Mitchell Experimental Treatment System Monitoring and Evaluation
Babb Creek Watershed, Tioga County

Technical Report Provided by Hedin Environmental through the Trout Unlimited AMD Technical Assistance Program

June 30, 2010

Background

This report serves as an addendum to a report titled "Optimizing the Design and Operation of Self-Flushing Limestone Systems for Mine Drainage Treatment" which was prepared in 2008 by Hedin Environmental as part of the Bureau of Abandoned Mines and Reclamation Innovative Treatment program and is available on the PADEP website at http://files.dep.state.pa.us/Mining/Abandoned%20Mine%20Reclamation/AbandonedMinePortalFiles/InnovativeTechnologyGrantFinalReports/Flushing.pdf . The report outlined the findings of a research project which involved the construction of two experimental self-flushing systems. At the conclusion of the research project one of the experimental systems was dismantled (East Box) while the other was allowed to continue operation (West Box). In November 2009 the Babb Creek Watershed Association (BCWA) requested that monitoring of the West Box resume under Trout Unlimited's Technical Assistance Program. Monthly samples were collected and the results are presented and discussed in this report. Additionally, this report contains recommendations for improvements to the existing Mitchell Tank, which is an earlier experimental system whose operation is managed by the BCWA.

The West Box is a 30 cubic yard roll off container filled with 30 tons of AASHTO #5 limestone aggregate. The limestone was purchased from Con-Stone Inc. (Aaronsburg, PA) and is a clean screened product with 100% of the aggregate between 0.5 and 1.0 inch diameter. Flushing of the West Box is achieved using an Agri Drain Smart Drainage System (SDS). The SDS is a standard inline water level control structure with a knife gate valve installed in place of the bottom boards. A linear actuator opens and closes the valve based on parameters programmed into a solar powered control unit. Flushing can be programmed to occur based on either time or water level.

The West Box was operated between October 2007 and October 2008 in a variety of modes that are described in the PADEP report. One result of the research was the finding that the containers produced an alkaline low-metal effluent when operated at ~1 gpm flow rate. The report contained three months of operational data for the West Box under this condition. The sustainability of the treatment could not be assessed within the time frame of the PADEP project. This report provides the results of additional sampling between November 2009 and June 2010.

Sampling

Seven sampling rounds were collected and the results are summarized in Table 1. All West Box effluent samples had a pH >6 and were net alkaline. The aluminum (Al) contained in the effluent samples was particulate and could be removed with a filter. The manganese (Mn) in the effluent was not filterable.

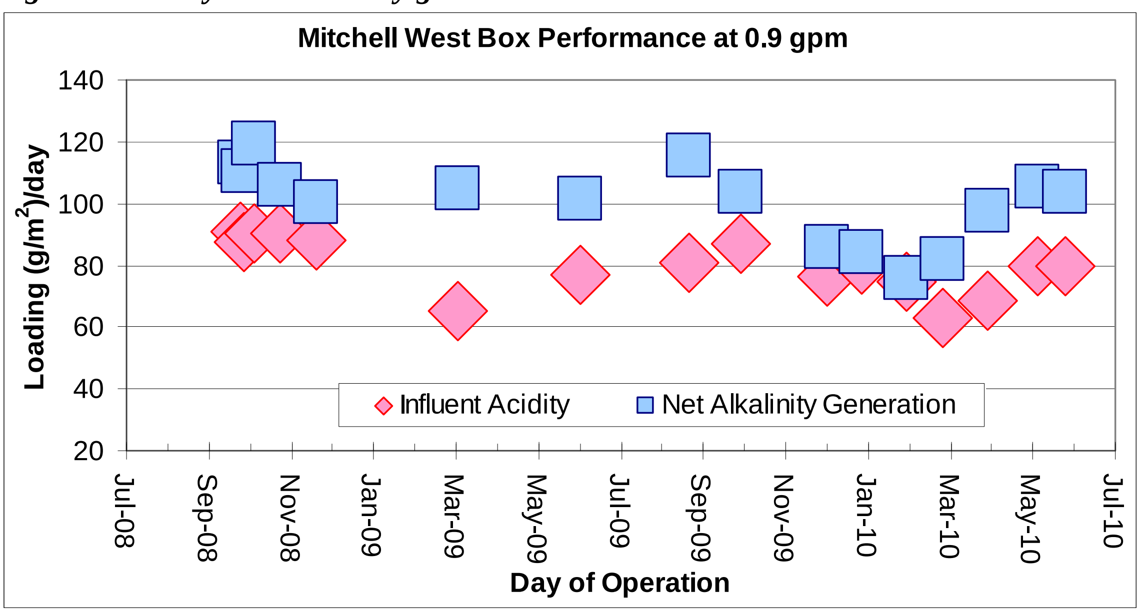
Table 1. Average water sampling results for the West Box, Dec 2009 -- June 2010

Location	Flow (gpm)	pH	Acidity (mg/L)	Fe (mg/L)	Mn (mg/L)	Al (mg/L)	Sulfate (mg/L)
Influent		3.0	226	8.2	12.1	24.4	790
Effluent	0.9	6.9	-46	0.5	4.2	4.3	810

Discussion

Data collected through the technical assistance project was combined with existing data for analysis. The West Box has been operated at an average flow rate of 0.9 gpm since October 2008. Figure 1 shows the influent acidity and net alkalinity generation in mass per unit area per day during that timeframe.

Figure 1. Acidity and alkalinity generation rates



The influent (Mitchell Mine discharge) chemistry varies with flow. Acidity and metal concentrations are higher during low flow than high flow. Because low flow conditions are most common in fall and high flows are most common in spring, the variation has a seasonal component. Under all conditions, the West Box neutralized the influent acidity and generated a residual alkalinity of 20-80 mg/L alkalinity. The West Box had its highest effectiveness in fall 2008 and fall 2009 (Figure 1, net alkalinity generation). This seasonality was a consequence of influent conditions, not a seasonal change in the Box's contaminant removal effectiveness.

The poorest treatment effectiveness of the West Box was between Dec 2009 and Feb 2010. During this period air temperatures were very low and a substantial portion of the Box was frozen solid. Pores in the limestone bed that are filled with ice reduce the residence time of the system and lower performance. The West Box's freezing was a consequence of the unit being placed above-grade. A system intended for long-term treatment (not a short-term research project) would consist of either an earthen pond or a tank that was buried. Both of these construction techniques would substantially eliminate freezing of the aggregate in cold weather.

The average acidity loading was 82 (g/m^2)/day and the average alkalinity generation rate was 100 (g/m^2)/day. These rates are 2-3 times larger than ones generally observed for vertical flow ponds (VFP). The typical design recommendations for VFP systems assume net alkalinity generation rates of 30-40 (g/m^2)/day. The Anna S Passive Treatment System treats water similar to the West Box influent and has generated net alkalinity at rates of 30-50 (g/m^2)/day. The technology demonstrated by the West Box has the potential to treat severe AMD in a footprint that is at least 50% smaller than current passive technologies.

The West Box has lowered Mn from 12 mg/L to 4 mg/L. Mn removal is the most difficult component of passive treatment. In VFP systems, Mn removal typically is accomplished in a limestone bed or wetland following the VFPs. The sustained removal of Al, Fe, and Mn in one passive treatment unit is a surprising discovery and has valuable implications for sites with NPDES permits or streams where Mn is considered an important water quality parameter.

Mitchell Tank Recommendations

The Mitchell Tank was constructed in December 2005 by BCWA using funding provided by the OSM Appalachian Clean Streams Initiative and Foundation for Pennsylvania Watersheds. The purpose was to test the effectiveness of a large flushable limestone bed for AMD treatment. If the unit proved effective, the BCWA would consider the installation of more units so that eventually most of the Mitchell discharge could be treated.

The Mitchell limestone system is 50 foot diameter circular concrete manure tank filled with AASHTO #1 limestone aggregate. Flushing is accomplished with an automatic dosing siphon. Initially the system performed well but effluent quality deteriorated within the first year of operation. Recently the automatic dosing siphon malfunctioned and the system is no longer providing any meaningful treatment. Lessons learned from the West Box can be applied to the Mitchell Tank to improve its performance.

Based on the West Box performance, if the Mitchell Tank was filled with 750 tons of AASHTO #5 stone and equipped with a Smart Drainage System that emptied the tank once per week, then the unit could treat about 25 gpm of flow to the condition shown in Table 1. A higher flow, perhaps 50 gpm, could be treated at the expense of Mn removal and more frequent cleaning of the limestone. The East Box was sustainably treating 2 gpm (15 tons limestone per gpm flow), but with higher effluent Mn before it was dismantled.

The Mitchell Tank currently contains about 600 tons of limestone. Filling the tank with 750 tons of limestone it will make cleaning of the limestone more difficult because some limestone will have to be temporarily stockpiled outside the tank to make room for cleaning. Limestone cleaning was accomplished for $2.50/ton with 600 tons of limestone in the tank. Filling the tank completely will increase this cost, but it will also increase the amount of water that can be treated. In this regard, the added maintenance cost is justified.

Two primary tasks are presented for improving the performance of the Mitchell Tank. Task A modifies the flush system and adds limestone from the site and is considered to be a short-term option. Task B involves replacement of limestone and should be performed in conjunction with Task A to provide long term performance improvement.

<u>Mitchell Tank Rehabilitation - Task A</u>

A low cost short-term option for improving the performance of the Mitchell Tank is to make modifications using existing materials on the site. This option uses the existing limestone contained in the tank and the ASSHTO #5 limestone aggregate and effluent plumbing from the dismantled East Box. Estimating a cost to perform this work is difficult but it is likely that it can be accomplished for $2,000-$5,000. This system will be able to treat 10-20 gpm. A conceptual construction sequence follows.

Conceptual Construction Sequence for Task A

1. Shut off flow and drain tank. The drain valve will not completely drain the tank so pumping will be required.
2. Drill two 3 inch diameter holes in the siphon overflow pipe at desired water level. These will be the primary outlet for the system.
3. Using a saddle fitting, connect the 8 inch gate valve from the East Box Smart Drainage System (SDS) to the siphon overflow pipe.
4. Mount the linear actuator from the SDS securely to either the overflow pipe or the concrete vault. The linear actuator should be placed above the highest anticipated water level to prevent damage.
5. Connect the linear actuator to the gate valve using a rigid push-rod.
6. Fabricate and install a protective covering for the actuator. The covering should protect the actuator from precipitation.
7. Mount the SDS control unit and solar panel and connect cables to linear actuator.
8. Return flow into tank. Adjust flow so that 25 gpm is treated initially then adjust as needed based on performance.

Alternatives to consider

- If mounting of the linear actuator securely is a problem then it may be possible to install the entire water level control structure inside the concrete vault. Measurements should be made to verify that it will fit. A taller inline water level control structure will need to be purchased since the structure from the East Box allows for only 4.5 feet of water. The new structure could be purchased for a few hundred dollars and the SDS components added.
- Add influent flow distribution. Add a length of perforated pipe perpendicular to the flow path.

Mitchell Tank Rehabilitation - Task B

To maximize performance for the long term the AASHTO #1 limestone should be removed and replaced with AASHTO #5 limestone. The tank contains about 530 tons of AASHTO #1 which could be used to make a cleaning pad next to the tank to facilitate future limestone cleaning events. A total of 650 tons of new AASHTO #5 limestone should be added to the tank. Estimated cost to replace the limestone is $15,000 (650 tons @ $20/ton plus $2,000 to remove old limestone).

Conclusions

Continued monitoring of the West Box has shown that effective treatment of acidic Al-contaminated water is sustainable for at least 33 months with a bed of AASHTO #5 limestone aggregate as long as it is drained empty once per week. The alkalinity generation rates achieved are 2-3 times faster than conventional passive treatment (VFP systems) which could result in substantial savings in system sizing and cost. The West Box also provided Mn removal which may be important in situations where Mn cannot be ignored. The findings could be applied to the existing Mitchell Tank system to test the feasibility of scaling up this technology. If the 100,000 gallon concrete tank was modified to mimic the West Box, it would be able to treat 20-30 gpm of Mitchell mine water. Modifications are estimated to cost $17,000-$20,000.