Yellow Creek Mine Hydrology Report

August 2022

Report prepared by Hedin Environmental for Indiana County Conservation District

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Summary

Yellow Creek is a large tributary to Two Lick Creek and joins Two Lick Creek near Homer City, Indiana County, PA. Yellow Creek is degraded by AMD as it flows by the Lucerne refuse pile. The Lucerne refuse pile is a large, abandoned coal refuse pile that is currently being mined and reclaimed. Refuse is removed, burned in a waste coal-burning power plant, and replaced with alkaline coal ash. The site was permitted in 1995 and mining of the refuse and ash placement is ongoing and expected to continue until about 2025.

A seep zone at the base of the refuse pile at approximately stream elevation was identified as the likely source of the degradation of Yellow Creek. The seep zone is approximately 200 feet long and discharges contaminated water with 4,500 mg/L net acidity to Yellow Creek. The seepage situation does not allow direct measurement of flow rates. Mass balance calculations suggest that about 135 gpm of this seepage accounts for 100% of the acidity and SO_4 loading gained by Yellow Creek as it flows past the pile. The origin of the flow is of interest in the development of remediation options.

The Lucerne refuse pile in underlain by several abandoned underground flooded coal mines that could be the source of flow. Determinations of mine pool discharge elevations and chemical characteristics suggest that mine pools are not the source of flow. Instead, the source of Lucerne seep zone water is likely precipitation on and infiltration through the refuse pile. The seep zone is at the mouth of a historical topographic drainage and its chemistry does not match local AMD discharges. Groundwater is likely still following original ground through the refuse.

The ultimate test of the hydrological connection proposed here will be the reclamation of the Lucerne refuse pile. Removal of refuse down to original ground and reclamation of the Lucerne refuse pile should eliminate or significantly reduce pollution loadings from the seep zone. If reclamation does not improve Yellow Creek, an alternative source of pollution must be investigated and identified through a detailed hydrogeological investigation.

Introduction

This report serves as an addition to the 2022 Yellow Creek Watershed Assessment prepared by Hedin Environmental for the Blacklick Creek Watershed Association and the Indiana County Conservation District. This report investigates the hydrology of mine pools in the Homer City area and the water source of the Lucerne refuse pile AMD seeps, the largest AMD source in the watershed.

Geology and Mining

Lower Yellow Creek watershed had extensive coal mining operations from the late 1800's to the mid 1900's in the Lower Kittanning and Upper Freeport coal seams. In the watershed, both coal seams are steeply dipping to the west and the Lowe Kittanning seam is about 200 feet deeper than the Upper Freeport seam (Maps 1 and 2).

Upper Freeport Coal Seam Mines

Local Upper Freeport coal seam mines include the Lucerne 1, 2, and 3 mines (Map 1). The Lucerne 1 mine is located north of Yellow Creek and West of Two Lick Creek and was mined from the early 1900s to 1929. The Lucerne 2 mine is located south of Yellow Creek and West of Two Lick Creek and was mined from the early 1900s to 1943. The Lucerne 3 mine is located west of Two Lick Creek and was mined from the early 1900s to 1967 and is the largest mine complex in the Two Lick watershed.

The Lucerne 1 and 3 mines are connected via 2 adjacent tunnels under Two Lick Creek. These tunnels were used to access deeper Lucerne 3 workings from the Lucerne 1 entry. It is unclear if these tunnels were sealed.

The Lucerne 1 and 2 mines are connected via two adjacent tunnels under Yellow Creek. These tunnels were sealed in 1942 (Map 3). This isolated the Lucerne 2 mine from the Lucerne 1 and 3 mines and created mine pools in the deeper workings of the Lucerne 1 and Lucerne 2 mines. The Lucerne 1 mine pool was managed via a pumping station along Two Lick Creek. The Lucerne 1 mine pool management was critical since access to the deeper Lucerne 3 mines required the Lucerne 1 mine pool to not spill over into the Lucerne 3 workings (Map 3).

<u>Lower Kittanning Coal Seam Mines</u>

The Lower Kittanning coal seam mine is the Waterman 2 mine (Map 2) which is approximately 200 feet below the Upper Freeport coal seam.

<u>Boreholes</u>

There are multiple boreholes, fan shafts, power holes, and/or pump holes that could connect Lower Kittanning and Upper Freeport coal seam mines. Connectivity depends on whether the holes were cased, the condition of that casing, and the timing of mining and drilling.

Lucerne Refuse Pile

The Lucerne refuse pile is a large, abandoned reuse pile located just east of Homer city. Refuse came from a tipple located on the opposite site of Yellow Creel. Before recent mining, it was approximately 150 acres and contained approximately 3,200,000 yd^3 of material. It was constructed from local coal mining (likely both Upper Freeport and Lower Kittanning seams) from the early 1900s to the late 1960s. The Lucerne refuse pile is underlain by the abandoned Lucerne 2 Upper Freeport coal seam mine and the abandoned Waterman 2 Lower Kittanning coal seam mine.

In 1995, the Lucerne refuse pile was permitted as a fuel source for waste coal burning plants. Coal refuse is removed, burned with limestone, and the ash is returned to the refuse pile. The ash is alkaline and cementitious and should reduce infiltration and neutralize acidity generated by remaining refuse. Similar refuse pile reclamation projects (e.g. Revloc refuse pile, Colver refuse pile) have dramatically improved local ground and surface water chemistry.

There are two portions of the Lucerne refuse pile: the north pile north of Tide Road and the south pile south of Tide Road. All refuse is removed from the south pile (completed in 2008), and ash placement and final reclamation remain to be completed. As of 2022, refuse is currently being removed from the north pile and is expected to continue until 2023. After which time, activities will consist of ash placement and reclamation. For the remainder of this report, when we refer to the "Lucerne refuse pile", we are referring to the north pile.

Water Quality

Yellow Creek is degraded as it flows by the Lucerne refuse pile for about 1 mile downstream to its confluence with Two Lick Creek. Above the refuse pile, the stream is neutral pH and net alkaline with low concentrations of Fe, Al, and Mn (<0.7 mg/L). Below the refuse pile, the stream is net acidic with up to 14 mg/L Fe. Yellow Creek gains 4,800 lb/day of acidity and 1,170 lb/day of Fe as is flows by the Lucerne refuse pile. The 2022 Yellow Creek Watershed Assessment sampled all surface water inputs around the Lucerne refuse pile. These inputs only accounted for about 5% of the pollution gained by Yellow Creek. Polluted groundwater was suggested as a source of pollution to Yellow Creek.

Objectives

The main objectives of this investigation were to: 1) determine the regional mine pool hydrology, 2) identify the AMD sources responsible for the degradation of Yellow Creek, and 3) to determine the source of this water.

Data Sources

Data collected for the 2022 Yellow Creek Watershed Report was used in this report.

Publicly available mine maps were obtained from the Pennsylvania Mine Map Atlas (https://www.minemaps.psu.edu/). The following mine maps were used:

- RPHB UMM 400 A25: Upper Freeport workings
- RPHB UMM 400 C25: Upper Freeport workings
- RPCC UMM 400 3591: Proposed sump area in Lucerne 1 workings
- RPCC UMM 400 622: Flooded workings of Lucerne 2 workings
- RPHB UMM 400 B47: Lower Kittanning workings

A 1928 USGS Indiana PA quadrangle was obtained from the USGS (https://ngmdb.usgs.gov/topoview/). The map incudes topography surveyed in 1900.

Historical and current aerial imagery and current topography was obtained from PASDA's Pennsylvania Imagery Navigator (https://www.pasda.psu.edu/apps.asp). Discharge elevation was obtained from 2 feet contours from PASDA's Pennsylvania Imagery Navigator (https://www.pasda.psu.edu/apps.asp).

Details of the Lucerne refuse pile mining permit was provided by the Ebensburg District Mining Office. Details on the site history and sampling was provided by MineTech Engineers, the company that prepared the mining permit and has performed site sampling and monitoring through multiple operators. MineTech provided the Exhibit 6.2 Environmental Resources map which has includes locations and data for sampling points, boreholes, and test pits.

The Lucerne refuse pile was visited by Hedin Environmental and Blacklick Creek Watershed Association (BCWA), and/or Indiana County Conservation District (ICCD) staff in March and May 2022. Water samples collected during these field visits were analyzed by G&C Coal Analysis Lab (Summerville, PA) or Geochemical Testing (Somerset, PA). Additional water quality data was taken from the 2022 Yellow Creek Watershed report.

Yellow Creek flow rates were obtained from the USGS Gauge 03042280 (Yellow Creek near Homer City, PA). This gauge is approximately 3 miles upstream from the Lucerne refuse pile.

Mining history was obtained from the National Park Service's America's Industrial Heritage Project Historic American Buildings Survey/Historic American Engineering Record publication titled "Indiana County, Pennsylvania, An Inventory of Historic Engineering and Industrial Sites", 1993.

Coal contours were obtained from the Pennsylvania Geological Survey publication titled "Coal resources of Indiana County, Pennsylvania. Part 1. Coal crop lines, mined-out areas, and structure contours", 1996. Upper Freeport and Lower Kittanning coal outcrops were obtained from USGS publications.

Additional GIS data were compiled from PASDA.

AMD Discharge Chemistry

AMD discharge chemistry is the Homer City area is presented in Table 1 and shown in Map 1. Water quality data for the Route 119 borehole, L-12, Lucerne 1 and 3 entry, Risinger, and Corrugated pipe (L-11) were from the 2022 Yellow Creek Watershed Report or the Lucerne refuse pile mining permit.

Two additional discharges were identified and sampled by this project: the Lucerne 2 entry and the Lucerne seep zone. Both were sampled twice by this project. The Lucerne 2 entry discharge is the old entry to the Lucerne 2 mine (Figure 1). It is along the bank of Yellow Creek and appears to be a wet seal. There is a clogged pipe protruding from a concrete block. AMD upwells from behind the concrete structure and from 2 adjacent locations. All have similar pH and conductivity suggesting they are the same AMD. The discharge was not sampled as part of the 2022 Yellow Creek Watershed Report and is not sampled as part of the Lucerne refuse pile mining permit.

Flow rates were estimated on the two days the discharge was sampled. In March 2022, flow was approximately 100 gpm. In May 2022, was significantly higher (approximately 500 gpm) and AMD was discharging from the hillside above the railroad grade about 15 feet above the discharge. There appears to be a restriction in the old entry that causes water to back up.

Figure 1. Old Lucerne 2 mine entry along Yellow Creek.

The Lucerne pile seep zone is located along the bank of Yellow Creek and the Lucerne refuse pile (see report cover photo and Figure 2). The seep zone is approximately 1 foot above the water elevation is Yellow Creek and is about 200 feet long. The seep zone discharges water containing 4,550 mg/L net acidity to Yellow Creek. The seep zone is coated in hard, iron oxide deposits. The seep zone was not sampled as part of the

2022 Yellow Creek Watershed Report and is not sampled as part of the Lucerne refuse pile mining permit. Flow rates are not able to be measured from the seep zone.

Figure 2. Lucerne seep zone along Yellow Creek.

On the days Yellow Creek was visited for this project, there was either no staining or no significant staining of Yellow Creek above this seep zone. Due to the lack of staining upstream and the severity of the AMD from the seep zone, we assume it is the primary cause of impairment of Yellow Creek.

Table 1. Chemistry for discharges near the Lucerne refuse pile.

Discharge	Flow	pH	Net acidity	Fe	Al	Mn	SO_4	Ca	Mg	Na	K	Cl	Surface elevation	Depth (ft) to:	
	gpm						mg/L						ft	Upper Freeport	Lower Kittanning
Upper Freeport coal seam mine discharges															
Route 119 borehole	54	5.82	23	36	4	3	472	103	34	60	5	41	1030	139	339
L-12	5	6.10	29	34	1	1	412						1029	127	
Lucerne 1 and 3 entry	147	5.22	28	3	4	1	423	90	31	48	3	35	1043	0	200
Lucerne 2 entry	100 to 500	2.67	310	13	26	3	667	78	42	4	14	4	1038	0	200
Lower Kittanning coal seam mine discharges															
Risinger	~500	4.01	404	107	32	5	969	127	47	30	5	14	1026	173	373
Corruagted pipe (L-11)	18	3.92	190	42	16	7	890	109	53	16	5	11	1036	108	308
Refuse impacted discharges															
Lucerne seep zone	115	2.36	4,550	718	466	13	5,450	330	66	10	1	5	1030	55	255

The chemistry of the AMD discharges near the Lucerne pile shown in Table 1 range from circumneutral pH (5 to 7) with low concentrations of metals to low pH (<3) with moderate and high concentrations of metals. Discharges with circumneutral pH and high concentrations of Na (e.g. Route 119 borehole) suggest flooded mine pool conditions. Waters in flooded mine pools have time to react with carbonate minerals and clays which raise pH and participate in cation exchange reactions that can generate alkalinity. Low pH water suggests either unflooded conditions or that carbonate minerals are not present in lithology associated with the mine pools. The Lucerne seep zone contains extremely high concentrations of metals and SO_4 which far exceed the values measure for mine discharges. This extreme AMD is characteristic in this area of contact with coal refuse. .

Mine Pools

Lucerne 2 (Upper Freeport seam)

There are both flooded and unflooded workings of the Lucerne 2 mine that discharge AMD. The sealed tunnels under Yellow Creek that connected Lucerne 1 and 2 caused the Lucerne 2 mine to flood and discharge from an old power borehole near the old power plant (named the Route 119 borehole in this report and the 2022 Yellow Creek Watershed Report) and an adjacent borehole (L-12 in the Lucerne mining permit). Chemistry from both discharges is circumneutral pH with higher concentrations of Na which suggests a flooded mine pool (Table 1). Both discharges are at approximately 1030 ft elevation above mean sea level (MSL) which suggests all Lucerne 2 workings below this elevation are flooded (Map 4).

According to Minetech engineers, the Route 119 discharge flowed many hundreds of gpm until the current Route 119 bridge over Yellow Creek was installed/replaced/rehabilitated. After that activity, flows from the borehole decreased to about 50 gpm (average from the 2022 Yellow Creek Watershed Report). Bridge installation may have compromised the tunnel seal between Lucerne 1 and 2. The details and cause of the change in flow rates were not investigated.

The Lucerne 2 entry is along Yellow Creek and is about 8 feet higher than the Route 119 borehole and discharges low pH AMD (Table 1). The low pH suggests that the workings above (shallower) than the Lucerne 2 entry are mostly unflooded (Figure 4).

Lucerne 1 and 3 (Upper Freeport seam)

After pumping was discontinued at Lucerne 1 and 3, Lucerne 3 workings likely filled with mine water since they are deeper than Lucerne 1 workings. The flooded workings of Lucerne 1 would overflow into Lucerne 3 via two mine tunnels under Two Lick Creek (Figure 4). The Lucerne 3 workings cover a huge area and any discharges west of Two Lick Creek were not identified.

The Lucerne 1 and 3 entry along Yellow Creek (Lucerne portal discharge in the 2022 Yellow Creek Watershed Report) intermittently discharges up to 500 gpm of circumneutral pH, low acidity AMD (Table 1). Flows are low or nonexistent in dry seasons and up to 500 gpm in wet seasons whereas net acidity is relatively constant (Figure 3). This chemistry and variable flow rate suggest the Lucerne 1 and 3 is as an overflow for the Lucerne 1 and 3 mine pool complex.

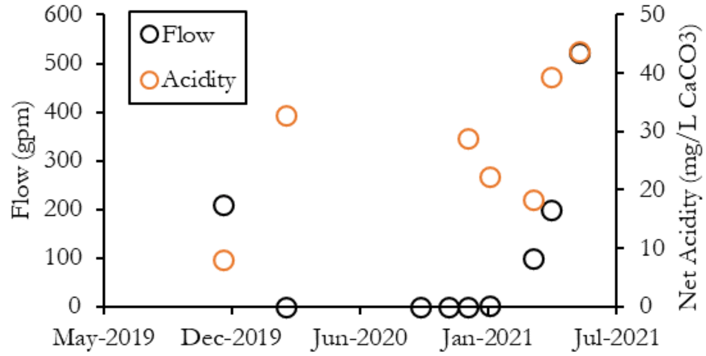

Figure 3. Flow from the abandoned Lucerne 1 and 3 mine entry. Flow was measured at the effluent of the pond that covers the entry.

Waterman 2 (Lower Kittanning seam)

The Waterman 2 mine is a huge complex below Yellow Creek and Two Lick Creek. The mine complex is flooded with enough head to discharge up to 350 feet to the surface. The two discharges from the Waterman 2 mine are the Risinger discharge and the Corrugated pipe discharge (named L-11 in the Lucerne mine permit monitoring). The Risinger discharge is a fan shaft on the bank of Two Lick Creek just north of Homer City. The Corrugated pipe discharge is a borehole into Waterman 2 mine workings. While the Waterman 2 workings are flooded, low pH AMD is produced from this mine. This chemistry is typical of flooded deep mine discharges in the Lower Kittanning seams.

Mine Pool Connectivity

There are likely three unconnected mine pools in the Homer City area:

1. The flooded portion of Lucerne 2 mine (Upper Freeport coal seam) which discharges from the Route 119 borehole and L-12. Both discharges are near the old power plant along Route 119.
2. The flooded mine pool of the Lucerne 1 and 3 mine complex (Upper Freeport coal seam). A primary discharge was not identified. The old Lucerne 1 and 3 entry, along Yellow Creek and just east of the town of Lucerne Mines, appears to act as an overflow for the mine pool in wet seasons.
3. The flooded mine pool of the Waterman 2 mine (Lower Kittanning seam) which is about 200 feet deeper than the Upper Freeport seam.

The fate of Lucerne 1 and 3 mine water in dry seasons is unclear. The Lucerne 1 and 3 entry is under a large pond which is surrounded by wetlands. The history of the pond is unclear. Flow was measured at the outflow of this pond. This pond may leak and therefore zero flow measured at the pond may actually be low flow. If this pond is leaky, the Lucerne 1 and 3 mine complex is likely flooded up to the elevation of the Lucerne 1 and 3 entry.

Alternatively, Lucerne 1 and 3 mine water could be flowing to other parts of the Lucerne 1 and 3 mine complex or to the Waterman mine complex. There are only two documented tunnels under Two Lick Creek connecting the Lucerne 1 and 3 workings. It is possible that in dry seasons, all water from the Lucerne 1 mine can enter the deeper Lucerne 3 mine. If there is a flow restriction in these tunnels, it is possible that in wet seasons water backs up in the Lucerne 1 mine and discharges from the Lucerne 1 and 3 entry.

Finally, Lucerne 1 and 3 mine water could be entering the Waterman 2 Lower Kittanning coal seam mine which is about 200 feet below the Lucerne 1 and 3 Upper Freeport coal seam mine. There are many boreholes that penetrate both coal seams that could provide hydraulic connectivity between the seams.

However, there is very different chemistry between the local flooded Upper Freeport and Lower Kittanning mine pools. The Upper Freeport mine pools (Route 119 borehole, L-12, and Lucerne 1 and 3 entry) are pH 5.5 with 25 mg/L net acidity. The Lower Kittanning mine pool (Risinger shaft and corrugated pipe discharge) are pH 4.0 with 200 to 400 mg/L net acidity. Therefore, it appears that there is limited connectivity between the Upper Freeport and Lower Kittanning mine pools and they should be treated independently.

Unraveling the large scale mine hydrology of the area is complex. A more detailed study would likely require pumping one mine pool down and evaluating the response of nearby mine pools. Additionally, mined areas for all mines could be estimated from historic mine maps and a discharge gpm per acre of deep mine ratio calculated. This ratio is typically about 0.5. Abnormally high or low values could indicate where mine water is lost or gained.

In this report, we assume that the Lucerne 2 mine acts an independent mine pool from the Lucerne 1 and 3 mine pool. Since Lucerne 2 is under the Lucerne refuse pile, we focus on Lucerne 2 mine water as a potential source of water to the Lucerne seeps.

Lucerne Pile Seep Zone Calculated Flow Rate

Because the Lucerne seep zone is widely distributed and only about 6 inches above the water elevation of Yellow Creek, it is not possible to measure a flow rate of the seep zone. The 2022 Yellow Creek Watershed Report calculated that Yellow Creek gains 4,818 ppd of net acidity, 1,170 ppd of Fe, and 291 ppd of Al, and 10,180 ppd of SO_4 when the creek flows by the Lucerne refuse pile. Using the chemistry collected from the Lucerne pile seep zone (Table 1), and the increas in contaminate loadings below the pile, the flow rate of the seep zone is estimated at approximately 120 gpm (Equation 1 and Table 2). of This flow rate is consistent with visual assessment at the seep zone.

Flow (gpm) = loading (lb/day) * 83.23 / concentration (mg/L)..Equation 1

83.23 is a factor to account for unit conversions.

Table 2. Lucerne seep zone flow calculations using Yellow Creek pollution loading gains from the 2022 Yellow Creek Watershed Report and Lucerne seep zone chemistry collected in this study (Table 1). Average flow is the average of net acidity, SO4, and Fe calculated seep flow rates.

	Net acidity		SO4		Fe		
Date	**Acidity gained ppd**	**Seep flow gpm**	**SO4 gained ppd**	**Seep flow gpm**	**Fe gained ppd**	**Seep flow gpm**	**Average flow gpm**
9/20/2020	3,723	68	7,997	122	1,076	125	120
5/25/2021	5,591	102	10,943	167	1,174	136	

A more robust seep zone flow estimate was conducted using mining permit data and USGS flow rates. For the Lucerne refuse pile mining permit, in-stream water samples are collected quarterly above and below the Lucerne refuse pile (L6 and L13, respectively). Flow rates are not collected with the data. On days Yellow Creek was sampled, average daily flow rates were obtained for Yellow Creek from the USGS gauge on Yellow

Creek approximately 3 miles upstream of the Lucerne refuse pile. Upstream and downstream calculated acidity loadings were calculated from these data.

Calculated acidity loading gains by the creek were calculated by the difference between upstream and downstream loadings. Using the chemistry collected from the Lucerne seep zone, the flow rate of the seep zone was calculated using Equation 1 and is show in Figure 4. On days when Yellow Creek gained acidity, the average seep zone flow rate was 136 gpm; similar to the estimate using data from the 2022 Yellow Creek watershed report.

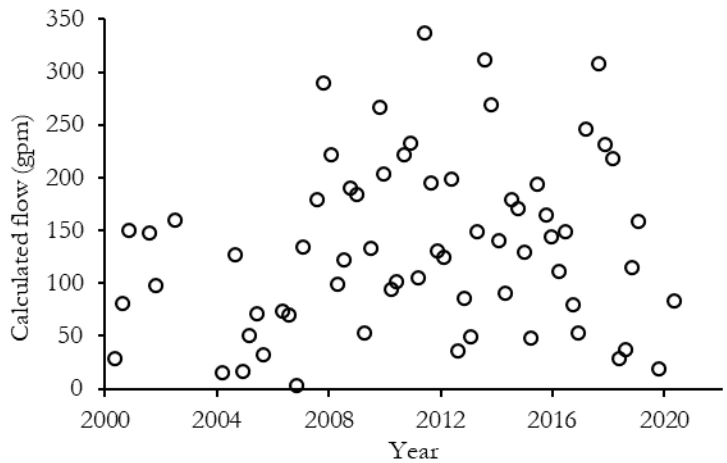

Figure 4. Calculated flow rates of the Lucene seep zone using chemical data collected above and below the Lucerne refuse pile (L6 and L13), USGS daily average flow rates, and seep zone chemistry.

Water Source to Lucerne Seep Zone

The Lucerne seep zone discharges extremely contaminated refuse-impacted water to Yellow Creek. Only about 126 gpm of Lucerne seep zone AMD accounts for the degradation of Yellow Creek. However, understanding the source of the flow is imperative to eliminating the seep zone and advancing the restoration of Yellow Creek. Water could be coming from precipitation on and infiltration through the Lucerne refuse pile or from abandoned deep mines under the pile. Mine water is of concern because of the similar elevations of minepools and the seep zone (Table 1).

The Lucerne seep zone is located in a historic topographic low (Map 5). The existence of this topographic low is supported by test hole data from the Lucerne pile permit (Exhibit 6, Environmental Resources) which show lower original ground in the historic topographic low.

Water is likely infiltrating through the Lucerne refuse pile and following original ground in this topographic low to Yellow Creek. A water budget for the pile (Table 3) shows that an average of 157 gpm of discharge from the pile is expected given the assumptions included in Table 3. This is a similar flow rate as calculated from the mass balances (Table 2 and Figure 4).

Table 3. Water budget for the Lucerne refuse pile. Average annual precipitation for Homer City from www.bestplaces.net.

North pile area ft^2	Average annual precipitation inches	Infiltration	Infiltration gal/year	Avg infiltration gpm
3,511,602	47	80%	82,302,587	157

Chemical differences between the Lucerne seep zone and local mine pools also suggest that abandoned mines are not providing water to the seep zone. Trace metals such as Na, K, and Cl can be used to determine source waters as they are chemically conservative, especially under acidic conditions. They are extremely soluble and should not precipitate in typical groundwater settings. Thus, if a potential source of water has higher concentrations of Na, K, and/or Cl than the Lucerne seep zone, that source is unlikely to be connected to the seep zone.

For example, the Lucerne 2 mine pool (chemistry from Rt 119 borehole) contains 60 mg/L Na and 41 mg/L Cl compared to the 10 mg/L Na and 5 mg/L Cl at the Lucerne seep zone (Table 1). The lower concentrations of Na and Cl at the Lucerne seep zone suggest that the water discharging from the Lucerne seep zone does not originate from the flooded portion of Lucerne 2.

Likewise, the unflooded portion of Lucerne 2 (chemistry from Lucerne 2 entry) has higher concentrations of K (14 mg/L) than the Lucerne seep zone (1 mg/L). The corrugated pipe discharge (L-11) is an upwelling from Waterman 2 mine (Lower Kittanning seam) and has higher concentrations of Na, K, and Cl (16, 5, 11 mg/L, respectively) than the Lucerne seep zone (10, 1, 5 mg/L, respectively). This suggests that the water discharging from the Lucerne seep zone does not originate from the unflooded portion of Lucerne 2 or from the Waterman 2 mine pool.

Based on the close proximity of the Lucerne seep zone to a historic topographic low and chemical differences between the seep zone and local mine water, the Lucerne seep zone water is likely sourced from precipitation onto and infiltration into the pile. Reclamation of the pile in a manner that substantially reduces infiltration should reduce the flow rate of and/or the severity of the chemistry of the Lucerne seep zone. This reduction should have significant stream quality benefits.

Conflicting Data

While the water that discharges from the Lucerne seep zone appears to be sourced from precipitation that flows along a historic topographic low, there are data that suggest otherwise. The groundwater monitoring wells in the Lucerne refuse pile provide contradictory information. MW-4 and MW-5 are between the refuse pile and Yellow Creek. MW-5 is very close to the Lucerne seep zone. Both indicate a shallow aquifer at 0 to 5 feet beneath the surface that contains water with pH 4.5-5.5 and 50 - 80 mg/L Fe. While this is AMD impacted groundwater, it is not the refuse impacted water from the Lucerne seep zone.

The presence of shallow groundwater without refuse chemistry suggests mine water could be upwelling in the bottom of the pile and discharging to Yellow Creek along the Lucerne seep zone. Alternative explanations are that the reclamation completed to date may have improved shallow groundwater at the Lucerne refuse pile while more polluted groundwater flows along original ground deep under the pile. Additionally, shallow alkaline addition could improve shallow groundwater chemistry.

The seasonality of Yellow Creek pollution also provides contradictory information. The 2022 Yellow Creek Report showed that Yellow Creek gains more acidity and Fe from the Lucerne refuse pile area in summer and fall compared to spring and winter. This suggests there may be a relatively constant source of upwelling mine water that interacts with Lucerne pile refuse that can be diluted in wet seasons and has more impact in dry seasons.

Recommendations

1. Monitor the water quality in Yellow Creek above and below the Lucerne refuse pile as the pile is reclaimed. This data review suggests that the Lucerne seep zone is sourced by precipitation onto and infiltration into the refuse pile. Remining and reclamation that removes refuse and reduces infiltration should reduce the flow rate and/or the severity of the chemistry of the Lucerne seep zone.

   A complication with the reclamation of the Lucerne pile is that refuse adjacent to Yellow Creek will not be removed. While refuse will be removed from the Lucerne refuse pile down to original ground, the permit boundary does not include the old rail line or water line along Yellow Creek. The Homer City water supply pipeline runs between the old rail line and Yellow Creek. Refuse under the rail bed and water pipeline will not be removed. While this is a relatively small amount of refuse compared to the entire pile, this refuse could still contribute pollution to Yellow Creek. If so, this strip of remaining refuse could be reclaimed or treated with alkaline addition to reduce acidity generation.

If remining and reclamation does not reduce the flow or contaminant loading from the Lucerne seep zone, hydrogeological, physical, and chemical investigations should be considered. These investigations should be focused on following priorities:

2. Identify additional sources of AMD. While the Lucerne seep zone appears to be the primary cause of impairment for Yellow Creek, other sources may exist that are either not connected to the refuse pile or not improved by refuse pile reclamation. Yellow Creek could be investigated by walking the creek and measuring pH, temperature, and conductivity to identify areas of pollution. An aerial survey using thermal imagery and/or terrain conductivity could also be conducted. Both approaches use pH, temperature, and/or conductivity anomalies to identify AMD discharges and AMD upwellings in the creek.

3. Identify subsurface AMD flow paths in the Lucerne refuse pile area. The possibility of mine pool water upwelling into the Lucerne refuse pile should be investigated. Specific investigations could involve:

   a. *Chemical tracers to constrain subsurface flow paths.* In addition to standard AMD analytes (Fe, Al, Mn, SO4, net acidity), trace metal (e.g. Na, Cl, K) concentrations in AMD discharges should continue be measured when sampling AMD. As illustrated in this report, these trace metals can indicate hydrological flow paths. Additional trace metals (e.g. Li, Br) and/or isotopes (e.g. Sr, Fe) of mine pools and discharges could be measured to further constrain subsurface flow paths.

   b. *Hydrogeological and chemical methods to constrain the connectivity between mine pools and AMD discharges.* Mine pool elevation could be measured via a borehole and correlated with discharge pollution loadings. In both vary in a consistent manner (e.g. pollution loadings increase when mine pool elevation is high), connectivity is likely.

      Additionally, tracer and/or pumping tests could be conducted to better determine mine pool connectivity. For example, a tracer such as a dye or inorganic chemical (e.g. rhodamine, Br) could be applied to the top of the Lucerne pile or injected into an Upper Freeport or Lower Kittanning mine pool. Discharges would be monitored for tracer concentrations via autosamplers or tracer specific probes to determine connectivity. For pumping tests, water could be either pumped into or out of mines and/or mine pools and the response of adjacent mine pools and discharge flow rates monitored.

   c. *Physical methods to identify shallow flow paths*. Noninvasive surface methods (e.g. ground resistivity and/or ground conductivity) could be used. Additionally, boreholes could be drilled into the Lucerne refuse pile across the historic topographic low and any water encountered along original ground sampled. One borehole should penetrate into/through the Upper Freeport coal seam to determine if a mine pool is present and if so, at what elevation.

4. <u>Investigate monitoring well hydrology.</u> The hydrology of the monitoring wells at the Lucerne refuse pile (MW-4 and MW-5) could be investigated to determine hydrological connection between shallow groundwater and the seep zone. The hydrogeological and/or geochemical methods described above could be used. For example, one well could be pumped down and the response of the Lucerne seep zone flow monitored. Additionally, the connection between the two wells could be determined. The local hydrology of the wells may be important because they could be used to treated residual pollution from the Lucerne refuse pile (e.g. pumping out polluted ground water for treatment or injecting reagents).

5. <u>Investigate the connectivity between Upper Freeport and Lower Kittanning mine pools.</u> Many of the investigations mentioned above would reveal hydrological connections between the Upper Freeport and Lower Kittanning mine pools. These investigations could be adapted to focus on the local connections between the two mine pools.