Tioga river watershed restoration: Design considerations and updates

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Abstract

The Tioga River, a major tributary to the Upper Susquehanna River Basin, has been negatively affected by Northern Bituminous Coal Field abandoned mine drainage (AMD) stemming from legacy coal mining that began in the mid-1800s, ending in the 1980s. This AMD loading pollution, centered around the Borough of Blossburg and the village of Morris Run in Tioga County, Pennsylvania (PA), has rendered over 32 km of the Tioga River and several tributaries as fishless due to acidity, iron, and aluminum loadings. The severe extent of the entire problem combining relatively high-flow AMD outfalls containing elevated acidity and metal concentrations, has created a pollution problem that was economically unfeasible to consider for treatment as a whole, historically. This economic problem was solved with the passage of the 2021 Infrastructure Investment and Jobs Act and the yearly funds allocated to PA for abandoned mine land (AML) reclamation and AMD treatment.

The five deep mine AMD discharges outfall near one another and enter the Tioga River within an 8-km stretch. This proximity of the outfalls and rural character of Tioga County allows for the capture / conveyance of these flows to a centralized active treatment plant that will be capable of treating 57×10^6 L/d. In 2021, the Susquehanna River Basin Commission (SRBC) received a PA Department of Environmental Protection AML Economic Revitalization grant to complete a full design to accomplish that objective. SRBC awarded Kleinfelder the design contract for the Morris Run AMD active treatment plant Project in 2022, with design completion slated for first-quarter 2024.

The combination of five AMD discharges with varying quantities and qualities creates future operational challenges that had to be managed through risk assessment design decisions. However, having nearly all watershed AMD now treated at one active treatment plant also allowed for considerations to be made as to where best to discharge the treated effluent to maximize the total length of stream restoration, while also keeping the treated water cold to aid wild salmonid presence and reproduction within the Tioga River and its tributaries. These considerations will restore around 32 km of the Tioga River, the 202 ha Tioga Lake, and an additional 6 km of cold-water fishery habitat on two Tioga River tributaries: Fall Brook and Morris Run.

These treatment design decisions that consider the management of uncontrollable AMD flows containing elevated acidity and metal loading, along with the applications implemented to best utilize the treated effluent to maximize stream restoration gains and protect river ecology, can be replicated in other watersheds containing similar large flow and loading AMD discharges.

Kleinfelder's presentation at the 2024 International Mine Water Association Conference will describe in more detail these complexities and how they were managed within the design plans for the active treatment plant.

Keywords: AMD, Morris run, Tioga river, stream restoration, wild trout, wastewater treatment, thermal pollution

Introduction

The 3,603 km² Tioga River Watershed is a major tributary to the Chemung River within the Susquehanna River Basin. The Tioga River's source is located in Armenia Township, Bradford County, Pennsylvania (PA) and generally flows north through Tioga County, PA and into New York (NY) State where it confluences with the Chemung River in Corning, NY.

Coal was discovered in the Northern Bituminous Coal Field in the Tioga River Basin near the Borough of Blossburg, PA in 1792, with the first deep-mine operation occurring in the Bear Creek subwatershed between 1812–1815, then expanding into other areas by 1865 creating the villages of Morris Run and Fall Brook (Swinsick, 1994). Deep-mining peaked in the areas surrounding Blossburg in 1886 when 1.3 million t of coal were extracted (United States Army Corp of Engineers, 1977). By the turn of the 20th Century, production from those deep-mines began to decline as a result of increased production in other areas of PA where mining was more economically viable (Orr, 2003). Starting around America's involvement in World War II, surface-mining increased in the same areas and from the same coal seams deep-mined previous. Surface mining began to decline substantially upon passage of the 1977 Surface Mining Control and Reclamation Act and ceased completely around 1990.

This legacy mining negatively affects the quality and biota of the Tioga River and several tributary streams mainly via six relatively large flow deep-mine discharge outfalls, rendering the river and those tributaries fishless due to acidity loading depressing pH, and elevating iron (Fe) and, particularly, aluminum (Al) concentrations. The first of these influences is from the DFB099 Discharge which enters the tributary of Fall Brook. Morris Run then enters the Tioga River about 5 km downstream and is affected by three separate discharge outfalls: DMR01, DMR03, and DMR04. About 1.5 km downstream of Morris Run, Coal Creek enters, containing the largest loading of acidity, Fe, and Al to the Tioga River from the DCC05 Discharge outfall. Lastly, a little less than 1.5 km downstream of Coal Creek, Bear Creek enters carrying the BC101 Discharge outfall, containing the least amount of abandoned mine drainage (AMD) loading of the six primary deep-mine outfalls.

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These six-discharges have rendered over 32 km of the Tioga River as fishless until its entry into the United States Army Corp of Engineers Tioga Lake Flood Control Dam (Fig. 1). Tioga Lake is part of a dual-lake system with Hammond Lake. Due to this AMD influence, this dual-lake flood control system was designed and constructed with available storage that could be used as water quality mitigation water, so that the Tioga River could be improved upon its exit from the dam flowing towards NY and its Chemung River confluence.

Due to the large flow amounts and elevated AMD acidity and metal loadings exiting these deep-mine outfalls, a treatment solution was not economically feasible until a new source of Federal funding was made available. In 2021, the Infrastructure Investment and Jobs Act (IIJA) provided approximately $250 million dollars per year to the Commonwealth of PA which could be utilized for large-scale AMD active treatment plant (ATP) construction and yearly operation and maintenance. In 2022, Kleinfelder (KLF) was awarded the contract to design a centralized ATP that will convey and treat the five largest loading AMD discharges which will restore the Tioga River and Lake and segments of Fall Brook, Morris Run, and Coal Creek tributaries. By time of the International Mine Water Association Conference, the design of the ATP will be complete, and the project will be in the permitting and construction bid phases.

Methods

The discharge outfalls affecting the Tioga River have been monitored for quantities and qualities for decades utilizing weirs and flumes of various sizes. Since the discharge flows will be mixed and treated at the same ATP, the initial project task involved the analysis of this historic data to determine the quantities of treated influent expected,

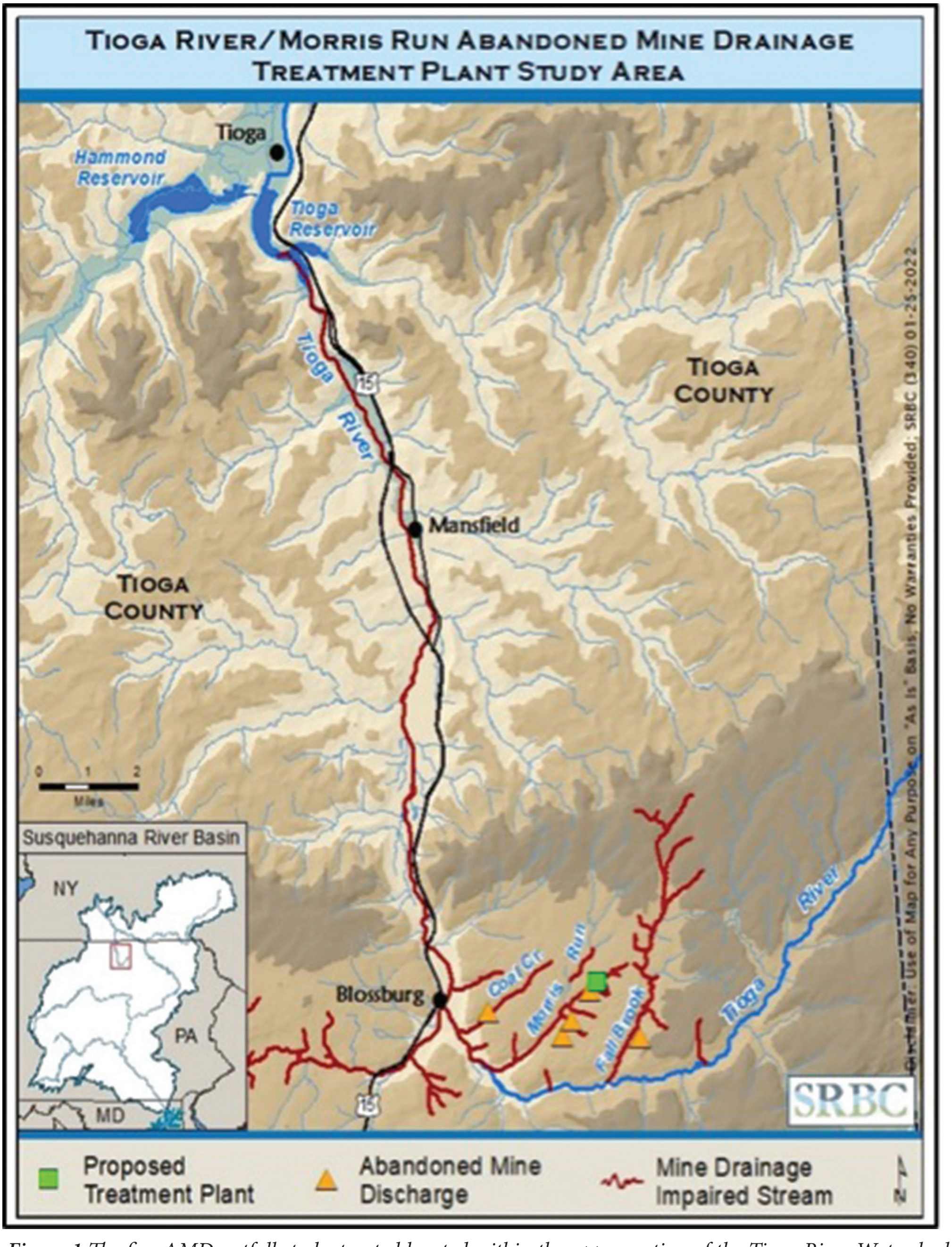

Figure 1 The five AMD outfalls to be treated located within the upper section of the Tioga River Watershed near Blossburg Borough, Tioga County, PA (Susquehanna River Basin Commission, 2022)

particularly at high-flow, and the mixed influent concentration of acidity and metals and their loading. This analysis helped determine sizing of needed conveyance piping and ATP components, as well as chemical types and amounts necessary for treatment and treatment byproducts that will need to be disposed.

Prior to ATP design, it was also unclear if any of the AMD outfalls were draining mine pools that could be utilized for storage to manage flows conveyed to the ATP particularly after intense precipitation events. Consequently, the project team conducted investigatory drilling operations to install mine pool monitoring boreholes, particularly into the mine workings drained by the DCC05 and DMR04 outfalls, to determine if any storage potential existed that could assist in managing flows. Solinst pressure transducers were installed for hydrologic year water-depth analysis within the boreholes containing mine pool water.

Upon the completion of the mine pool investigations, the capture / conveyance of the AMD outfalls to the plant were considered. Of particular difficulty were the capture / conveyance of the two highest flow-rate outfalls, DCC05 and DFB099. In addition to that difficulty, the ability to bypass extreme high-flows to avoid inundation of the ATP (that will be designed to treat a finite capacity) had to also be evaluated. A triple-redundant dual 61 cm perforated pipe collection system into the collapsed mine opening flowing into a modified spring box with bypass ability was selected for DCC05. The ability to tie into a previous semi-successful passive treatment system was selected for DFB099. Collected water would then enter a flow-control vault which will divert around 1.5 ML/d to the passive treatment system, to improve its efficiency by reducing influent flow amount, with all water between 1.5- ML/d to 11- ML/d conveyed to the ATP DFB099 pump station. Although rare, any flow from DFB099 over 11- ML/d would be again diverted to the passive treatment system as it contains a design capacity of around 4.5- ML/d.

With discharge outfalls of this scale, both in terms of quantity and quality, if operations cease for a period at the ATP, stream restoration gains can be lost quickly. In addition, being located in northeastern PA, which can experience heavy snowfall and tropical rainfall events, continuous operation of the plant must be maintained despite protracted disruption of services like electricity. Consequently, it is imperative that operational flexibility and redundancy be built into the designs, not only at the ATP site, but also for the capture / conveyance routing schemes particularly at the numerous pump stations within the project footprint. Diesel generated electrical backups and inline redundant pumps will ensure that needed redundancy and operational flexibility, which will also assist with necessary scheduled and ongoing maintenance activities by allowing the ability to offline one-side, but still convey and treat with the other.

With any ATP, byproducts of the treatment process need to be disposed. Usually, injection back into advantageous sections of the same deep-mine workings far enough away from the ATP to minimize the risk of recirculation, is the chosen method. To determine if injection was plausible (and if plausible, where best), a similar investigatory drilling operation was conducted into the northern section of the Jones Mine, which is drained by the DCC05 Discharge. This mine was selected for injection due to its large size and ability to dispose of those byproducts as far away from AMD collection points as possible to minimize the risk of recirculation through the mine and back out the DCC05 outfall and to the ATP. In addition, as was completed at nearly all levels of conveyance and treatment, two redundant injection wells will be drilled to allow for the ability to offline one-side of injection during any operation and maintenance activities, and still dispose with the other.

Due to the Tioga River and its tributaries being listed as cold-water streams that contain segments listed by the PA Fish and Boat Commission as holding Wild Trout or Class A Status (the highest wild trout listing in PA), methods to minimize thermal pollution through the treatment process were considered. In addition, where best to discharge those low temperature, treated effluents to maximize stream restoration gains were also examined. Consequently, no final polishing wetland is included in the design to reduce that thermal pollution potential through the treatment process. In addition, a treated effluent pump station has been designed within the ATP footprint which will allow for treated cold water return to restore an additional 3 km of Fall Brook and another 3 km of Morris Run.

Results and Conclusions

Based on monitoring investigations, it was discovered that adequate mine pools for storage were not available and that each AMD discharge was essentially free-draining. Consequently, high-flow events would have to be managed at the AMD discharge outfall locations and ATP components sized for effective treatment. As shown in Table 1, average daily flows to the ATP should be around 20 ML/d and that observable high-flows could be nearly 44 ML/d. Since the high-flows were merely observed high-flows, which contain obvious uncertainty, 30 % was added to the sizing of the ATP which pushed designs to a nearly 57 ML/d capacity.

With average influent calculated at around 20 ML/d and fully-mixed average concentrations of 246 mg/L acidity, 16 mg/L of Fe, and 21-mg/l of Al, it is anticipated that the Morris Run ATP will treat around 1,800 Mt of acidity, 120 Mt of Fe, and 150 Mt of Al per year.

Because borehole monitoring investigations showed that mine pools with adequate storage drained by the five AMD outfalls did not exist, the free-draining high-flows of each discharge will have to be managed at the capture location and allow for extreme flow bypass through adequate conveyance pipe and ATP treatment component sizing. If those high-flow situations cannot be managed through adequate conveyance / treatment component sizing and bypass, then all stream restoration gains could be lost. Fig. 2 shows how the various influent / effluent conveyance paths enter / exit and the sizing of the ATP components to accommodate those high-flow events.

With the volume and loading of the raw discharges being so elevated, even a short period shutdown of the ATP could cause a loss of all stream restoration gains and even cause fish kills in segments where fish have recolonized post-treatment. To combat this issue, additional operational controls and redundancy, that normally are not built into other ATPs, are being designed for Morris Run. The ATP contains a dual treatment train with each side capable of treating up to about 28.5 ML/d. This allows for the average flow to be treated on one side, as maintenance activities can be completed on the other. This also allows for the increase of raw influent discharge water up to nearly 57 ML/d, which is 30% higher than the observed maximum flow of the combined discharges. In addition to the dual-train, diesel generators and inline redundant pumps have been installed at the ATP and at all conveyance pump stations so that operations can continue during longer period power disruptions.

Table 1. *Anticipated discharge quantity (ML/d) and constituent concentrations (mg/L)**

Parameter	DCC05	DFB099	DMR01	DMR03	DMR04	Ave Mix
Quantity (ML/d)						
Min. Daily Quantity	1.93	8.03	0.03	0.19	1.79	4.74
Ave. Daily Quantity	8.96	4.96	0.64	0.98	4.42	19.97
Max. Daily Quantity	17.86	11.31	2.21	2.66	9.84	43.90
Acidity (mg/L)						
Min. Concentration	270	59	70	209	126	
Ave. Concentration	375	89	165	276	164	246
Max. Concentration	550	131	225	331	400	
Iron (mg/L)						
Min. Concentration	22.44	0.44	1.57	4.61	3.36	
Ave. Concentration	31.50	0.56	3.39	5.29	5.78	16
Max. Concentration	43.15	0.66	7.00	6.21	17.00	
Aluminum (mg/L)						
Min. Concentration	18.88	8.27	11.13	22.13	10.46	
Ave. Concentration	31.12	10.49	14.39	28.24	12.50	21
Max. Concentration	43.64	13.20	17.60	32.41	17.76	

*Data represents sampling events from 2014-2018 since qualities have improved slightly over time.

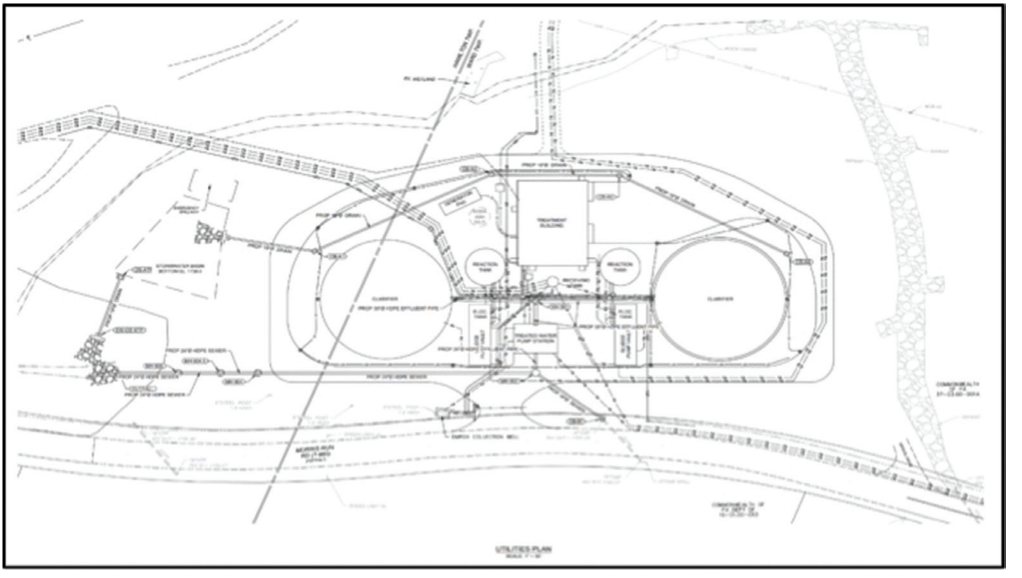

Figure 2 *Morris Run ATP site utilities plan*

Finally, to ensure that thermal pollution of the treated flow is minimized and that stream restoration gains are maximized, no wetland polishing is included and treated flow is split between Morris Run and Fall Brook, restoring an additional 6 km of those tributaries.

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