: Cold Water Fishery (CWF)
Projected Use: Trout Stocked Fishery (TSF) – as communicated by Daniel Ryan of PFBC
Miles Restored (Lower Tier): 1.794
Use Rate: 1100 trips/year/mile
Valuation in 2019 dollars: $99.22/trip
Lost Value: $195,800.75

Stream Segment #3 – Tioga River Impaired Section from Bear Creek to Tioga-Hammond Dam
Chapter 93 Designation: Cold Water Fishery (CWF)
Projected Use: Warm Water Fishery (WWF) – as communicated by Daniel Ryan of PFBC
Miles Restored (Lower Tier): 15.879
Use Rate: 306 trips/year/mile
Valuation in 2019 dollars: $74.53/trip
Lost Value: $362,139.33

Stream Segment #4 – Morris Run Impaired Sections
Chapter 93 Designation: Cold Water Fishery (CWF)
Projected Use: Wild Trout (WT) – as communicated by Daniel Ryan of PFBC
Miles Improved (Lower Tier): 7.320
Use Rate: 500 trips/year/mile
Valuation in 2019 dollars: $83.94/trip
Lost Value: $307,220.40

The Net Present Value (NPV) of the benefits can be calculated using the uniform series, present worth equations, or values extracted from the uniform series present worth table in Appendix E of PADEP's *Acid Mine Drainage Set-Aside Program: Program Implementation Guidelines* document (2016).

The annual economic lost values of the portions of the Tioga River and Morris Run identified above are the basis of the project's NPV benefit evaluation. The lost value is $1,066,196.78. The following parameters are then applied to the NPV equation:

N = 50 Year
I = 5 percent
USPWF = 18.25593

Net Present Benefit = $1,066,196.78 x 18.25593 = **$19,464,413.80**

SRBC Consumptive Use Water Storage Benefit

Due to Tioga River water quality issues, five feet of storage (3,200 acre-feet or ~ one billion gallons) is held within the Hammond Lake side of the Dam complex to dilute the Tioga side, thereby improving downstream sections of the Tioga River. However, due to water quality improvements in the Tioga River, this storage water has not been used by USACE for dilution since 2011. Consequently, SRBC is interested in repurposing that water and changing operations at Tioga-Hammond that would instead allow that water to be used during drought periods for consumptive use mitigation. SRBC would pay for this use.

Utilizing SRBC's payment model used for the Billmeyer Quarry Consumptive Use Project, the worth of this water would be:

> 3,200 acre-feet x 325,851 gallons per acre-foot = 1,042,700,000 gallons
> 1,042,700,000 gallons x $0.33/1,000 gallons = $344,091 per year
> $344,091 x 18.25593 = **$6,281,701.21**

Increase in Property Value Benefit

According to *An Economic Benefit Analysis for Abandoned Mine Drainage Remediation in the West Branch Susquehanna River Watershed, Pennsylvania* (2008) report from TU and Downstream Strategies, there is a $2,587 per acre property value loss within 200 feet from an AMD-impaired stream. Using the same stream segments outlined in the PFBC Use Loss section, property value gains upon a restored Tioga River and Morris Run would be as follows:

Stream Segment #1 – Tioga River Impaired Section Upstream of Fall Brook to Morris Run
Miles Restored: 4.790
Calculation 4.79 miles (25,291.20 feet) x 400 feet (200 feet on both sides of stream) / 43,560 square feet per acre x $2,587
Value: $600,811.15

Stream Segment #2 – Tioga River Impaired Section from Morris Run to Bear Creek
Miles Restored: 1.794
Calculation 1.794 miles (9,472.32 feet) x 400 feet / 43,560 square feet per acre x $2,587
Value: $225,021.96

Stream Segment #3 – Tioga River Impaired Section from Bear Creek to Tioga-Hammond Dam
Miles Restored: 15.879
Calculation 15.879 miles (83,841.12 feet) x 400 feet / 43,560 square feet per acre x $2,587
Value: $1,991,707.78

Stream Segment #4 – Morris Run Impaired Sections
Miles Improved: 7.320
Calculation 7.320 miles (38,649.60 feet) x 400 feet / 43,560 square feet per acre x $2,587
Value: $918,149.82

Total Property Value Increases - **$3,735,690.71**

Tioga-Hammond Recreation Use Economic Increase Benefit

In the Clarion River Restoration Plan QHUP, the USACE estimated a $750,000 per year economic benefit to a restored East Branch Dam (1160 acres). Using this value to extrapolate, a restored

Tioga Dam at 498 acres should have a $321,975 yearly economic increase. Using the 50-year USPWF of 18.25593, the NPV is **$5,877,953.06.**

TCCCC Save the River Campaign Contribution

The $127,000 raised by TCCCC for operation and maintenance needs of the future AMD treatment systems to be built is also added as a benefit.

Total Tioga River ATP Benefit	**$35,486,758.80**
Design Cost	$1,682,191.90
Capital Construction Cost	$16,821,919.00
Operation and Maintenance Cost	$13,063,961.80
Total Cost	**$31,568,072.70**
Benefit/Cost Ratio	**1.124 : 1.000***

*Costs of the plant can overrun cost projections by $3,918,686 and still meet the Benefit/Cost Analysis

Literature Cited

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Appendix A

October 25 and 26, 2018 Water Quality Data

Station Description	Lat	Long	Date	Time	Q	F pH	L pH	F Cond	L Cond	DO	Temp	Turb	Alk	Acid	Fe	Mn	Al	SO_4	TSS	TDS
					CFS	SU	SU	uS/cm	uS/cm	mg/l	^{o}C	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Tioga at Morris Run Road Bridge	41.6589	-77.0479	10/25/2018	930	93.563	6.75	6.6	57	70	11.89	6.24	0.41	7	0.2	0.127	0.24	0.112	16.2	<5.00	41
Morris Run Near Mouth	41.6610	-77.0450	10/25/2018	930	9.124	3.55	3.44	669	670	11.07	6.96	-1.7	0	71	1.911	8.305	8.393	254.2	<5.00	393
Morris Run Discharge #1	41.6701	-77.0209	10/25/2018	1015	0.344	3.28	3.19	1167	1150	8.43	9.32	-2.7	0	108	1.811	14.86	11.542	574.5	<5.00	750
Morris Run Discharge #3	41.6741	-77.0172	10/25/2018	1000	0.312	3.09	3	1390	1370	9.82	9.9	-2.4	0	209	4.75	17.04	24.48	612.1	<5.00	862
Morris Run Discharge #4	41.6821	-77.0099	10/25/2018	1030	2.78	3.23	3.19	1074	1040	4.44	8.79	0	0	126	3.983	14.69	13.705	336.6	<5.00	671
Morris Run US Discharge #4	41.6807	-77.0199	10/25/2018	1045	2.054	6.29	5.41	31	40	11.13	6.29	-1.8	2	7	0.096	0.26	0.224	10.7	<5.00	26
Unnamed Trib #1	41.6636	-77.0570	10/25/2018	1100	0.101	3.76	3.86	529.8	550	9.55	8.46	0.36	0	77	0.41	8.264	11.507	261.1	6	366
Unnamed Trib #2	41.6666	-77.0573	10/25/2018	1130	0.022	6.36	6.65	74.8	80	12.56	5.65	4.75	12	-4	0.135	0.037	0.108	18.7	<5.00	55
Coal Creek Mouth	41.6715	-77.0581	10/25/2018	1130	6.685	2.96	2.88	1274	1240	10.93	8.11	-1.8	0	241	19.13	6.03	20.13	583.7	<5.00	640
Coal Creek Discharge #5	41.6766	-77.0581	10/25/2018	1300	6.186	2.93	2.66	1431	1380	9.73	9.54	-2.8	0	277	22.441	7.064	24.039	802.2	<5.00	734
Coal Creek US Discharge #5	41.6764	-77.0493	10/25/2018	1245	0.499	6.38	6.16	83	90	11.42	5.53	1.8	5	5	1.625	0.374	0.466	24.9	9	85
Bear Creek Mouth	41.6826	-77.0626	10/25/2018	1215	1.213	3.12	2.97	898	880	11.03	7.74	-2.5	0	142	4.96	6.39	14.52	273.5	<5.00	463
Johnson Creek Mouth	41.6780	-77.0683	10/25/2018	1200	28.415	6.71	6.52	147.8	160	11.52	7.11	1.66	11	-2	0.202	0.397	0.355	35.7	<5.00	109
Tioga River DS Bear Creek	41.6918	-77.0692	10/25/2018	940	145.104	4.32	4.52	167	180	11.83	6.44	4.7	0	17	1.073	1.109	1.713	60.2	6	129
East Creek Mouth	41.6950	-77.0693	10/25/2018	1230	3.719	6.4	6.45	33.2	40	11.68	6.62	15.21	5	2	0.382	0.018	0.339	12.8	<5.00	51
Unnamed Trib #3	41.6945	-77.0752	10/25/2018		0	dry	NA	dry	NA	dry	dry	dry	NA	NA	NA	NA	NA	NA	NA	NA
Unnamed Trib #4	41.6985	-77.0759	10/25/2018	1300	1.247	6.6	6.56	35.2	40	11.47	7.37	0.06	6	1	0.044	0.018	0.057	<10.0	<5.00	43
Unnamed Trib #5	41.7024	-77.0719	10/26/2018	1015	0.579	7.34	6.64	50	50	11.31	7.83	2.1	10	-4	0.017	0.0134	0.002	21	<5.00	51
Unnamed Trib #6	41.7191	-77.0794	10/26/2018	1030	0.056	7.5	6.94	64	80	11.62	7.06	1.4	26	-22	0.023	0.011	0.051	<10.0	<5.00	61
Tioga River at Williamson Road	41.7272	-77.0821	10/25/2018	1030	157.62	4.78	4.7	156	170	11.77	6.52	3.1	1	12	0.881	1.049	1.57	57.9	5	98
Marvin Creek Mouth	41.7295	-77.0837	10/25/2018	1215	4.657	6.95	7.06	115	130	11.65	7.81	2.2	45	-37	0.205	0.036	0.163	<10.0	<5.00	78
Unnamed Trib #7	41.7328	-77.0809	10/25/2018	1145	0.092	6.99	6.96	85	90	12.38	5.59	2.1	34	-27	0.622	0.038	0.613	<10.0	9	64
Unnamed Trib #8	41.7396	-77.0772	10/25/2018	1115	0.008	6.62	7.51	330	350	12.13	4.89	0.2	103	-98	0.034	0.018	0.007	12.9	<5.00	198
Wilson Creek Mouth	41.7489	-77.0782	10/25/2018	1330	0.834	7.14	7.47	208	220	11.2	8.16	8.4	79	-73	0.358	0.116	0.315	15.3	<5.00	120
Unnamed Trib #9	41.7447	-77.0827	10/25/2018	1400	0.022	7.12	7.12	201	220	8.86	7.15	173.4	83	-75	0.096	0.022	0.018	<10.0	<5.00	119
Unnamed Trib #10	41.7464	-77.0838	10/25/2018	1430	0.792	8.47	7.8	211	230	11.96	7.11	66.1	93	-86	2.857	0.051	3.718	19.8	50	129
Elk Run Mouth	41.7605	-77.1028	10/25/2018	1530	14.544	9.04	7.91	179	190	11.98	8.3	6.5	70	-63	0.248	0.023	0.213	22.3	<5.00	95
Unnamed Trib #11	41.7808	-77.0692	10/25/2018	1600	0.587	7.55	7.59	317	340	10.9	7.69	3.82	109	-103	0.644	0.281	0.025	15.8	<5.00	175
Canoe Camp Creek Mouth	41.7828	-77.0693	10/25/2018	1330	7.425	8.43	7.59	179	200	12.48	7.85	67.85	73	-67	1.387	0.037	1.623	14.3	22	106
Slate Creek Mouth	41.7861	-77.0756	10/25/2018	1400	0.634	8.18	7.79	239	260	12.36	7.06	62.32	94	-85	1.101	0.024	1.472	12.2	12	141
Tioga River US Mansfield	41.7970	-77.0800	10/25/2018	1015	195	6.75	6.59	151	170	12.01	6.5	10.45	10	-2	0.697	0.804	1.142	46.8	10	85
Unnamed Trib #12	41.8006	-77.0707	10/25/2018	1500	0.066	8.06	7.61	142	160	12.49	7.93	1.04	66	-56	0.032	0.017	0.111	<10.0	<5.00	87
Ellen Run Mouth	41.8051	-77.0838	10/25/2018	1515	0.763	8.9	8.3	348	370	13.16	7.14	9.39	115	-111	0.113	0.031	0.116	18.7	<5.00	199
Corey Creek Mouth	41.8109	-77.0820	10/25/2018	1345	14.551	7.57	7.63	229	240	12.52	8.08	1	79	-73	0.098	0.046	0.072	12.3	<5.00	139
Manns Creek Mouth	41.8237	-77.0948	10/25/2018	1530	1.609	7.98	7.62	179	200	11.97	7.84	20.1	78	-74	0.871	0.03	1.141	<10.0	13	113
Kelly Creek Mouth	41.8297	-77.0911	10/25/2018	1500	0.627	6.61	7.75	205	230	12.18	6.62	6.5	81	-64	0.687	0.052	0.84	11.9	7	131
Lambs Creek Mouth	41.8400	-77.1085	10/26/2018	915	6.075	8.1	7.55	149	160	12.33	6.28	1.5	59	-53	0.015	0.014	0.02	<10.0	<5.00	96
Unnamed Trib #13	41.8520	-77.1095	10/25/2018	1430	1.383	7.63	7.5	140	150	11.53	8.1	0.9	53	-47	0.673	0.163	0.167	<10.0	6	79

Appendix B

TCCCC Save the River Campaign Letter

TCCCC, Inc.
P.O. Box 124
Blossburg, PA 16912
www.tcccc-inc.org

May 7, 2019

Mr. Tom Malesky, P.E.
Environmental Program Manager - DEP
Bureau of Abandoned Mine Reclamation
Acid Mine Drainage Division
Cambria District Office
286 Industrial Park Road
Ebensburg, PA 15931

Dear Mr. Malesky:

The Tioga County Concerned Citizens Committee (TCCCC) was formed in 1984 to help protect and improve the environment of Tioga County, PA. In 2001, we partnered with the Hillside Rod & Gun Club and other local organizations and government agencies to spearhead the reclamation of the Upper Tioga River Watershed which has been polluted with Acid Mine Drainage from deep and strip mining for coal.

In 2013, we began working with Southwestern Energy to use private industry funds to construct the first AMD treatment systems. In 2015, following the completion of the construction of those systems, we began an effort to raise money for future operation and maintenance expenses for the subsequent systems we hope to see constructed. To date we have raised just over $127K. This total represents donations from as little as $5.00 to as much as $15,000 from 23 individuals and families, 13 businesses, 5 municipalities, and 15 civic organizations.

Everyone is excited and supportive of the efforts of the Bureau of Abandoned Mine Reclamation to pursue the treatment of the two remaining significant polluting tributaries to the Tioga River, Morris Run and Coal Creek. We hope our financial contribution to this effort will demonstrate our commitment to see the Tioga River restored so that it once again supports aquatic life.

Sincerely,

Charles W. Andrews
President – TCCCC

cc: Tom Clark - SRBC

Appendix C

Tioga River and Morris Run Macroinvertebrate Data

Location	Morris Run Headwaters	Morris Run Mouth	Tioga Headwaters	Tioga US Morris Run	US Coal Creek	US East Creek	At Mansfield
Agency	DEP	DEP	DEP	DEP	DEP	DEP	DEP
Lat	41.6963	41.6633	41.6947	41.6588	41.6684	41.6935	41.8066
Long	-77.0102	-77.0530	-76.9315	-77.0478	-77.0586	-77.0717	-77.0830
Date	9/4/2018	9/4/2018	9/4/2018	5/9/2018	5/9/2018	5/9/2018	5/9/2018
Leuctra	51		17	18	15	5	
Chironomidae	45	81	51	18	10	15	8
Sweltsa	23		9	11			
Nemoura	22						
Rhyacophila	16		3				
Cheumatopsyche	16		15	4		2	
Polycentropus	13			6	1		
Dicranota	7						
Pseudulimnophilia	3						
Cambaridae	3						
Cambarius				1			
Acroneuria	1		3	1	1		
Simulium	1		4				
Oligochaeta	1				2	2	
Sialis		2		1			
Agabus		1					
Oulimnius		1					
Hemerodromia		1					
Dolophilodes			44				
Hydropsyche			24	11			4
Twinnia			1				
Probezzia			1			1	
Hexatoma			4	5	1	1	
Mesovelia			3				
Boyeria			1				
Neophemera			1				
Leptophlebia			15	3			
Cinygmula			1	1			
Epeorus			2	34	2		
Ephemerella			5	8	2	1	
Baetis			9	2			
Isoperla			1	8			
Stenelmis				2			
Lepidostoma				2	2		
Mystacidea				1			
Alloperla				2			
Haploperla				31			
Maccaaffertium				2	6	1	3
Stenocron				1			
Isonychia				1			
Serratella				22			
Drunella				4			
Nigronia					2		
Allocapnia					2		
Chelifera	2					4	
Amphinemura						2	
Gammarus							1
Total	204	86	214	200	46	34	16

Appendix D

Tioga River Watershed Fish Data

Location	Morris Run Headwaters	Morris Run Mouth	Tioga Headwaters	Tioga Headwaters	Tioga Headwaters	Tioga Headwaters	Tioga Headwaters
Agency	**DEP**	**DEP**	**SRBC**	**SRBC**	**SRBC**	**SRBC**	**DEP**
Lat	**41.6963**	**41.6633**	**41.6838**	**41.694482**	**41.67737**	**41.694482**	**41.6947**
Long	**-77.0102**	**-77.0530**	**-76.9355**	**-76.93187**	**-76.94263**	**-76.93187**	**-76.9315**
Date	**9/4/2018**	**9/4/2018**	**10/6/2009**	**9/9/2013**	**9/16/2015**	**9/27/2016**	**9/4/2018**
Banded Darter							
Black Crappie							
Blacknose Dace	3		167	310	418	472	84
Bluegill							
Bluntnose Minnow							
Brown Bullhead			2	1			
Central Stoneroller							**1**
Chain Pikeral							
Channel Catfish							
Comely Shiner							
Common Carp							
Common Shiner							
Creek Chub			22	79	62	53	**1**
Cutlips Minnow			2	4	11	11	**1**
Fallfish							
Green Sunfish							
Greenside Darter							
Hatchery Brook Trout							
Hatchery Brown Trout							**1**
Hatchery Rainbow Trout							
Largemouth Bass							
Longnose Dace			9	7	46	15	
Marginated Madtom							
Mimic Shiner							
Northern Hogsucker							
Pearl Dace				2		63	
Pumpkinseed					1		
Redbreast Sunfish							
Redside Dace						1	
River Chub							
Rock Bass							
Rosyface Shiner							
Sculpin			26	94	128	256	**3**
Shield Darter							
Smallmouth Bass							
Spottail Shiner							
Spottail Shiner							
Tesselated Darter			1	2	10	1	**2**
White Crappie							
White Sucker			11	37	10	28	
Wild Brook Trout			7	40	15	43	**5**
Wild Brown Trout			1	18		30	
Yellow Bullhead							
Yellow Perch							
Total Individuals	3	0	248	594	701	973	98
Total Species	1	0	10	11	9	11	8

Location	Tioga US Morris Run	Tioga US Morris Run	Tioga US Morris Run	Tioga US Coal Creek	Tioga US East Creek	Tioga @ Mansfield	Tioga at Mansfield
Agency	**SRBC**	**SRBC**	**DEP**	**DEP**	**DEP**	**SRBC**	**DEP**
Lat	**41.66071**	**41.653888**	**41.6588**	**41.6684**	**41.6944**	**41.760386**	**41.8066**
Long	**-77.04926**	**-77.031944**	**-77.0478**	**-77.0586**	**-77.0738**	**-77.083952**	**-77.0830**
Date	**7/21/2015**	**9/16/2015**	**9/4/2018**	**5/9/2018**	**5/9/2018**	**5/3/2010**	**5/9/2018**
Banded Darter							
Black Crappie							
Blacknose Dace	75	2	16				
Bluegill		1					
Bluntnose Minnow							
Brown Bullhead							
Central Stoneroller							
Chain Pikeral							
Channel Catfish							
Comely Shiner							
Common Carp							
Common Shiner							
Creek Chub	27	12					
Cutlips Minnow							
Fallfish							
Green Sunfish							
Greenside Darter							
Hatchery Brook Trout							
Hatchery Brown Trout							
Hatchery Rainbow Trout	1						
Largemouth Bass							
Longnose Dace							
Marginated Madtom						1	
Mimic Shiner							
Northern Hogsucker							
Pearl Dace							
Pumpkinseed							
Redbreast Sunfish							
Redside Dace							
River Chub							
Rock Bass							
Rosyface Shiner							
Sculpin	8	1					
Shield Darter							
Smallmouth Bass							
Spottail Shiner							
Spottail Shiner							
Tesselated Darter							
White Crappie							
White Sucker	14						
Wild Brook Trout	22	6					
Wild Brown Trout			**1**				
Yellow Bullhead							
Yellow Perch							
Total Individuals	147	22	17	0	0	1	0
Total Species	6	5	2	0	0	1	0

Location	Tioga DS Tioga-Hammond	Tioga DS Tioga-Hammond	Fall Brook Headwaters	Fall Brook at River Road	Carpenter Run	Taylor Run	Bellman Run	Elk Run	Elk Run	Lambs Creek
Agency	**SRBC**	**SRBC**	**DEP**	**SRBC**	**SRBC**	**SRBC**	**SRBC**	**SRBC**	**SRBC**	**SRBC**
Lat	**41.9226**	**41.9226**	**41.7243**	**41.6779**	**41.65094**	**41.64904**	**41.65169**	**41.75616**	**41.827003**	**41.82679**
Long	**-77.1292**	**-77.1292**	**-76.9806**	**-76.9885**	**-77.03459**	**-77.04449**	**-77.09486**	**-77.1316**	**-76.98668**	**-77.14464**
Date	**8/4/2009**	**8/21/2013**	**4/16/1981**	**11/21/2017**	**6/3/2014**	**6/2/2014**	**6/2/2014**	**8/5/2009**	**6/26/2017**	**6/3/2014**
Banded Darter	6	27								
Black Crappie		18								
Blacknose Dace						20	97	547	53	437
Bluegill	4	51							2	
Bluntnose Minnow	10	94							30	
Brown Bullhead										
Central Stoneroller		17						298	318	8
Chain Pikeral	5	24								
Channel Catfish	1	2								
Comely Shiner	1									
Common Carp	1	2								
Common Shiner								33	21	
Creek Chub								58	21	167
Cutlips Minnow								88	100	
Fallfish	31									
Green Sunfish		12							38	
Greenside Darter	12	12								
Hatchery Brook Trout						17	1			
Hatchery Brown Trout						2				
Hatchery Rainbow Trout								1		
Largemouth Bass	2	8								
Longnose Dace	1	3						185	42	
Marginated Madtom		1						13	103	
Mimic Shiner	5	335								
Northern Hogsucker	2	2						5		
Pearl Dace										
Pumpkinseed		10							4	
Redbreast Sunfish	1								11	
Redside Dace								5		
River Chub	1	2						11		
Rock Bass	13	20							8	
Rosyface Shiner		1								
Sculpin		1			61	24	54			523
Shield Darter	3									
Smallmouth Bass	3	4								
Spottail Shiner		37						2		
Spottail Shiner		4							264	
Tesselated Darter	22	35						2	109	
White Crappie	1									
White Sucker	17	15						15	25	
Wild Brook Trout			151		145	50	57			1
Wild Brown Trout										
Yellow Bullhead	4	18								
Yellow Perch	4	43								
Total Individuals	150	798	151	0	206	113	209	1263	1149	1136
Total Species	23	27	1	0	2	5	4	14	16	5

Appendix E

Tioga River and Morris Run Habitat Data

Location	Morris Run Headwaters	Morris Run Mouth	Tioga Headwaters	Tioga US Morris Run	US Coal Creek	US East Creek	At Mansfield
Agency	DEP	DEP	DEP	DEP	DEP	DEP	DEP
Lat	41.6963	41.6633	41.6947	41.6588	41.6684	41.6935	41.8066
Long	-77.0102	-77.0530	-76.9315	-77.0478	-77.0586	-77.0717	-77.0830
Date	9/4/2018	9/4/2018	9/4/2018	5/9/2018	5/9/2018	5/9/2018	5/9/2018
Instream Cover	15	17	18	15	17	12	16
Epifaunal Substrate	18	17	19	17	17	12	16
Embeddedness	14	8	17	18	18	16	6
Velocity/Depth Regimes	14	10	18	19	18	15	15
Channel Alteration	19	18	15	15	15	15	15
Sediment Deposition	14	18	19	17	17	16	16
Frequency of Riffles	19	18	19	19	18	14	15
Channel Flow Status	19	18	19	19	19	19	19
Condition of Banks	18	18	18	17	19	13	19
Bank Vegetative Protection	18	18	14	17	16	19	8
Grazing or Other Disruptive Pressure	16	18	14	12	12	19	8
Riparian Vegetative Zone Widths	15	18	14	12	13	13	3
Total	199	196	204	197	199	183	156

Appendix F

DCC05 Historical Water Quality Data

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	DisFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1/10/1967	2.92				2.7		1427	115	0.5					755		
1/17/1967	3.45				2.8		1412	126	0.6					787		
1/25/1967	2.76				2.8		1096	97.5	1.2					666		
4/4/1967	20.5				2.8		680	61.5	4.7					437		
4/11/1967	12.5				3		680	62	2.5					433		
4/18/1967	7.2				2.9		747	68	4.3					474		
6/13/1973	14.938				2.8		1059	39.8			12.5	39	0	550		1465
6/21/1973	10.241				2.8		1300	49.5			13.9	22.5	0	736		1612
6/28/1973	9.606				2.8		1310	44.3			12	26.9	0	700		1634
7/5/1973	11.619				2.8		1240	37.9			9.7	26	0	690		1605
7/12/1973	8.9				2.8		1496	53			16.2	29.8	0	730		1670
7/19/1973	6.957				2.7		1200	42			12.1	46.9	0	710		1784
7/26/1973	7.487				2.8		1180	42.5			12	42.7	0	780		1784
8/2/1973	7.098				2.8		1230	45.6			12.2	40.1	0	790		1871
8/8/1973	5.933				2.8		1240	68.3			16.2	45.2	0	840		1970
8/16/1973	8.581				2.8		1670	71.2			17.5	50.5	0	870		2092
8/23/1973	9.817				2.8		1460	69.8			15.8	52	0	850		1803
8/30/1973	6.886				2.8		1310	56.1			12.8	51.5	0	820		1858
9/6/1973	5.756				2.8		1480	52.1			14.9	56.9	0	860		1945
9/13/1973	5.297				2.8		1510	63			18.3	54.1	0	870		2041
9/19/1973	6.674				2.8		1520	69.5			16.8	46.8	0	800		1927
10/4/1973	7.875				2.8		1370	75.2			17.5	38.3	0	790		1901
10/16/1973	4.979				2.8		1420	84.5			18.7	57.5	0	860		1948
11/1/1973	9.994				2.9		1370	78.6			17.4	52.4	0	830		1815
11/15/1973	7.628				2.9		1350	72.8			16.1	48.5	0	830		1774
11/29/1973	11.548				2.9		1100	75.1			14.9	42.6	0	700		1636
12/12/1973	16.28				2.9		1090	66			14.1	42.1	0	680		1540
12/26/1973	15.821				2.9		950	75.2			13.2	41.5	0	564		1406

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	DisFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1/10/1974	9.535				2.9		1150	82.6					0	660		
1/23/1974	9.535				2.9		1090	64.9					0	670		
2/5/1974	13.702				2.9		850	69.7					0	600		
2/20/1974	6.92				2.9		1150	88.6			15	38.1	0	690		
3/6/1974	7.204				2.9		1060	50.3					0	630		
3/19/1974	7.098				2.8		920	40.1					0	590		
4/1/1974	6.498				2.8		850	50.3					0	590		
4/15/1974	10.983				2.8		820	47.6					0	570		
4/29/1974					2.8		1050	56.2					0	590		
5/13/1974					2.8		1040	49.6					0	630		
5/27/1974	5.121				2.8		1050	49.4					0	620		
6/10/1974	3.567				2.8		1200	60					0	650		
6/24/1974	3.108						1290	64.4					0	770		
7/11/1974	3.885				2.8		1260	69.8					0	790		
7/29/1974	2.613				2.8		1310	73.3					0	780		
8/5/1974	2.507				2.8		1500	77.2					0	860		
8/19/1974	2.613				2.9		1350	75					0	840		
9/2/1974	1.872				2.8		1700	100					0	960		
9/16/1974	1.872				2.8		1700	84.9					0	990		
9/30/1974	2.013				2.8		1960	81.1					0	1020		
10/13/1974	1.872				2.8		2130	84.3					0	1065		
10/27/1974	1.872				2.8		1650	115					0	970		
11/10/1974	2.154				2.8		1660	99.4					0	1060		
11/23/1974	3.567				2.9		1260	75.6					0	790		
12/9/1974	5.121				2.8		1240	77.8					0	840		
12/21/1974	6.498				2.9		1320	87.8					0	770		
1/5/1975	4.944				3		1070	67.6					0	760		
1/18/1975	8.052				3		940	65.7					0	710		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	DisFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
2/2/1975	6.816				2.9		1000	61.1					0	690		
2/15/1975	4.485				2.9		1040	68.8					0	810		
3/7/1975	6.816				3		1120	83.7					0	810		
3/14/1975	5.262				3.1		950	62.7					0	700		
3/31/1975	6.957				2.9		850	58.1					0	600		
4/13/1975	5.262				2.9		1050	62.7					0	680		
4/25/1975	4.026				2.7		1070	66.1					0	730		
5/9/1975	7.275				2.9		980	60.6					0	630		
6/3/1975	3.39				2.9		900	61.5					0	650		
6/7/1975	4.803				2.9		1180	71.4					0	670		
6/14/1975	2.013				2.8		1690	86.8					0	1080		
6/23/1975	3.885				2.8		1140	71.2					0	755		
7/1/1975	3.108				2.8		1350	92.8					0	790		
7/16/1975	2.79				2.8		1350	79.5					0	820		
8/1/1975	2.472				2.8		1650	80.7					0	960		
8/28/1975	1.836				2.8		2000	124					0	1130		
9/12/1975	1.766				2.8		1850	98.4					0	1140		
9/28/1975	17.975				2.7		1820	181					0	1240		
10/12/1975	4.803				2.8		1300	74.7					0	930		
10/19/1975	5.121				2.8		1200	92					0	850		
10/25/1975	7.593				2.8		1320	65.6					0	850		
11/2/1975	5.403				2.8		1130	63					0	820		
11/9/1975	4.485				2.7		1250	104					0	850		
11/16/1975	4.167				2.8		1200	92					0	840		
11/23/1975	4.167				2.9		1340	80.7					0	800		
11/30/1975	3.39				2.8		1320	87.2			14	46.7	0	760		1814
12/21/1975	5.721				2.8		980	75.4					0	750		
1/4/1976	4.803				2.8		1050	75.4					0	720		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	DisFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1/19/1976	2.931				2.8		920	74.6					0	640		
2/1/1976	6.78				2.8		1090	79.3					0	700		
2/13/1976	3.708				3		990	74.7					0	650		
2/27/1976	9.288				2.9		870	61.6					0	560		
3/11/1976	8.052						870	69.7					0	590		
3/23/1976	5.262				2.9		940	68.3					0	620		
4/8/1976	6.18				2.8		950	66.4					0	690		
4/23/1976	3.567				2.8		1170	77.8					0	770		
5/7/1976	3.567				2.7		1310	70.7					0	720		
5/24/1976	7.098				2.9		950	67.5			9.8	38.5	0	680		1652
6/3/1976	4.167				2.8		1120	58.5					0	690		
6/18/1976	4.167				2.8		1090	76					0	740		
7/4/1976	3.708				2.8		1090	65.4					0	645		
7/19/1976	3.39				2.9		1220	70.4					0	750		
7/29/1976	2.79				2.9		1130	82.2					0	870		
8/11/1976	5.403				2.7		1170	77.7					0	820		
8/25/1976	4.026				2.9		1140	79.1					0	790		
9/8/1976	2.931				2.8		1420	93.4					0	810		
9/22/1976	2.331				2.9		1480	95.7					0	940		
10/6/1976	2.331				2.9		1550	103					0	970		
10/21/1976	3.673				2.8		1300	97.3					0	790		
11/9/1976					2.5		1000	70.5								
11/21/1976	3.32				2.5		950	80						820		
12/19/1976	12.36				2.7		900	74.75						710		
12/29/1976					2.88		900	89								
1/9/1977	3.178				2.7		1090	81						880		
1/23/1977	2.719				2.7		1280	88						780		
2/6/1977	2.472				2.6		1480	99								

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	DisFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
2/20/1977					2.8		1350							850		
3/6/1977	8.228				2.8		1220	82						760		
3/17/1977	10.383				2.8		1360									
3/30/1977					2.9		460	57						400		
4/12/1977	9.57				2.9		520	55.5								
4/26/1977	4.873				2.9		640	54								
5/10/1977	5.58				2.9		720	56								
5/24/1977	4.838				2.6		840	65.5						610		
6/7/1977	3.48				2.8		800	76.5						750		
6/21/1977	3.128				2.5		920	83.12						850		
7/5/1977	3.708				2.9		1020	83.1								
7/19/1977	3.637				2.7		1000							870		
8/3/1977	3.037				2.8		1100	100						870		
8/14/1977	2.613				2.8		1920	42						1360		
8/28/1977					2.8		870	49.5								
9/8/1977					2.6		940	103						920		
9/22/1977	4.52				2.7		800	97								
10/6/1977					2.7		736	82.5								
5/9/2001	5.35	9.4	1540		2.8		506	37.5			6.93	24	0	374	8	
6/18/2001	3.614	11.2	1718		2.8		565	39.7			9.5	34	0	447	6	
11/7/2001	2.865	10	1258		2.7		572	42.8			9.66	37.1	0	495	3	
3/19/2002	4.508	8.6	1556		2.8			37.6			12	29.7	0	415	4	
4/10/2002	7.168	8.6	1619		2.9		588	42.5			7.43	28.6	0	362	2	
5/24/2002	11.751	9.8	1524		2.9		470	39.6			6.92	25.5	0	342	2	
5/30/2002	7.146	11.6	1452		2.9		293	30.8			5.92	18.8	0	327	4	
6/19/2002	9.737	12.6	1566		2.9		423	31.5			6.9	23.3	0	352	8	
7/18/2002	4.111	17.2	1770		2.8		616	44.5			10.6	34.6	0	456	12	
8/8/2002	3.565	16.8	1972		2.8		747	51.6			13.2	40	0	521	8	

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	DisFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
8/20/2002	2.803	11	1946		2.8		128	53.4			12.4	44.8	0	578	10	
9/18/2002	2.36	18.9	2120		2.7		987	63.6			14.3	51.5	0	619	2	
4/27/2014	5.494	10.3	1220	3.04	2.9		468	23.17			5.52	18.88	0	270	5	885
7/3/2014	1.98	12.1	1480	3.09	2.8		606	28.2			7.7	30.54	0	326	5	1144
8/29/2014	1.416		1760	2.74	2.8		865	34.95			9.63	39.17	0	507	5	1326
10/23/2014	1.41	9.6	2060	2.69	2.8		939	42.58			10.08	43.64	0	499	5	1473
8/11/2015	4.802		1450	2.53	2.8		619	27.92			6.89	27.62	0	331	5	1243
9/17/2015	2.696	9.9	1640	2.8	2.8		739	31.31			8.28	33.34	0	407	5	1467
10/30/2015	5.109	9.6	1890	2.8	2.8		823	35.89			9.38	39.61	0	457	5	1569
11/24/2015	4.084	9.5	1610	3			677	27.57			7.14	30.5	0	330		
1/8/2016	7.159	9.4	1508	2.9			574	28.39			6.12	25.06	0	332		
2/1/2016	6.765	9.9	1512	2.9	2.8		609	26.51			5.94	23.2	0	304		
3/2/2016	7.351	9.3	1404	2.7			505	27.65			5.33	20.58	0	305		
3/31/2016	2.572	9.5	1458	3.1	2.8		585	28.6			6.77	26.51	0	304	5	1000
4/28/2016	3.572	9.4	1510	3	2.8		742	27.91			6.77	25.63	0	310	5	890
6/1/2016	2.435	9.6	1509	2.7	2.8		651	31.04			7.09	30.56	0	338		865
6/29/2016	2.008	9.7	1620	3.2	2.8		792	33.29			7.97	32.46	0	389		1276
8/1/2016	0.938	9.8	1167	2.8	2.8		818	40.22			9.62	43.39	0	467	5	1700
9/2/2016	0.795	9.9	1807	2.9	2.8		960	42.47			10.1	42.04	0	505	5	1720
10/10/2016	1.114	9.7	1929	2.8	2.7		1082	43.15			10.23	43.08	0	550		
2/17/2017	5.918	9	1239	3.1	2.9		590	26.64			5.5	22.56	0	288	5	895

Appendix G

DMR04 Historical Water Quality Data

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
9/21/1965	0.76				3		3437	54.5	18.5			0	352		
9/23/1965	0.7				3.5		3139	38	17.5				248		
9/30/1965	0.81				3.8		3873	46	15.4				311		
10/7/1965	0.9				3.7		4237	42	13.2				371		
10/14/1965	0.96				3.8		4448	26	8.4				300		
10/21/1965	0.55				3.7		2530	45	9.3				281		
10/28/1965	0.65				3.7		4124	76	32.7				362		
11/4/1965	0.68				3.8		4854	100	36				350		
10/19/1966								20				0	320		
1/11/1967	1.18				3.1		931	30	0.5				307		
1/18/1967	1.52				3		702	31.5	0.6				305		
1/25/1967	1.32				3.4		531	30	2.5				182		
3/28/1967	4.7				3.1		710	26	0.5				284		
4/4/1967	3.98				3.3		857	16.5	4.5				261		
4/11/1967	3.87				3.5		584	18	0				214		
4/18/1967	3.3				3.2		523	18.5	2.7				223		
7/2/1968								7.5				0	200		
8/16/1971								13				0	140		
9/18/1972								42.5				0	370		
6/13/1973	5.862				3.1		1085	16.4		45.1	27.2	0	363		1663
6/23/1973	5.121				3.1		1100	18.1		50	15	0	428		1576
6/28/1973	4.803				3.1		1210	15.4		45.9	18.7	0	400		
7/5/1973	4.626				3		1230	13.2		45.1	19.9	0	420		1839
7/12/1973	4.061				3		1288	20.1		54.9	19.9	0	410		1648
7/19/1973	3.885				3		1100	12.9		40	27.9	0	390		1632
7/26/1973	3.531				3		1060	13		39.7	23.6	0	410		1632
8/2/1973	4.026				3.1		1140	13.6		43.7	22.1	0	410		1689
10/16/1973	3.002				3.1		1410	34.8		76.2	33.8	0	480		1912

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
11/1/1973	2.649				3.2		1280	36.3		66.5	30.4	0	450		1768
11/15/1973	3.249				3.2		1160	28.4		61.2	26.8	0	450		1667
11/29/1973	3.355				3.1		1020	28.9		62.2	26.1	0	390		1610
12/12/1973	5.615				3.2		1160	33.4		67	34.2	0	480		1908
12/26/1973	6.992				3.2		1540	45.6		86.8	37.9	0	500		2115
1/10/1974	5.403				3.2		1320	38.4				0	500		
1/10/1974	5.403				3.2		1320	38.4				0	500		
1/23/1974	5.544				3.2		1090	26.7				0	420		
1/23/1974	5.544				3.2		1090	26.7				0	420		
2/5/1974	2.437				3		1150	36.4				0	470		
2/20/1974	1.201				3.2		950	32.5				0	400		
3/6/1974	2.578				3.2		1060	22.3				0	460		
3/19/1974	3.072				3		1000	17.1				0	410		
4/1/1974	2.649				3		920	16.7				0	330		
4/15/1974	3.284				3		1070	25.6				0	540		
4/29/1974	3.214				3		1000	17.8				0	350		
5/13/1974					3		960	16.6				0	340		
5/27/1974	2.367				3.1		1060	19.3				0	340		
6/10/1974	1.942				3		950	11				0	260		
6/24/1974	1.554				3		1090	13.1				0	300		
7/11/1974	1.801				3		1150	20.6				0	440		
7/29/1974	1.448				3		1100	18.6				0	370		
8/19/1974	1.095				3.1		1170	19.4				0	410		
9/2/1974	0.918				3		1150	22.5				0	410		
9/16/1974	0.989				3		1350	17.3				0	470		
9/30/1974	0.989				3		1480	22.6				0	580		
10/13/1974	0.989				3.1		1980	20				0	600		
10/27/1974	0.918				3		1570	33.2				0	560		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
11/10/1974	0.883						1570	36				0	540		
11/23/1974					3		1640	30.3				0	510		
12/9/1974					3		1460	30.2				0	490		
12/21/1974	2.154				3.1		1670	46.3				0	640		
1/5/1975	2.048				3.1		1450	31.2				0	570		
1/18/1975					3.1		1650	40.2				0	690		
2/2/1975	2.507				3.1		1570	34.2				0	630		
2/15/1975					3.1		1170	20.3				0	500		
3/7/1975	3.426				3.2		2040	42.9				0	770		
3/14/1975	2.966				3.2		1080	23.8				0	430		
3/31/1975					3.1		1150	15.8				0	380		
4/13/1975					3.2		1200	22.2				0	380		
4/25/1975	2.26				2.9		1010	17.8				0	390		
5/9/1975	2.19				3.1		1080	16.6				0	360		
6/3/1975	2.154				3.1		940	16.1				0	340		
6/7/1975	2.119				3.1		1170	19.5				0	385		
6/23/1975					3.1		1080	12				0	440		
7/1/1975	2.013				3		1150	14.9				0	440		
7/16/1975	1.624				3		1100	16.8				0	370		
8/1/1975	1.377				3		1300	15.8				0	410		
8/14/1975	1.236				3		1300	13.1				0	440		
8/28/1975	1.095				3		1120	22.7				0	440		
9/12/1975	0.989				3		1260	20				0	490		
9/28/1975	2.649				2.9		2860	72				0	900		
10/12/1975	2.755				3		1920	24.3				0	760		
10/19/1975					3		1580	30.4				0	560		
10/25/1975					3		1650	24.2				0	600		
11/2/1975					3		1420	17.1				0	510		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
11/9/1975					3		1300	28.4				0	500		
11/16/1975					3		1250	29.7				0	470		
11/23/1975					3.2		1350	24				0	410		
11/30/1975					3		1500	36.2			27.2	0	430		1826
12/7/1975					3.1		990	19.3				0	310		
12/21/1975					3		1200	20.1				0	450		
1/4/1976					3.1		1040	20.4				0	360		
1/19/1976					3		1040	20.4				0	360		
2/1/1976							1310	22.4				0	450		
2/13/1976	2.26				3.2		1080	26.4				0	410		
2/27/1976	3.249				3.1		1290	21.5				0	450		
3/11/1976	3.531				3.1		1100	19.5				0	390		
3/23/1976	2.86				3.1		900	12.4				0	340		
4/8/1976	2.26				3.1		950	14.5				0	420		
4/23/1976	2.26				3.1		1020	12.8				0	320		
5/7/1976	2.048				3		930	11.2				0	290		
5/24/1976	2.366				3.2		950	17.9			21.5	0	400		1564
6/3/1976	2.366				3		880	9.4				0	330		
6/18/1976	2.084				3.1		860	15				0	320		
7/4/1976	2.755				3.1		1270	17.3				0	415		
7/19/1976	2.507				3.1		1110	15.6				0	370		
7/29/1976	2.154				3.2		1120	14.2				0	380		
8/11/1976	2.119				3		1400	18.6				0	480		
8/25/1976	2.295				3.2		1310	18.6				0	470		
9/8/1976	1.978				3.1		1110	20.3				0	410		
9/22/1976	1.554				3.1		1160	15.2				0	400		
10/6/1976	1.236				3.2		1120	17.3				0	380		
10/21/1976					3.1		1100	17.6				0	400		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
11/9/1976					2.8		1400	27.75				0	202		
11/21/1976	1.836				2.8		1050	22.5				0	406		
12/5/1976					2.8		1220	21.2				0	340		
12/19/1976					3		1150	23.25				0	314		
12/29/1976					3		1020	18.2					350		
1/9/1977	1.589				3		880	20.4					400		
1/23/1977					3.1		1020	20.75					260		
2/6/1977	1.271				2.9		1200	19.75					358		
2/20/1977					3		860	21.5					340		
3/6/1977	1.66				3.2		1300	22.5					304		
3/17/1977	2.331				3.1		980	16.65					206		
3/30/1977	2.649				3.1		780	21					310		
4/12/1977	4.767				3.1		860	15.4					460		
4/26/1977	3.108				3.2		840	18.5							
5/10/1977	2.578				3.2		980	16.6					322		
5/24/1977	2.507				2.8		820	17.5					340		
6/7/1977					3.1		800	18.5					400		
6/21/1977							850	18.25					330		
7/5/1977					3.1		900	15.15							
7/19/1977					3		1020	19.9					456		
8/3/1977					3		850	19.5					408		
8/14/1977	1.201				3		1090	19					460		
8/28/1977	1.095				3		840	19.4					256		
9/8/1977	0.989				2.9		780	17.9							
9/22/1977					2.9		1040	23.9					426		
10/6/1977	1.554				2.9		1140	26.5					528		
9/18/1997								11.4		29.5	14	0	196		
7/11/1999	1.041							8.63		25.5	15.2				

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
7/25/1999	1.041							9.5		31.8	18				
8/15/1999	0.735							12.5		28.7	15.6				
8/29/1999	0.833				11.9					28.8	15.6				
9/12/1999	0.468							12.3		27.6	14.5				
10/3/1999	0.735							9.55		23.1	18.3				
11/14/1999	1.283							10.9		27.7	17.8				
12/12/1999	1.439							9.18		23.8	17.7				
1/9/2000	1.439							8.29		28.8	18.6				
2/13/2000	1.283							8.49		24.9	15.9				
5/9/2001	3.951	9.3	1338	3	3.2		724	7.79		21.9	19.3	0	224	8	
6/18/2001	1.513	9.7	1294	3.3	3.2		475	8.76		23.4	16.5	0	211	6	
11/7/2001	1.406	8.9	1427	2.4	3.1		636	10.1		25	18.8	0	266	3	
3/19/2002	2.199	8.9	1290	3.1	3.2		397	7.34		20.4	14.5	0	249	4	
4/10/2002	3.632	8.3	1392	2.8	3.2		607	7.14		28.8	24.4	0	206	2	
5/23/2002	5.421	10.4	1472	2	3.2		610	7.23		26.5	23.6	0	262	2	
5/29/2002	4.113	9.8	1324	2.9	3.2		310	5.52		19.8	17.9	0	203	4	
6/19/2002	3.418	11	1372	3.8	3.3		582	7.09		25.4	23.9	0	278	8	
7/17/2002	5.615	15.5	1340	3.2	3.2		599	8.03		30.4	22.1	0	208	6	
8/8/2002	1.319	14.3	1357	2.8	3.2		469	9.46		25.3	15.2	0	203	6	
8/20/2002	1.014	9.9	1312	3.2	3.2		509	9.66		24.7	16.9	0	265	8	
9/17/2002	1.107	13.3	1386	3	3.2		618	11.1		27.4	16	0	219	2	
4/27/2014	4.05	10.6	1010	3.31	3.2		493	4.36		15.64	15.06	0	175	5	807
7/3/2014	1.77	10	1080	3.4	3.2		420	3.36		15.22	11.46	0	137	5	811
8/5/2014	1.307				3		1170	17				0	400		
8/29/2014	1.33	8.5	1150	2.99	3.2		500	5.8		15.36	10.81	0	163	5	783
9/4/2014					3.1		573	7		17	12	0	161		
10/23/2014	2.07	8.8	1140	3.19	3.2		500	6.73		15.48	11.39	0	154	5	810
8/11/2015	1.923		1100	2.93	3.2		488	4.73		15.42		0	158	5	937

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	FerrousFe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
9/17/2015	1.82	9.1	1110	3.5	3.2		379	5.27		16.4	12.45	0	166	5	940
10/30/2015	1.163	8.9	1147	3.3	3.3		527	5.73		15.97	11.73	0	143	5	873
11/24/2015	1.201	9.8	1677	3.5			504	5.98		16.43	12.98	0	150		
1/8/2016	1.82	8.7	1125	3.5			457	5.06		14.85	12.11	0	154		
2/1/2016	2.001	8.8	1175	3.6			519	4.86		14.97	13.19	0	166		
3/2/2016	3.079	8.8	1198	3.2			561	4.01		15.27	15.62	0	191		
3/31/2016	2.051	8.9	1116	3	3.2		495	4.64		14.23	13.61	0	154	5	810
4/28/2016	1.734	8.8	1093	3	3.2		500	4.94		14.14	12.02	0	134	5	727
6/1/2016	1.591	8.8	1043	3.1	3.2		462	5.48		14.41	11.84	0	130	5	690
6/29/2016	1.23	8.8	1035	3.4	3.2		526	5.48		14.51	10.54	0	137	11	737
8/1/2016	1.003	8.9	1027	3.5	3.2		440	5.74		14.55	10.46	0	131	5	767
9/2/2016	0.836	8.8	1062	3.5	3.2		513	6.2		15.49	10.8	0	143	5	842
10/10/2016	0.735	8.7	1084	3.4	3.2		367	6.29		15.09	10.47	0	159	5	876
2/17/2017	2.669	8.8	1105	3.4	3.2		623	4.57		16.13	17.76	0	170	5	871

Appendix H

DMR03 Historical Water Quality Data

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
6/13/1973	3.072				2.8		2860	46.1	53.4	150.2	0	1280		3851
6/21/1973	2.26						3310	50.8	65.8	75.9	0	1508		3975
6/28/1973	3.002				2.7		3470	47.1	54.7	93.2	0	1685		4079
7/5/1973	3.637				2.8		3420	38.2	48.4	75.2	0	1560		4011
7/12/1973	2.472				2.7		3190	53	63.3	70	0	1520		3820
7/19/1973	2.366				2.7		2860	39.6	48.3	144	0	1640		4531
7/26/1973	2.119				2.7		2980	40.1	48.2	131	0	1650		4094
8/2/1973	2.966				2.7		2820	43.7	49.9	96.7	0	1660		4174
8/8/1973	1.766				2.7		2880	50.6	71.9	112.5	0	1730		4137
8/16/1973	5.756				2.8		2830	44.6	62.9	123.1	0	1440		3578
8/23/1973	3.885				2.8		2860	22.9	59.7	131.2	0	1630		3687
8/30/1973	2.048				2.7		2720	43.1	45.9	59.8	0	1425		3565
9/6/1973	2.048				2.8		2720	31.5	42.2	123.7	0	1380		3271
9/13/1973	1.907				2.8		3030	39.1	67.2	135.5	0	1690		3889
9/19/1973	2.225				2.7		2920	54.2	68.4	107.1	0	1220		3628
10/4/1973	1.907				2.8		2750	56.9	74.2	84.8	0	1420		3718
10/16/1973	1.519				2.8		2910	65.2	81.6	135.2	0	1490		3687
11/1/1973	3.743				2.8		2970	67.6	78.3	132.7	0	1380		3672
11/15/1973	2.084				2.9		2820	53	72.7	117.9	0	1430		3468
11/29/1973	2.613				2.9		2330	58.4	75.1	105.5	0	1350		3225
12/12/1973	4.979				2.9		2400	56.6	73.6	104.4	0	1335		3373
12/26/1973	5.121				2.9		2210	67.4	75.1	105.2	0	1160		3157
1/10/1974	3.072				2.9		2700	72.6			0	1400		
1/23/1974	4.485				2.9		2360	46.4			0	1210		
2/5/1974	1.13				2.8		1880	50			0	990		
2/20/1974	0.424				2.9		2340	60			0	1180		
3/6/1974	1.236				2.9		2000	31.8			0	1040		
3/19/1974	1.13				2.8		1780	29.7			0	1020		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/1/1974	0.989				2.8		1880	40.1			0	1050		
4/15/1974	3.284				3		1070	25.6			0	540		
4/29/1974	1.095				2.8		2520	49.4			0	1260		
5/13/1974	1.095						2350	38.7			0	1170		
5/27/1974	0.918				2.8		2470	42.4			0	1220		
6/10/1974	0.53				2.8		2650	44.7			0	1060		
6/24/1974	0.494				2.8		3070	33.1			0	1310		
7/11/1974	0.848				2.8		2740	58.9			0	1470		
7/29/1974	0.494				2.8		2790	51.7			0	1380		
8/5/1974	0.424				2.8		2870	41.2			0	1400		
8/19/1974	0.318				2.8		2720	54.4			0	1500		
9/2/1974	0.318				2.8		3000	58.4			0	1420		
9/16/1974	0.495				2.8		3140	51.5			0	1630		
9/30/1974	0.742				2.8		2990	42.5			0	1700		
10/13/1974	0.494				2.8		3150	42.4			0	1565		
10/27/1974	0.353				2.8		3200	62			0	1450		
11/10/1974	0.318				2.8		3200	57.1			0	1555		
11/23/1974	0.53				2.9		3130	51			0	1470		
12/9/1974	1.307				2.8		3050	58.1			0	1570		
12/21/1974	1.236				2.9		2720	74.4			0	1430		
1/5/1975	0.742				2.9		2470	56.1			0	1530		
1/18/1975	1.448				2.9		2700	56.8			0	1410		
2/2/1975	1.836				2.9		2750	58			0	1410		
2/15/1975	0.812				2.9		2630	50.1			0	1410		
3/7/1975	1.978				2.9		2270	55.9			0	1350		
3/14/1975	0.989				3.1		1880	36.5			0	1170		
3/31/1975	1.095				2.9		2350	34			0	1030		
4/13/1975	0.848				2.9		2700	38.4			0	1180		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/25/1975	0.636				2.7		2470	44.6			0	1290		
5/9/1975					2.9		2330	47.7			0	1140		
6/3/1975	0.636				2.9		2350	44.4			0	1280		
6/7/1975	1.377				2.9		2430	42.4			0	1080		
6/14/1975	0.565				2.8		2900	53.9			0	1760		
6/23/1975	0.989				2.9		2670	50.5			0	1350		
7/1/1975	0.706				2.8		3040	57.1			0	1510		
7/16/1975					2.8		2870	54.6			0	1450		
8/1/1975					2.8		2820	55.2			0	1630		
8/28/1975	0.459				2.8		3300	62.7			0	1750		
9/12/1975	0.706				2.8		2660	50.4			0	1700		
9/28/1975	2.013				2.8		2580	78			0	1541		
10/12/1975	1.201				2.8		2660	36.7			0	1390		
10/19/1975	1.413				2.8		2360	42			0	1270		
10/25/1975	1.377				2.8		2650	38.1			0	1320		
11/2/1975	0.989				2.8		2570	35.7			0	1290		
11/9/1975	0.812				2.9		2750	50.8			0	1150		
11/16/1975	0.883				2.8		2710	50.7			0	1310		
11/23/1975	0.777				2.9		2950	44.4			0	1240		
11/30/1975	0.671				2.9		3050	47.2		117	0	1230		3638
12/7/1975	0.671				2.9		2680	41.1			0	1300		
1/4/1976	0.953				2.8		2590	45.5			0	1390		
1/19/1976					2.8		2680	45.4			0	1260		
2/1/1976					2.8		2320	42.6			0	1150		
2/13/1976	1.448				2.9		2320	41.7			0	1020		
2/27/1976	1.73				2.9		1540	29.7			0	780		
3/11/1976	1.766				2.9		1800	32.7			0	850		
3/23/1976	0.989				2.9		1820	29.8			0	860		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/8/1976	1.13				2.8		2080	30.9			0	1070		
4/23/1976	0.742				2.8		2440	28.9			0	1110		
5/7/1976	0.671				2.8		2600	31.4			0	1100		
5/24/1976	1.519				2.9		2320	37.1		94.9	0	1120		3326
6/3/1976	0.812				2.8		2230	36.6			0	1180		
6/18/1976	0.6				2.8		2380	37.6			0	1220		
7/4/1976	1.236				2.8		2380	38.8			0	1160		
7/19/1976	0.812				2.9		2600	34.7			0	1170		
7/29/1976					3		1710	25.7			0	880		
8/11/1976	1.766				3.1		2370	43.3			0	1170		
8/25/1976	1.095				3		2060	42.7			0	1190		
9/8/1976	0.777				2.9		2550	45.7			0	1260		
9/22/1976	0.636				2.9		2900	45.3			0	1340		
10/6/1976	0.636				2.9		2800	50.1			0	1340		
10/21/1976	0.848				2.9		2720	49			0	1300		
11/9/1976	1.13				2.6		1800	43						
11/21/1976	0.953				2.6		1780	40				964		
12/19/1976	0.777				2.7							1900		
12/29/1976	0.742				2.8		2205	53						
1/9/1977					2.7		2688	44.5				1500		
1/23/1977	0.353				2.7		2604	45.75				1030		
2/6/1977	0.283				2.6		2940	48				1856		
2/20/1977					2.8		2562	54				1300		
3/6/1977	2.013				2.9		1740	32				880		
3/17/1977	1.307				2.9		1300	26.25						
3/30/1977	2.04				2.9		1050	27.25				510		
4/12/1977	1.73				2.9		1380	40.5				800		
4/26/1977	1.413				2.9		1400	29.75						

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
5/10/1977	1.236				3		1480	29.75				880		
5/24/1977	1.024				3		1480	29.75				880		
6/7/1977	0.742				2.8		1700	42				590		
6/21/1977	0.494				2.5		1800	42				1050		
7/5/1977	1.695				2.9		2310	37.5				1260		
7/19/1977	0.742				2.8		2000	46.5						
8/3/1977	0.706				2.8		1900	46				1180		
8/14/1977	0.636				2.7			44.8				930		
8/28/1977	0.565				2.8		1740	44				1450		
9/8/1977	0.388				2.6		1840	48				1030		
9/22/1977	2.507				2.7		1740	57				1100		
10/6/1977	1.377				2.7		1500	42.75				984		
7/11/1999	0.234							10.8	35.2	41.8				
7/25/1999	0.234							15.1	43.6	50.4				
8/15/1999	0.089							15	41.7	47.8				
8/29/1999	0.049							12.3	43.9	50.2				
9/12/1999	0.051							13.4	43.8	24.3				
10/3/1999	0.234							8.86	32.7	39.4				
11/14/1999	0.049							10.3	35.2	42.2				
12/12/1999	0.156							9.49	33.6	40.8				
1/9/2000	0.276							9.28	39	42.6				
2/13/2000	0.321							12.5	35.9	41.2				
5/9/2001	1	10.5	1825	2.7	3		960	9.4	26.4	35	0	362	10	
6/18/2001	0.254	11.8	1931	3.6	3			8.93	31.4	41.1	0	387	10	
11/7/2001	0.39	10.1	1990	2.1	2.8		880	9.59	32.3	42.4	0	443	3	
3/19/2002		9.5	1916	2.9	2.9		631	8.34	27.7	35.3	0	441	4	
4/9/2002	0.804	10.6	1999	2.7	2.9		827	10.9	32.8	43.7	0	373	2	
5/29/2002	11.9		1805	2.7	2.9		481	8.69	22.5	31.3	0	352	8	

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
6/20/2002	1.076	12.9	1822	3.4	2.9		699	10.2	28.3	37.9	0	365	12	
7/17/2002	0.798	18.9	1941	3	2.9		814	10	33.6	44.8	0	383	16	
8/8/2002	0.441	16.4	2080	2.7	3		858	9.53	33	39.8	0	413	12	
8/21/2002		11.5	2020	3	2.9		336	9.33	31.9	45.8	0	420	6	
9/17/2002	0.292	16.2	2210	2.8	2.9		1131	10.6	28.7	46.8	0	440	2	
4/27/2014	1.036				3		651	5	18	24		260		
4/27/2014	1.035	11.1	1320	3.15	3		651	5.27	18.23	23.64	0	260	5	1140
7/3/2014	0.484				3		670	5	20	28		250		
7/3/2014	0.484	11.2	1420	3.2	3		670	5.4	19.8	28.17	0	250	5	1248
8/29/2014	0.203				3		835	6	21	28		296		
8/29/2014	0.202	9.4	1600	2.81	3		835	5.81	21.22	27.52	0	296	5	1268
9/4/2014					2.9		843	5	22	31		331		
10/23/2014	0.476	9.7	1820	2.84	3		874	6.05	23.97	32.28	0	305	5	1318
8/11/2015	0.236		1470	2.64	3		709	4.83	19.16	29.15	0	268	5	1351
9/17/2015	0.205	10.2		3.4	3.1		755	5.32	20.55	28.22	0	282	5	1421
10/30/2015	0.152	9.9	1685	3.1	3		809	4.67	21.15	30.8	0	272	5	1314
11/24/2015	0.245	9.8	1677	3.2			859	4.91	21.07	29.62	0	257		
1/8/2016	0.452	9.8	1596	3			843	5.28	20.33	27.77	0	293		
2/1/2016	0.381	9.9	1598	3.6	3		743	5.19	20.1	29.39	0	278		
3/2/2016	1.096	9.9	1462	3.1			627	5.44	17.75	22.13	0	262		
3/31/2016	0.348	9.9	1539	3	3		774	4.61	18.87	26.79	0	256	5	1179
4/28/2016	0.256	9.8	1574	2.7	3		732	5.25	19.58	25.61	0	252	5	1079
6/1/2016	0.194	9.9	1577	3.2	3		766	5.16	21.2	31.36	0	282	5	1119
6/29/2016	0.123	9.6	1637	3.2	3		829	5.16	21.99	28.05	0	305	5	1680
8/1/2016	0.08	9.9	1638	3	3		713	5.4	22.15	32.41	0	276	5	1310
9/2/2016	0.123	10	1697	3.2	3		912	5.95	23.8	30.47	0	296	5	1437
10/10/2016	0.127	9.8	1740	3.1	2.9		703	6.21	23.81	30.32	0	312	5	1670
2/17/2017	1.063	9.7	1386	3.1	3		810	5.38	18.8	28.49	0	267	5	1156

Appendix I

DMR01 Historical Water Quality Data

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
6/13/1973	1.519				2.9	1840	13.2	50.1	67.9	0	626		2748
6/21/1973	1.095				2.9	2650	20	70.3	56	0	1036		3449
6/28/1973	1.095				2.9	2690	13.9	52.3	52.1	0	905		3110
7/5/1973	1.766				2.9	2280	10.1	44.8	39.8	0	760		2737
7/12/1973	0.883				2.9	2210	18.5	59.1	44.1	0	785		2802
7/19/1973	0.883				2.9	2080	13	46.9	74.8	0	950		3106
7/26/1973	0.636				2.9	2180	13.3	47	74.7	0	990		3119
8/2/1973	1.059				2.9	2000	13	46.9	49.8	0	850		3018
8/8/1973	0.6				2.9	2180	17.8	64.2	70.1	0	930		3055
8/16/1973	5.05				3	2010	18	55.3	68.8	0	800		2697
8/23/1973	2.013				3	1730	11.9	46.7	64	0	730		2356
8/30/1973	0.777				2.9	1850	13.7	40.4	64.6	0	760		2530
9/6/1973	0.812				2.9	2370	14.1	43.9	77.9	0	840		2779
9/13/1973	0.848				3	2190	14	60.5	74.9	0	880		2930
9/19/1973	1.024				2.8	2070	18.4	59.7	65.3	0	640		2795
10/4/1973	0.742				3	1690	19.7	62.2	48.4	0	770		2718
10/16/1973	0.565				3	2000	22.6	71.8	78.9	0	830		2860
11/1/1973	2.295				3	2170	25.4	67	74.4	0	780		2777
11/15/1973	0.671				3	1970	18.3	61.9	66.1	0	790		2596
11/29/1973	1.624				3	1950	26.6	71.6	68.9	0	780		2825
12/12/1973	3.39				3.1	1420	15.8	51.8	46.4	0	570		2093
12/26/1973	2.472				3.1	1600	19.3	59.7	53.7	0	580		2193
1/10/1974	1.589				3.1	2470	29.2			0	900		
1/23/1974	2.401				3	2270	22.6			0	890		
2/5/1974	1.801				3	1370	18.7			0	630		
2/20/1974	0.848				3	2520	31.5			0	920		
3/6/1974	1.73				3	2130	19.1			0	1020		
3/19/1974	1.377				2.9	2170	26.8			0	850		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/1/1974					3.1	2580	18.9			0	840		
4/15/1974					3.1	2050	19.7			0	790		
4/29/1974					2.9	2850	30.9			0	1110		
5/13/1974					3	2470	22.1			0	900		
5/27/1974	0.388				3	1800	18.5			0	740		
6/10/1974	0.247				3	2470	18.8			0	920		
6/24/1974	0.212				3	2670	17			0	850		
7/11/1974	0.424				3	2300	25.5			0	940		
7/29/1974	0.212				3	2470	25.3			0	900		
8/5/1974	0.212				3	2720	27.1			0	930		
8/19/1974	0.177				3	2740	28.2			0	1010		
9/2/1974	0.177				3	2820	30.8			0	950		
9/16/1974	0.247				2.9	2750	22.2			0	1070		
9/30/1974	0.283				3	2630	21.6			0	970		
10/13/1974	0.141				3	3050	20.4			0	1055		
10/27/1974	0.106				3	2830	36.5			0	1060		
11/10/1974	0.035				3	2950	35.4			0	1000		
11/23/1974	0.071				3	2920	33.5			0	1010		
12/9/1974	0.953				3	2400	33.1			0	910		
12/21/1974	0.706				3	2170	38.4			0	930		
1/5/1975	0.388				3	2380	30.4			0	1000		
1/18/1975	0.953				3	2390	29.4			0	920		
2/2/1975	1.059				3.1	2550	33.6			0	1000		
2/15/1975	0.424				3.2	2580	28.4			0	1020		
3/7/1975	2.119				3.1	2120	29.7			0	890		
3/31/1975	1.13				3	2230	25.2			0	800		
4/13/1975	0.353				3.2	2270	27.2			0	820		
4/25/1975	0.318				2.8	2570	31.3			0	930		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
5/9/1975	0.424				3	2130	29.4			0	900		
6/3/1975	0.247				3	2350	31.4			0	800		
6/7/1975	0.848				3	3020	41.1			0	985		
6/23/1975	0.494				3	2620	36.5			0	940		
7/1/1975	0.353				3	2930	33.2			0	1130		
7/16/1975	0.283				2.9	3090	37			0	1060		
8/1/1975	0.318				2.9	2700	38			0	1230		
8/14/1975	0.247				2.9	3100	45.1			0	1430		
8/28/1975	0.141				2.9	3120	50.2			0	1340		
9/12/1975	0.494				2.9	2760	56.6			0	1360		
9/28/1975	2.684				3	2200	31.3			0	840		
10/12/1975	0.848				3	2760	25.3			0	1070		
10/19/1975	0.742				2.9	2820	37.7			0	1000		
10/25/1975	0.918				2.9	2470	29.4			0	870		
11/2/1975	0.989				2.9	2750	27.4			0	940		
11/9/1975	0.953				3	2710	45.5			0	860		
11/16/1975	0.918				3	2710	46.7			0	980		
11/23/1975	0.706				3	2800	38.7			0	870		
11/30/1975	0.6				3	2720	40.5		75.8	0	870		4705
12/7/1975					3	2670	34.7			0	890		
12/21/1975	0.989				2.9	2320	36.2			0	940		
1/4/1976	0.953				2.9	2740	36.9			0	950		
1/19/1976					2.9	2620	39.1			0	920		
2/1/1976	0.812				2.9	2130	25.3			0	780		
2/13/1976	0.671				3	2470	34.3			0	760		
2/27/1976	1.13				3	1780	22.4			0	640		
3/11/1976	1.095				3	2020	25.7			0	680		
3/23/1976	0.494				3	2510	25.5			0	790		

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/8/1976	0.636				3	2130	28.8			0	820		
4/23/1976	0.388				3	2750	30.1			0	850		
5/7/1976						2970	35.7			0	940		
5/24/1976	0.812				3	2260	28.5		59.9	0	760		3232
6/3/1976					2.9	2600	32.5			0	1010		
6/18/1976					2.9	2550	40.2			0	940		
7/4/1976					3	2530	32.2			0	920		
7/19/1976					3	2940	34			0	920		
7/29/1976					3.3	1300	7.09			0	480		
8/11/1976	0.953				2.9	2430	35.8			0	870		
8/25/1976	0.636				3.1	2560	33.9			0	930		
9/8/1976	0.388				3	2870	38.4			0	1030		
9/22/1976	0.247				3.1	3170	39.2			0	1090		
10/6/1976					3	3350	46.4			0	1130		
10/6/1976					3	3350	46.4			0	1130		
10/21/1976					3	2930	44.4			0	920		
5/9/2001	0.595	10.1	1587	2.9	3.2		4.05	24.4	17.7	0	206	10	
6/18/2001	0.234	12.1	1652	3.2	3.2	771	3.56	27.6	18.5	0	206	26	
11/7/2001	0.203	9	1803	2.4	3.1	810	3.95	30.4	21.7	0	277	8	
3/19/2002	0.41	7.4	1650	3.1	3.2	627	3.88	25.6	17.3	0	270	3	
4/9/2002	0.499	10.5	1694	2.8	3.1	732	6.21	30.2	23	0	207	2	
5/29/2002	0.869	12	1530	2.9	3.1	669	3.95	21.5	16.1	0	184	3	
6/19/2002	0.758	12	1607	3	3.2	642	5.38	25.4	19.6	0	243	10	
7/17/2002	0.279	17.1	1678	3.1	3.1	789	6.58	32.1	22.3	0	224	12	
8/8/2002	0.205	16.2	1781	2.8	3.1	880	6.64	33.6	20	0	246	10	
8/21/2002		11.9	1669	3.2	3.1	617	3.3	28.1	19.4	0	227	2	
9/17/2002	0.123	15.8	1876	2.9	3.1	1021	7.7	36.1	24.1	0	262	2	
4/27/2014	0.704	10.3	1220	3.31	3.2	586	2.13	14.8	11.13	0	163	5	961

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	ºC	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
7/3/2014	0.291	10.9	1330	3.33	3.2	599	2.98	19.62	14.67	0	154	5	1122
8/29/2014	0.102	9.2	1510	2.94	3.1	759	3	20.76	15.49	0	225	5	1200
9/4/2014					3.1	573	7	17	12	0	161		
10/23/2014	0.011	8.7	1610	2.5	3.1	793	1.57	23.32	17.6	0	182	5	1250
8/11/2015	0.187		1230	2.94	3.2	628	2.45	16.7	13.14	0	146	5	1150
9/17/2015	0.131	13.7	1360	3.6	3.3	735	3.17	19.24	14.84	0	201	5	1222
10/30/2015	0.058	9.7	1504	3.3	3.2	794	3.92	21.39	16.22	0	192	5	1319
11/24/2015	0.131	9.5	1492	3.4		718	4.07	21.31	16.49	0	163		
1/8/2016	0.332	9.4	1316	3.4		585	3.28	17.15	13.6	0	174		
2/1/2016	0.314	9.6	1349	3.4	3.2	673	2.59	16.81	13.93	0	70		
3/2/2016	0.909	9.3	1290	3.2		615	2.49	15.07	12.72	0	169		
3/31/2016	0.332	9.5	1318	3.4	3.2	628	2.52	16.58	13.1	0	165	5	991
4/28/2016	0.245	9.6	1324	2.7	3.2	608	2.91	17.61	13.26	0	144	5	966
6/1/2016	0.183	9.6	1327	3.2	3.2	659	3.69	19.98	15.21	0	171	5	974
6/29/2016	0.098	9.7	1404	3.5	3.2	758	4.05	21.31	14.33	0	153	6	1139
8/1/2016	0.058	9.8	1434	3.5	3.2	823	4.38	21.23	15.58	0	194	5	1408
9/2/2016	0.04	9.8	1498	3.4	3.2	798	4.83	22.61	15.57	0	168	5	1290
10/10/2016	0.016	9.2	1490	3.3	3.2	678	5.46	23.28	15.52	0	211	5	1400
2/17/2017	0.795	9.4	1219	3.2	3.2	756	2.96	18.55	16.28	0	155	5	1031

Appendix J

Bear Creek Historical Water Quality Data

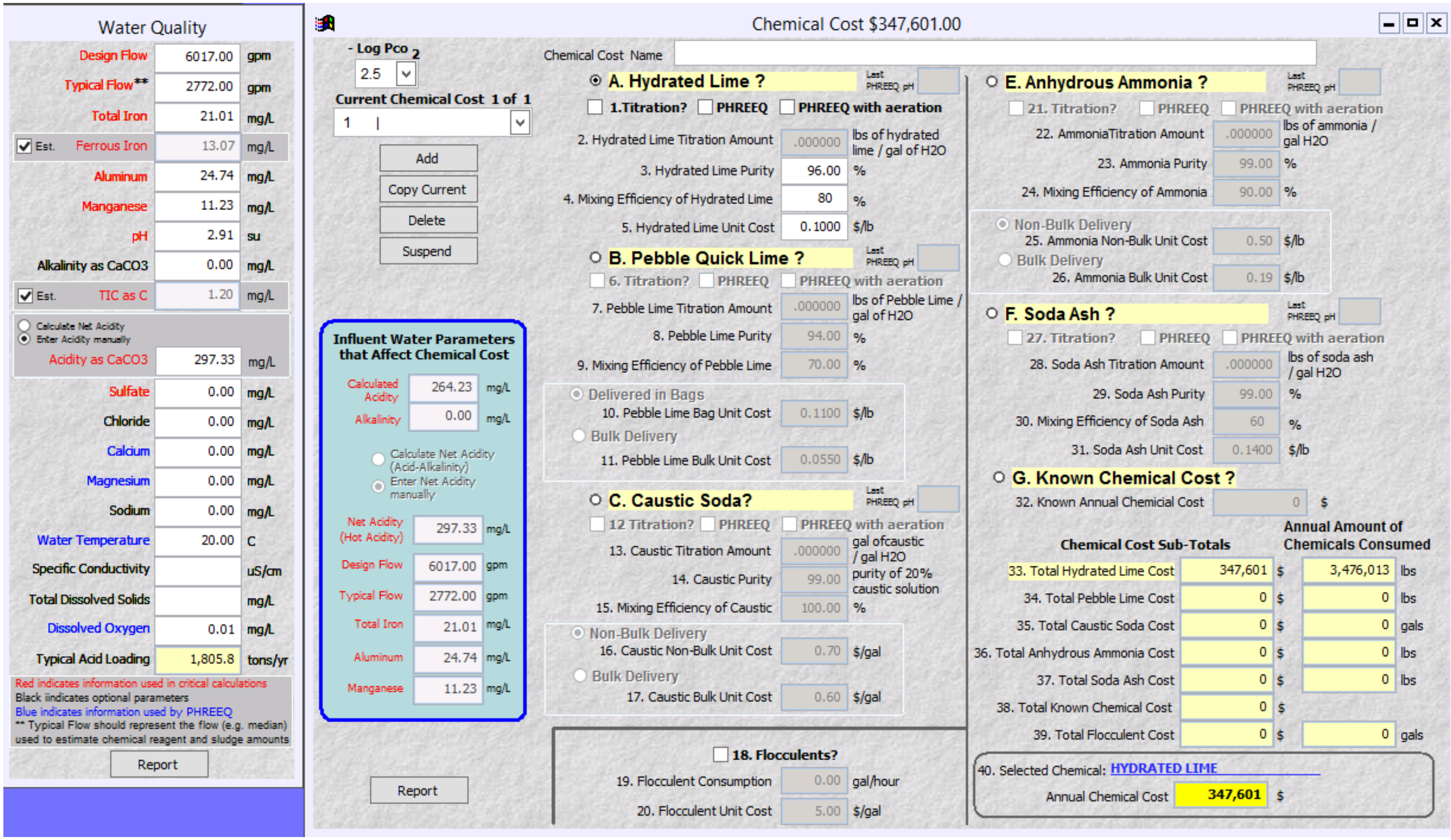
SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	^{o}C	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
5/4/1966	1.898		1000		3.1		528.8	46.8	8.8			225.6		
5/18/1966	1.199		980		2.9		477.4	14	19.3			370.8		
6/14/1966			1410		2.8		785.8	13	10.6			309.2		
7/19/1966	0.499		1700		2.8		1226.5	40.3	9.2			530.8		
1/12/1967	0.9		1150		2.9		1663.2	55.5	20			656.3		
1/19/1967	0.301		1600		2.8		1145	60.5	21.6			636.6		
1/26/1967	0.8		1000		2.9		905.1	46.5	16			424.8		
1/28/1967	9.2		260.1		3		547	21.2	7.7			266.1		
4/4/1967	2.4		1100		3		428.7	26	6.8			265.5		
4/11/1967	2.099		940		3.1		450.9	21	7.8			252.8		
4/18/1967	1.399		1250		3.1		498.2	21	8.8			274.1		
4/3/1968	0.499		750		3.1		444.2	19	7.4			251.6		
5/27/1970	1.7		1060		3		507	15	9.6			210		
6/9/1970	2.799		1100		3		481	11	9.6			228		
6/10/1970	0.8		1000		3		517	11	9.7			236		
6/11/1970	0.8		1260		2.9		512	13	10			233		
4/25/2001	1.483		788	2.65	3.1	6.99	220	5.33	3.55	8.87	0	120	3	
6/5/2001	0.107		1190	2.95	3.2	8.78	428.5	8.31	8.59	19.1	0	226	3	
10/4/2001	0.312		1222	2.3	3	7.51	320.4	7.73	7.64	18.9	0	227.8	3	
3/13/2002	0.534		1034	2.85	3	9.68	214.3	6.35	5.05	11.8	0	206.8	3	
4/10/2002	0.998	9	1109		3		307	8.02	5.06	13.9	0	174	2	
5/22/2002	2.188	8.5	843		3.1		216	5.9	3.7	9.28	0	140	2	
5/29/2002	1.303		802	2.8	3	10.07	205.1	4.49	3.5	8.63	0	125.4	4	
6/20/2002	1.76	10.3	867		3		234	6.43	4.27	10.2	0	131	16	
7/18/2002	0.234	14.8	1228		3		471	10.7	8.88	19.1	0	230	18	
8/8/2002	0.281	15.1	1523		2.9		545	16	13.2	25.3	0	305	8	
8/19/2002	0.129		1376	2.9	3	6.29	476.9	7.03	11.4	26.5	0	268.5	3	
9/18/2002	0.187	16.8	1786		2.8		771	20.6	16.6	34.8	0	406	4	

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	^{o}C	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
4/27/2014	0.914	10.5	711	3.23	3		247	3.57	3.29	8.68	0	137	5	449
7/3/2014	0.229	14.6	1140	3.23	3		432	5.69	7.84	19.19	0	190	5	795
8/29/2014	0.228	10.8	1290	2.85	2.9		675	7.97	10.46	25.68	0	304	5	1015
10/23/2014	0.174	9.1	1640	2.78	2.9		735	9.41	11.52	30.66	0	325	5	181
5/1/2015		9.1	796	3.07	3.09		250	3.69	4.09	6.15	0	121		
6/16/2015	0.345		1114	2.8	2.9		368.6	6.63	7.55	17.65	0	191	6	742
7/14/2015	1.749	11	797	2.92	3		240.4	4.69	3.25	9.3	0	126	5	374
8/13/2015		11.2	1022	2.93	3		417	4.61	5.55	15.01	0	162	5	636
9/24/2015	0.47	10.1	1203	2.87	2.8		671.7	7.03	8.79	22.85	0	208.6	5	734
10/27/2015	0.196	5.88	1406	2.89	2.9		559.7	8.83	10.25	26.56	0	271	5	864
11/18/2015	0.187	7.72	1059	2.91	2.9		415.6	6.28	5.78	15.69	0	181.2	5	536
12/15/2015	0.582	8.38	1055	2.85	3		422.1	6.27	5.49	14.74	0	178.6	5	682
1/20/2016		1.77	809	2.96	3		265.4	3.98	3.5	9.51	0	126	5	356
2/18/2016		1.72	581	3.24	3.2		181.8	2.37	2.66	6.79	0	80	14	266
3/24/2016		7.88	856	2.98	3		282.7	4.64	4.28	11.42	0	134	5	494
4/26/2016		10.5	680	2.91	3		356.6	5.17	5.19	13.58	0	160.4	5	532
5/18/2016		8	902	2.92	3		284.1	4.81	4.74	12.59	0	145	5	502
4/18/2017	5.517	3.11	745	2.95	3.1		242.3	2.96	3.24	9.28	0	108.2	5	342
5/17/2017	6.139	9.72	691	2.92	3.1		209.1	2.51	2.83	8.5	0	93.4	5	332
6/28/2017		10.11	995	2.9	3.1		369.3	4.15	6.66	17.57	0	168.4	5	652
7/26/2017		13	992	2.86	3		503.4	4.9	8.99	24.2	0	229.4	5	830
8/24/2017		12.8	1415	2.82	2.9		705.2	5.77	11	30.4	0	294.2	5	900
9/21/2017	0.149	13.5	1501	2.82	2.9		711.1	0.654	11.72	31.89		315.8	5	1236
10/26/2017	0.381	8.1	1586	2.8	2.9		744.7	8.4	12.44	34.79	0	334.4	5	1124
10/30/2017	7.636													
11/29/2017	0.481	5.94	1175	2.8	3		446.6	6.82	7.22	20.35	0	219.6	5	680
12/27/2017			1522	2.73	3		543.8	8.47	9.21	25.96	0	263.8	5	860
1/31/2018		2.77	907	2.19	3		336.1	4.43	4.64	13	0	146.8	5	428

SampleDate	Flow	WaterTemp	SpecCond	FieldpH	LabpH	DO	SO4	Fe	Mn	Al	Alk	Acid	TSS	TDS
	CFS	^{O}C	uS/cm	SU	SU	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
2/26/2018	3.177													
2/27/2018		6.4	689	3.09	3.2		225.5	0.543	3.572	9.238	0	114.2	5	316
3/28/2018	0.882	5.22	858	2.99	3.1		290.1	4.18	4.83	13.21	0	156.8	5	448
4/24/2018					3.1		217.9	2.74	3.31	8.77		119	5	
5/30/2018		10.9	733	2.87	3.1		221.9	0.281	3.643	9.446	0	121	5	334

Appendix K

AMDTreat Estimation of Annual Hydrated Lime Amounts and Costs for the Tioga ATP


Water Quality
Design Flow 6017.00 gpm
Typical Flow** 2772.00 gpm
Total Iron 21.01 mg/L
Est. Ferrous Iron 13.07 mg/L
Aluminum 24.74 mg/L
Manganese 11.23 mg/L
pH 2.91 su
Alkalinity as CaCO3 0.00 mg/L
Est. TIC as C 1.20 mg/L
Calculate Net Acidity
Enter Acidity manually
Acidity as CaCO3 297.33 mg/L
Sulfate 0.00 mg/L
Chloride 0.00 mg/L
Calcium 0.00 mg/L
Magnesium 0.00 mg/L
Sodium 0.00 mg/L
Water Temperature 20.00 C
Specific Conductivity uS/cm
Total Dissolved Solids mg/L
Dissolved Oxygen 0.01 mg/L
Typical Acid Loading 1,805.8 tons/yr
Red indicates information used in critical calculations
Black iindicates optional parameters
Blue indicates information used by PHREEQ
** Typical Flow should represent the flow (e.g. median) used to estimate chemical reagent and sludge amounts
Report
Chemical Cost $347,601.00
- Log Pco 2
2.5
Current Chemical Cost 1 of 1
1
Add
Copy Current
Delete
Suspend
Influent Water Parameters that Affect Chemical Cost
Calculated Acidity 264.23 mg/L
Alkalinity 0.00 mg/L
Calculate Net Acidity (Acid-Alkalinity)
Enter Net Acidity manually
Net Acidity (Hot Acidity) 297.33 mg/L
Design Flow 6017.00 gpm
Typical Flow 2772.00 gpm
Total Iron 21.01 mg/L
Aluminum 24.74 mg/L
Manganese 11.23 mg/L
Report
Chemical Cost Name
A. Hydrated Lime ?
Last PHREEQ pH
1.Titration? PHREEQ PHREEQ with aeration
2. Hydrated Lime Titration Amount .000000 lbs of hydrated lime / gal of H2O
3. Hydrated Lime Purity 96.00 %
4. Mixing Efficiency of Hydrated Lime 80 %
5. Hydrated Lime Unit Cost 0.1000 $/lb
B. Pebble Quick Lime ?
6. Titration? PHREEQ PHREEQ with aeration
7. Pebble Lime Titration Amount .000000 lbs of Pebble Lime / gal of H2O
8. Pebble Lime Purity 94.00 %
9. Mixing Efficiency of Pebble Lime 70.00 %
Delivered in Bags
10. Pebble Lime Bag Unit Cost 0.1100 $/lb
Bulk Delivery
11. Pebble Lime Bulk Unit Cost 0.0550 $/lb
C. Caustic Soda?
12 Titration? PHREEQ PHREEQ with aeration
13. Caustic Titration Amount .000000 gal ofcaustic / gal H2O
14. Caustic Purity 99.00 purity of 20% caustic solution
15. Mixing Efficiency of Caustic 100.00 %
Non-Bulk Delivery
16. Caustic Non-Bulk Unit Cost 0.70 $/gal
Bulk Delivery
17. Caustic Bulk Unit Cost 0.60 $/gal
18. Flocculents?
19. Flocculent Consumption 0.00 gal/hour
20. Flocculent Unit Cost 5.00 $/gal
E. Anhydrous Ammonia ?
21. Titration? PHREEQ PHREEQ with aeration
22. AmmoniaTitration Amount .000000 lbs of ammonia / gal H2O
23. Ammonia Purity 99.00 %
24. Mixing Efficiency of Ammonia 90.00 %
Non-Bulk Delivery
25. Ammonia Non-Bulk Unit Cost 0.50 $/lb
Bulk Delivery
26. Ammonia Bulk Unit Cost 0.19 $/lb
F. Soda Ash ?
27. Titration? PHREEQ PHREEQ with aeration
28. Soda Ash Titration Amount .000000 lbs of soda ash / gal H2O
29. Soda Ash Purity 99.00 %
30. Mixing Efficiency of Soda Ash 60 %
31. Soda Ash Unit Cost 0.1400 $/lb
G. Known Chemical Cost ?
32. Known Annual Chemicial Cost 0 $
Chemical Cost Sub-Totals
Annual Amount of Chemicals Consumed
33. Total Hydrated Lime Cost 347,601 $ 3,476,013 lbs
34. Total Pebble Lime Cost 0 $ 0 lbs
35. Total Caustic Soda Cost 0 $ 0 gals
36. Total Anhydrous Ammonia Cost 0 $ 0 lbs
37. Total Soda Ash Cost 0 $ 0 lbs
38. Total Known Chemical Cost 0 $
39. Total Flocculent Cost 0 $ 0 gals
40. Selected Chemical: HYDRATED LIME
Annual Chemical Cost 347,601 $