OPERATIONS, MAINTENANCE, AND REPLACEMENT PLAN FOR PA DEP GROWING GREENER GRANT ME NO.

BREWSTER HOLLOW SX8-D1 AMD REMEDIATION PROJECT

BROAD TOP TOWNSHIP
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SITE BACKGROUND

The Brewster Hollow watershed is located in Broad Top Township in the northeastern corner of Bedford County. From its headwaters to its confluence with the mainstem of Six Mile Run in the village of Defiance, the watershed is primarily forested with several residences near the mouth. Six Mile Run watershed, the mainstem of which enters the Raystown Branch of the Juniata River (HUC = 02050303) approximately two miles downstream at Riddlesburg, PA, is classified as a warm water fishery (WWF).

The impacts of abandoned underground and surface coal mines have severely impaired the water quality and aquatic life communities in the Six Mile Run watershed. Old mining operations have resulted in at least 20 different identified abandoned mine drainage (AMD) sites in the Six Mile Run watershed including at least three in the Brewster Hollow subwatershed. The AMD discharges in the watershed lower the naturally low pH and produce elevated dissolved metals concentrations in Brewster Hollow and ultimately Six Mile Run. The entire 6.16-mile mainstem of Six Mile Run from the headwaters to the confluence with the Raystown Branch of the Juniata River is listed as impaired on Pennsylvania Department of Environmental Protection's (PA DEP) 303(d) list for both pH and metals as a result of the AMD discharges. The SX8-D1 AMD discharge was identified in the 2001 AMD Assessment and Remediation Plan as a significantly influential discharge to Brewster Hollow as well as to the mainstem of Six Mile Run. In that report, the SX8-D1 discharge was identified as a priority for remediation. The SX8-D1 AMD discharge is net acidic, with high iron and low aluminum concentrations. This AMD discharge contributes approximately 0.6 tons of aluminum, 7.9 tons of iron, and 33.4 tons of acidity annually to Brewster Hollow and Six Mile Run. The SX8-D1 AMD discharge was targeted for passive treatment to increase pH and to provide adequate alkalinity to neutralize the acidity and reduce metals loading, specifically iron and aluminum. The SX8-D1 AMD remediation project is one of the priority steps in working downstream from the headwaters to help restore Six Mile Run from the historic AMD pollution.

TREATMENT SYSTEM

Broad Top Township received PA DEP Section 319 Grant funding for the construction of a passive treatment system for this priority AMD discharge. Broad Top Township selected Skelly and Loy, Inc. to prepare the final engineering design and permitting of the passive treatment system with an estimated 20 to 25-year lifespan. The treatment system engineering design was completed in 2013 and construction was completed in the summer of 2014, following receipt of all the necessary permitting approvals. Using information from the 2001 AMD Assessment and Remediation Plan, LIDAR topographic mapping, and an in-field survey performed by Skelly and Loy personnel, the project team evaluated alternatives for capture and treatment of the AMD discharge. The goal was to intercept the mine water further away from the stream than where it was discharging. Exploratory excavation work by Township personnel showed that the mine water could be intercepted further north of the stream and kept from discharging along the bank of Brewster Hollow. The area between the hillside and Brewster Hollow provided a suitable area for a large passive treatment system, but required considerable excavation. The final plans even show a portion of the Flushable Limestone Bed (FLB) covered with backfill material so as to achieve the desired grade in the cut back slope. The final treatment system design also involved installation of a mine seal that forced the water from the buried mine tunnel up into the system above it on the site. Concrete and clay were used to prevent the AMD from leaking into Brewster Hollow from the source.

The AMD enters the upstream end of the FLB directly from the underground mine workings. The FLB consists of a five foot layer of limestone containing approximately 3,000 tons of high calcium carbonate (greater than 80% $CaCO_3$) limestone. After flowing through the long and narrow limestone layer of the FLB, the water flows into a large settling pond to provide aeration and to help to oxidize and precipitate the iron and aluminum. Following the settling pond, the AMD is directed into a polishing/aerobic wetland segregated by concrete structure baffles to reduce incoming velocities and to lengthen the flow path of the water before the final outfall. The polishing/aerobic wetland contains a 0.5-foot mixed layer of spent mushroom compost and limestone fines with wetland plantings. The aerobic wetland is the final polishing step in the passive treatment process to remove any remaining metals before finally discharging into Six Mile Run just below the confluence with Brewster Hollow.

The AMD discharge, from the sealed underground mine tunnel, enters the upstream end of the FLB, and passes through the high calcium carbonate limestone material generating alkalinity sufficient to neutralize the acidity and begin the process of precipitating the iron and aluminum. The net alkaline water from the FLB is then routed to a long and narrow settling or retention pond for precipitation and/or oxidation of the metals, primarily iron. Skelly and Loy designed passive flushing systems to aid in the removal of any aluminum and iron precipitates from the void spaces in the limestone layer of the FLB. Before treatment the AMD discharge was characterized as follows:

SX8-D1 Raw AMD Discharge Characterization

FLOW (gpm)	Field pH (SU)	ALKALINITY (mg/L)	ACIDITY (mg/L)	TOTAL IRON (mg/L)	FERROUS IRON (mg/L)	TOTAL ALUMINUM (mg/L)	TOTAL MANGANESE (mg/L)
120	3.50	0	127	30.0	16.5	2.3	1.6

SX8-D1

The source of this discharge is an abandoned underground mine entry located on the north side of Brewster Hollow. This AMD discharge is characterized as fairly consistent with respect to flow rate and has historically ranged from 60 to greater than 250 gallons per minute (gpm).

The engineering design was determined through evaluation of water quality and discussions with the project team members. A passive treatment system consisting of a large FLB, containing approximately 3,000 tons of limestone was chosen. The FLB consists of a five feet deep layer of AASHTO #3, with a perforated header pipe near the bottom downstream end of the limestone layer and attached to an automatic inline structure. Based on historic water chemistry data and a maximum design flow of approximately 150 gallons per minute (75^{th} percentile of measured flows) the system provides the AMD a minimum of 20 hours contact time. Calculations indicate that amount of limestone in the FLB will produce enough alkalinity to raise the pH and precipitate the dissolved aluminum and iron from the SX8-D1 discharge for a minimum of 20 years.

A perforated header pipe is installed near the bottom downstream end of the limestone layer and is attached to an automatic inline water level control structure, which controls both normal outflow and scheduled, programmed flushes. The water then discharges out of the FLB and into a settling pond with a floating baffle where the iron is oxidized and metal precipitates are settled and retained. A rock-lined principal spillway was installed in the settling pond to control the water level and to discharge the water in a diffuse manner into the polishing/aerobic wetland. Additionally, a piping system with a manual control valve was installed from the settling pond into the wetland to provide a means of draining the pond for any necessary maintenance. The final component of the passive treatment system is an aerobic wetland, which provides additional retention and capacity to settle and retain any remaining aluminum and iron precipitates. An inlet water level control structure with a stone walkway was installed in the aerobic wetland to control the water level and provide a means of draining the wetland for any necessary maintenance.

An automatic inline water level control structure and associated perforated piping are used to set the water level in the FLB and to automatically flush the aluminum and iron precipitates from the void spaces in the limestone layer to the adjacent settling pond on a preset, programmed schedule (normally once or twice a week).

The FLB outlets directly into the settling pond that was designed for the purpose of iron oxidation and metal precipitates removal using detention time and settling mechanisms. A baffle was constructed on-site using cable and PVC/HDPE liner material with window flaps cut into the material roughly one foot below the water surface. The baffle was installed perpendicular to the flow path to reduce velocities of the incoming water and to encourage settling of the metal precipitates. A rock-lined principal spillway was installed in the settling pond to control the water level and outfall the water in a diffuse manner into the polishing/aerobic wetland. Additionally, a piping system with a manual control valve was installed from the settling pond into the wetland to provide a means of draining the pond for any necessary maintenance.

An inlet water level control structure was designed in the aerobic wetland to allow for adjustment of the water elevation for adequate retention in the pond in response to sediment and/or metals accumulation. The inlet structure also allows for dewatering of the pond for maintenance purposes (e.g., sludge removal). The outfall from the aerobic wetland inlet structure serves as the final discharge of the treatment system and discharges directly into a constructed stormwater diversion channel near the confluence of the treatment system with the mainstem of Six Mile Run.

OPERATIONAL CHECK-UPS

In order to ensure the proper operation of the passive treatment system for the SX8-D1 AMD discharge along Six Mile Run, water quality sampling must be performed and flow measurements must be collected at various locations within the system. The water quality sampling and flow measurement events must be conducted prior to any manual flushing events from the different treatment system components, due to the potential impact of flushing on the monitoring results. Water quality sampling and flow measurements shall be collected at two primary locations, Sampling Point #1, the outfall of the FLB and Sampling Point #3, which is the final system outfall (see descriptions below and Figure 1). These points should be sampled at least once every six months to provide periodic snapshots of the operations and effectiveness of the passive treatment system. Other sampling locations shall be sampled based on the results of analyses on the Sampling Location #3 to determine the source of any problems with the system.

Flow rates should be measured at all locations, wherever possible, where water (AMD) enters and leaves the passive treatment system. In addition, understanding flow rates of the Flushable Limestone Bed may help to identify problems associated with hydraulic conductivity or permeability of the treatment cell. All locations identified as flow measurement locations for the passive treatment system shall be measured using the bucket and stopwatch approach, installation of weirs or as a last resort, through visual estimation. It is recommended to survey and install a staff gauge in front of all inlet structures used as outlets for settling ponds, in order to make flow measurements at these locations quicker and easier. The staff gauge would eliminate the bucket and stopwatch approach and simply require reading the water level on the staff gauge, which correlates to a flow rate specific for each location. As indicated above, the flow measurements and water quality sampling shall be conducted every six months at a minimum at Sampling Point #1 and 3 and the other location on an as needed basis.

Flow and Water Chemistry Sampling Points:

1 - Outlet of Inline Structure (FLB Outfall)
2 - Outlet of the Settling Pond
3 - Outlet of Aerobic Wetland, Inlet Structure (Final System Outfall)

Water chemistry sampling shall include both field water quality measurements and water samples collected and sent for analysis to an off-site independent laboratory. Water samples collected and sent to an off-site independent laboratory for analysis shall be performed at least once every six months at Sample Points #1 and 3 and other locations as needed and shall include the following parameters for analysis.

- Total Iron
- Total Aluminum
- Total Manganese
- Total Alkalinity
- Hot Acidity
- pH

Normally, the primary sampling locations (#1 and #3), should be tested for the above parameters, but additional parameters are recommended should results from a sampling event indicate problems with the treatment system. In order to investigate the problem, dissolved metals analysis for both iron and aluminum may be necessary at certain sampling locations. For the dissolved iron and aluminum analyses, the water sample can be either filtered in the field and placed directly into a nitric acid preserved bottle (after filtering) or sent to the laboratory unpreserved (no nitric acid) for filtering. If the FLB is not working properly, it will allow dissolved metals to persist through the system. This should be checked at different outfalls to assist in determining the source of the problem, which may not be concluded from a total metals analysis.

In addition to the standard analyses performed at least twice a year at Sampling Locations #1 and #3, other field analyses should be performed more frequently to closely track the system operation and to serve as indicators for maintenance, particularly at the final outfall location (Sampling Point #3). Field kits and meters can be used to easily measure parameters at the sites for such things as acidity, alkalinity, total iron, and pH. Since certain components of the treatment system may require somewhat frequent maintenance, as often as once every month for flushing the FLB, it would be advantageous to measure some of the parameters easily measured in the field such as pH at certain locations during each visit, even if it is Sampling Location #3. However, it is important to note that water quality measurements should not be collected for an outfall of a pond during a flushing event from the upstream pond(s). A good example of this would be, while FLB is flushing from the Inline Structure into the Settling Pond, water quality samples or flow measurements should not be collected at the downstream pond or at the aerobic wetland. Locations recommended for field testing of water quality (at a minimum pH, acidity, and alkalinity) during more frequent maintenance activities but at a minimum on an annual basis at the treatment system should include the following.

Water Quality and Flow Sampling Points:

1 - Outlet of Inline Structure (FLB Outfall)
2 - Outlet of Settling Pond
3 - Outlet of Aerobic Wetland, Inlet Structure (Final System Outfall)

Figure 1

MAINTENANCE ACTIVITIES

Periodic maintenance must be performed in order to maintain the functionality and longevity of the passive treatment system for the SX8-D1 AMD discharge at the site. While certain components of the treatment system may require more frequent monitoring and maintenance, a basic outline, set forth in this document to provide guidelines for performing maintenance on the system components. Measured flow rates and water quality data collected from the site at the locations indicated above will ultimately provide the best information necessary for performing maintenance activities on the treatment system. Each component of the passive treatment system is discussed below relative to potential maintenance activities and the estimated frequency associated with each activity. Following the component specific maintenance activities, general maintenance items associated with the site are addressed.

Flushable Limestone Bed

The raw SX8-D1 AMD is captured and discharges into the upper end of the FLB. The FLB is operated by an inline water level control structure, which is capable of maintaining the water level within the FLB, serving as the normal outfall structure, and performing automatic flushes of the limestone bed regularly based on a pre-set, programmed schedule.

Flushing the FLB is recommended every month at a minimum. Manual flushing of the FLB can be accomplished by removing all of the stop logs from Inline Structure for at least 10 minutes. Flushing the FLB and the settling pond at the same time is not recommended as this will not allow proper settling and retention of the solids within the aerobic wetland. Prior to a manual flushing of the FLB, lowering the water level in the Settling Pond is recommended. Water level in the Settling Pond may be lowered by opening up the drain valve, allowing the pond to drain until the level is about 6 inches from the discharge channel. This will provide storage and retention of the flushed water for settling the metal precipitates. It is imperative to rely on monitoring of the inline structure outfall water quality and make visual observations of accumulated material (metal precipitates) to determine when the limestone bed need to be stirred. Finally, if after manually flushing the FLB the AMD is not being treated adequately (minimum outfall pH between 5.0 and 6.0) or if visual observations indicate short-circuiting of water across the top due to accumulated ferric iron precipitates or debris on the surface, then arrangements should be made to remove the accumulated material and stir up the limestone bed. The limestone should be stirred with a piece of heavy equipment such as a backhoe, making sure to not damage the perforated piping network near the bottom of the limestone layer. The water level in the FLB may need to be lowered to perform the maintenance on the limestone portion of the bed. The water level in the FLB may be lowered by removing enough stop logs from the Inline Structure to keep the water level at or just below the portion to be stirred.

Settling Pond

This settling pond receives the outfall from Inline Structure #1 continuously discharges water from the FLB. Each time a site visit is conducted for maintenance, the Settling Pond should be inspected for debris accumulation and debris should be removed as needed. It is important to have storage volume available in the settling pond prior to a manual flush event from the FLB to allow for settling and retention of any flushed precipitates. Therefore, the water level in the Settling Pond should be dropped prior to flushing the FLB. Sludge accumulation within the Settling Pond is dependent on the treatment efficiency of the FLB and the flow rates entering the pond. However, every two years, the sludge levels in the bottom of the pond should be measured. Once the sludge levels accumulate to more than 1.0 foot at any location within the pond, steps should be taken to perform a sludge clean-out event. Depending on the method used for sludge cleanout, dewatering most or all of the water from the pond will be necessary. The pond may be dewatered by opening the drain valve or by pumping water from the pond. Inflow from the FLB may also be routed around the pond temporarily to assist in dewatering efforts.

Methods of sludge removal include the use of a vacuum truck, pumping and dewatering the sludge material in a geomembrane textile bag, or completely dewatering the pond and using heavy equipment with a bucket to remove the material and place it in a pile on the site for drying before hauling off-site. Upon removal of the sludge material, the inflow from the FLB may be directed back into the pond.

The Settling Pond has a baffle installed across the center of the pond perpendicular to the incoming flow to allow slowing and settling of the suspended solids entering the pond. This baffle, which is suspended using wood and a cable anchored on the inside pond berm, should be inspected at least once per year for weathering, cracking, tearing, or sagging to ensure that the baffle continues to function as needed to reduce migration of solids to the aerobic wetland. Any repairs to the baffle shall be performed as needed and replacement may be necessary due to deterioration from the continued exposure of the baffle material to the sunlight.

Aerobic Wetland

The stone used around Inlet Structure as a walkway for access may need to be managed which includes adding stone as necessary to maintain a safe means of accessing the structure for maintenance. General health of the wetland vegetation should be monitored. If sediments choke out the wetland plants, the sediments should be removed and new wetland vegetation should be planted.

GENERAL SITE MAINTENANCE RECOMMENDATIONS

In addition to the maintenance needs for main components of the passive AMD treatment system, other components also require some basic inspection and less frequent maintenance work. These items include the rock-lined emergency spillway for ponds, rip-rap outlet protections at many pipe outfalls, the off-site stormwater diversion channel rock-lining along the southern boundary of the site, and the condition of the access road. These items should be inspected every six months at a minimum and after major rainfall events. Pipe openings should be cleaned as needed to ensure they remain unobstructed and allow water to flow freely to the FLB. All constructed berms and embankments involved with the treatment system should be inspected at least twice a year to monitor for potential failure caused by either excessive flows or areas of surface erosion. Any areas experiencing significant erosion should be immediately regraded and stabilized with seed and mulch, and the cause of the erosion should be addressed to prevent future concerns.

REPLACEMENT OF TREATMENT COMPONENTS/MATERIALS

The FLB treatment cell containing limestone is designed to provide adequate treatment for 20 to 25 years. After 20 to 25 years of operation, the limestone contents of the treatment cells must be replenished. This is accomplished by removing the spent limestone and replacing it with 3,000 tons of new high calcium carbonate limestone. Care must be exercised during this process to avoid damaging the piping networks in the bottom of the limestone beds. Once the contents of the treatment cells have been replenished, they should provide adequate treatment for another 20 to 25 years.