Sandy Creek restoration – the tale of two acid mine drainage treatment systems

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Abstract

The Sandy Creek watershed, spanning approximately 23,387.6 ha across Barbour, Taylor, and Preston Counties in West Virginia (WV), faces degradation from coal mining as defined by the Surface Mining Control and Reclamation Act (SMCRA). These activities contribute 49.5% of all acidity loading (4,230 kg/d) to Tygart Lake and Tygart Valley River. Tributaries of Left Fork Sandy Creek and Little Sandy Creek suffer from acid mine drainage (AMD) within the Sandy Creek watershed. In response, the West Virginia Department of Environmental Protection's (WVDEP) Office of Special Reclamation (OSR) initiated the design of three AMD treatment systems in 2016 to rectify the impaired streams by improving pH.

By 2017, OSR had retrofitted F&M Coal Co. in the headwaters of Left Fork Sandy Creek to ensure consistent AMD treatment. The outdated treatment was replaced with a combination of high-density lime slurry systems and larger settling ponds. This retrofitting aimed to meet water quality standards under the National Pollutant Discharge Elimination System (NPDES) Permitting program and was completed in 2020. Groundwork for AMD treatment within Left Fork Little Sandy (LFLS) Creek and Maple Run watersheds commenced in 2016 after legislative revisions to the state's water quality standards. WVDEP received USEPA approval for a watershed-based NPDES Permitting Variance on February 20, 2018. Construction of an in-stream doser using the high-density lime slurry system on LFLS Creek and a hydrated lime mechanical feed system along Maple Run concluded in 2019.

Before 2016, no efforts made to improve the water quality or stream ecology of Sandy Creek had worked due to the overwhelming amount of AMD. Upon completion of all water treatment systems, the previously depressed pH approached near neutrality, allowing the migration of fish species upstream. Fish and benthic macroinvertebrate surveys in 2021 and 2023 demonstrated increased diversity and richness. Similar positive results were observed below the F&M Coal permits in Left Fork Sandy Creek. Utilizing AMD treatment systems, the Sandy Creek watershed has made noteworthy strides in achieving long-term ecological restoration goals outlined in the Watershed-based Variance. While 22.9 km of Sandy Creek and Little Sandy Creek have begun to experience relief from the long-term AMD problem, evidence now shows improved water quality and the return of aquatic life in the watershed.

Keywords: Acid mine drainage, water treatment, watershed-based NPDES permitting variance, high-density lime slurry treatment, ecological restoration

Introduction

The Sandy Creek watershed has a rich history of coal mining dating back to the late 19th century, characterized by small house coal mines and underground operations targeting coal seams, predominantly the Upper Freeport and Lower Kittanning formations. Similar to the Cheat River watershed, the initial mining activities commenced in the Tunnelton area near the B&O Railroad, marking the headwaters of LFLS Creek (Pavlick 2005). Throughout the 20th century, underground mining expanded both in scale

and depth, reaching challenging coal seams as mining technology advanced. The watershed experienced a peak in coal production during World War II, sustaining strong output until the 1960s. With the enactment of SMCRA in 1977, many mining operations ceased and a few transitioned permitted operations. In the 1980s, there was a resurgence in both underground and surface coal mining within the watershed. However, by early 2009, the last active mining permit in the watershed concluded its operations and closed, marking a shift in the mining landscape.

In 1984, F&M Coal Co. (F&M Coal) obtained surface coal mining permits for operations on Laurel Mountain (Fig. 1). These permits authorized the extraction of coal, following the guidelines specified in the SMCRA regulations, allowing surface mining to access existing underground mine workings and remove residual coal. Subsequent to the issuance of these permits, complaints from concerned citizens began surfacing and were reported to the WV Department of Energy. By 1989, a report from the WV Department of Energy identified a substantial increase in acidity and total iron concentration resulting from mining activities conducted by F&M Coal. This report highlighted the further degradation on two abandoned underground mines, emphasizing the necessity for treating the AMD generated by these operations (Evans 1989). In 1992, the mining permits associated with F&M Coal's activities on Laurel Mountain were revoked and coal mining operations ceased. To address the land and water reclamation liabilities, the responsibility for abatement fell under the jurisdiction of the OSR.

The citizens, disturbed by the heightened AMD and environmental harm caused by F&M Coal mining permits, formed the Laurel Mountain-Fellowsville Area Clean Water Association (LMFACWA). They relied on springs and wells for drinking water, which were adversely affected by coal mining activities. LMFACWA successfully reached settlements with various entities related to water pollution in Left Fork Sandy Creek caused by AMD from specific mine sites. The Laurel Mountain Trust, established through collaboration between LMFACWA and WVDEP, spans a 90-year term with an initial joint investment of nearly 3.5 million USD.

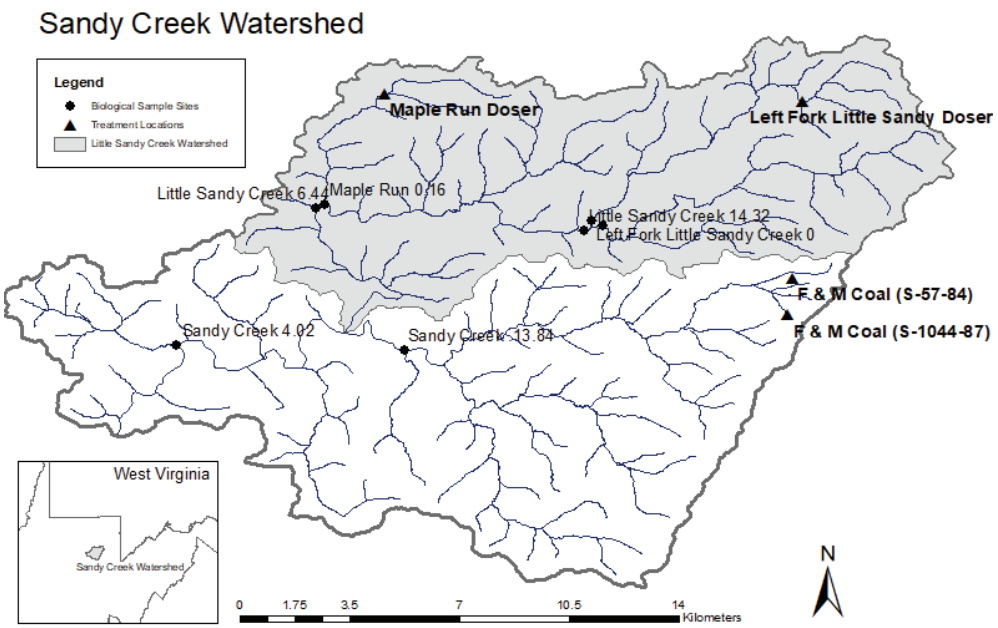

Figure 1 *Sandy Creek watershed*

This fund is exclusively dedicated to AMD treatment within Left Fork Sandy Creek (Cohen 1993).

In the Little Sandy Creek watershed, surface and underground mines are situated in the headwaters of Little Sandy Creek and its tributary, Maple Run. Both streams face substantial AMD effects from these pre-SMCRA sources. Notably, three mining permits have been revoked, near Kanestown on Left Fork Little Sandy Creek, and the others in the Scotch Hill area within the Maple Run headwaters (Fig. 1).

In the late 2000s, a watershed AMD treatment initiative was undertaken in the Three Forks Creek watershed, which is part of the Tygart Valley River system. The innovative approach involved utilizing in-stream dosers to dispense a high-alkalinity chemical, specifically calcium oxide (CaO), in order to elevate the pH of key tributaries-Squires Creek, Birds Creek, and Raccoon Creek. The primary aim was to improve the water quality of the Three Forks Creek to facilitate the return of benthic macroinvertebrates and fish species. Subsequent evaluations in 2012 revealed positive outcomes in the lower reaches of Three Forks Creek through comprehensive benthic and aquatic surveys, demonstrating the effectiveness of the in-stream dosing approach (Coberly 2012). In the same year, a watershed-based plan for Sandy Creek was established by the Save the Tygart Watershed Association (STTWA). Recognizing the benefits of active treatment, STTWA emphasized the parallels between the in-stream dosing in the Three Forks Creek headwaters and potential benefits for Sandy Creek (Hansen 2012).

Utilizing the F&M Coal water treatment facility and the strategically placed in-stream dosers on LFLS Creek and Maple Run to improve the water quality of Sandy Creek. Designs to increase alkalinity to achieve a near neutral pH, an increase in species richness and diversity, and to revive the macro invertebrate community within Sandy Creek (OSR 2016).

Methods

In 2014, OSR faced challenges in meeting NPDES compliance for F&M Coal mining permits in Left Fork Sandy Creek. Concurrently, OSR engaged the WV Water Research Institute (WVWRI) at WVU to explore a watershed-scale approach for AMD treatment in Sandy Creek using in-stream treatment.

F&M Coal – Left Fork Sandy Creek

Between 1992 and 2011, F&M Coal had multiple discharges which were classified as non-point sources and adhered to technical limits achievable by the AMD treatment system. In 2011, a judicial decision mandated OSR obtain NPDES permits for discharges from revoked permits. These discharges were given NPDES limits for settleable solids, pH, total iron, and total aluminum. Chemicals like anhydrous ammonia, sodium hydroxide, and calcium oxide were used for water treatment from 1992 to 2017. Anhydrous ammonia and sodium hydroxide were added to AMD, with pH hand-adjusted, but the treatment ponds were inadequate, leading to sludge disposal challenges. Discharges needed additional pH treatment using anhydrous ammonia or in-stream calcium oxide dosers. From 2012 to 2014, raw water sampling (flow, acidity, alkalinity, iron, aluminum, and manganese) of all known locations of AMD was conducted. In 2014, an Expression of Interest (EOI) was issued for retrofit proposals, seeking gravity conveyance lines, force main lift stations, and high-density lime slurry systems for AMD treatment as well as larger settling ponds and enhancing sludge removal and transport capacities.

Between late 2017 and spring 2020, extensive construction took place at F&M Coal mining permits to retrofit AMD treatment. At S-57-84, Buildings A and B each address distinct locations within the permit area. Building A handles mine water from underground mine portal and S-1073-86 (Fig. 2), while Building B addresses AMD from the bottom of the pit location on S-57-84 and cracks in rock outcroppings above Left Fork Sandy Creek. Both buildings utilize lime slurry for AMD treatment, adjusted based on pH monitoring. After two years, trials switched to sodium hydroxide for more adaptable treatment based on variable

Figure 2 *Iron and aluminum precipitating out in streambed causing staining (image: Ben Fancher)*

AMD flows. Treated water passes through settling ponds and limestone aggregate filters before discharge, with sludge pumped into a centralized cell.

At S-1044-87, the main silo (Fig. 3) employs a high-density lime slurry system, treating AMD from the pit, an open ditch collecting various seeps around the reclaimed pit, and a lift station. Building C treats AMD from underground mine portals. Both buildings utilize lime slurry, with Building C receiving it from the main silo.

Treatment is pH-controlled, with lime slurry pumped from storage tanks to mix tanks where it meets the AMD. Treated water undergoes settling in ponds and limestone aggregate filters before discharge, and sludge is regularly pumped into cells around the permit.

LFLS Creek and Maple Run In-Stream Dosers – Little Sandy Creek

In LFLS Creek and Maple Run, several OSR revoked mining permits underwent water treatment. However, post-2011, discharges meeting NPDES limits offered minimal benefit due to the prevalence of AMD from pre-SMCRA discharges. In 2015, temporary in-stream dosers with electrical power were installed on both streams, operating until December 2016 to determine if in-stream treatment of AMD was feasible (Ziemkiewicz 2017). Based on water data collected throughout the Sandy Creek watershed, it was possible to elevate the alkalinity and increase the pH of the streams.

Figure 3 *Main Silo at F&M Coal (image: Ben Fancher).*

By middle 2016, Legislative revision to the water quality standards for LFLS Creek and Maple Run were finalized. Following approval from USEPA, OSR collaborated on a watershed-based variance for in-stream treatment of mining waters at the confluence with the main stem of Little Sandy Creek. WVDEP received USEPA approval for a watershed-based NPDES Permitting Variance in 2018 (McManus 2018). Upon USEPA approval, the design of permanent in-stream dosers commenced for LFLS Creek and Maple Run, with construction completed in 2019. The LFLS in-stream doser employs a high-density lime slurry system, differing only in the absence of a rapid mix tank from the main silo at F&M Coal. Lime slurry is pumped directly into the stream, with pH control approximately 150 ft (46 m) downstream. Conversely, on Maple Run, the in-stream doser is a hydrated lime mechanical feed system with a smaller silo. The chemical is fed directly into the stream, concentrating the flow for efficient mixing. Downstream, the pH-controlled system mirrors the LFLS in-stream doser.

Results

The primary aim of in-stream treatment was to neutralize high acidity in Left Fork Sandy Creek, Left Fork Little Sandy Creek, and Maple Run, thereby elevating pH to near neutral levels in the main stem Sandy Creek and Little Sandy Creek. This initiative aimed to restore and support diverse wildlife within the Sandy Creek watershed.

Water treatment facilities at F&M Coal, operational since spring 2020, consistently discharge below NPDES limits. LMFACWA monitoring below the facilities observed increased benthic macroinvertebrates since construction was completed in 2020. At an April 2022 event with local a 4-H (youth development organization) chapter, LMFACWA conducted benthic surveys indicating improvements in pollution intolerant species and increased species diversity. Although not fully restored to pre-mining conditions (Hansen 2012), the watershed exhibits enhanced ecological attributes. Fish and macroinvertebrate surveys have been requested by LMFACWA but have not been conducted.

In 2015, WAB, in collaboration with OSR, conducted a pre-treatment biological monitoring report, revealing minimal benthic macroinvertebrate and fish communities in Sandy Creek and Little Sandy Creek watersheds' lower reaches (WAB 2016). There were no fish observed at any sampling station except at sampling station km 13.84. In 2021 and 2023, a vast increase has been observed in the fish communities when compared to pre-treatment samples. The WV Stream

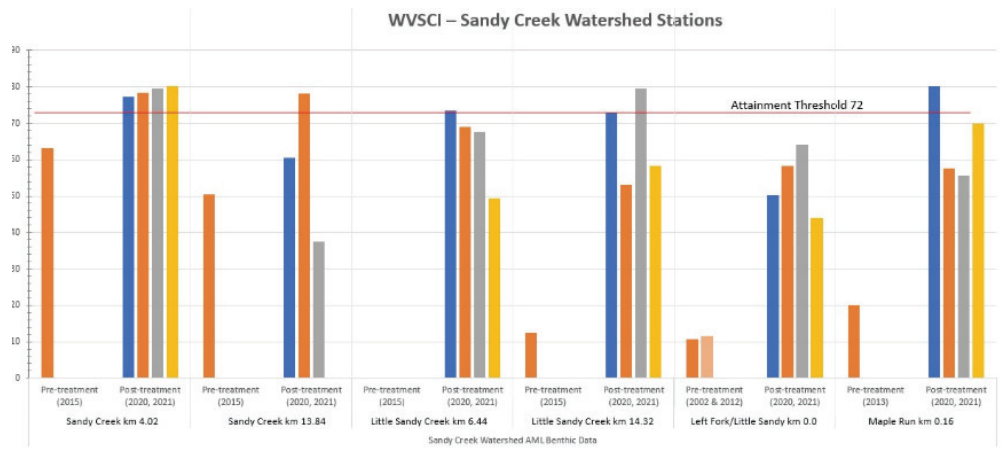

Figure 4 Preliminary Sandy Creek watershed WVSCI data from WAB (Personal Communication 2023)

Condition Index pre-treatment, found no samples had a score above the attainment threshold of 72. All post-treatment samples collected from 2020 and 2021 have scored higher than the attainment threshold (Fig. 4).

Post-treatment biological monitoring in 2022 and 2023 demonstrated improved fish and macro- invertebrate communities at all sample stations, but no official report has been issued at this time (Fig. 5). Correspondence between OSR and WAB highlights improved water quality facilitating fish species recruitment and the rising benthic macroinvertebrate population of previously impaired waterways (Personal Communication 2023).

Discussion

The USEPA's watershed-based variance for Left Fork Little Sandy Creek and Maple Run aims to restore 9.2 mi (15 km) of Little Sandy Creek and 5.0 mi (8 km) of Sandy Creek (McManus 2018). Despite improvements in fish populations, visual challenges persist in these streams due to sludge embeddedness from in-stream dosing (Fig. 6). A known issue of in-stream treatment was the precipitation of metals with the stream channel below the dosers, but was not anticipated as the high flow events to periodically flush out the watershed was highly variable through each season, specifically during the summer when the lowest stream flows occur (OSR 2016).

OSR, in collaboration with WVDEP Office of Abandoned Mine Lands & Reclamation (AML&R), is constructing an in-stream water treatment facility to address this issue. The facility will settle and return clear water to the stream while injecting settled sludge into underground mine workings for disposal.

The ongoing need for re-evaluating the watershed-based variance every five years

Sandy Creek Fish Community Comparison
Pre-treatment (2013, 2015) Post-treatment (2021, 2023)

Stream Name	Sandy Creek				Little Sandy Creek				Left Fork/ Little Sandy Creek			Maple Run		
Km Point	4.02			13.84	6.44	14.32			0.0			0.16		
Sample Year	2015	2021	2023	2015	2015	2015	2021	2023	2013	2021	2023	2013	2021	2023
White Sucker	No fish Observed from a 275m reach	42	1	7	No fish Observed from a 300m reach	No fish Observed from a 220m reach			No fish Observed from a 160m reach			No fish observed From a 160m reach	13	1
Creek Chub		373		165			62	59		14	37		98	101
River Chub		68	14	49										
Green Sunfish		25	2	1			104	35		32	13		12	
Yellow Bullhead		4											1	
Bluntnose Minnow		192	3	88			13						9	8
Fantail Darter		1	2	8										1
Johnny Darter		1	2	7										
Smallmouth Bass		2	66	53										
Northern Hogsucker		1	73	152				1					1	
Western Blacknose Dace		6					1						1	
Mottled Sculpin		2						13			3			
Rock Bass		8		49										
Bluegill				13										1
Spotted Bass				1										
Largemouth Bass														2
Total Species	0	13	N/A	12	0	0	4	4	0	2	3	0	7	6
Total Collected	0	725	N/A	593	0	0	180	108	0	46	53	0	135	114
Fish/meter	0	2.64	N/A	1.98	0.00	0.00	0.82	0.49	0.00	0.23	0.27	0.00	0.84	0.71

Figure 5 *Preliminary Sandy Creek Fish Community Comparison from WAB (Personal Communication 2023)*

underscores its dynamic nature. As regulations evolve, the specificity of watershed-based variances and their application must be tailored to address specific water quality challenges within a watershed. Early consultation with USEPA during planning stages is crucial if considering a watershed-based variance as a viable solution.

Conclusion

Historical mining activities in the Sandy Creek watershed, particularly coal mining, have considerable influence on the water quality, leading to the generation of Acid Mine Drainage (AMD) and environmental degradation. The evolution of mining practices, from small-scale operations in the late 19th century to the peak during World War II and subsequent decline after the implementation of the SMCRA, has shaped the current state of the watershed.

The case study of F&M Coal mining permits on Laurel Mountain illustrates the challenges associated with AMD, citizen complaints, and the subsequent formation of the Laurel Mountain Trust for long-term environmental rehabilitation. The implementation of in-stream dosing in the Three Forks Creek watershed and the subsequent application in Left Fork Sandy Creek and Maple Run showcases the innovative approaches adopted to address water quality issues.

The retrofitting of AMD treatment systems at F&M Coal mining permits in 2020 and the installation of in-stream dosers have demonstrated positive results. Monitoring efforts by the LMFACWA indicate improvements in benthic macroinvertebrates and fish populations in Left Fork Sandy Creek. While challenges remain, such as the increased stream embeddedness of LFLS Creek due to sludge precipitation and aesthetics in certain areas, collaborative efforts between the OSR and WVDEP aim to further enhance water treatment methods and address lingering environmental concerns.

Figure 6 Confluence of Left and Right Fork Little Sandy Creek in Fellowsville, WV (image: Ben Fancher)

The USEPA-approved watershed-based variance for Left Fork Little Sandy Creek and Maple Run represents a pronounced step toward restoring water quality standards. However, the dynamic nature of watershed conditions requires ongoing evaluation and adaptation of strategies. The commitment to re-evaluate the variance every five years emphasizes the importance of flexible and context-specific approaches in water quality management. Sandy Creek watershed's journey from historical mining degradation to contemporary rehabilitation efforts highlights the complexity of environmental challenges and the need for adaptive, science-based solutions. Continued collaboration among government agencies, environmental organizations, and local communities will be crucial in sustaining and furthering the positive trajectory observed in recent years.

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