Banning no. 4 mine: A tale of title V facility retrofit project development

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Abstract

The LTV Steel Corporation's Banning No. 4 mine operated until the early 1980s as a room and pillar deep mine within the Pittsburgh Seam of the Main Bituminous Coal Field on the east and west sides of the Youghiogheny River near the Borough of West Newton in Westmoreland County, Pennsylvania (PA).

Upon closure, the mine pool increased in elevation and created a surface discharge in downtown West Newton. The PA Department of Environmental Protection then ordered the mining company to use the two active water treatment plants that were used for dewatering during active mining operations, Banning and Euclid, to reduce the mine pool to a safe elevation preventing further surface expression into West Newton and the Youghiogheny River and for treatment of the subsequent daily quantity to keep the mine pools at that elevation. Those two plants continue in that same capacity to this day, but have operational difficulties due to age and antiquated technology. Banning and Euclid mine pool water quality can be characterized as anoxic, circumneutral, highly alkaline, with elevated concentrations of iron, around 10 mg/L within Banning and 30 mg/L within Euclid. Normal combined plant influent flows are near 38 ML/d.

In the first quarter of 2023, Kleinfelder Inc (KLF) was awarded the design contract by the Clean Streams Foundation and the PA Department of Environmental Protection to update treatment facility technology, improve operational flexibility through added redundancy, and to combine treatment into one larger active treatment plant strategically located downstream which will simplify future operation and maintenance.

KLF will discuss the process of developing the conceptual design for the facility and the assumptions, considerations, and risk analysis completed to effectively manage both the pumping system to maintain the mine pool at an adequate elevation, and the treatment facility design deliverables that will offer increased redundancy and treatment operational flexibility for this planned hydrogen peroxide-based mine drainage treatment plant.

Keywords: AMD, banning, hydrogen peroxide, mine pool, title V, wastewater treatment, youghiogheny river, title V

Introduction

Clean Streams Foundation, Inc. (CSF) and the Pennsylvania (PA) Department of Environmental Protection (DEP) have contracted Kleinfelder, Inc. (KLF) to provide engineering design and permitting services necessary for constructing a new mine water collection and treatment facility to control and maintain the Banning No. 4 Mine Pool in Rostraver Township, Westmoreland County, PA south of West Newton Borough with effluent discharge to the Youghiogheny River (Fig. 1).

The existing Banning and Euclid Active Treatment Plants that collect and treat the mine water from the Banning No. 4 Mine pool have been selected for replacement. Rather than construct two separate Active Treatment Plants, a single Active Treatment Plant with a higher pumping and treatment capacity, and to be located adjacent to the existing Banning Active Treatment Plant, has been defined.

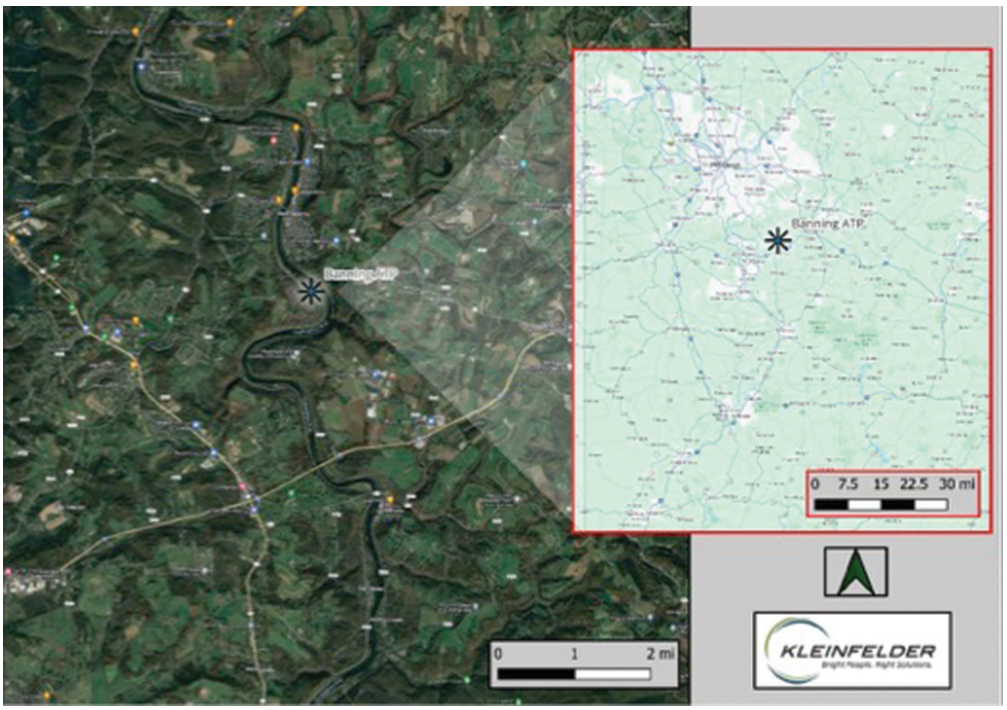

Figure 1 *Location of the current Banning No. 4 Active Treatment Plant in relation to West Newton Borough, Interstate 70, PA State Route 51, and the Youghiogheny River in Rostraver Township, PA. Inset shows project location within Western PA*

The stated objectives of the project are to maintain control of the Banning No. 4 Mine Pool at a maximum elevation of 225.5 m above mean sea-level (AMSL) (NAVD 88). This strategy will prevent a surface discharge, will provide treatment to the required design standards, and will help to preserve the water quality in the Youghiogheny River.

Upon the International Mine Water Association and West Virginia Mine Drainage Task Force Combined Conference in April 2024, KLF expects that the Banning No. 4 Active Treatment Plant design to be within the 75-percent design review.

Methods

The primary deliverables of the project include:

1. Mine Pool Control and Evaluation
2. Mine Water Pumping System
3. Sludge Disposal System
4. Active Treatment Plant Design
5. Plant Discharge and Conveyance System
6. Power, Potable Water, and Sanitary Sewer
7. Access Road Upgrades
8. Permits and Authorizations

Given the requirements of the project, maintaining and controlling the Banning No. 4 Mine Pool elevation will require a large-scale pumping and conveyance system. The ability to control the entire Banning No. 4 Mine Pool from one pumping location largely depends on how well the water flows through a limited number of mine entries crossing under the Youghiogheny River between the two mined areas that make up the mine pool (Fig. 2). A spreadsheet was developed using treatment plant operational data, mine pool elevation data, and actual pumping rates of the mine pumps and sludge pumps, to calculate the recommended maximum and average mine pool withdrawal rate to control the Banning No. 4 Mine Pool. The spreadsheet considers the downtime entered in the daily operating sheets provided by the plant operator as well as the sludge volumes and density of the sludge being pumped back

into the mine pool. It also considers the rate of change in the mine pool elevation based on data provided by the plant operator.

A Flexim, Fluxus Model 601, clamp on style, portable flow meter was installed on both vertical turbine pumps and the sludge disposal pipeline at the Banning Water Treatment Plant to determine each pumping rate. Empirical methods were employed to determine the pumping rates of the mine pump and sludge pumps at the Euclid Water Treatment Plant.

Sludge has been deposited in the Banning No. 4 Mine for many years at low densities. The primary tasks of this deliverable include attempting to determine available sludge storage area remaining and if the currently active sludge borehole can be utilized or if new sludge boreholes will need to be drilled. The fact that the active sludge borehole has worked well over such a prolonged period without flushing it with water is evidence that the diluted sludge has good flowability within the Banning No. 4 Mine workings.

As mentioned, the primary goal of this project is a singular Active Treatment plant design to replace the separate and aged Banning No. 4 and Euclid Active Treatment Plants. This would include an analysis of mixed raw water influent quantities and qualities, determination of an Active Treatment Plant capacity based upon that analysis, the type and quantities of treatment chemical, mixing/flocculation/clarifier sizing, operations building design, sludge/process water systems, polishing wetland size and design, and instrumentation and controls.

The plant discharge conveyance system needs to be able to direct effluent to the constructed polishing wetland or directly to the Youghiogheny River. Each effluent is complicated by difference in grades between the Active Treatment Plant and river, a nearby perennial tributary, and needed scour protection within the tight effluent area due to the relatively high treated flows exiting the Active Treatment Plant.

KLF also needed to determine if the existing overhead power supply is adequate for the draw of the new plant or if modifications will be necessary. An analysis of the potable water availability was also completed, including determining if an onsite well would be needed to meet Active Treatment Plant demand. In terms of sewage, an evaluation between a possible sanitary sewage extension, onsite holding tank, or sand mound/conventional percolation system would be the best option.

As required in the request-for-proposal, an upgrade to the access road from the end of the Rostraver Township Budds Ferry Road down to the new treatment plant is required. The existing access road is approximately 1,774 m in length and has a variable width gravel travel lane, ranging from 3 m to 5 m wide of unknown thickness/construction. This existing road has one hairpin turn and one crossing of the Great Allegheny Passage Rail Trail, both of which will need to be considered during the construction process.

Results and Conclusions

The recommended maximum mine pumping rate is around 24,605 L/min. The recommended average flow rate is 19,684 L/min with 6-weeks of annual downtime (4-weeks of scheduled and 2-weeks of unscheduled downtime), assuming sludge densities being injected back into the mine are approximately 1.6 % or higher.

The Banning No. 4 Mine Pool is to be maintained between an elevation of 225.5 m and 213.5 m AMSL at all times with the preferred maintenance elevation being 221 m AMSL (Gardner 1984). From the mine pool elevation data plotted with pumping operations provided in the Federal Office of Surface Mining (OSM) Report, there appears to be little, if any, resistance to the flow of water and treatment sludge between the mine pools on either side of the river.

The fact that the active sludge borehole has worked well over such a prolonged period without flushing it with water is evidence that the diluted sludge has good flowability within the Banning No. 4 Mine workings. It is impossible to accurately predict how long mine drainage sludge can be injected into the Banning No. 4 Mine Pool prior to recycling sludge with the new vertical turbine pumps because it is not known if all areas of the mine pool are open for sludge to accumulate, how much void space was eliminated when the

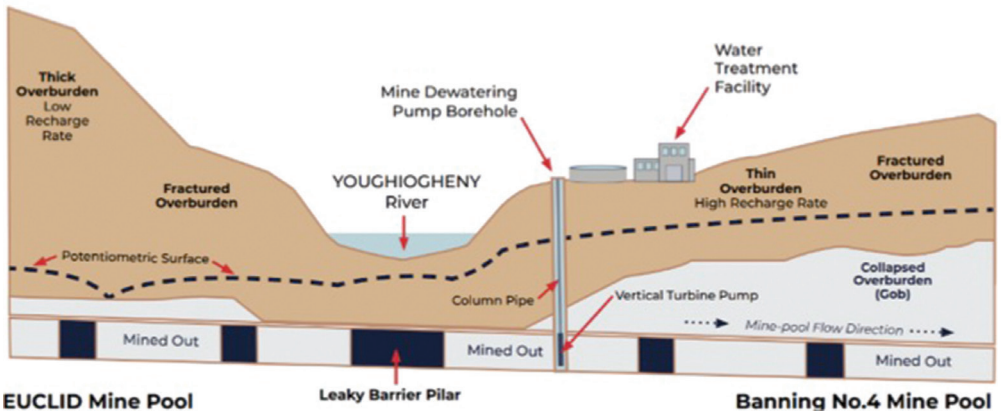

Figure 2 Pre-investigation cross-section of Banning No.4 / Euclid Mine Pool with dewatering plan illustrated

roof fell during second mining operations, and how much the sludge will densify over the long term. The mine pool downdip of the sludge injection boreholes is approximately 75 % of the 17 km² mine pool area. Based on operations data, the treatment sludge is injected at a rate of nearly 320×10^6 L/d. If the mining height averaged 2 m and the average coal recovery rate was 50 %, it would take approximately 43-years to fill the mine void with sludge if the mine void is assumed to be open with a sludge density of 0.656 % (equal to that of the Euclid Plant). The water treatment plants have already injected sludge into the mine void for approximately 25-years, but the sludge density should increase substantially over time where it has permanently settled. This sludge densification effect should allow the mine water treatment plant to inject sludge for a longer period than 43-years.

New sludge injection boreholes do not appear to be required for operations of the new treatment plant because the No. 1 Sludge Borehole is functioning and has required no maintenance or flushing. The No. 2 Sludge Borehole was cleared with a drill rig in September 2023.

The Active Treatment Plant will receive the mixed Banning and Euclid raw water at the influent box (Table 1). This influent box will serve for mixing and aeration of the returned sludge and the influent. The influent box will also direct the mixed and aerated flow into the reaction/flocculation tanks. The reaction/flocculation tanks will include a block of four tanks, normal operation includes a combination of three or four tanks with two or three used as reaction tanks and one used as a flocculation tank. These tanks are designed to allow any one tank to be taken out of service for maintenance and the remaining tanks will include two reaction tanks and one flocculation tank. If desired, the four tanks can also be operated as two parallel trains each including a reaction tank and a flocculation tank. Polymer is injected into the flocculation tank(s) and flocculated water is controlled by weir gates to feed any one or both proposed conventional clarifiers. Underflow from the clarifier(s) will be pumped back to the raw water inlet to increase the suspended solids concentration to between 1,000 to 3,000 mg/L (based on pilot testing results and discussions with PA DEP) for enhanced flocculation. One sludge recirculation pump and two sludge blow-down (or sludge wasting) pumps are dedicated to each clarifier with a cross connection that allows the redundant sludge blow-down pump to also serve as a sludge recirculation pump to increase the flexibility and redundancy of the treatment plant. The sludge recirculation pumps and the sludge blow-down pumps (all progressive cavity type) are equipped with variable frequency drives (VFD) to control the recirculation flow for reaching the target solids level in the reaction tanks. The sludge recirculation pumps and the sludge wasting pumps are located in the open vault of the new

operations building. A dry polymer make-down system will use clarifier effluent water to make a diluted anionic polymer solution. Excess sludge will be periodically pumped with the sludge blow-down pumps through buried sludge pipelines to the two existing sludge injection boreholes that convey sludge back into the Banning No. 4 Mine Pool. The influent flow to the Active Treatment Plant will be measured using in-line magnetic flow meters installed at the discharge of each of the vertical turbine pumps; wasted sludge will also be measured with in-line magnetic flow meters at the sludge injection pipes; the difference between these two measured flows (influent and wasted) will be the plant effluent discharged to the Youghiogheny River. The clarifier effluent is discharged to a splitting structure and slide gates are installed to discharge the treated water either directly into the Youghiogheny River or into a wetland (after the wetland is constructed) first and then discharged into the Youghiogheny River (Fig. 3).

The new singular combined flow Active Treatment Plant will continue to use 50 % hydrogen peroxide for metals oxidation. The new water treatment plant clarifiers will discharge flows up to 24,605 L/min by gravity either directly to the Youghiogheny River or to a constructed wetland and then to the Youghiogheny River. Discharge to the proposed wetland will be designed as a traditional gravity conveyance system with an outfall to a protected forebay at the head of the wetland including riprap and other energy dissipation measures to ensure the wetland is not washed out by variations in flow. Because of the grades and overall system layout, the discharge pipe from Active Treatment Plant to wetland will be designed as a siphon because the pipe must be buried. Discharge from the wetland to the Youghiogheny River will again entail steeper slopes. These flows will be conveyed with a pipe to an energy dissipator.

PA DEP has directed that the potable water source for the new facility for both the Operations Building and the existing peroxide building will be by truck delivery into an adequately sized water storage tank located at each of these buildings.

KLF recommends that sewage holding tanks be used to store wastewater and that it be hauled away periodically by a third-party truck.

References

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Table 1 *Banning No.4 and Euclid influent water quality on June 15, 2022*

Parameter	Unit	Banning	Euclid	Ave Mixed Concentration	Loading (kg/d)
Quantity	ML/d	15.26	21.80	37.07	
pH	–	7.3	7.1	≈ 7.17	
Specific Cond.	µS/cm	2,700	2,730		
TDS	mg/L	1,850	1,956	1,912	70,900
TSS	mg/L	20	28	25	916
Field Alkalinity	mg/L	512	410	452	16,758
Lab Alkalinity	mg/L	538	388	450	16,675
Hot Acidity	mg/L	-509	-361	-422	-15,643
Total Aluminum	mg/L	0.30	0.30	0.300	11
Dissolved Aluminum	mg/L	0.30	0.30	0.300	11
Total Iron	mg/L	10.24	30.00	21.864	811
Dissolved Iron	mg/L	8.62	23.20	17.196	638
Total Manganese	mg/L	0.29	0.64	0.496	18
Dissolved Manganese	mg/L	0.27	0.62	0.476	18
Sulfate	mg/L	811	1,025	937	34,729

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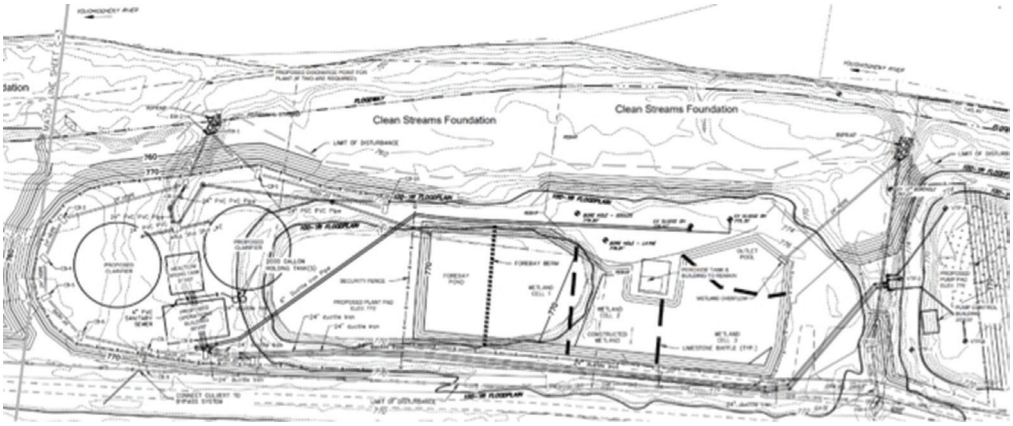

Figure 3 *The 35-percent conceptual plan for the new Banning No.4 Active Treatment Plant*