Passive Treatment Options for the Warden Mine Discharge, Elizabeth Township, Allegheny County, PA

Prepared for Pennsylvania Environmental Council by Hedin Environmental

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Background

The Warden Mine is an abandoned underground coal mine that discharges a large flow of Fe-contaminated water to Douglass Run. The mine is in the Pittsburgh Coal seam and is in the southernmost portion of the Irwin Syncline coal basin. The mine was operated in the early 1900's and has been abandoned for many decades. The mine discharges from an entry located behind houses along Douglass Run Road. At some point, probably in the 1970's, the discharge was collected into a pipe that carries it under Douglass Run road and discharges to a short channel into Douglass Run. The entry was backfilled and is no longer visible. The discharge pollutes Douglass Run and also degrades the Youghiogheny River at its inflow near the Sutersville Bridge. Photos in the Appendix show the discharge and its impact on Douglass Run.

The pipe that carries the discharge between the buried mine entry and Douglass Run accumulates iron sludge that, over time, restricts the release of water from the Warden Mine. When the discharge pipe is restricted, water backs up in the mine and risks a blowout that could damage houses below the coal outcrop. In the 1980s, the US Department of Interior Office Surface Mining and Enforcement (OSM) attempted to develop an alternative piped discharge from the mine. A horizontal borehole was drilled into the Warden Mine, however, the pipe never discharged a substantial flow and did not significantly affect the existing discharge.

The primary pipe discharge has been cleaned out on several occasions by the Pennsylvania Department of Environmental Protection (PA DEP) Bureau of Abandoned Mine Reclamation (BAMR). In late winter 2011 seeps developed along the coal outcrop indicating that the discharge flow was restricted and water was building up within the mine. On March 21, 2011 a blowout occurred while BAMR was cleaning the pipe. A huge flow of mine water was released from the mine (>10,000 gpm) which flooded the basement of a nearby house and washed out a retaining wall along Douglass Run Road.

This project was initiated in 2009 through discussions between the Pennsylvania Environmental Council (PEC) and Hedin Environmental (HE). HE designed and manages the Marchand Mine passive treatment system in Lowber PA. The Marchand Mine is in the same coal seam and discharges water with similar chemistry as the Warden Mine. The Marchand passive treatment system, installed by Sewickley Creek Watershed

Association with PADEP Growing Greener funding, has effectively treated the discharge for six years. The operation and maintenance requirements of the Marchand system have been modest. PEC and HE discussed whether a similar approach could be used to treat the Warden Mine. A proposal was prepared to evaluate the feasibility and partially implemented through this project.

Sampling

Water samples were collected from the Warden Discharge pipe at Douglass Run Road and from Douglass Run upstream and downstream of the discharge inflow. Raw and acidified samples were collected and analyzed by G&C Laboratory (Summerville, PA) for standard AMD parameters. Samples were not filtered, so all results represent total concentrations.

Two methods were used to calculate flow for the mine discharge at Douglass Run. The first method used the average velocity of the flowing water multiplied by the cross sectional area of the water discharging from the 24-inch diameter concrete pipe. The velocity meter was slowly moved in the flowing water for 60 seconds to acquire an accurate average value. This method was used from January to June, 2011.
The second method was use of Manning equation, $Q = Kn^{-1}AR^{2/3}S^{1/2}$, where Q is flow, K is a conversion factor, n is the Gauckler–Manning coefficient and was set equal to 0.14 for the concrete pipe, A is the cross sectional area of the flowing water, R is the hydraulic radius (which is area divided by the wetted perimeter), and S is slope of the pipe. A site survey determined that the slope of the 24-inch diameter concrete pipe that passes under Douglass Run Road is 5.3%. This method was used from March 2011 to March 2012. The second method could only be used if the pipe was free of iron build up - which was the case for all flows after the blowout in March 2011. For four measurements in 2011 (March, April, May and June), both methods were used. Comparison of these two methods showed excellent agreement between the two. The ratio of flow using method 1 divided by the flow using method 2 resulted in values of 0.89, 0.95, 0.99 and 1.00.

Biological conditions in Douglass Run are currently being assessed by Trout Unlimited (TU). The TU sampling stations include the upstream and downstream locations used for AMD sampling, and additional upstream locations associated with the inflow of major tributaries to Douglas Run. Macro-invertebrates were collected in April 2012 and fish will be surveyed in June 2012. The macro-invertebrate study found large populations of stoneflies at all stations above the Warden Discharge inflow and very few macro-invertebrates below the inflow. The final results of the TU study will be available by the end of 2012.

Precipitation during the Monitoring Period

Flow rates were measured between January 13, 2011 and March 29, 2012. Precipitation records were obtained for the same period for Allegheny County Airport from the Pennsylvania State Climatologist website (www.climate.met.psu.edu). The airport is located 10 miles northwest of the Warden Mine. The station recorded 51.4 inches of

precipitation between January 13, 2011 and March 29, 2012, or an average of 0.116 in/day. The long-term average for the Pittsburgh area is 39 in/yr or 0.109 in/day. Precipitation during the monitoring period was 9% higher than normal.

Sampling Results

The sampling results are shown in Tables 1, 2 and 3. The Warden Mine discharge is alkaline and contaminated with iron (Fe) which ranged between 9 and 38 mg/L and averaged 23 mg/L. Concentrations of manganese (Mn) and aluminum (Al) are very low and not environmentally significant. The water has a high net alkalinity (negative acidity) which indicates that removal of Fe will not lower the pH. This alkaline Fe-contaminated water chemistry is typical of flooded deep mines in this part of Pennsylvania.

The measured flow rates ranged from 1,668 to 3,462 gallons per minute (gpm) and averaged 2,208 gpm. These rates do not account for the blowout when flow rates were likely well above 10,000 gpm.

The iron loading rate ranged from 80 to 713 kg/day and averaged 294 kg/day. The loading was lowest immediately after the blowout, likely because of the low flow rate measured one week afterward. The highest loading was measured in June 2011 when flows and chemistry were both the highest measured. It is unusual for flow and Fe concentrations to peak at the same time. Most mine discharges contain lower flows of contaminants during high flow periods. It is not known if this is a general characteristic of the Warden Mine discharge or consequence of the March 2011 blowout.

Douglass Run is classified as a warm water fishery with instream limits of 1.5 mg/L Fe, 1.0 mg/L Mn, and 0.75 mg/L Al. The stream is not polluted with mine drainage above the Warden Mine inflow. The stream is visibly clean and every sample collected had pH 7-9 and contained very low concentrations of Fe, Al, and Mn (Table 2). The downstream station shows the degradation caused by the Warden Mine inflow. Instream concentrations ranged as high as 20 mg/L and averaged 9 mg/L (Table 3). These values far exceed the instream limit for Fe.

Passive Treatment Options

Fe-contaminated mine discharges can be treated by conventional and passive means. Conventional treatment involves chemical additions (lime or hydrogen peroxide) and clarifiers that are expensive to build and operate. It is unlikely that DEP would finance the construction of chemical treatment plant or that a local non-profit would be willing to finance its operation. Passive treatment is less expensive and the routine O&M is easy for a non-profit to manage. Also, passive treatment does not involve hazardous chemicals or conditions and is more appropriate for implementation in a location utilized by the public. This report only considers passive treatment.

The Warden Mine discharge is strongly net alkaline and contaminated with 9 – 38 mg/L Fe. This chemistry is ideally suited for passive treatment where the iron is oxidized to iron oxide solids that are settled in ponds and constructed wetlands. The Marchand Mine passive system, located in Lowber PA, has treated a flow of 1,200 – 2,400 gpm of drainage containing 73 mg/L Fe to an effluent with < 3 mg/L Fe for six years. The Upper Latrobe system, in Latrobe PA, has treated a flow of 300 – 600 gpm of drainage containing 40 mg/L to less than 5 mg/L for two years. The Wingfield Pines system, in Upper St Clair PA, has treated 1,500 gpm of flow containing 15 mg/L Fe to less than 1 mg/L for three years. All three systems consist of ponds, where the iron is oxidized and 75-85% removed by settling, followed by constructed wetlands where the remaining iron is removed. A similar approach is recommended for the Warden Mine.

The sizing of the passive treatment system is determined from the design Fe loading rate divided by the anticipated Fe removal rate. The design loading should be for higher flow and loading conditions. Based on Hedin Environmental's experience, systems designed for at least the 75th percentile loading condition generally provide good treatment performance. The removal of iron in the system is based on empirical measurements made at systems receiving similar water chemistry and treated with a similar technology. A passive system consisting of the pond → wetland design would be expected to lower Fe in the ponds to about 10 mg/L by removing Fe at a rate of 20 gFe per m^2 per day (g $m^{-2}d^{-1}$). The following wetland would lower Fe to about 2 mg/L day by removing Fe at a rate of 5 g $m^{-2}d^{-1}$. Table 4 shows the recommended pond and wetland sizes based on these removal rates and the observed Fe loadings.

Table 4. Pond and Wetland Sizing Calculations	
Flow rate, 75th percentile	2,388 gpm
Fe loading, 75th percentile	371 kg/day
Pond discharge	10 mg/L
Pond Fe removal rate	20 g $m^{-2}d^{-1}$
Wetland discharge	2 mg/L
Wetland Fe removal rate	5 g $m^{-2}d^{-1}$
Pond requirement (calculated)	3.0 acres
Wetland requirement (calculated)	5.1 acres

In order to treat the 75th percentile conditions to a good effluent (< 2 mg/L), the system should contain 3.0 acres of ponds followed by 5.1 acres of constructed wetland.

Location of Potential Passive Treatment System

Sites suitable for placement of a passive treatment system were searched for based on the following requirements.

1. The site needed to be located lower than the discharge so that all water transfers would occur by gravity.
2. The site should be undeveloped.
3. The site should be large enough to accommodate the sizing requirements developed in Table 4.

One site was identified where a functional passive treatment system might be constructed. The attached plan shows the layout of a conceptual system. The site is located between the Great Allegheny Passageand the Youghiogheny River. It is undeveloped and contains woodlands. The highest portion of the site is at an elevation of 784 ft. The elevation of the discharge is approximately 790 ft. Property ownership was investigated. Most of the land that is suitable for the passive treatment system is owned by United States Steel Corporation (USX).

The USX property contains an upper terrace that is largely above the flood plain and a lower terrace that is within the flood plain. The conceptual plan includes four ponds that are located on the upper terrace and thus would be protected from flooding events. The total surface area of the ponds is 2.9 acres. This is very close to the 3.0 acres needed. It is likely that the 3.0 acres of total pond surface area could be obtained with further design efforts. The conceptual plan includes two wetlands on the lower terrace. These wetlands would be flooded during high flow events. Such events are unlikely to materially damage the wetlands. The total surface area of the two wetlands is 3.6 acres. This is 1.5 acres less than the recommended acreage. The conceptual design is constrained by the USX property boundaries. In order to achieve the recommended wetland size, expansion of the current design outside the USX property must be investigated. There is undeveloped suitable land to the east and along the river to the south.

Relocation of the Discharge to the Treatment Site

The treatment site is located about 1,800 feet from the discharge. The possibility of boring horizontally from the treatment site into the mine was discussed with OSM staff familiar with the mine. The drilling option was discouraged because of the previous failure of a horizontal bore to capture the mine pool and because of the very high cost of the horizontal drilling. The alternative is to pipe the discharge from its current location to the treatment site. A sewer line currently exists along lower Douglass Run the follows the Great Allegheny Passagetwo miles east to the Buena Vista treatment plant. The location of the sewer line was determined from discussions with the treatment plant operator and is shown on the Plan. Between the Warden Mine discharge and the bike trail, the sewer follows a single property that appears to be an old railroad line. It may be possible to pipe the discharge from Douglass Run to the treatment site on the same property that contains the sewer line.

Calculations were made to determine the size of pipe necessary to relocate the discharge from the Warden Mine entry to the USX property. The calculations indicate that a 24 in diameter pipe would be sufficient to carry 5,000 gpm flows. This rate is 50% higher than the highest flow rate measured in this study.

If the water is to be piped to the treatment area, an improved collection system should be installed because the current system is prone to plugging. It is recommended that the mine entry be reopened and a better collection system installed. The system should include gas traps that prevent oxygen from being transferred into the mine by the pipe.

Recommendations

This investigation determined that the Warden Mine discharge is well suited for passive treatment and that a suitable site exists next to the Great Allegheny Passage. The discharge could be piped by gravity to the treatment site by following an existing sewer line. A flat bench that is adjacent to the bike trail is large enough to fit ponds necessary to treat most of the iron contained by the discharge. Further polishing of the discharge requires wetlands that could be built on lower benches along the Youghiogheny River. The upper bench is owned by USX. The lower benches are owned by USX and others.

In order to proceed with this project, several actions are recommended.

- DEP involvement in any future project is likely to involve the Title IV Set-aside Program. In order to be considered for this program, a Hydrologic Unit Plan (HUP) must be developed and several specified project evaluations must be completed. The data collected in this study and currently being collected by TU should provide much of the background information needed for the HUP. PEC should request that the DEP develop an HUP for Douglass Run and that the Set-aside evaluations be made for the Warden Mine treatment project.
- The feasibility of piping the discharge to the bike trail must be further evaluated. Discussions should be initiated with the Elizabeth Township Sanitary Authority about the feasibility of placing a 24 in pipe adjacent to their sewer line along lower Douglass Run.
- Discussions should be initiated with USX about their property adjacent to the bike trail. Without this property, the project cannot proceed. If USX becomes a partner, then other property owners of the lower bench should be identified about project involvement.

PEC should not rely solely on the DEP Set-aside Program for funding support for this project. Current Set-Aside spending rules require a benefit-cost evaluation that is based solely on fishery benefits. It is unlikely that a treatment project would generate enough fishery benefits in lower Douglass Run to justify the project. The fishery benefits to the Youghiogheny River may be difficult to calculate. This project would create intangible benefits associated with the Great Allegheny Passagethat are not easy to quantify and fit into DEP's analysis.

PEC is very interested in the opportunities to connect this remediation to the trail and interpretive opportunities that exist. PEC should consider finding other financial partners who recognize the benefits of remediating this highly visible mining legacy through a passive system and who also value the educational and historical value of a passive treatment system next to the highly travelled bike trail.