Yellow Creek Watershed Assessment

January 2022

Report prepared by Hedin Environmental for Blacklick Creek Watershed Association and Indiana County Conservation District

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Cover photo was taken on Yellow Creek approximately 1 mile upstream from Yellow Creek's confluence with Two Lick Creek.

Summary

This report is intended to be used as an update to the 2005 Blacklick Creek Watershed Assessment/Restoration Plan specific to coal mine drainage. This report updates and details the mine drainage pollution sources in the Yellow Creek watershed, Indiana County, PA. It does not discuss aquatic habitat or other potential sources of pollution. It includes data from four, mass balance sampling efforts from November 2019 to May 2021 and monthly discharge monitoring from November 2020 to May 2021.

The report finds that the Yellow Creek is generally of good quality and able to assimilate many minor sources of mine drainage from its headwaters to about 1 mile from its mouth. At the 1-mile mark, the stream flows by the Lucerne refuse pile. AMD from this area significantly degrades Yellow Creek to its mouth and confluence with Two Lick Creek. The source of this pollution is likely polluted groundwater.

As of 2021, the Lucerne refuse pile is being mined for burnable coal and reclaimed. Unfortunately, since the reclamation started in 1997 there is no evidence of water quality improvement in Yellow Creek.

This report details and contextualizes the results of the mass balance and discharge sampling and offers recommendations to improve water quality.

Introduction

Mining History

Yellow Creek (YC) is a major cold-water fishery (CWF) tributary to Two Lick Creek in Indiana County, Pennsylvania. The YC watershed had extensive coal mining operations from the late 1800's to the mid 1900's in the Kittanning and Freeport coal seams. These operations resulted in abandoned underground mines, reclaimed and unreclaimed surface mines, and large piles of coal refuse. Some surface and deep mining continues in the watershed to this day, and some of the abandoned refuse piles are being reprocessed for their BTU value. While the section of Yellow Creek upstream of Route 954 is generally of good quality, abandoned mine lands have produced acid mine drainage (AMD) which has degraded the lower Yellow Creek basin for decades. Impairment due to AMD was documented in the 1971 Operation Scarlift Report and continues 50 years later.

Reclamation and Remediation Efforts

Several reclamation projects have occurred or are ongoing in the Yellow Creek watershed. The Blacklick Creek Watershed Association has spearheaded the construction of four passive treatment systems in the watershed: the 1A, 1B, 2A/2B, and 2C systems. These systems are described in detail below.

The Lucerne refuse pile, located approximately 1 mile northeast of Homer City, is a massive, abandoned coal refuse disposal and coal tipple site. The pile is being mined and reclaimed by the Cambria Reclamation Corporation. Burnable coal is shipped to local waste coal burning power plants and alkaline ash is backhauled and mixed with remaining refuse. The fly ash will provide neutralization and reduce infiltration and is expected to improve water quality from the pile. Once reprocessing is complete, the pile will be vegetated.

Previous Studies

In previous reports, YC was divided into Upper Yellow Creek (UYC) above Yellow Creek State Park Lake and Lower Yellow Creek (LYC) below the lake. This report maintains this division and divides the watershed at a similar location: approximately 4 miles downstream from the Yellow Creek State Park Lake (Figure 1).

Water quality data in this report was obtained from the following sources:

- 1971 Two Lick Creek Operation Scarlift report by L Robert Kimball Consulting Engineers.
- L Kimball & Associates 2005 Blacklick Creek Watershed Assessment/Restoration Plan.
- A review of the PADEP permit for the Lucerne refuse pile mining/reclamation project (permit #32950202 reviewed in September 2021 at the Cambria District Mining Office).
- A fish survey conducted by Conemaugh Valley Conservancy's Stream Team at LYC at Route 954 and LYC at Floodway Park (July 2020).
- www.Datashed.org for passive treatment systems and discharges.
- A compilation of the groundwater data from the PADEP Colver refuse pile reclamation (permit # 11900201 & 11970201).
- Sampling from 2019 to 2021 conducted for this project.

The 2005 Blacklick Creek Watershed Assessment/Restoration Plan addressed water quality across the entire Blacklick Creek Watershed. Portions of the report focus on UYC and LYC. The report concluded that UYC is generally good quality. While AMD discharges were documented in the headwaters of Little Yellow Creek and Leonard Run (tributaries to UYC), impacts on the receiving streams and UYC were minor. Little Yellow Creek is designated a high-quality cold-water fishery by the PADEP. AMD discharges and impacts in LYC were much more significant. Yellow Creek below the Judy 14 tributary and the Tide tributary had pH less than 5 and contained elevated metals. These conditions were consistent to the mouth of Yellow Creek.

The mining/reclamation permit for the Lucerne refuse pile (permit # 32950202) in LYC was reviewed at PADEP's Cambria District Mining Office on September 15, 2021. Data collected for this report includes surface and ground water chemistry. PADEP staff also provided insight into the details, status, and future plans of the project.

Current Assessment Goal

Despite extensive sampling of YC over the last 20 years, a loading-based assessment of the stream had not been conducted. This type of analysis attempts to balance measurements of contaminant loads produced by mine discharges with concurrent measurements of in-stream contaminant loads. The data are used to calculate unmeasured mine drainage sources, prioritize remediation projects, and calculate expected instream impacts of remediation projects. A primary goal of this project was to collect data suitable for a loading-based assessment of mine drainage impacts.

A loading-based analysis measures flow rates and chemistry and calculates loads from the product of these values. In this report, flows are reported as gallons per minute (gpm), concentrations as milligrams per liter (mg/L), and loadings as pounds per day (lb/day). This mix of metric and English units is consistent with other watershed studies in PA. Conversions between metric and English values are provided in the methods section. Load calculations are used to construct mass balances for the creek.

Report organization

The results of the sampling are described and contextualized below. First, the instream conditions of UYC and LYC are presented. Then, the discharges to LYC are presented, arranged by acidity loading (highest to lowest). Finally, an assessment of existing passive treatment systems is presented.

A map of the entire YC watershed is shown in Map 1. Sampling locations in UYC and LYC are shown in Maps 2 and 3, respectively. Detailed sampling location maps for LYC and the Lucerne refuse pile are shown in Maps 4 and 5. A mine map in the Lucerne pile area is shown in Map 6. The Tide refuse pile is shown in Map 7. Passive treatment systems are detailed in Maps 8, 9, and 10. The Route 119 borehole is detailed in Map 11. A conceptual sampling schematic is shown in Appendix 1. A description of all sampling locations and all data collected and organized for this report is provided as an excel table in Appendix 5.

Methods

Two types of sampling efforts were undertaken: quarterly sampling and monthly discharge sampling. Quarterly sampling involved collecting flows and chemistry at instream, tributary, discharge, and treatment system locations in a single day. Quarterly sampling was completed by the Blacklick Creek Watershed Association members and volunteers, Hedin Environmental staff, Indiana County Conservation District staff, and St. Francis University staff and students. Flow rates, pH, conductivity, temperature, and alkalinity were measured in the field. Water samples were collected for analyses of pH, conductivity, alkalinity, net acidity, and total metal concentrations by the PADEP state laboratory in Harrisburg, PA. Quarterly sampling events occurred in November 2019, February 2020, September 2020, and May 2021. See Table 1 for location names, descriptions, and latitude/longitude coordinates.

Select discharges were monitored monthly for flows and chemistry from November 2020 to May 2021 by Blacklick Creek Watershed Association members and volunteers and Indiana County Conservation District staff. Flow rates, pH, conductivity, temperature, and alkalinity were measured in the field. Water samples were collected for analyses of pH, conductivity, alkalinity, net acidity, and total metal concentrations at the PADEP state laboratory.

Pollution loadings were calculated from concentration and flow rate data using the equation below. The 0.012 term is a conversion factor to generate lb/day units.

$$\text{Loading (lb/day)} = \text{Flow rate (gal/min)} * \text{Concentration (mg/L)} * 0.012$$

Differences in in-stream loadings were used to calculate chemical impacts from the Lucerne and Tide refuse piles. Surface flows from the piles do not equal the pollution from these piles; ground water inflows from the piles to Yellow Creek are substantial. For example, the Lucerne refuse pile extends along the eastern side of LYC for approximately 0.5 mile. To quantify the pollution loading from the Lucerne refuse pile, the difference between downstream and upstream in-stream loadings were calculated. Then, loadings from measured surface discharges in this reach of stream were subtracted out. The remaining loading was assumed to be ground water from the Lucerne pile. A similar method was followed for the Tide refuse pile.

More detailed methods can be found at the end of this report in “Detailed Methods”.

Upper Yellow Creek In-stream Water Quality

This assessment sampled several in-stream and tributary locations for water chemistry in UYC (Map 2). Leonard Run and the upper reaches of Little Yellow Creek were reported to have mine drainage impacts and portions of these creeks are listed as non-attaining by the PADEP.

Average water chemistry for all UYC sampling locations is shown in Table 1 and UYC instream chemistry is shown graphically in Figure 1. Streamflow was not measured. Generally good water quality was found at all locations sampled. Sampling revealed elevated sulfate concentrations, an indication of inflows of mining-impacted waters. However, none of the stream stations exceeded the in-stream limits for metals or pH. Metal concentrations in the discharges in UYC have apparently decreased with the passage of time (a common occurrence) and any residual acidity is being naturally neutralized. Biological surveys should be conducted to determine if delisting from the non-attaining list is warranted.

Table 1. Average water quality at all UYC locations sampled in this study (2019-2021). Flow rates were not measured.
[1] N = 4 water samples
[2] N = 3 water samples

ID	Location	pH	Alkalinity	Net Acidity	Fe	Al	Mn	SO_4
			mg/L as $CaCO_3$		mg/L			
Instream locations (ordered from upstream to downstream)								
UYC-1[1]	YC in Mentcle	7.38	68	-48	0.1	0.3	0.1	50
UYC-3[2]	YC Below Leonard Run	7.12	96	-85	0.1	0.2	0.1	136
UYC-4[1]	YC at Spruce Grove Road	7.46	75	-68	0.3	0.2	0.1	106
UYC-5[2]	YC above Reservoir	7.64	70	-49	0.6	0.3	0.2	63
Tributary locations								
UYC-2[2]	Leonard Run at foot bridge	7.20	33	-15	0.3	0.3	0.2	136
UYC-6[1]	Little YC at Malloy Hollow Road	7.37	70	-49	1.4	0.4	0.3	93
UYC-7[2]	Little TC at SR 2027	7.55	75	-54	0.2	0.2	0.1	62
Instream Standards for CWF								
		6 - 9			1.5	0.75	1.0	

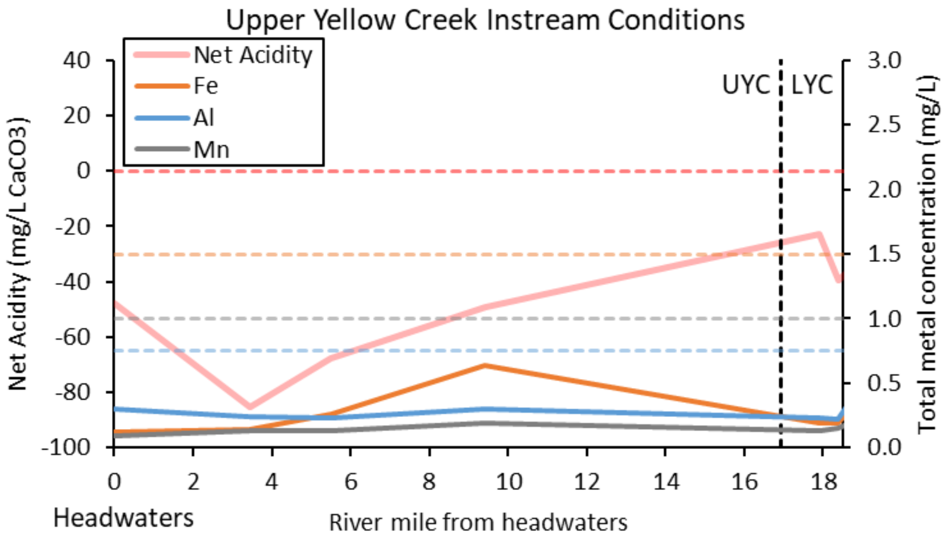


Figure 1. Average in-stream chemistry along Upper Yellow Creek (UYC; above Yellow Creek State Park lake) is net alkaline with low concentrations of total metals for its entire length. Horizontal dashed lines indicate instream standards of the constituent of identical color. River miles are measured from the most upstream in-stream monitoring point, UYC-1, in Mentcle, PA.

Lower Yellow Creek In-stream Water Quality

This assessment sampled several in-stream, tributary, and discharge locations for water chemistry and flow rates in LYC (Maps 3-5). Average water chemistry and loadings for all LYC sampling locations are shown in Table 2 and LYC instream chemistry is shown graphically in Figure 2. Upstream of the Lucerne refuse pile (LYC-10.5), LYC is net alkaline with low concentrations of metals. LYC is degraded as it passes the refuse pile and remains degraded to its mouth (LYC-12), one mile downstream of the pile.

Table 2. Average chemistry and loadings for in-stream sampling locations in LYC. Sampling locations are ordered from upstream to downstream.
Alk = field alkalinity. Acid = measured net acidity.
[a] Flow rates were not collected at every sampling location during every sampling event. Available flow rates are averaged.

ID	Location	Flow[a]	pH	Alk	Acid	Fe	Al	Mn	SO_4	Acid	Fe	Al	Mn	SO_4
		gpm		mg/L as $CaCO_3$		mg/L				lb/day				
LYC-1	YC above Rt. 954 Bridge	10,970[a]	7.38	26	-23	0.2	0.2	0.1	41	-2,582	25	34	16	5,249
LYC-2	YC above Judy 14 Trib	11,431[a]	7.25	42	-40	0.2	0.2	0.1	88	-3,458	23	36	13	7,568
LYC-5	YC above Tide Trib	11,698[a]	7.13	36	-33	0.3	0.4	0.2	97	-2,966	49	79	23	9,963
LYC-9	YC above Lucerne #1 & #3	21,170[a]	7.24	41	-19	0.4	0.4	0.2	79	-3,079	136	137	34	13,908
LYC-10	YC above Lucerne refuse pile	13,496[a]	7.20	35	-30	0.4	0.4	0.3	104	-2,852	61	90	34	12,411
LYC-10.5	YC mid-refuse pile	27,365[a]	6.13	16	25	11.5	2.0	2.7	123	10,066	2,996	1,021	245	32,859
LYC-11	YC above Route 119 Borehole	28,908[a]	6.04	16	11	7.5	1.5	1.8	119	3,646	1,674	653	237	32,362
LYC-12	YC Mouth (@ Floodway Park)	22,885[a]	6.38	19	8	8.8	2.1	1.0	140	2,177	1,358	537	137	28,684
Instream Standards for CWF														
			6 - 9			1.5	0.75	1.0						

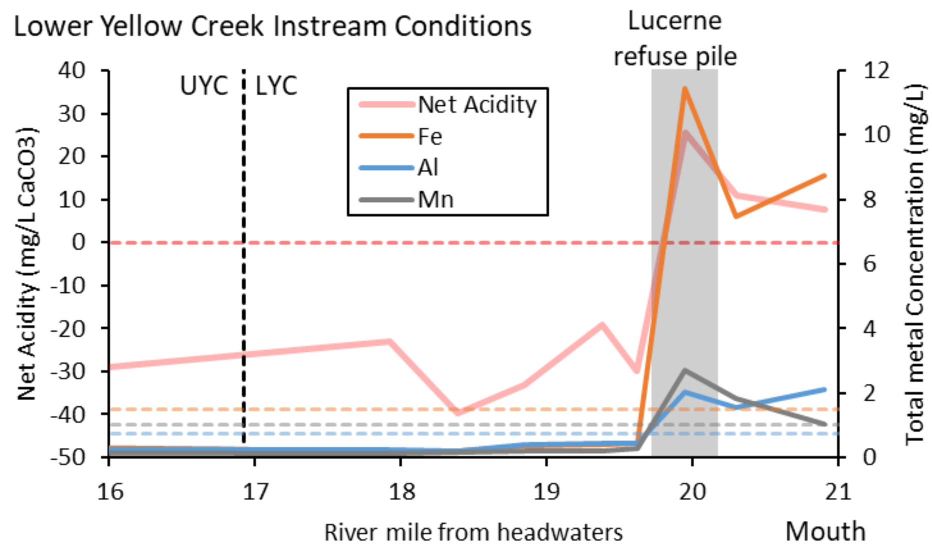


Figure 2. Average in-stream chemistry along Lower Yellow Creek (LYC; below YC reservoir) is clean until the Lucerne refuse pile where the creek becomes net acidic and impaired with Fe, Al, and Mn. The impairment continues approximately 1 mile to the mouth of the creek. Horizontal dashed lines indicate instream standards of the constituent of identical color. River miles are measured from the most upstream in-stream monitoring point, UYC-1, in Mentcle, PA.

Lower Yellow Creek In-stream Biology

A fish survey was conducted in July 2020 by the Conemaugh Valley Conservancy's Stream Team (Table 3) and the final report is provided as Appendix 2. Two locations in LYC were surveyed: LYC-1 (above Route 954 Bridge) and LYC-12 (Floodway Park). At LYC-1, many fish were found but diversity was relatively low. River Chub were found which are a relatively pollution intolerant species. A fish IBI score of 30 was calculated. While this is still considered impaired, this impairment may be due to impairment downstream of LYC-1 creating a barrier to fish migration or lack of habitat in the sampling section. There is a diversity of species upstream of Rt. 954, including trout.

At LYC-12, zero fish were found. LYC at this location is severely polluted with particulate Fe and Al.

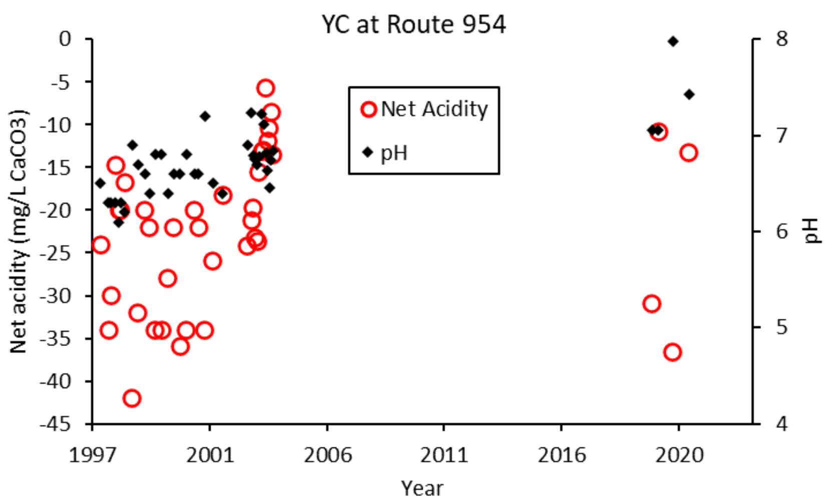
Table 3. Fish survey results from two locations in LYC. Survey conducted in July 2020 by the Conemaugh Valley Conservancy's Stream Team.

Location	Fish IBI Score
LYC-1 LYC Above Rt. 954	30
LYC-12 LYC at Floodway Park	N/A (No fish present)

Historic Lower Yellow Creek Water Quality

Historic data were compiled from the 2005 Blacklick Creek Watershed Assessment and data collected by this project. The only locations sampled by assessments include LYC at the Route 954 Bridge (LYC-1) and the mouth of LYC at Floodway Park (LYC-12).

Sample data collected from LYC at Rt. 954 are shown in Figure 3. At this location, LYC has been good quality since the late 1990s. There are a few samples with higher concentrations of Fe, SO_4, and/or Al in the older data sets, but overall, the water quality meets in-stream standards. All samples collected in 2019-2021 contained low metal concentrations.



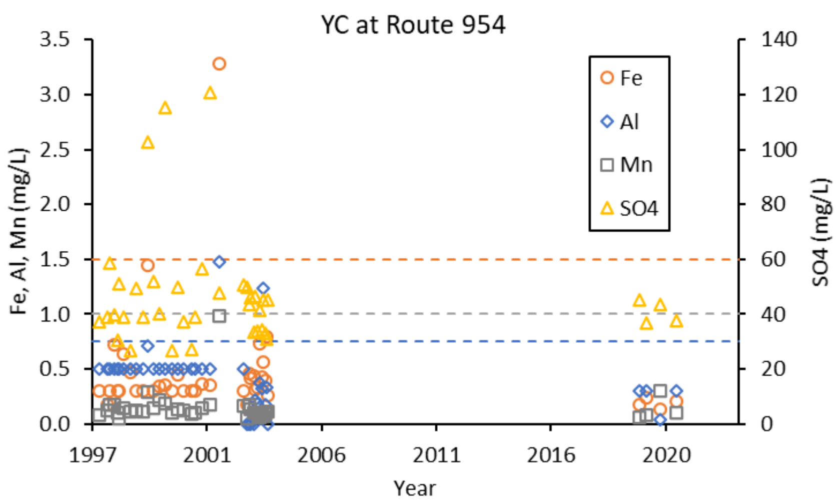


Figure 3. Chemical conditions in LYC at Rt. 954 bridge from 1997 to 2021. Upper plot shows pH and net acidity (negative acidity is net alkalinity). Lower plot shows metals and sulfate. Dotted horizontal lines are instream standards for Fe (orange), Al (blue), and Mn (grey).

Sampling data collected at the mouth of LYC in Floodway Park are shown in Figure 4 and summarized in Table 4. Between 1997 and 2004, chemical conditions were variable but on average LYC had low pH acidic water containing elevated concentrations of Fe, Al, and Mn. Conditions have improved recently. In 2019-2020, sampling found higher pH, lower acidity, and lower concentrations of metals. This decrease in acidity is likely due to natural attenuation (a natural decrease in pollution concentrations over time). Typically, metal concentrations in AMD decrease exponentially by about 5% per year to site specific background concentration (Perry and Rauch, 2013).

Despite the decrease in metals concentrations in the past 20 years, LYC at Floodway Park continues to be degraded by metals. Out of the four samples collected for this report, all four exceed the instream Fe standard, three exceed the instream Al standard, and one exceeded the instream Mn standard. Flow and Fe concentrations are inversely correlated (Fe concentrations are lowest when flow is high) suggesting Fe concentrations are diluted by high flows. While dissolved samples were not collected, particulate Fe and Al clearly stain LYC at this location. Additionally, the moderate pH and low acidity concentrations, suggests that Al is particulate, and most Fe is particulate.

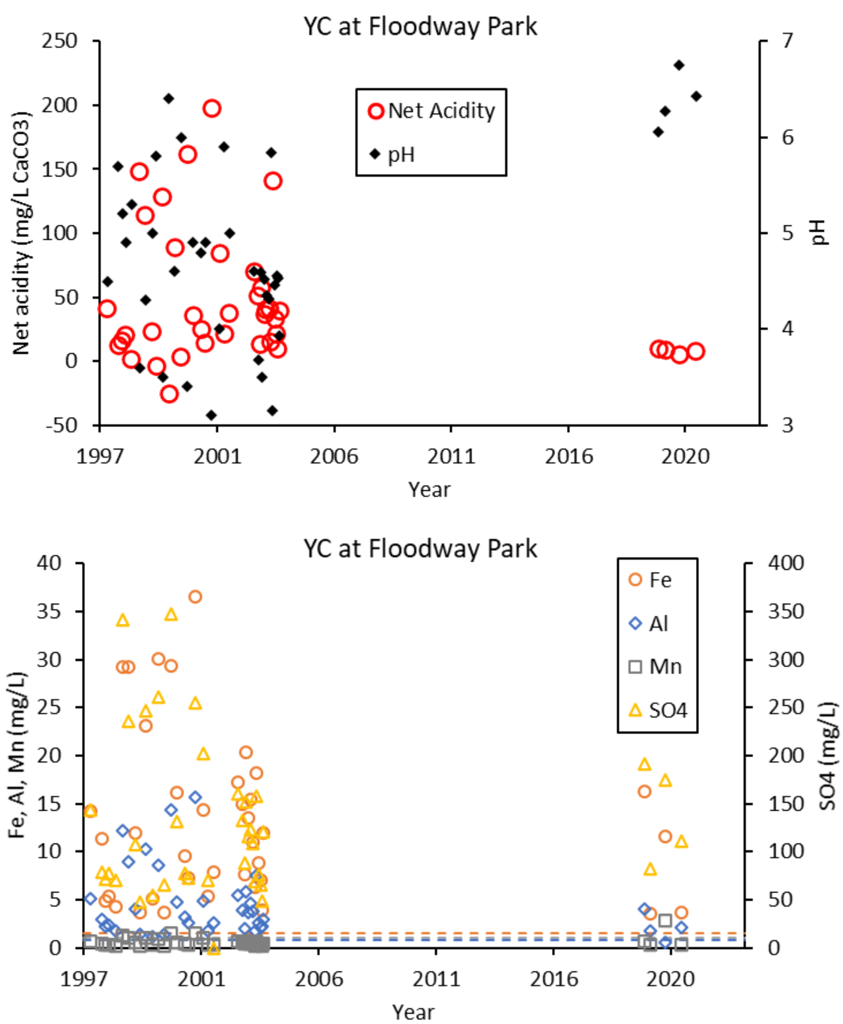


Figure 4. Chemical conditions in LYC at Floodway Park from 1997 to 2021. Upper plot shows pH and net acidity (negative acidity is net alkalinity). Lower plot shows metals and sulfate. Dotted horizontal lines are instream standards for Fe (orange), Al (blue), and Mn (grey).

Table 4. Average chemistry at the mouth of Yellow Creek (YC at Floodway Park) from 1997 to 2004 (data from the 2005 Blacklick Creek Watershed Assessment report) and from 2019-2021(data from this report). N=34 for 1997-2004 data and N=4 for 2019-2021 data.

Date	pH	Alkalinity	Net Acidity	Fe	Al	Mn	SO_4
		mg/L as $CaCO_3$		mg/L			
1997-2004	4.79	9	55	14.5	5.3	0.6	149
2019-2021	6.38	68	8	8.8	2.1	1.0	140
Instream Standards for CWF							
	6-9			1.5	0.75	1.0	

Lower Yellow Creek Pollution Sources

All known significant sources of mine water entering LYC were identified and sampled for this project. There are many known lesser sources of AMD throughout the watershed, but the strategy here was to concentrate on those with the potential to materially degrade Yellow Creek. Table 5 shows average flow, chemistry, and loadings for mine water inflows to LYC, including polluted tributaries. This table only includes water chemistry that flows into Yellow Creek, which is not discharge chemistry in all cases. For example, the Route 119 borehole discharge flows through a large, natural wetland that provides some natural treatment before entering LYC. Since the discharge is partially treated, we include the natural wetland effluent monitoring location and not the borehole discharge in this table.

Table 5 sorts the AMD inflows by decreasing acidity loading. The Lucerne refuse pile area is, by far, the most significant source of acidity and metals in the watershed.

The pollution loadings from the Lucerne and Tide refuse pile areas are calculated using the difference between downstream and upstream loadings and subtracting out any point source loadings in that stretch of creek. See methods for details. Because flow rates from the refuse piles are uncertain, there are no concentration data from these pollution sources.

In the following sections, the Lucerne refuse pile is described in detail. Then, all other pollution sources to LYC are described in order of highest acidity loading to lowest acidity loading. Finally, the passive treatment systems in the Yellow Creek watershed are detailed.

Table 5. Average chemistry and loadings for the locations that discharge directly to LYC from 2019 to 2021. In-stream locations, tributaries, Lucerne refuse pile, and Tide refuse pile are averaged data from the quarterly sampling efforts (Nov. 2019, Feb. 2020, Sep. 2020, May 2021). All other pollution sources entering LYC are from monthly discharge sampling efforts.
Alk = field alkalinity. Acid = measured net acidity.
[a] calculated by mass balance methods. [b] Average data from Sep. 2020 and May 2021 only. [c] Average data from Nov. 2019, Sep. 2020, and May 2021 only. [d] Major tributaries to LYC.

ID	Location	Flow	pH	Alk	Acid	Fe	Al	Mn	SO_4	Acid	Fe	Al	Mn	SO_4
		gpm		mg/L as $CaCO_3$		mg/L				lb/day				
Mine water sources entering LYC (ordered from highest to lowest acidity loading)														
Lucerne pile	Lucerne refuse pile area [a,b]	511								4,657	1,125	281	207	9,470
Tide pile	Tide refuse pile [a,c]	234								426	24	37	9	2,213
LYC-6	Tide Tributary [d]	225	3.78	1	95	6.1	4.8	5.7	424	138	19	9	5	881
D-8	Refuse Pile Tributary	44	4.13	0	179	80.9	8.2	9.8	907	83	30	6	3	236
D-7	Concrete Pipe Discharge	16	3.70	0	501	145.9	34.3	9.8	1,582	76	22	5	1	257
LYC-3	Judy 14 Tributary [d]	33	3.24	0	135	3.8	10.2	6.6	388	66	2	6	2	182
D-6B	Lucerne Portal Discharge at LYC	129	4.46	1	29	4.6	2.3	1.5	417	38	5	3	2	597
D-9A	Route 119 Borehole at LYC	54	6.27	41	19	27.7	3.1	2.9	471	19	18	3	2	309
Passive treatment systems entering LYC														
1A+1B	1A and 1B systems (common effluent)	18	5.01	7	32	0.3	4.6	3.7	664	9	0	1	0	65
2A/2B	2A and 2B systems (common effluent)	11	4.78	3	16	0.8	1.1	3.4	518	2	0	0	0	65
2C	2C system	35	6.70	129	-121	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Lucerne Refuse Pile Area

Site History

The Lucerne refuse pile is a large, abandoned coal refuse disposal site and coal tipple about 1 mile northeast of Homer City, PA. It includes approximately 200 acres of abandoned mine land (AML). In the PADEP's AML inventory, the refuse pile area is named "Homer City" and is site number PA 2402 (Map 5). There are five AML features associated with the area (Table 6). The northern portion of the site is identified as feature 2402-02 and contains approximately 3,200,000 yd^3 of refuse.

The Lucerne pile is underlain by the abandoned workings of the Lucerne No. 2 and the Waterman No. 2 mines in the Freeport and Kittanning coal seams. The Upper Freeport seam outcops along Yellow Creek along the northern side of the pile and shallow underground abandoned workings underlay the remainder of the pile at approximately 100 feet depth. Abandoned workings in the Lower Kittanning seam underlay the pile at approximately 300 feet depth. Mine maps documenting the extensive mine workings in the area can be found at the Pennsylvania Mine Map Atlas (https://www.minemaps.psu.edu/).

Table 6. AMD polygons on the Homer City (Lucerne refuse pile) site (AML inventory site # PA 2402. Data from PADEP.				
ID #	**AML type**	**Status**	**Priority**	**Refuse volume (yd^3)**
2402-02	Refuse pile	Abandoned	2	3,200,000
2402-03	Coal processing settling basin	Abandoned	3	0
2402-04	Coal processing settling basin	Abandoned	3	0
2402-05	Coal processing settling basin	Abandoned	3	0
2402-06	Coal processing settling basin	Abandoned	3	0

The refuse pile is divided into southern and northern sections by Tide Road. PADEP reports that as of 2021, all burnable refuse has been removed from the southern portion of the pile and replaced with ash. The southern pile is mostly vegetated. The northern portion of the pile is currently being mined and refuse removal is expected to be completed by summer 2023. Ash placement will likely continue after this date until regrading of the pile is complete.

Cambria Reclamation Corporation permitted the pile in 1995 with the intention of utilizing it as a primary fuel source for the Cambria Reclamation Corporation waste coal-burning power plant located in Ebensburg. The permit requires that the permittee complete remining and reclamation of the pile using alkaline ash in exchange for receiving legal protection from liability for the surface water pollution sources that existed prior to permit issuance. Under PADEP regulations, this type of permit is called a "subchapter F" permit in reference to the section of Pennsylvania's mining regulations that govern mining permits with pre-existing polluting discharges.

Using a technology known as circulating fluidized bed combustion (CFBC), waste coal-burning power plants, such as the Cambria Reclamation plant, have the ability to burn relatively low BTU, high sulfur and high ash fuels that traditional coal-fired power plants cannot burn. Ground limestone is injected into the boiler during combustion to help capture air-pollutants. Because of the high noncombustible content of the fuel and the addition of the limestone, CFBC plants produce relatively large volumes of alkaline ash, which has cementitious properties. The ash is backhauled to the refuse remining sites and aids in water quality remediation in two ways. First, because of the addition of limestone to the boiler, the ash is highly alkaline and thus can neutralize acidic materials remaining in the refuse pile. Second, because of its cementitious properties, when the ash is mixed with the non-burnable rock and sub-quality refuse back at the pile it encapsulates the acid-bearing components of those materials and helps isolate them from the environment. Water is added to the ash to aid in its handling and to start the hardening process. When the ash and refuse reject mixture is compacted and further exposed to water from the environment, the result is a relatively low permeable pile of mostly alkaline material as opposed to the highly permeable acidic refuse pile that previously occupied the site. The ash/reject mixture is then covered with soil and revegetated. Reclamation of large refuse piles in this way has been accomplished at many locations across the state, including five others in the Blacklick Creek watershed with documented substantial improvements in water quality. A PADEP presentation about these five projects is included as Appendix 3 (Gregory Aaron, 2017).

While Cambria Reclamation permitted the Lucerne site in 1995, for many years it obtained most of its fuel from another site at Ernest, PA (Crooked Creek watershed), and only conducted sporadic and limited mining and reclamation at the Lucerne pile. As the company was transitioning its operations from Ernest to Lucerne, it encountered financial difficulties and eventually closed the Cambria Reclamation plant. Refuse from Ernest was then shipped to the Colver Generating station (another CFBC plant) for a period of time. That plant also eventually closed, but was subsequently purchased by Robindale Energy Services. Refuse from the Lucerne pile is currently being shipped to the three waste-coal plants that Robindale operates in the area (Seward, Colver, and Ebensburg Power). In addition to Robindale, which works on the Lucerne site as a subcontractor, Compass Coal Company, Inc. also has an operation on the site that screens refuse and extracts coal from it. As of November 2021, an application was in process with the DEP to transfer the permit from Cambria Reclamation Corp. to Compass Coal Company, Inc.

Compass Coal Company manages five National Pollution Discharge Elimination System (NPDES) Individual Permit (Coal) discharges from settling ponds associated with the Lucerne pile mining (see Appendix 4 for permit information). The NPDES permit number is PA0213039. The average monthly discharge limits are a minimum of pH 6 and maximum of 1.5 mg/L Fe, 1.0 mg/L Mn, and 0.75 mg/L Al (see Appendix 4 for additional details on effluent limits).

Current Pollution Loadings

The Lucerne refuse pile area is the largest source of acidity and metals to LYC. It degrades LYC for about 1 mile to its mouth and confluence with Two Lick Creek. Table 7 shows stream flow and chemistry above and below the refuse pile. LYC transitions from net alkaline with low concentrations of metals above the pile (LYC-10) to net acidic and impaired with metals below the pile (LYC-11). The refuse pile area's contaminant load is calculated from the difference of upstream and downstream measurements made on two days when both were sampled. Loadings from the refuse pile are shown in Table 8. The Lucerne refuse pile area produced, on average, 4,657 ppd acidity, a loading ten times higher than the next largest source of acidity in the watershed. While this number is based on only two samples and is approximate, it highlights the magnitude of pollution from the Lucerne pile.

Table 7. Chemistry and pollution loadings in LYC above the Lucerne refuse pile (LYC-10) and below the pile (LYC-11).
[a] 11/17/2020 sample from LYC-11 was not included as it is not representative of average LYC chemistry.

Date	Location	Flow	pH	Net acidity	Fe	Al	Mn	SO4	Net acidity	Fe	Al	Mn	SO_4
		gpm		mg/L					lb/day				
LYC above Lucerne Pile													
11/17/2019	LYC-10	6,450	7.04	-32	0.6	0.5	0.3	146	-2,477	44	40	26	11,269
9/20/2020	LYC-10	4,684	7.63	-48	0.4	0.2	0.3	109	-2,698	25	9	17	6,132
5/25/2021	LYC-10	29,353	6.93	-10	0.3	0.6	0.2	56	-3,381	113	220	58	19,831
LYC below Lucerne Pile [a]													
2/24/2020	LYC-11	50,001	6.12	12	4.2	1.9	0.3	85	7,380	2,544	1,149	208	50,761
9/20/2020	LYC-11	6,484	6.11	14	14.4	0.6	4.8	184	1,089	1,120	46	377	14,336
5/25/2021	LYC-11	30,240	5.89	7	3.7	2.1	0.3	88	2,468	1,357	764	125	31,988

Table 8. Calculated pollution loadings from the Lucerne refuse pile.					
Date	**Net acidity**	**Fe**	**Al**	**Mn**	**SO_4**
	lb/day				
9/20/2020	3,787	1,095	37	360	8,204
5/25/2021	5,849	1,244	544	67	12,157
Average	*4,818*	*1,170*	*291*	*213*	*10,180*

Surface Water Pollution from the Lucerne Refuse Pile

The section of stream between LYC-10 and LYC-11 was walked to identify sources of surface water pollution. Four polluted surface water flows/discharges from the Lucerne refuse pile area were identified and monitored during this project. NPDES discharges that were listed as "in-compliance" on the eMapPA website (https://gis.dep.pa.gov/emappa/) were not sampled. Average chemistry of the four untreated discharges is shown in Table 9. The summed contaminant loadings of these discharges account for 3-6% of the increase in instream loadings (Table 8). These monitored surface flows of AMD are a minor contributor to the pollution of LYC.

Table 9. Average chemistry for the four surface water flows from the Lucerne refuse pile area from 2019 to 2021. L-12 was monitored by the Cambria Reclamation Corp. and includes 10 samples from Feb 2019 to May 2021. All other discharges were monitored by this project. N=10 for D-7 and D-8 and N=9 for D-14.												
Location	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
	gpm		**mg/L**					**lb/day**				
L-12	4	6.13	29	34.3	0.7	1.4	411	3	2	0	0	24
D-7	16	3.70	501	145.9	34.3	9.8	1,582	76	22	5	2	257
D-8	44	4.13	179	80.9	8.2	9.8	907	83	31	6	3	236
D-14	18	3.92	280	74.6	20.5	6.4	938	45	12	3	1	174
Sum								*207*	*67*	*14*	*6*	*691*

In addition to the points above, Cambria Reclamation Corp. also monitors several Subchapter F discharges between the Lucerne refuse pile and LYC. They are labeled as L46, L47, L48, L8, L5, and L7 on the mining permit map. These locations are either perennially dry or flow less than 2 gpm. Acidity concentrations are as high as 3,000 mg/L which is typical of coal refuse impacted water. Because of the low flow, the combined acidity loadings of these discharges low (less than 200 lb/day) and they do not account for the missing contaminant loading. However, if these discharges are representative of local groundwater entering LYC, a wide seep zone or polluted baseflow could be responsible for some, or all, of the pollution to LYC.

Other Sources of AMD Pollution

The sampling data in Table 9 indicate that surface water discharges are not the primary source of the increase in pollution loadings between LYC-10 and LYC-11. LYC gains significant pollution loading from unmeasured, nonpoint sources. These sources of pollution could include polluted groundwater/baseflow from the refuse pipe or deep mine discharges from the mines beneath the pile.

Before 2007, a discharge from the Lucerne #2 deep mine (Freeport seam) originated from the northern section of the Lucerne refuse pile (Map 6). It was identified as LYC-095 in the 2005 watershed assessment. Average chemistry from this assessment is shown in Table 10. Sampling by the Cambria Reclamation Corp. in 2007 as L-4 (Map 5) and showed similar chemistry. The acidity loading of approximately 4,500 lb/day roughly equals the acidity loading gained by LYC from the Lucerne refuse pile.

Table 10. Average chemistry and acidity loadings from the Lucerne #2 deep mine from the north section of the Lucerne refuse pile. Data from sampling point LYC-095 from the 2005 Watershed Assessment. N=17.

Flow	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**
gpm		**mg/L**					**lb/day**
19	2.32	19,444	>300	>500	10	17,553	4,623

The Lucerne #2 deep mine discharge was graded over during reclamation of the 2404-08 AML refuse pile in 2007 and a surface discharge no longer exists. Additionally, LYC-10, which is downstream of this discharge, is not impaired. Therefore, it is unlikely that this discharge is still flowing from its historic location. The discharge may be discharging from another hydrologically connected location or polluting local groundwater.

The Lucerne pile area contains boreholes into abandoned coal mines noted on mine maps. Borehole discharges from a sump in the Lower Kittanning mine are noted on the bank of LYC between LYC-10 and LYC-11 (Map 6). These boreholes, and others, could hydrologically connect the Kittanning and Freeport mines and provide a conduit for AMD to discharge to the surface or to shallow groundwater systems and into LYC.

An addition to deep mine discharges, an additional or alternative source of AMD to LYC could be polluted baseflow. The Lucerne pile could pollute local groundwater which could enter LYC or more direct subsurface flowpaths from the pile to LYC may exist. Significant pollution of local aquifers around other refuse piles is well documented (Appendix 3).

Although this study did not determine the AMD source in the Lucerne pile area (abandoned deep mines vs refuse polluted groundwater), it documented that pollution is entering LYC from the Lucerne pile side (eastern side) of the creek. A chemical gradient is visible across LYC at the Lucerne refuse pile with white/orange turbidity on the side of the creek nearest of pile (Photo 1). This gradient could be due to a single, or few, subsurface discharge(s) that do not mix with the creek or due to polluted baseflow entering LYC along the length of the Lucerne pile.

During the September 2020 quarterly sampling event, five unfiltered and two filtered samples were collected from a cross section of LYC at the reuse pile (LYC-10.5). The unfiltered samples are shown in

Figure 5. These five samples show that LYC near the western stream bank opposite of the refuse pile (Sample 1) was good quality while LYC near the eastern stream bank and Lucerne refuse pile was degraded (Sample 5). Two filtered samples were collected which showed that Fe, the main pollutant, is primarily dissolved at this location (Table 11). LYC below the Lucerne refuse pile (LYC-11) showed similar, but less extreme cross sectional chemical differences. While these samples do not elucidate the source of AMD (deep mines or baseflow polluted by refuse), it documents that pollution is entering from the Lucerne pile side of LYC.

Photo 1. LYC at the Lucerne refuse pile at approximately LYC-10.5. The pile is along the right bank (east bank). Note the staining only along the right bank.

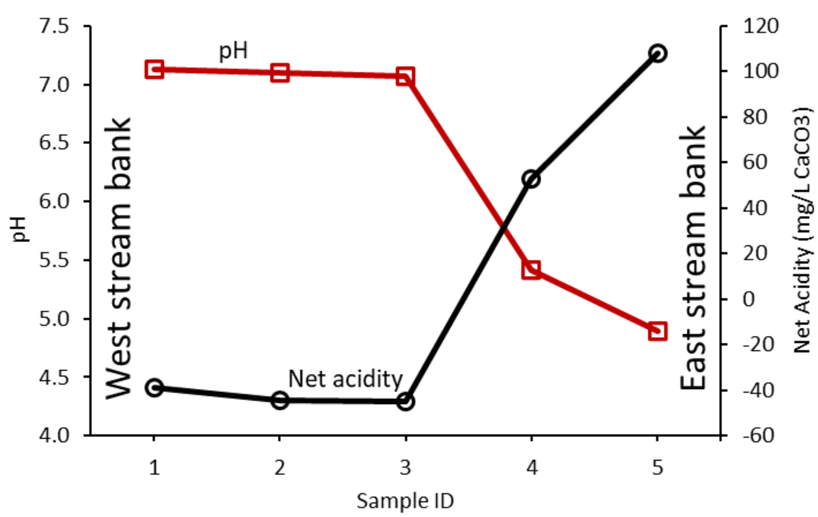


Figure 5. pH and net acidity gradient across LYC at the Lucerne refuse pile in September 2020. The Lucerne refuse pile is along the eastern stream bank.

Table 11. Chemistry across LYC at LYC-10.5 in September 2020. Dis = dissolved. Tot = total. Sample ID locations correspond to those in Figure 5 with Sample 1 along the western stream bank and Sample 2 along the eastern stream bank.

Sample ID	pH	Net acidity	Fe, tot	Fe, dis	Al, tot	Al, dis	Mn, tot	Mn, dis	SO_4, tot
		mg/L							
1	7.13	-39	2.0		0.3		0.8		121
2	7.10	-45	2.3	1.7	0.4	0.3	1.0	0.3	127
3	7.07	-45	2.7		0.4		1.1		129
4	5.42	53	24.5		0.6		9.2		218
5	4.89	108	39.8	37.8	0.8	0.8	13.9	8.6	263

Lucerne Pile Groundwater Wells

Cambria Reclamation Corp. monitors groundwater around the refuse pile at three monitoring well locations (MW-3, MW-4, and MW-5; Map 5). MW-3 is between the southern portion of the pile and LYC, MW-4 is near the mouth of the Refuse tributary, and MW-5 is between the northern portion of the pile and LYC (Map 5). The monitoring wells were drilled into bedrock to the first water bearing zone. The total depth of MW-3 is 33 feet and of MW-4 and MW-5 are 35 feet. Because the Freeport coal seam is deeper than these wells, it is unlikely that these wells penetrate the abandoned Freeport coal seam coal mines under the Lucerne pile.

These wells show that the local aquifer is relatively shallow with groundwater elevations less that 6 feet below the surface. Average groundwater surface elevations for the wells are 1,047 feet for MW-3, 1,038 feet for MW-4, and 1,039 feet for MW-5. These elevations are 5-15 ft higher than the surface elevation of nearby AMD discharges (D-7, D-9, D-14) 1028 and 1038 feet. Additionally, the average groundwater surface elevations are between 11 to 29 feet above the water surface of LYC. This suggests that the groundwater monitored in these wells is from a local aquifer.

Table 12 shows average chemistry for the three wells. All wells contain net acidic groundwater primarily contaminated with Fe and secondarily contaminated with Al and Mn. This chemistry matches the large increase in Fe and acidity loading gained by LYC as it flows by the refuse pile. Baseflow polluted by the Lucerne refuse pile could be responsible for all, or a portion, of the pollution to LYC around the Lucerne pile.

Table 12. Average chemistry of the monitoring wells at the Lucerne refuse pile over the course of this study (November 2019 to May 2021). Dissolved metals data are shown. N = 7 for all wells. Data obtained from a review of the Cambria Reclamation Corp.'s mining permit (#32950202) on file at PADEP's Cambria District Mining Office.

Well	pH	Alkalinity	Acidity	Fe	Al	Mn	SO_4
		mg/L $CaCO_3$		mg/L			
MW-3	5.93	< 10	271	161.3	<0.1	14.3	1,235
MW-4	4.69	< 10	183	48.7	7.8	4.9	668
MW-5	5.69	25	140	73.7	<0.1	3.5	575

Figure 6 shows groundwater chemistry trends at monitoring wells 3, 4, and 5 the Lucerne Pile from 2010 to 2021. Net acidity concentrations in MW-3 and MW-5 increased in substantially around 2018 while net acidity concentrations in MW-4 have stayed relatively consistent since 2010. While the reason(s) for increasing pollution concentrations are unknown, it could be due to the disturbance to the pile during the remining/reclamation effort exposing unweathered mineral surfaces and/or increasing infiltration.

MW-3 is located in the reclaimed southern portion of the refuse pile and contains the highest concentrations of acidity, Fe, Mn, and sulfate. Samples from monitoring wells are not always representative of flowing ground water conditions. However, the sampling suggests that the reclamation project has, to date, not remediated polluted groundwater conditions.

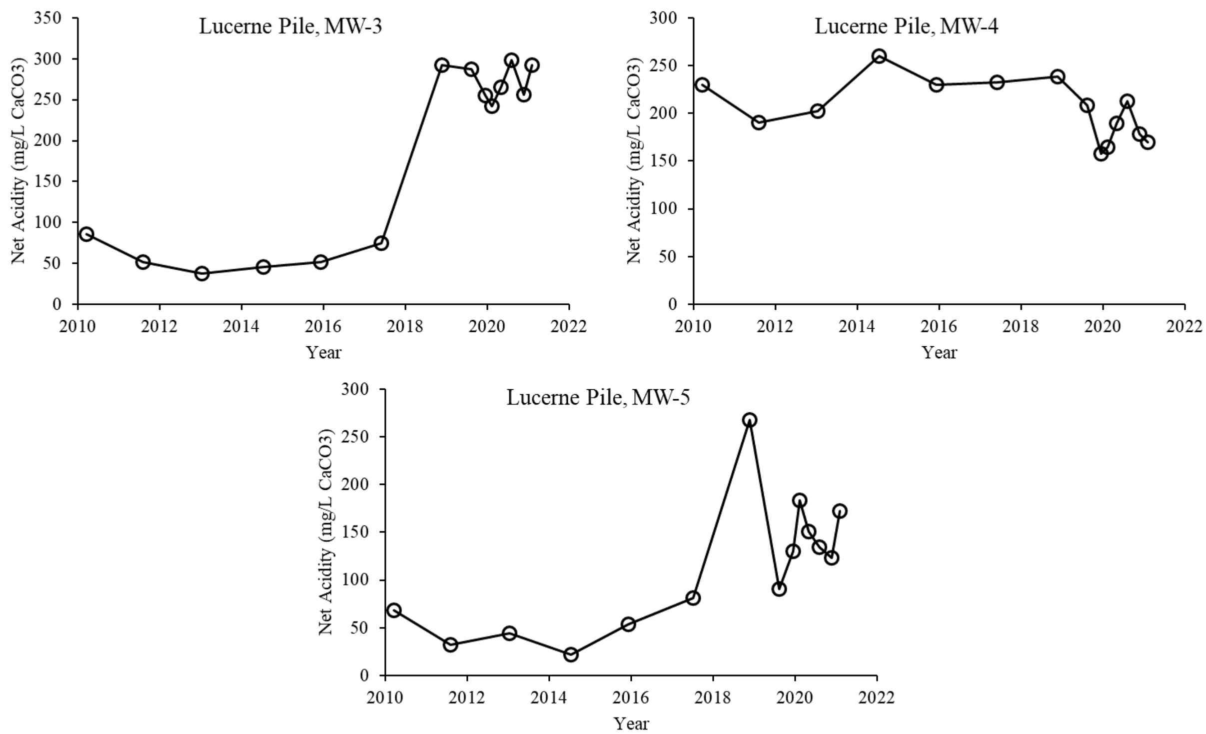


Figure 6. Net acidity concentrations at groundwater monitoring wells (MW) 3, 4, and 5 at the Lucerne refuse pile from 2010 to 2021.

Current Impact of Reclamation on Lower Yellow Creek Water Quality

As part of their mining permit, Cambia Reclamation Corp. has collected quarterly LYC instream water quality samples above and below the Lucerne refuse pile since 1994. The upstream location is L-6 (approximately LYC-10 in this study) and the downstream location is L-13 (approximately LYC-11 in this study) (Map 5). Flow rates are not measured.

The difference between downstream and upstream concentrations of calculated acidity and Fe concentrations were calculated. On average, the Lucerne pile increases net acidity by 26 mg/L and Fe by 7 mg/L Fe. These changes are consistent with measurements made by this study that found an increase of 36 mg/L acidity and 9 mg/L Fe.

Since remining of the Lucerne refuse pile started in 1997, net acidity gains from the pile have not meaningfully changed (Figure 7). The lack of high peaks of acidity and Fe gain from 2017 to 2021 may indicate that reclamation is helping limit high pollution events. The pile continues to impair LYC despite the extensive refuse removal. However, for many coal refuse piles, major pollution loading reductions are not observed until reclamation is completed.

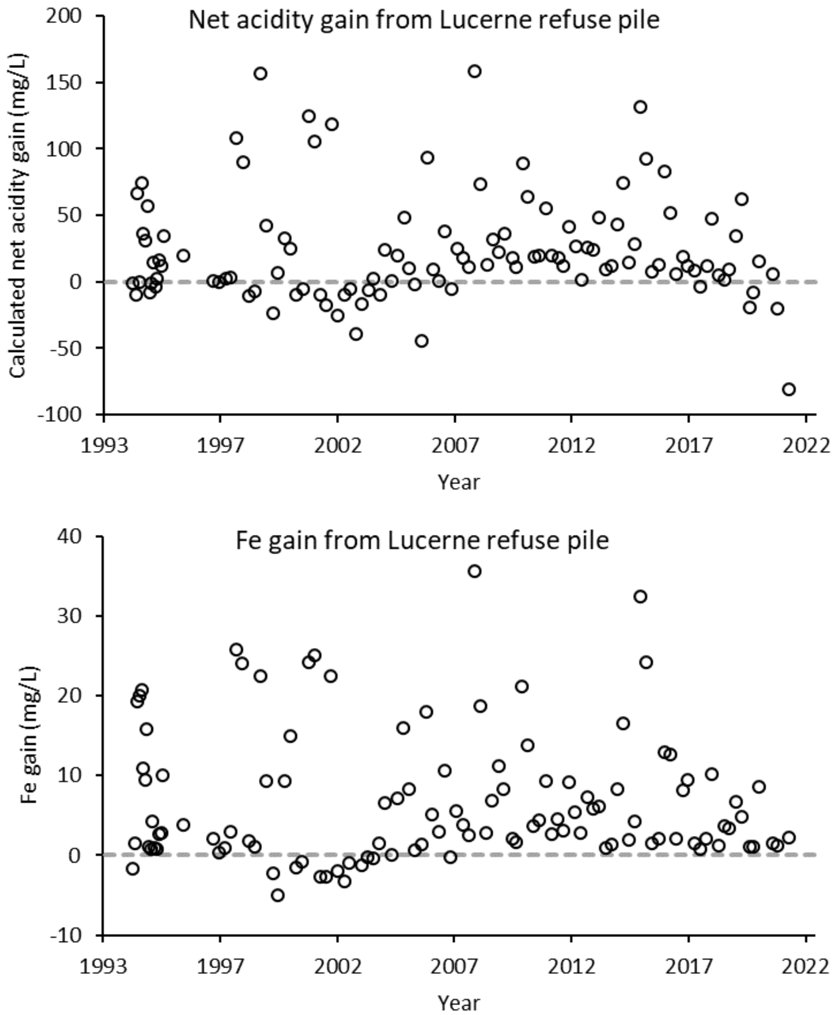


Figure 7. LYC calculated net acidity gain from the Lucerne refuse pile (top) and Fe gain (bottom). Gain calculated as difference between the upstream (L6) and downstream (L13) data. The horizontal dashed line represents 0 mg/L (no impact). Data obtained from a review of the Cambria Reclamation Corp.'s mining permit (#32950202) on file at PADEP's Cambria District Mining Office. Mining started in 1997 and continues thru 2021.

The frequent sampling conducted by Cambria Reclamation Corp. allowed evaluation of seasonal differences in impairment. LYC gains significantly more acidity and Fe from the Lucerne pile in the summer and fall than in the spring and winter (Figure 8). This is likely due to lower streamflow in LYC in summer and fall and less dilution and neutralization by upstream flow.

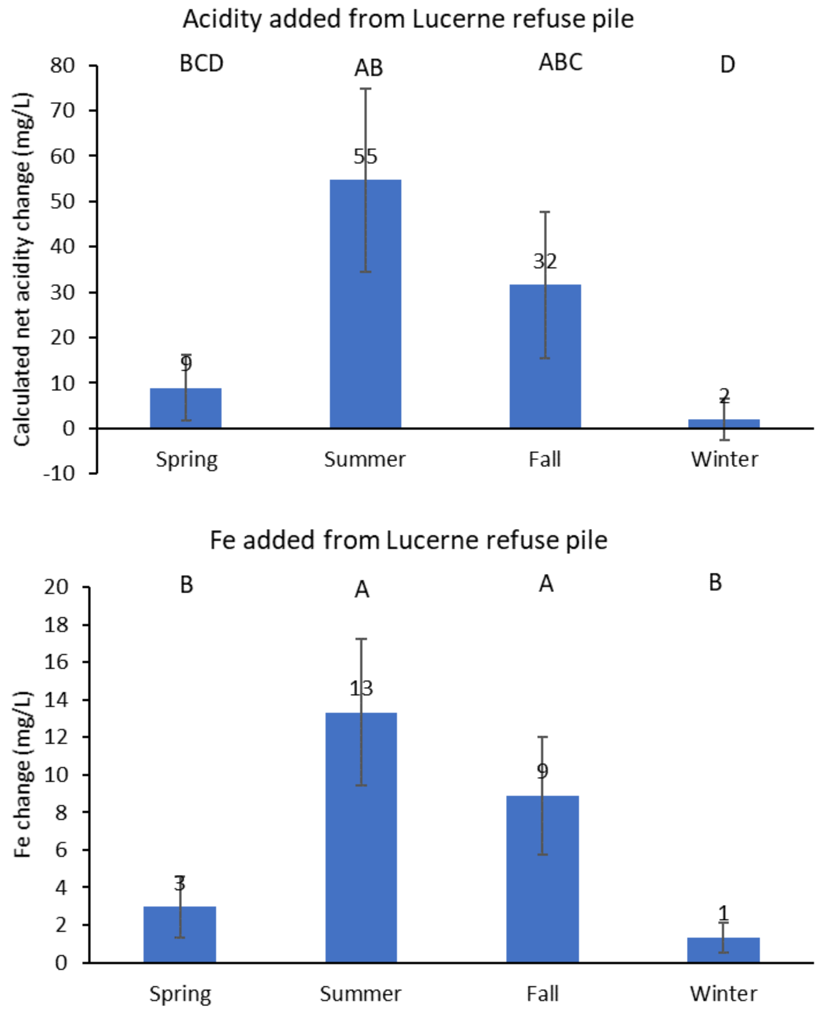


Figure 8. LYC calculated net acidity gain from upstream to downstream of the Lucerne refuse pile (top) and Fe gain (bottom). Error bars show 95% confidence intervals and letters on top indicate significance at the p=0.05 level. Data was collected quarterly from 1994 to 2019 and includes at least 25 samples for each season.

Reclamation Goals and Expectations

Several coal refuse remining and reclamation projects have been completed in the Blacklick Creek Watershed in the past 25 years. A PADEP presentation describing five such projects is provided as Appendix 3. While none of these projects occurred in the Yellow Creek watershed, the practices described in these projects are similar to what is currently taking place at the Lucerne refuse pile. Burnable refuse was removed for combustion and ash was returned and mixed with unburnable refuse.

All five reclamation projects substantially improved local surface water chemistry, and some have restored local streams. Net acidity, Fe, Al, Mn, and SO_4 loadings from surface water discharges from the piles decreased from between 82% to 99%. Additionally, reclamation of the Revloc refuse piles (Revloc, PA) substantially improved the water chemistry of Blacklick Creek.

In addition to decreasing pollution concentrations in surface water, these refuse pile reclamation projects also improved groundwater chemistry. The reclamation of the Colver refuse pile (Colver, PA) is presented as an example. Ash placement started in 1995 and reclamation was completed in 2016. Figure 9 shows net acidity and Fe concentrations at monitoring wells 2 and 3 at the Colver refuse pile over the course of the reclamation project. In monitoring well 2, net acidity concentrations decreased from 4,300 mg/L before 2001 to 460 mg/L after 2001 (89% decrease). Fe concentrations decreased from 1,500 mg/L before 2001 to 140 mg/L after 2001 (91% decrease). A similar, although more gradual, improvement occurred in monitoring well 3 where acidity and Fe concentrations decreased by 67% and 57%, respectively.

The improvements in groundwater chemistry at the Colver refuse pile took approximately 6 years to be realized after reclamation started. While net acidity and Fe concentrations are substantially lower compared to pre-reclamation conditions, the groundwater was still highly contaminated with hundreds of mg/L of acidity and Fe after reclamation.

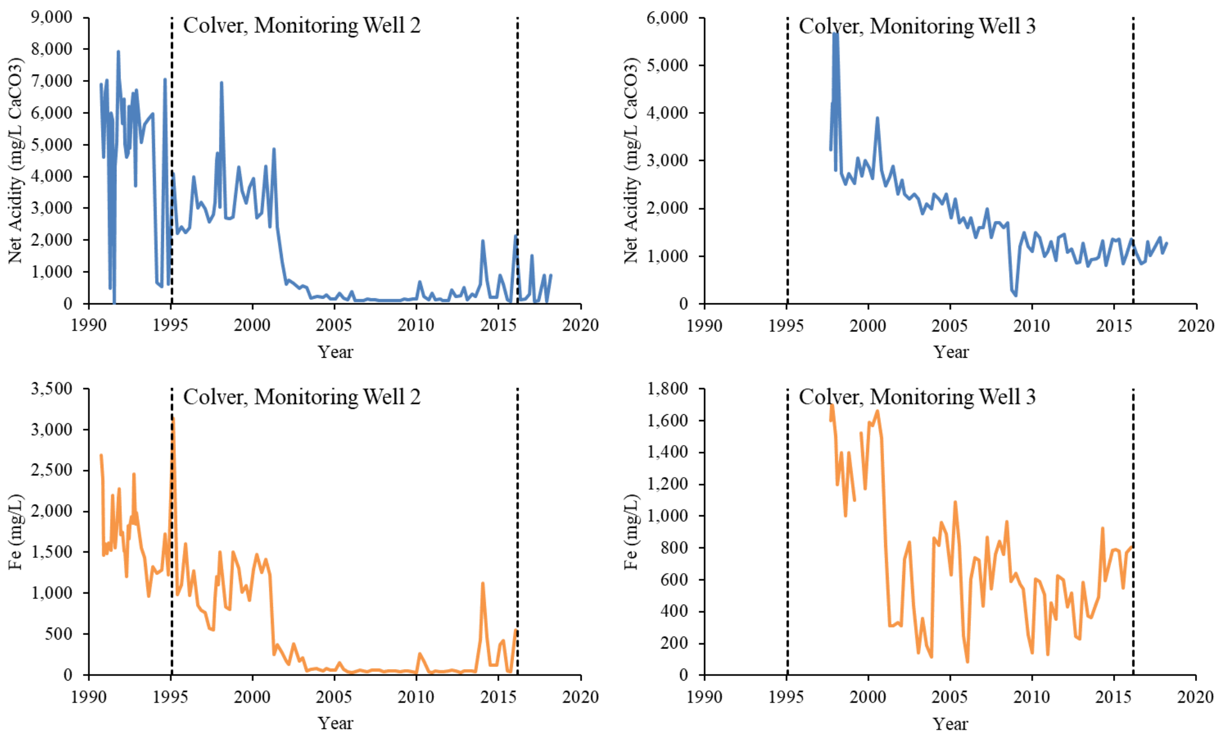


Figure 9. Net acidity concentrations (top) and Fe concentrations (bottom) from two groundwater monitoring wells at the Colver refuse pile through its reclamation. Horizontal dashed lines represent the beginning and end of reclamation.

If refuse-polluted groundwater is responsible for all/most of the pollution to LYC, the Lucerne pile reclamation could improve groundwater and LYC instream chemistry. However, pollutant concentrations in the Lucerne groundwater (100s of mg/L acidity) are substantially lower than concentrations in the Colver wells before reclamation (1,000s of mg/L acidity). The impacts of lower initial pollution concentrations are unknown.

Based on water quality improvements observed at refuse reprocessing projects described above, the Lucerne reclamation project could decrease pollutant loadings by 90%. Table 13 shows predicted LYC water chemistry should this benefit be realized. The current and expected chemistry for the two instream sampling locations downstream and of Lucerne refuse pile (LYC-11 and LYC-12) for the September 2020 and May 2021 sampling events are shown. Loadings are calculated by subtracting 90% of the Lucerne pile loadings from instream loadings. Concentrations are calculated from the loading and the measured flow rate at the instream monitoring location.

A 90% reduction in Lucerne refuse pile loadings would result in LYC at Floodway Park (LYC-12) around the instream limits of Al, Fe, and Mn.

Table 13. Current and predicted water quality at instream locations in LYC based on predicted reductions in acidity loading from the Lucerne refuse pile reclamation.

Date	**Location**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO_4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO_4**
		mg/L $CaCO_3$	**mg/L**				**lb/day**				
Current conditions											
9/20/2020	LYC-11	14	14.4	0.6	4.8	184	1,089	1,120	46	377	14,336
9/20/2020	LYC-12	5	11.6	0.6	2.8	175	333	714	34	172	10,783
5/25/2021	LYC-11	7	3.7	2.1	0.3	88	2,468	1,357	764	125	31,988
5/25/2021	LYC-12	8	3.6	2.2	0.4	111	2,623	1,249	742	124	38,345
90% loading reduction from Lucerne refuse pile											
9/20/2020	LYC-11	-29	2.0	0.2	0.7	92	-2,261	152	14	57	7,139
9/20/2020	LYC-12	-37	2.7	0.3	0.9	120	-2,269	167	16	58	7,408
5/25/2021	LYC-11	-7	0.8	0.8	0.2	61	-2,564	301	291	72	22,139
5/25/2021	LYC-12	-7	0.9	0.9	0.2	65	-2,533	322	294	75	22,561
Instream standards for CWF											
			1.5	0.75	1.0						

While these projections are promising, abandoned deep mines below the Lucerne pile could be contributing AMD. In which case, reclamation of the surface refuse pile many not improve water quality in LYC. Additionally, sampling of LYC and the Lucerne pile groundwater wells has not yet indicated substantial water quality improvements. As of fall 2021, the remining and reclamation at the Lucerne pile has not meaningfully improved LYC water chemistry. However, a substantial portion of the northern pile is still to be remined and reclaimed.

Other Pollution Sources to Lower Yellow Creek

In the following sections, all AMD pollution sources, other than the Lucerne pile, are presented in order of decreasing acidity loadings. See Table 5 for a list of AMD sources and loadings to LYC.

1. Tide Refuse Pile

The Tide refuse pile is a large, abandoned refuse pile along LYC and near the Judy 14 tributary (Map 7). The main pile is approximately 8 acres with 15 acres of additional AML to the south of the pile. In the PADEP's AML inventory sites list, the Tide site is identified as number PA 2404. Table 14 shows the five specific refuse pile and settling basin AML areas identified on Tide site. The only unreclaimed refuse pile on the site (number 2404-10) is the large pile in the northeastern part of the site. This pile is a priority 2 feature with an estimated 1,080,000 cubic yards of refuse (approximately 1/3 the size of the Lucerne pile before remining).

Table 14. AMD polygons on the Tide site (AML inventory site # PA 2404. Data from PADEP.

ID #	AML type	Status	Priority	Refuse volume (yd^3)
2404-06	Coal processing settling basin	Abandoned	2	0
2404-07	Coal processing settling basin	Abandoned	3	64,000
2404-08	Refuse pile	Reclaimed	3	94,000
2404-09	Refuse pile	Reclaimed	3	16,000
2404-10	Refuse pile	Abandoned	2	1,080,000
2404-11	Refuse pile	Reclaimed	3	80,000

LYC was sampled upstream (LYC-2) and downstream (LYC-5) of the Tide refuse pile and Judy 14 tributary. Both locations were net alkaline with low concentrations of metals (Table 15). However, the combined influence of the Tide refuse pile and the Judy 14 tributary roughly double the Fe, Al, and Mn concentrations and loadings in the LYC and causes Al concentrations to approach in-stream criteria at times.

Table 15. LYC instream conditions above and below the Tide refuse pile an Judy 14 tributary.
[a] lab pH values at LYC-2 and LYC-5 were 7.8 and 7.4, respectively.
[b] lab pH values at LYC-2 and LYC-5 were 7.8 and 7.9, respectively.

Date	Location	Flow	pH	Net acidity	Fe	Al	Mn	SO_4	Net acidity	Fe	Al	Mn	SO_4
		gpm		mg/L					lb/day				
LYC above Tide refuse pile and Judy 14 tributary													
11/17/2019	LYC-2	4,834	6.01[a]	-52	0.2	0.3	0.1	129	-3,028	12	17	5	7,494
9/20/2020	LYC-2	4,865	8.58[b]	-52	0.2	0.0	0.3	104	-3,036	12	3	18	6,060
5/25/2021	LYC-2	24,595	7.16	-15	0.2	0.3	0.1	31	-4,309	45	89	17	9,149
LYC below Tide refuse pile and Judy 14 tributary													
11/17/2019	LYC-5	5,732	6.40[a]	-41	0.4	0.5	0.2	136	-2,847	29	34	12	9,361
9/20/2020	LYC-5	5,485	8.03[b]	-48	0.3	0.1	0.3	107	-3,186	17	4	20	7,062
5/25/2021	LYC-5	23,878	6.96	-10	0.4	0.7	0.1	47	-2,865	101	197	38	13,467

Pollution loadings from the Tide refuse pile were calculated by subtracting the pollution loadings at LYC-5 and the mouth of the Judy 14 tributary from the pollution loadings at LYC-2 (see methods for details).

The calculated pollution loadings to LYC are shown in Table 16. While the Tide pile has the second largest acidity loading in LYC, its acidity and metal loadings do not exceed the neutralization capacity of LYC.

Table 16. Calculated pollution loadings from the Tide refuse pile.

Date	Acidity	Fe	Al	Mn	SO4
	lb/day				
11/17/2019	16	13	3	4	1,439
9/20/2020	-153	6	2	2	993
5/25/2021	1,415	55	106	21	4,207
Average	**426**	**24**	**37**	**9**	**2,213**

In addition to acidity and metals, the Tide refuse pile is a source of coal fines to LYC. The Tide refuse pile is located about 500 feet east of LYC (Map 4). Between the pile and LYC, several ponds and a large, constructed mitigation wetland were built by the Homer City Generating Station to retain coal fines washing off the Tide pile. These ponds have received little maintenance in recent years and appear be reaching their sediment storage capacity causing coal fines to wash into LYC.

Two, point source discharges (D-12 and D-13) originate from the Tide refuse pile area. D-13 is the intermittently flowing mitigation wetland effluent. A single sample was collected when it was flowing and found to be severely polluted (Table 17).

Table 17. Characteristics of discharge from of the Tide refuse pile mitigation pond (D-13) on 2/24/2020. Flow was zero during 4 other visits.

Date	Location	Flow	pH	Net acidity	Fe	Al	Mn	SO4	Net acidity	Fe	Al	Mn	SO4
		gpm		mg/L					lb/day				
2/24/20	D-13	3	2.6	1,768	127	255	5	2,166	53	4	8	0	65

D-12 is the Tide refuse pile diversion ditch effluent. There are several seeps at the toe of the Tide Pile that are collected into this ditch. It is a moderate flow of highly contaminated mine water (Table 18). Although less 25 gpm was measured for each sample, the high acidity concentrations produce a high acidity loading to LYC. Pollution loadings to LYC from the Tide refuse pile and this diversion ditch (D-12) are not separated. Therefore, the acidity loads calculated for the Tide pile above include this discharge. Acidity loadings from the Tide pile and D-12 were both measured in May 2021. On this sampling event, D-12 contributed only 12% of the total acidity load added by the Tide pile. This suggests that there was other polluted water, in addition to D-12, entering LYC from the Tide refuse pile.

Table 18. Average Tide refuse pile diversion ditch (D-12) effluent to LYC. N=5.

Date	Location	Flow	pH	Net acidity	Fe	Al	Mn	SO4	Net acidity	Fe	Al	Mn	SO4
		gpm		mg/L					lb/day				
Average	D-12	12	2.50	3,545	294	424	6	3,392	407	32	51	1	420

In addition, the Tide pile site on top of a shallow underground deep mine. One the discharges from this mine is D-3 which is treated at the 2-C passive treatment system. The contribution of the refuse pile to this mine discharge is unknonw.

2. Tide Tributary

The Tide Tributary enters LYC between the Tide refuse pile and the Lucerne refuse pile (Map 3). Flow in the Tide Tributary is distinct from the Tide refuse pile. The stream has a 1.46 mi^2 watershed that drains a mostly forested watershed. The headwaters of the watershed were heavily strip mined and underground mines also likely exist. The 2005 watershed assessment found significant mine drainage pollution in the watershed.

Two discharges in the Tide Tributary watershed were monitored, D-5 (Nancy mine discharge) and D-15 (Sipos mine discharge). Average flow and chemistry are shown in Table 19. D-5 flows intermittently and ranges from low pH and net acidic to neutral pH and net alkaline. D-15 was only flowing one out of the seven times it was visited. The single sample is low pH and polluted with Fe and Al. Neither discharge is treated.

Table 19. Average chemistry measured at the D-5 (Nancy mine) discharge (N=9) from 2019 to 2021. Chemistry from a single sample collected at the D-15 (Sipos mine) discharge. Flow was zero during 6 other visits.

Location	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
	gpm		**mg/L**					**lb/day**				
D-5	11	4.6	19	13	7	0.4	429	-4	1	0.4	0	46
D-15	3	2.7	247	18	14	0.3	290	8	1	0	0	10

The mouth of the Tide Tributary was the third largest acidity loading to LYC. Table 20 shows pollution loadings of the Tide Tributary and LYC above and below Tide Tributary. Pollution loadings are much larger than the sum of D-5 and D-15 suggesting that other, unmeasured sources of AMD pollute the stream. AMD could be contributing from the Tide refuse pile which is along the southern bank of the tributary near its mouth.

The tributary's contaminant loading was diluted and/or neutralized by the LYC's large flow of alkaline uncontaminated water upstream. LYC below the Tide Tributary did not exceed any water quality standards.

Table 20. Chemistry at LYC above and below the Tide Tributary and the mouth of the Tide Tributary. [a] Measured acidity concentration is -5 mg/L and assumed to be an error, calculated net acidity concentration and loading is shown.

Date	Location	Flow	pH	Net acidity	Fe	Al	Mn	SO4	Net acidity	Fe	Al	Mn	SO4
		gpm		mg/L					lb/day				
LYC above Tide Trib													
11/17/2019	LYC-5	5,732	6.40	-41	0.4	0.5	0.2	136	-2,847	29	34	12	9,361
9/20/2020	LYC-5	5,485	8.03	-48	0.3	0.1	0.3	107	-3,186	17	4	20	7,062
5/25/2021	LYC-5	23,878	6.96	-10	0.4	0.7	0.1	47	-2,865	101	197	38	13,467
LYC below Tide Trib													
11/17/2019	LYC-9	6,118	6.93	-56[a]	0.4	0.5	0.2	125	-4,126[a]	31	35	15	9,191
2/24/2020	LYC-9	49,135	7.05	-9	0.7	0.6	0.1	45	-5,189	399	356	64	26,769
9/20/2020	LYC-9	5,817	7.81	-52	0.2	0.1	0.3	100	-3,658	15	6	21	7,008
5/25/2021	LYC-9	23,610	7.15	-11	0.3	0.5	0.1	45	-3,116	98	152	35	12,664
Tide Trib mouth													
11/17/2019	LYC-6	137	2.86	108	8	8	3	432	178	13	0	0	713
2/24/2020	LYC-6	598	4.78	32	7	3	1	252	233	53	20	7	1,810
9/20/2020	LYC-6	27	3.11	193	5	5	18	504	62	2	2	6	163
5/25/2021	LYC-6	137	4.35	48	4	4	1	507	80	7	6	2	837

3 and 4. Refuse Pile Tributary and Concrete Pipe Discharge

The Lucerne Refuse Pile Tributary (D-8) and Concrete Pipe Discharge (D-7) are adjacent to each other and enter LYC near the boundary between the northern and southern portions of the Lucerne refuse pile (Map 5). D-8 is a small tributary with a 0.34 mi^2 watershed. The stream generally follows Tide Road and is adjacent to the Lucene refuse pile. The tributary is typically low pH but is pH 6 to 7 at flows greater than 100 gpm. Near the mouth of D-8, the tributary receives the intermittent flow from a corrugated pipe (D-14) that carries flow from deep mine borehole. This borehole is labeled on Kittanning coal seam maps as “Power Holes”.

D-7 flows from a concrete pipe about 20 feet up the bank from LYC. The pipe is below an old railroad grade, and it may be an old railroad drain. D-7 is a perennially flowing discharge polluted with acidity and metals. The surface elevation of D-7 is approximately 1030 feet.

The Refuse Pile Tributary (D-8) and Concrete Pipe Discharge (D-7) were the fourth and fifth largest acidity sources to LYC, respectively (Table 21). Cambria Reclamation Corp. monitors the refuse pile tributary (D-8) as point L-10 and the concrete pipe discharge (D-7) as point L-9. They also monitored the corrugated pipe discharge (D-14) as monitoring point L-11 until 2018 when it was determined to be an old borehole and monitoring was discontinued. The surface elevation of D-14 is approximately 1034 feet.

Table 21. Average chemistry for D-7 (concrete pipe discharge), D-8 (refuse pile trib), and D-14 (corrugated pipe discharge @ Lucerne refuse pile) from 2019 to 2021. N=10 for D-7 and D-8 and N=9 for D-14.													
Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
Average	D-7	16	3.70	501	145.9	34.3	9.8	1582	76	22	5	1	257
Average	D-8	44	4.13	179	80.9	8.2	9.8	907	83	30	6	3	236
Average	D-14	18	3.92	280	74.6	20.5	6.4	938	45	12	3	1	174

5. Judy 14 Tributary

The Judy 14 tributary enters LYC just upstream of the Tide refuse pile (Map 3). It has a 0.82 mi^2 watershed that drains a mostly forested watershed. The headwaters of the watershed were strip mined and underground mines likely exist. The 2005 watershed assessment found significant mine drainage pollution in the watershed.

The Judy 14 tributary is polluted by mine drainage from its headwaters. An upstream monitoring location (LYC-4) along Snyder Road showed impaired chemistry (Table 22).

Table 22. Average chemistry for LYC-4 (Judy 14 tributary above Snyder road) from 2019 to 2021. Flow rates were not measured. N=4.								
Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**				
Average	LYC-4	n/a	3.49	136	25.1	8.6	6.0	365

Two discharges in the Judy 14 tributary watershed were monitored monthly: the Tide Mine discharge (D-3) and the Judy 14 discharge (D-4). The Tide mine discharge is at the base of the Tide refuse pile and was a low pH, intermittently flowing discharge polluted with acidity and metals (Table 23). The Judy 14 discharge (D-4) flows from an old mine entry and was a low pH, perennially flowing discharge polluted with acidity and metals (Table 23).

Table 23. Average chemistry for D-3 (Tide mine discharge) and D-4 (Judy 14 discharge) from 2019 to 2021. N=10 for D-3 and D-4.													
Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
Average	D-3	30	3.26	196	25.7	15.0	4.9	625	75	10	6	1	226
Average	D-4	50	3.01	351	24.6	30.7	9.0	609	160	10	16	2	278

The Tide Mine discharge (D-3) is treated at the 2C passive treatment system and the Judy 14 Discharge (D-4) is partially treated by the 2A/2B passive treatment systems. Both systems are described in the passive treatment systems section below.

The Judy 14 tributary receives many inflows of polluted mine water. This tributary (LYC-3) was the sixth largest source of acidity to LYC. It was a perennially flowing stream with low pH and elevated metals. While Judy 14 tributary was degraded by polluted mine drainage during every sampling event, the pollution was assimilated by LYC (Table 24). The Judy 14 tributary had negligible impact on LYC.

Table 24. Chemistry at LYC above and below the Judy 14 Tributary and the mouth of the Judy 14 Tributary. n/a = not measured.

Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
LYC above Judy 14 tributary													
11/17/2019	LYC-2	4,834	6.01	-52	0.2	0.3	0.1	129	-3,028	12	17	5	7,494
9/20/2020	LYC-2	4,865	8.58	-52	0.2	0.0	0.3	104	-3,036	12	3	18	6,060
5/25/2021	LYC-2	24,595	7.16	-15	0.2	0.3	0.1	31	-4,309	45	89	17	9,149
LYC below Judy 14 tributary and Tide refuse pile													
11/17/2019	LYC-5	5,732	6.40	-41	0.4	0.5	0.2	136	-2,847	29	34	12	9,361
9/20/2020	LYC-5	5,485	8.03	-48	0.3	0.1	0.3	107	-3,186	17	4	20	7,062
5/25/2021	LYC-5	23,878	6.96	-10	0.4	0.7	0.1	47	-2,865	101	197	38	13,467
Judy 14 tributary mouth													
11/17/2019	LYC-3	76	2.77	180	5.2	15.6	4.1	467	165	5	14	4	427
2/24/2020	LYC-3	n/a	3.41	97	6.0	8.8	1.9	253	n/a	n/a	n/a	n/a	n/a
9/20/2020	LYC-3	2	3.34	154	0.4	6.1	18.1	403	3	0	0	0	9
5/25/2021	LYC-3	22	3.43	111	3.5	10.3	2.3	429	29	1	3	1	111

6. Lucerne Portal Discharge at Lower Yellow Creek

The Lucerne portal discharge (D-6) is an upwelling discharge just southeast of the town of Lucerne Mines (Map 3). It is named the "LYC-038, Lucerne #3 Mine" in the 2005 Watershed Assessment report and "Lucerne Mines #1 & 3 portal" in the Operation Scarlift report. The discharge flows through approximately 1.5 acres of wetlands before entering LYC at monitoring location D-6B. The surface elevation of the discharge was unable to be determined because it upwells into a pond.

The Lucerne portal discharge (D-6) and the wetland effluent to LYC (D-6B) were monitored monthly. Average data from both locations are presented in Table 25. The Lucerne portal discharge was an intermittently flowing discharge polluted with acidity and low concentrations of metals. Flows and concentrations were similar at the portal discharge (D-6) and where it enters LYC (D-6B).

Table 25. Average chemistry at the Lucerne portal discharge (D-6) and where it enters LYC (D-6b) from 2019 to 2021.
N=9 for D-6 and N=10 for D-6B.

Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
Average	D-6	147	5.22	28	2.9	3.9	1.3	423	51	4	8	2	643
Average	D-6B	129	4.46	29	4.6	2.3	1.5	417	38	5	3	2	597

The Lucerne portal discharge at LYC (D-6B) was the eighth largest source of acidity to LYC. The Lucerne Portal pollution was assimilated by LYC (Table 26). As can be seen from the loadings, the acidity load of the Lucerne portal discharge at LYC is negligible compared to the alkalinity load (negative net acidity load) in LYC. The Lucerne Portal discharge had a negligible impact on LYC.

Table 26. Chemistry at LYC above and below the Lucerne portal discharge and where the discharge enters LYC. [a] Calculated acidity concentrations are -56 mg/L and -4,126 lb/day.

Date	Location	Flow	pH	Net acidity	Fe	Al	Mn	SO4	Net acidity	Fe	Al	Mn	SO4
		gpm		mg/L					lb/day				
LYC above Lucerne portal discharge													
11/17/2019	LYC-9	6,118	6.93	-5[a]	0.4	0.5	0.2	125	-352[a]	31	35	15	9,191
2/24/2020	LYC-9	49,135	7.05	-9	0.7	0.6	0.1	45	-5,189	399	356	64	26,769
9/20/2020	LYC-9	5,817	7.81	-52	0.2	0.1	0.3	100	-3,658	15	6	21	7,008
5/25/2021	LYC-9	23,610	7.15	-11	0.3	0.5	0.1	45	-3,116	98	152	35	12,664
LYC below Lucerne portal discharge													
11/17/2019	LYC-10	6,450	7.04	-32	0.6	0.5	0.3	146	-2,477	44	40	26	11,269
9/20/2020	LYC-10	4,684	7.63	-48	0.4	0.2	0.3	109	-2,698	25	9	17	6,132
5/25/2021	LYC-10	29,353	6.93	-10	0.3	0.6	0.2	56	-3,381	113	220	58	19,831
Lucerne portal discharge at LYC													
11/17/2019	D-6B	252	4.60	29	7.5	1.3	1.8	417	88	23	4	5	1,260
2/24/2020	D-6B	350	4.91	25	1.3	2.7	1.4	391	107	6	11	6	1,643
9/20/2020	D-6B	10	3.87	39	7.7	1.6	1.2	350	5	1	0	0	42
5/25/2021	D-6B	Not measured	3.99	31	0.1	3.2	1.5	742	n/a	n/a	n/a	n/a	n/a

7. Route 119 Borehole at Lower Yellow Creek

The Route 119 borehole (D-9) is an upwelling discharge located just north of where Route 119 crosses LYC and behind the old power plant (Map 3). The source was not included in the 2005 Watershed Assessment report and was named "Churn holes by power plant" in the Operation Scarlift report. The discharge flows through about 4 acres of wetlands before flowing into LYC at D-9A (location LYC-094 in the 2005 Watershed Assessment. D-9 was sampled for chemistry and D-9A for chemistry and flow rates. The discharge surface elevation is approximately 1030 feet.

Both the Route 119 borehole source (D-9) and the Route 119 borehole at LYC (D-9B) were monitored monthly. Average chemistry for both monitoring locations are shown in Table 27. The Route 119 borehole was a perennially flowing slightly net acidic discharge mainly polluted with Fe. The wetlands between the discharge and LYC provide partial treatment removing an average 8.5 mg/L Fe.

Table 27. Average chemistry at the Route 119 borehole (D-9) and where the borehole enters LYC (D-9a) From 2019 to 2021. Flow rates at D-9 were not measured. N=10 for D-9 and D-10.													
Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
Average	D-9	n/a	5.82	23	36.2	4.4	3.0	472	n/a	n/a	n/a	n/a	n/a
Average	D-9A	54	6.27	19	27.7	3.1	2.9	471	19	18	3	2	309

The Route 119 borehole at LYC (D-9A) was the ninth largest source of acidity and sixth largest source of Fe to LYC. The Route 119 borehole pollution was assimilated by LYC (Table 28). As can be seen from the loadings, net acidity and Fe loadings are minimal compared to LYC loadings. The Route 119 borehole had negligible impact on LYC.

Table 28. Chemistry at LYC above and below the Route 119 borehole and where the borehole enters LYC.													
Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
LYC above Route 119 borehole													
2/24/2020	LYC-11	50,001	6.12	12	4.2	1.9	0.3	85	7,380	2,544	1,149	208	50,761
9/20/2020	LYC-11	6,484	6.11	14	14.4	0.6	4.8	184	1,089	1,120	46	377	14,336
5/25/2021	LYC-11	30,240	5.89	7	3.7	2.1	0.3	88	2,468	1,357	764	125	31,988
LYC below Route 119 borehole													
11/17/2019	LYC-12	6,611	6.05	9	16.3	4.0	0.7	192	730	1,293	320	57	15,216
2/24/2020	LYC-12	51,024	6.27	8	3.6	1.7	0.3	82	5,021	2,174	1,053	195	50,391
9/20/2020	LYC-12	5,144	6.75	5	11.6	0.6	2.8	175	333	714	34	172	10,783
5/25/2021	LYC-12	28,762	6.43	8	3.6	2.2	0.4	111	2,623	1,249	742	124	38,345
Route 119 borehole at LYC													
11/17/2019	D-9A	32	6.60	-2	25.0	2.2	2.5	398	-1	9	1	1	151
2/24/2020	D-9A	106	5.00	85	33.8	8.9	5.1	534	109	43	11	7	681
9/20/2020	D-9A	60	5.91	-11	21.7	2.2	1.2	374	-8	16	2	1	269
5/25/2021	D-9A	48	6.78	54	37.4	5.8	3.9	736	31	21	3	2	422

Yellow Creek Passive Treatment Systems

There are four passive treatment systems in the LYC watershed. Their locations are shown on Map 4. They are all between the Route 954 bridge and the Tide refuse pile (0.6 stream miles). The following sections detail each system and are ordered from upstream systems (1A and 1B systems) to downstream systems (2C system). Detailed maps of each treatment system are presented as Maps 8, 9, and 10.

Data and information for all four systems were obtained from Datashed (www.datashed.org), a Trout Unlimited Technical Assistance project, BCWA, and sampling conducted for this report.

All systems utilize Vertical Flow Pond (VFP) technology to neutralize acidity and generate alkalinity for metals removal. VFPs are layered treatment units where limestone aggregate is overlain by compost which is overlain by standing water. AMD flows vertically down through each layer. The most common problem with VFPs are decreased compost permeability resulting from compaction and metal precipitation. If permeability decreases below a site-specific threshold, untreated water typically overflows/bypasses the VFP. Generally, the compost should be stirred or replaced every 10-15 years to maintain permeability and reactivity.

1. 1A and 1B Passive Treatment Systems

The 1A and 1B systems are two adjacent passive treatment systems just south of the Route 954 bridge over LYC (Map 8). The 1A passive treatment system treats the D-1 discharge (also referred to as SR-954 northern seep). The 1B passive treatment system treats the D-2 discharge (also referred to as the SR-954 southern seep). Both discharges are intermittently flowing and polluted with acidity and metals (Table 29). Both treatment systems consist of forebay pond(s)/wetlands followed by a VFP followed by a settling pond. Water bypassing the VFPs also flows to the settling ponds. Both settling ponds discharge to a common channel that flows to LYC. The combined effluent channel was monitored as LYC (1A+1B out) for this report.

Table 29 shows water chemistry from the common effluent channel from the 1A and 1B systems (1A+1B out) and LYC upstream and downstream of the systems. While the treatment systems decreased acidity and metal concentrations, the combined effluent to LYC was still net acidic. However, compared to the large alkaline loading in LYC at this point, there was negligible impact to LYC.

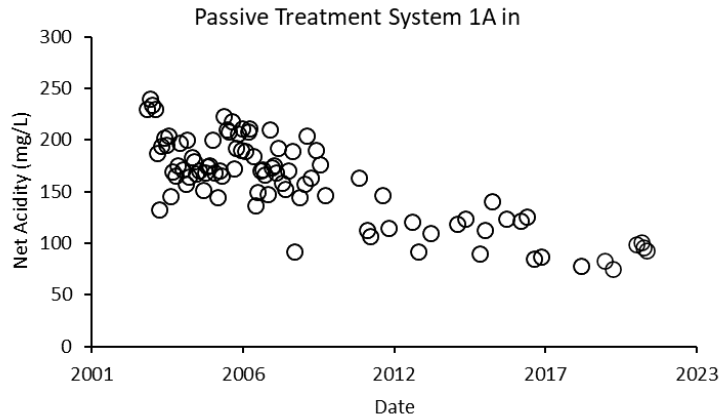
The following sections describe, in detail, the 1A and 1B passive treatment systems.

Table 29. Average chemistry collected from this study from 2019 to 2021. D-1 = Route 954 seep north. D-2 = Route 952 seep south. 1A+1B out = 1A and 1B passive treatment systems common effluent. LYC-1 = LYC above Route 954 bridge. LYC-2 = LYC above Judy 14 trib. D-1 is treated at the 1A treatment system and D-2 is treated at the 1B treatment system. LYC-1 is upstream of the 1A and 1B systems and LYC-2 is downstream of the 1A and 1B systems.
N=9 for D-1 and D-2, N=4 for 1A+1B out and LYC-1 and N=3 for LYC-2.

Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
Average	D-1	22	4.19	91	0.2	12.8	4.1	590	26	0	4	1	156
Average	D-2	28	2.93	195	2.7	21.1	3.7	556	65	1	7	1	186
Average	1A+1B out	18	5.01	32	0.3	4.6	3.7	664	9	0	1	0	65
Average	LYC-1	10,970	7.38	-23	0.2	0.2	0.1	41	-2,582	25	34	16	5,249
Average	LYC-2	11,431	7.25	-40	0.2	0.2	0.1	88	-3,458	23	36	13	7,568

1A Passive Treatment System

The 1A system treated the D-1 discharge. Figure 10 shows net acidity concentrations in the untreated mine water (D-1) from 2002 to 2021. Net acidity concentrations have decreased from about 225 mg/L to about 100 mg/L. Figure 10 shows net acidity concentrations from the 1A system effluent from 2004 to 2017. From 2002 to 2009, the 1A system decreased acidity concentrations but typically produced a net acidic discharge. From 2009 to 2017, the system reliably produced a net alkaline discharge. The compost in the VFP was mixed in 2018 but permeability continues to be a problem. The cause of this increase in performance is suspected to be due to decreasing influent acidity concentrations.



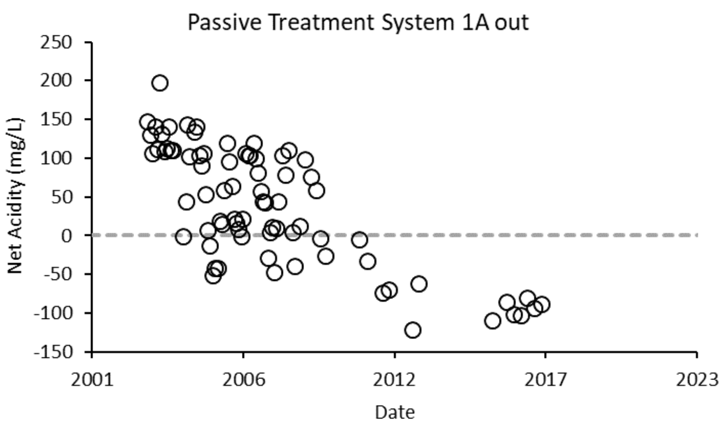


Figure 10. Net acidity concentrations at the influent of the 1A passive system (D-1 in this study) on top and concentrations at the effluent of the 1A passive treatment system on bottom. Data is from Datashed.org and 2019-2021 sampling for this report.

1B Passive Treatment System

The 1B system treats the D-2 discharge. Figure 11 shows net acidity concentrations in the untreated mine water (D-2) from 2002 to 2021. Net acidity concentrations have decreased from about 400 mg/L to about 150 mg/L. Figure 11 shows net acidity concentrations from the 1B system effluent 2002 to 2017. From 2002 to 2012, the treatment system decreased acidity but typically produced a net acidic discharge. From 2015 to 2017, the system typically produced a net alkaline discharge. The cause of this increase in performance is unknown but suspected to be due to decreasing influent acidity concentrations.

The effluents of the 1A and 1B systems flow to a common channel that also receives untreated mine water bypassing the 1A system (the 1B system bypasses AMD around the entire system). This channel, 1A+1B out, was sampled four times in this study. Despite the effluents of both VFPs being net alkaline, the effluent from the wetland was net acidic (Table 29). This condition was due to untreated AMD bypassing the 1A VFP. The bypass is likely due to inadequate permeability of the VFP substrate.

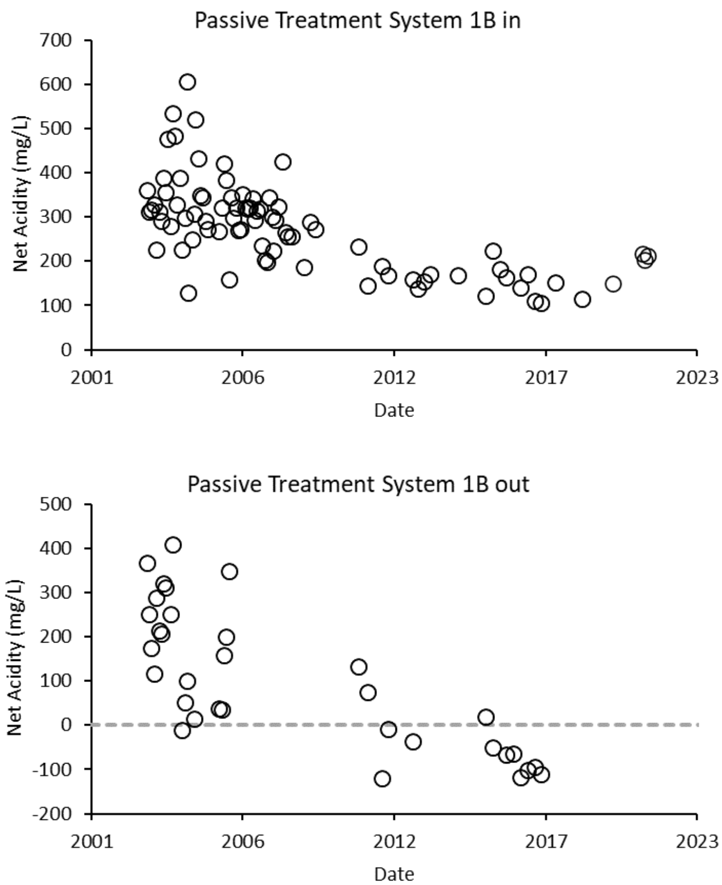


Figure 11. Net acidity concentrations at the influent of the 1B passive system (D-2 in this study) on top and concentrations at the effluent of the 1B passive treatment system on bottom. Data is from Datashed.org and 2019-2021 sampling for this report.

2. 2A/2B Passive Treatment System

The 2A/2B passive treatment system is located to the north of the mouth of the Judy 14 tributary (Map 9). The 2A/2B system partially treats the Judy 14 discharge. Approximately 20% of the Judy 14 discharge is captured and piped approximately 3,000 feet to the system.

The system contains two separate treatment systems, the 2A and 2B system. The 2A system contains a VFP to generate alkalinity. The 2B system contains an experimental organic material bioreactor. Approximately 75% of the influent is treated with the VFP and 25% with the bioreactor. Effluents from the 2A VFP and 2B bioreactor combine in a common settling pond/wetland that discharges to LYC.

Table 30 shows water chemistry for the 2A/2B system and LYC upstream and downstream of the system. The 2A/2B system decreased acidity and metal concentrations but did not produce a net alkaline discharge. However, compared to the large negative net acidity loading in LYC above, there was negligible impact to LYC.

Table 30. Average chemistry collected for this study from 2019 to 2021. D-4 is partially treated by the 2A/2B system.
D-4 = Judy 14 discharge. 2A/2B out = effluent of the 2A/B system. D-4 is partially treated by the 2A/B system. LYC-1 is upstream of the 1A and 1B systems and LYC-2 is downstream of the 1A and 1B systems.
N=10 for D-4, N=4 for 2A/2B out and LYC-1 and N=3 for LYC-2.

Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
Average	D-4	50	3.01	351	24.6	30.7	9.0	609	160	10	16	2	278
Average	2A/2B out	11	4.78	16	0.8	1.1	3.4	518	2	0	0	0	65
Average	LYC-1	10,970	7.38	-23	0.2	0.2	0.1	41	-2,582	25	34	16	5,249
Average	LYC-2	11,431	7.25	-40	0.2	0.2	0.1	88	-3,458	23	36	13	7,568

Figure 12 shows net acidity concentrations in the influent to 2A/2B passive treatment system from 2002 to 2021. The influent to the treatment system is the Judy 14 discharge (D-4). Acidity concentrations have slightly decreased from about 500 mg/L to about 300 mg/L in that time frame. Figure 12 shows net acidity concentrations in the 2A/2B system effluent. The treatment system has historically reduced acidity concentrations but typically discharges a net acidic effluent. From 2017 to 2021, the effluent has low concentrations of acidity. In 2018, Stream Restoration Inc. (SRI) conducted maintenance on the 2A/2B system including cleaning pipes, stirring VFP compost, and general vegetation and sludge management.

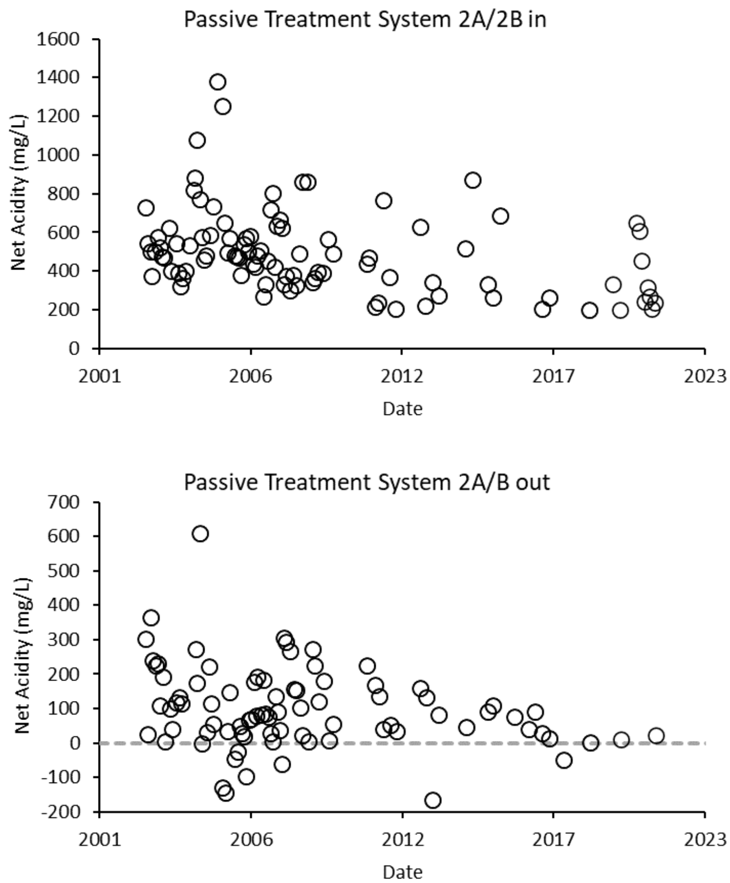


Figure 12. Net acidity concentrations at the influent of the 2A/B passive system (D-4 in this study) on top and concentrations at the effluent of the 2A/B passive treatment system on bottom. Data is from Datashed.org and 2019-2021 sampling for this report.

3. 2C Passive Treatment System

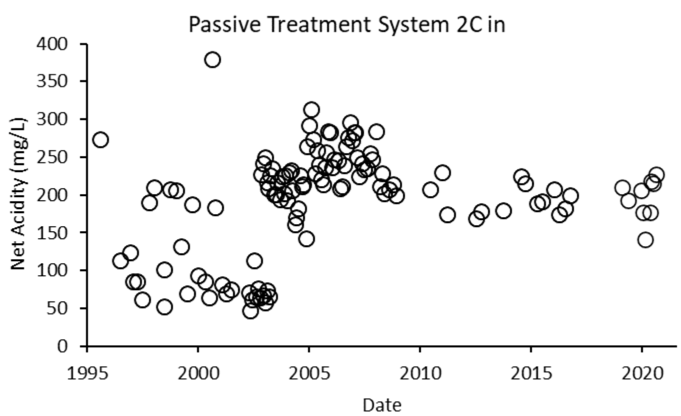
The 2C passive treatment system is located on both sides of the mouth of the Judy 14 tributary (Map 10). The 2C system treats the Tide mine discharge which is located at the base of the Tide refuse pile. The discharge is piped across the Judy 14 tributary to a VFP. The VFP effluent is piped back across the Judy 14 tributary to a settling pond and wetland before discharging to LYC. This pond and wetland also receives runoff and AMD from the Tide refuse pile. Because of this complication, the effectiveness of the 2C system was evaluated at the effluent of the VFP.

Table 31 shows water chemistry for the 2C system and LYC upstream and downstream of the system. The 2C system generated a net alkaline discharge. The alkalinity loading is small compared to the alkalinity loading of LYC.

Table 31. Average chemistry collected for this study from 2019 to 2021.
D-3 = Tide mine discharge. 2C out = effluent of the 2C system. The 2C system treats D-3.
LYC-2 is upstream of the 2C system and LYC-5 is downstream of the 2C system.
N=10 for D-3, N=1 for 2C out, N=3 for LYC-2 and LYC-5
[a] Metal concentrations were not measured.

Date	**Location**	**Flow**	**pH**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**	**Net acidity**	**Fe**	**Al**	**Mn**	**SO4**
		gpm		**mg/L**					**lb/day**				
Average	D-3	30	3.26	196	25.7	15.0	4.9	625	75	10	6	1	226
5/5/2021	2C out [a]	35	6.65	-121	n/a	n/a	n/a	n/a	-51	n/a	n/a	n/a	n/a
Average	LYC-2	11,431	7.25	-40	0.2	0.2	0.1	88	-3,458	23	36	13	7,568
Average	LYC-5	11,698	7.13	-33	0.3	0.4	0.2	97	-2,996	49	79	23	9,963

Figure 13 shows net acidity concentrations in the influent to the 2C system (D-3) from 1996 to 2021. In about 2003, acidity concentrations increased from about 75 mg/L to about 200 mg/L and have remained at that higher level since. Figure 13 shows net acidity concentrations in the 2C system VFP effluent. The treatment system has routinely discharged net alkaline water. In 2018, SRI conducted maintenance on the 2C system including cleaning pipes, stirring VFP compost, and general vegetation and sludge management.



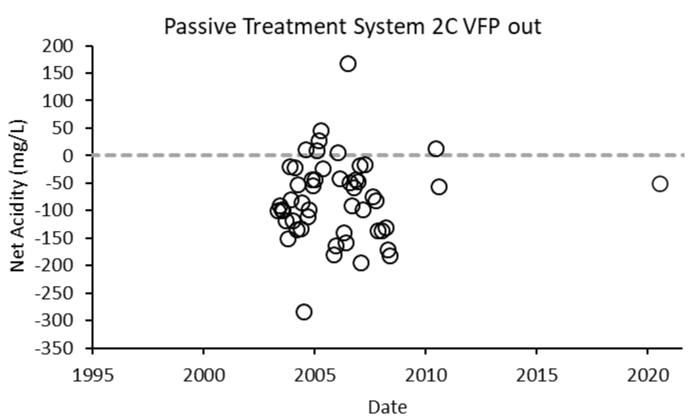


Figure 13. Net acidity concentrations at the influent of the 2C passive system (D-3 in this study) on top and concentrations at the effluent of the 2C passive treatment system on bottom. Data is from Datashed.org and 2019-2021 sampling for this report.

Yellow Creek Water Quality Summary

Upper Yellow Creek, the portion above Yellow Creek State Park Lake, contains good water quality. All in-stream samples collected from Upper Yellow Creek in this study complied with in-stream standards for pH, Fe, Mn, and Al. Upper Yellow Creek should be further investigated and considered for removal from the commonwealth's impaired waters list.

Lower Yellow Creek, the portion below Yellow Creek State Park Lake, is impaired by AMD. The impairment has existed for decades and is due to abandoned deep mines, surface mines, and coal refuse piles. Sampling by this study found that the impairment is less than was documented in 2005, and that most of the stream degradation is due to AMD from the Lucerne refuse pile area. Upstream of the Lucerne pile, Yellow Creek's high flow rate and alkalinity loading is sufficient to neutralize and dilute inputs of untreated mine water. All in-stream water samples collected above the Lucerne pile complied with instream standards for pH, Fe, Mn, and Al. While significant flows of untreated AMD exist in this part of the watershed, their treatment is not a recommended priority at this time.

Lower Yellow Creek is seriously impaired by inputs of AMD near the Lucerne refuse pile. Below the pile, the stream has is net acidic and exceeds in-stream standards for Fe, Al, and Mn. A recent biological survey found numerous fish below Yellow Creek State Park Lake and zero fish below the Lucerne pile in Homer City. Instream measurements of contaminant loadings above and below the pile suggest that most of the degradation is due to ground water inflows to the stream or from abandoned deep mines in the Lucerne refuse pile area. While monitoring data from wells in the refuse pile site support the presence of groundwater polluted with acidity and metals, the exact source of AMD was not able to be determined.

The Lucerne refuse pile is currently being reclaimed via remining and ash placement. There is an expectation that these activities will substantially lessen the inflow of AMD to Yellow Creek. To date, reclamation activities have not lessened the impact of the pile on Yellow Creek.

While AMD from the Lucerne refuse pile area may be the primary source of AMD impairment to Lower Yellow Creek, other significant flows of AMD exist in the watershed. The second largest source of AMD is from the Tide refuse pile. In addition to its contribution of metals and acidity to Lower Yellow Creek, coal fines from the pile wash into the creek. The next largest sources of AMD pollution to Lower Yellow Creek (in order of decreasing acidity loading) were the Tide Tributary, Refuse Pile Tributary, Concrete Pipe Discharge, Judy 14 Tributary, Lucerne Portal Discharge, and Route 119 Borehole.

Four passive treatment systems exist in the Lower Yellow Creek watershed. These systems were installed between 1999 and 2004. This assessment found that all are functioning, however, all are in need of rehabilitation. Because of the very minor impact of the discharges from the passive systems on Yellow Creek, rehabilitation of the systems is not a high priority recommendation.

Recommendations

Recommendations to address AMD impacts in Yellow Creek are listed below. They are listed from most important and easiest to achieve to least important. Due to the complexity of some AMD sources, recommendations are broken into sections listed in order of what should occur first or is easiest to implement. A significant portion of the recommendations focus on the Lucerne refuse pile area because it is responsible for the degradation of Yellow Creek.

1. Investigate delisting UYC from the impaired waters list

Sections of Upper Yellow Creek are currently designated as impaired due to mine drainage inputs. Sampling of Upper Yellow Creek in 2019-2021 found no impairment due to AMD. A biological assessment of UYC should be carried out to determine if sections of UYC can be delisted from PADEP's impaired waterways list.

2. Lessen AMD inflows from the Lucerne refuse pile area

The Lucerne refuse pile area is the largest source of mine drainage pollution in the Yellow Creek watershed and is the primary cause of stream impairment. Lessening pollution loadings from this area is the highest mine water remediation priority. Recommended steps are as follows:

a. Continue evaluating the LYC monitoring data collected above and below the Lucerne refuse pile.

LYC water quality data above and below the Lucerne pile are collected quarterly by the Cambria Reclamation Corp. for their PADEP mining permit. These data will continue to be collected quarterly for 2 to 3 years after mining is completed (estimated to be 2023). This data should be periodically reviewed to evaluate the impact of the Lucerne pile on LYC.

This data can be requested/reviewed at the PADEP's Cambria District Mining Office. The permit number is #32950202 and the upstream permitting monitoring point is L-6 and the downstream permitted monitoring point is L-13.

BCWA and its partners should consider additional periodic sampling of LYC above and below the Lucerne pile (stations LYC-10 and LYC-11) and at its mouth in Floodway Park (LYC-12) which is not monitored by Cambria Reclamation Corp. Flow rate measurement should be made, if feasible, to calculate pollution loadings. At least two samples should be collected from LYC-11, one from the eastern side of the stream and one from the western side, to determine average chemical concentrations. The eastern side of the stream has higher concentrations of AMD pollutants than the western side.

b. Continue evaluating the monitoring data from the groundwater wells at the Lucerne refuse pile

Cambria Reclamation Corp. collects monthly samples from three groundwater monitoring wells between the Lucerne refuse pile and LYC. Samples will be collected monthly for 5 years after ash placement is complete and quarterly for another 5 years after that. It is not clear when ash placement will be completed but it will likely continue for a few years after mining is complete.

As of 2021, these wells contain severely polluted groundwater which is could be polluting LYC. Groundwater data from these wells should be evaluated periodically to determine if the reclamation project improves groundwater chemistry. This data can be requested/reviewed at the PADEP's Cambria District Mining Office. The permit number is #32950202 and the wells are MW-3, MW-4, and MW-5.

These wells are also monitored for hazardous metals which can leach from coal fly ash (e.g. selenium and arsenic). PADEP should be tracking these results to determine if the concentrations are below regulatory limits. The data are also available in the permit file at the Cambria District Mining Office.

c. Investigate the source(s) of AMD to LYC from the Lucerne refuse pile area

The source(s) of AMD that impairs LYC in the Lucerne pile area is unknown. Monitored surface AMD flows only account for a small fraction of total acidity loading gained by the creek. Possible additional AMD sources include abandoned deep mine discharges below the Lucerne pile, inflow of groundwater polluted by the Lucerne refuse pile, or a combination of the two. Documented boreholes into abandoned deep mines under the pile and the presence of AMD polluted local groundwater suggest either are possible.

A hydrogeological study could be conducted to determine the AMD source(s) to LYC in the Lucerne pile area. Geochemical and/or isotopic signatures of deep mine and refuse AMD could be identified and used to determine the pollution source(s) to Yellow Creek. This study may need to include piezometers, monitoring wells, and/or nearby existing discharges/boreholes to get a better understanding of local minewater hydrology and geochemistry. Alternatively, BCWA could wait until reclamation of the Lucerne pile is complete and evaluate whether the reclamation his improved LYC.

d. Develop an action plan for post-reclamation water treatment activities

Mining at the Lucerne refuse pile is expected to be complete in 2023; after which point ash placement will likely continue for a couple of years before vegetation. The permittee of the Lucerne refuse pile is responsible for monitoring 10 years after the last ash placement. During this time, entities other than the permittee or PADEP will likely have limited access to the site. BCWA should open discussions with PADEP to determine whether remediation of polluted water flowing from the Lucerne pile can occur before the permit is closed. An action plan should be developed that includes scheduled re-evaluations of Lower Yellow Creek water quality and water treatment actions that would be implemented should the reclamation not reduce pollution loadings to LYC.

3. Reclaim the Tide refuse pile.

The Tide refuse pile is the second largest source of pollution to Yellow Creek. In addition to acidity and metals entering the creek, coal fines from the pile are washing into the mitigation wetlands, treatment system settling ponds, and Yellow Creek itself. Reclaiming the Tide refuse pile would decrease pollution loadings into LYC and eliminate sedimentation from coal fines.

BCWA has reported that the quality of the Tide refuse does not make it a viable remining project by a private entity. However, BCWA, ICCD, Central Indiana Water Authority, Homer City Borough, and Center Township are currently in discussions with PADEP regarding the reclamation of the Tide Refuse Pile. BCWA should continue to press for reclamation of the pile. If that is not possible, the sediment ponds should be rehabilitated to prevent coal fines from washing into LYC.

4. Treat the Judy 14 discharge

The Judy 14 discharge had the largest acidity loading of any point source discharge in the Yellow Creek watershed sampled in this study. This discharge is partially treated by the 2A/B passive treatment system. A 3,500 ft long pipeline transports about 20% of the discharge to the treatment system. BCWA reported that this pipeline may be plugged and/or have holes in it. While the 2A/2B system lowers metals and acidity concentrations, the system does not produce a net alkaline discharge.

Problems with the existing system should be investigated and a plan to correct them and enhance the treatment effectiveness of the system advanced. Two possible scenarios include rehabilitating the existing 2A/B treatment system and pipeline or constructing a new system closer to the Judy 14 discharge.

5. Treat the Route 119 Borehole

The Route 119 borehole has the largest Fe loading of any point source discharge in the Yellow Creek watershed sampling in this study. The discharge currently discharges into a natural wetland that decreases Fe concentrations from 36 mg/L to 28 mg/L. Map 11 shows the Route 119 borehole area. Two options are provided:

a. Improve the existing ponds/wetlands to remove more Fe

The discharge contains alkalinity and pH 5.8 to 6.2. Iron removal could be increased through increased retention and aeration. The existing wetland could be investigated and modified to eliminate short-circuiting features. Passive aeration technologies should be employed to add dissolved oxygen and degas carbon dioxide.

b. Construct an alkalinity generating unit to create net alkaline conditions

Better treatment would be achieved through the addition of an alkalinity-producing treatment unit. The current raw water chemistry is suitable for treatment with a vertical flow pond (VFP). An anoxic limestone drain (ALD) is not recommended as the borehole periodically contains high concentrations of Al which will clog an ALD and create an operation and maintenance difficulties.

Topographic data suggest there is about 8 feet of available head between the discharge and LYC which is sufficient for a VFP (Map 11). This option is potentially complicated by the large natural wetland on the site, which may create permitting difficulties.

If this option is chosen, the discharge should be periodically sampled to determine if Fe concentrations decrease low enough to transition to a net alkaline discharge. Such a transition would make passive treatment much simpler.

Detailed Methods

Two types of sampling efforts were undertaken: quarterly sampling and monthly discharge sampling.

Quarterly Sampling

Quarterly sampling involved collecting flows and chemistry at instream, tributary, discharge, and effluent treatment system locations in a single day. Quarterly sampling was completed by Blacklick Creek Watershed Association members and volunteers, Hedin Environmental staff, Indiana County Conservation District staff, and St. Francis University staff and students. Flow rates, pH, conductivity, temperature, and alkalinity were collected in the field. Water samples were collected for lab analyses of pH, conductivity, alkalinity, net acidity, and total metal concentrations at PADEP's lab in Harrisburg, PA. Four quarterly sampling events occurred in November 2019, February 2020, September 2020, and May 2021. See Table 1 for location names, descriptions, and latitude/longitude coordinates.

At LYC-10.5 and LYC-11, the eastern side of LYC is more polluted than the western side. During the November 2019 quarterly sampling event, one sample was collected from each location. This single sample was concluded to not be representative of LYC conditions at these points. During the February 2020 and May 2021 quarterly sampling events, two water samples were collected for each sampling location. One sample from the eastern side of the creek and one sample from the western side of the creek. Sample data were averaged to calculate a combined water quality sample for each location.

During the September 2020 quarterly sampling event, seven water samples were collected at each of the LYC-10.5 and LYC-11 locations. Five total metals samples were collected at equal distances across each stream transect. Two dissolved metal samples were collected, one from each of the sampling locations closest to each streambank. This data was combined with detailed streamflow data output by the flow meters to calculate a flow weighted average chemical composition of each location. The chemistry from the flow weighted average of 5 samples was similar to the average chemistry of the two streambank samples. For consistency with other sampling efforts, averages of the two streambank samples were used for the Fall 2020 sampling.

Monthly Discharge Sampling

Select discharges were monitored for flows and chemistry during the four quarterly sampling events and monthly from November 2020 to May 2021. Monthly discharge sampling was completed by Blacklick Creek Watershed Association members and volunteers and Indiana County Conservation District staff. Flow rates, pH, conductivity, temperature, and alkalinity were collected in the field. Water samples were collected for lab analyses of pH, conductivity, alkalinity, net acidity, and total metal concentrations at PADEP's lab in Harrisburg, PA.

Average flows include zero values when no flow was observed.

Calculated Acidity

Net acidity concentrations were calculated using the equation below (Hedin, 2006):

$$\text{Calculated Net Acidity} = 50*(2*Fe^{2+}/56 + 3*Fe^{3+}/56 + 3*Al/27 + 2*Mn/55 + 1000*10^{-pH}) - \text{alkalinity}$$

Where acidity and alkalinity are measured as mg/L $CaCO_3$ and metals as mg/L. In this report, we assume all Fe is Fe^{+2}.

Net Acidity values were calculated for monitoring points L6 and L13 in Cambria Reclamation Corp.'s permit. These calculated acidity data are used in this assessment.

Loadings and Mass Balances

Pollution loadings were calculated from concentration and flow rate data (when available) using the equation below. The 0.012 term is a conversion factor to generate lb/day units.

Loading (lb/day) = Flow rate (gal/min) * Concentration (mg/L) * 0.012

Differences in in-stream loadings were used to calculate chemical impacts from pollution sources that were not directly measured. For example, the Lucerne refuse pile is along the eastern side of LYC for approximately 0.5 mile. Fe and Al staining along the eastern side of LYC, but not the western side, suggests that polluted groundwater is entering the creek. Therefore, a single point source discharge is unable to be measured.

To quantify the pollution loading from the Lucerne refuse pile, the difference between downstream and upstream in-stream loadings were calculated. Then, loadings from measured discharges in this reach of stream were subtracted out. The remaining loading is assumed to be from the Lucerne pile. This calculation was only able to be carried out for the September 2020 and May 2021 quarterly sampling efforts. The calculation for the acidity loadings from the Lucerne refuse pile is shown below:

> Lucerne refuse pile acidity (lb/day) = LYC-11 acidity (lb/day) – LYC-10 acidity loading (lb/day) – D-7 acidity (lb/day) – D-8 acidity (lb/day) – D-14 acidity (lb/day).

A similar approach was used to quantify the pollution loading from the Tide refuse pile using the equation below. This calculation was only able to be carried out for the November 2019, September 2020, and May 2021 quarterly sampling efforts.

> Tide refuse pile acidity (lb/day) = LYC-5 acidity (lb/day) – LYC-3 acidity (lb/day) – LYC-2 acidity (lb/day)

Current Reclamation Projects

At the time of this report (summer 2021), the Lucerne refuse pile was being mined by Cambria Reclamation Corp. for burnable coal. The permit for the remining project (#32950202) was reviewed at PADEP's Cambia District Mining Office on 9/15/2021. PADEP employees Daniel Chverchko and Michael Schirato assisted with the permit review and provided information about the project.

Past Reclamation Projects

PADEP employee Gregory Aaron provided compiled monitoring well chemistry data from the Colver reclamation project (permit # 11900201 & 11970201). The data is from 10/11/1990 to 7/10/2018.

References

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