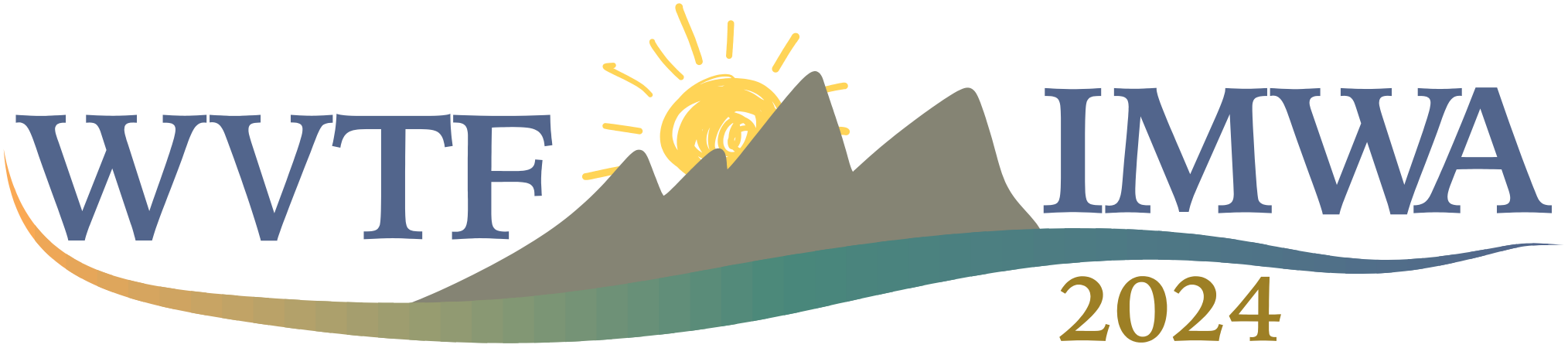

Sandy Creek restoration – the tale of two acid mine drainage treatment systems

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Introduction – Sandy Creek Watershed

Approximately 23,387.6 hectares or 90 square miles in Barbour, Taylor, and Preston Counties in West Virginia (WV).

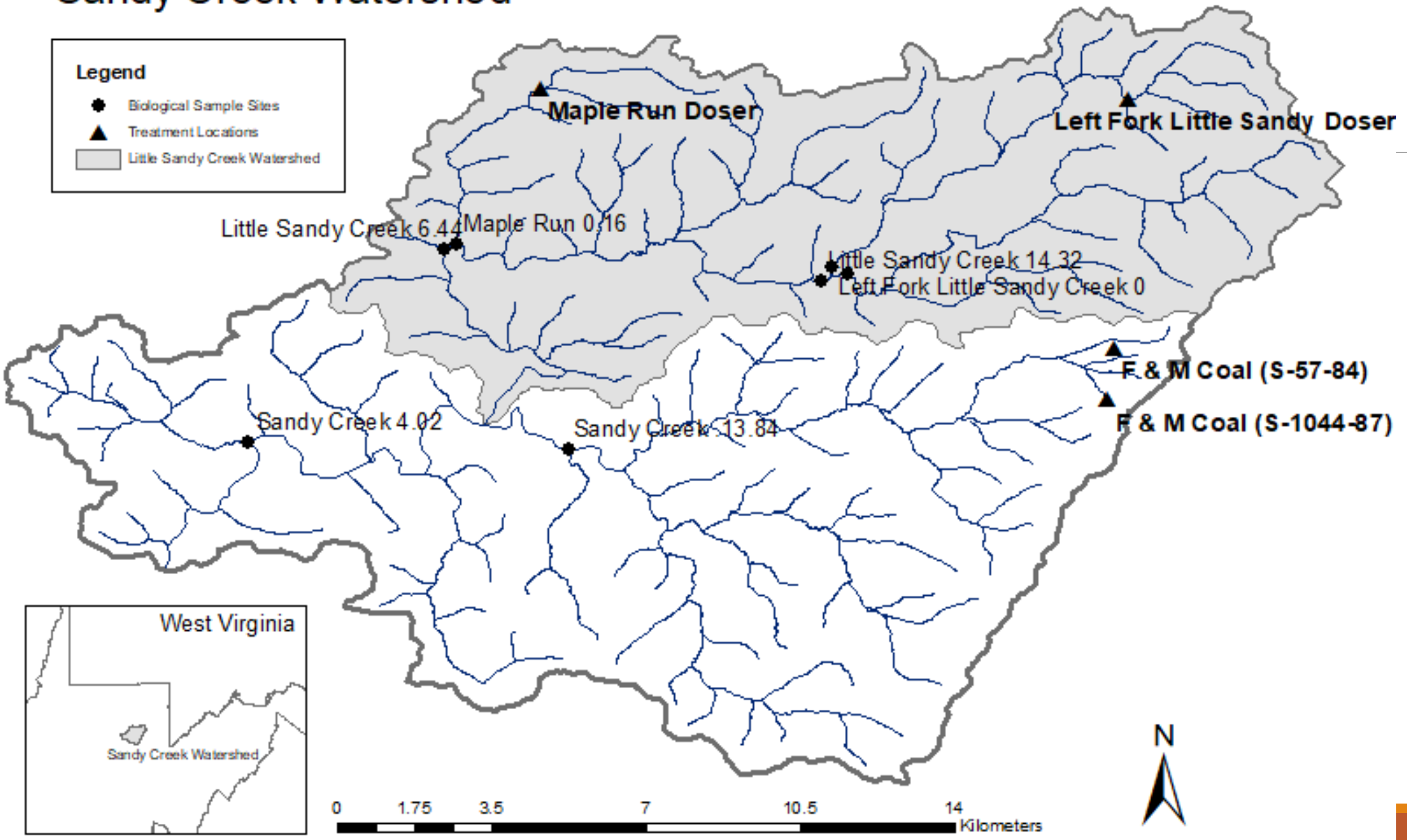
Waters impaired due to coal mining activities. These activities contribute 49.5 percent of all acidity loading (4,229.75 kg/day or 9,322.8 lbs/day) to Tygart Lake and Tygart Valley River.

Rich history characterized by small house coal mines to underground operations mainly in Upper Freeport and Lower Kittanning formations.

Two different AMD treatment systems:

- F&M Coal within Left Fork Sandy Creek and is a point source discharge.
- In-stream Dosers Little Sandy Creek and watershed based discharges.

Sandy Creek Watershed



Introduction – F&M Coal (point-source)

- In 1984, F&M Coal obtained surface coal mining permits for operations within the headwaters of Left Fork Sandy Creek.
- By 1989, substantial increases in acidity and total iron concentrations within Left Fork Sandy Creek.
- In 1992, the mining permits were revoked and coal mining operations ceased. OSR was responsible for the land and water reclamation liabilities abatement.
- The same year, the Laurel Mountain-Fellowsville Area Clean Water Association (LMFACWA) was formed. Through litigation, they were awarded damages from F&M Coal's insurer. The Laurel Mountain Trust, established between LMFACWA and WVDEP, spans a 90-year term with an initial joint investment of nearly 3.5 million dollars (USD).

F&M Coal

Introduction – In-Stream Dosers and Watershed Initiatives

In the Little Sandy Creek watershed, surface and underground mines are situated in the headwaters of Little Sandy Creek. Notably, three mining permits have been revoked, near Kanestown on Left Fork Little Sandy Creek, and the others in the Scotch Hill area within the Maple Run headwaters.

In the late 2000s, a watershed AMD treatment initiative was undertaken in the Three Forks Creek watershed lead by WVDEP AML. The innovative approach involved utilizing in-stream dosers to calcium oxide (CaO) to elevate the pH. The primary aim was to improve the water quality of the Three Forks Creek to facilitate the return of benthic macroinvertebrates and fish species.

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.

Birds Creek South Fork Outlet (WVDEP AML)

AMD From Mangus Coal (S-1036-91) – Maple Run Headwaters

Methods – F&M Coal in Left Fork Sandy Creek

- Between 1992 and 2011, F&M Coal had multiple discharges which were classified as non-point sources.
  - Anhydrous ammonia, sodium hydroxide, and calcium oxide hand-adjusted.
  - Treatment ponds were inadequate, leading to sludge disposal challenges.
  - Discharges needed additional pH treatment using anhydrous ammonia or in-stream calcium oxide dosers.

In 2011, a judicial decision mandated discharges from revoked permit meet NPDES limits for limits for settleable solids, pH, total iron, and total aluminum.

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 EOI was issued for retrofit proposals to include:

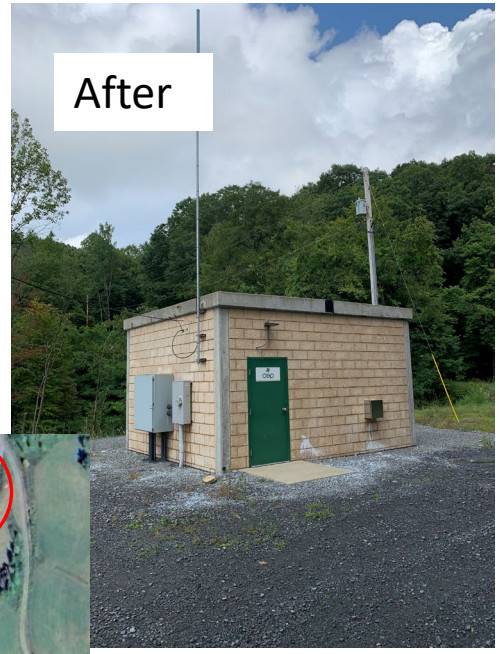
- gravity conveyance lines to one location
- force main lift stations
- high-density lime slurry systems for AMD treatment
- larger settling ponds
- enhancing sludge removal and transport capacities

Between late 2017 and spring 2020, extensive construction took place at F&M Coal mining permits to retrofit AMD treatment.

F&M Coal (S-57-84) Before and After Retrofit

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



F&M Coal (S-1044-87) Before and After Retrofit

At S-1044-87, the main silo 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.

Before

After

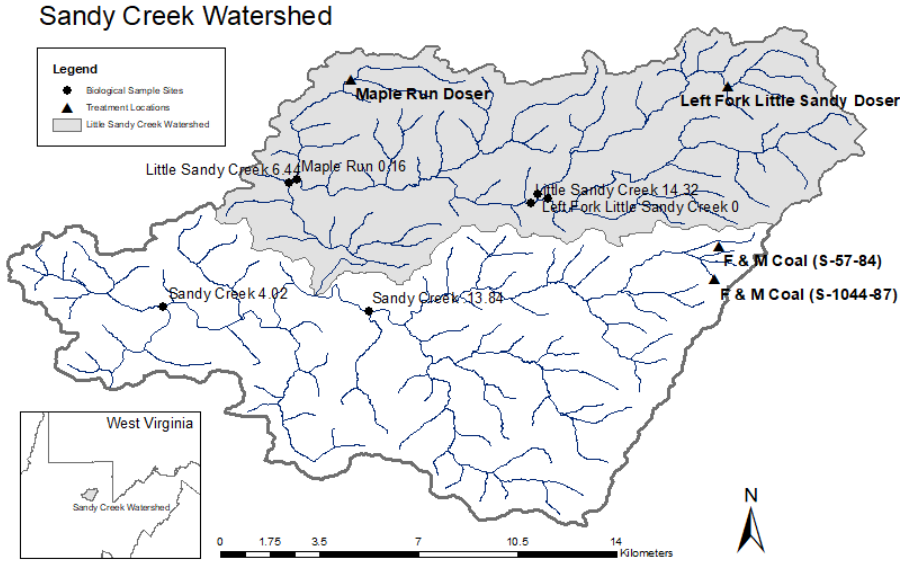
Methods – LFLS Creek and Maple Run In-Stream Dosers in Little Sandy Creek

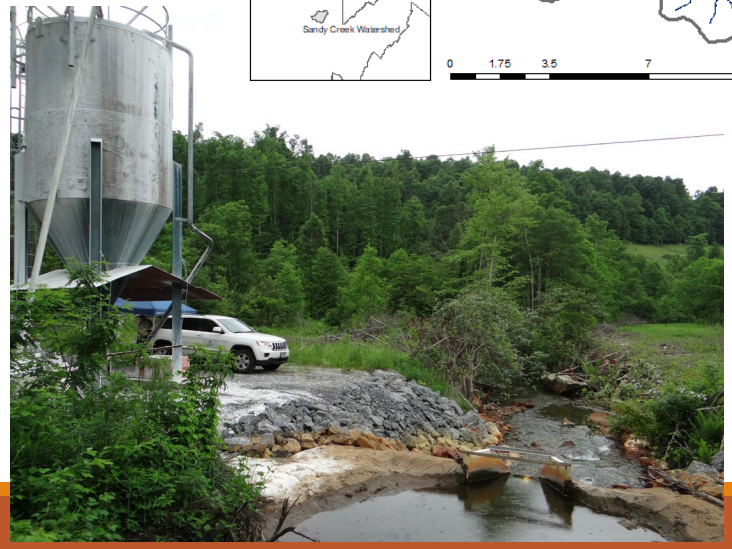
In LFLS Creek and Maple Run, several OSR revoked mining permits underwent water treatment. However, post-2011, discharges meeting NPDES limits offered minimal benefit due to the prevalence of AMD from pre-SMCRA discharges.

In 2015, working with WV WRI and STTWA, 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. Based on water data collected throughout the Sandy Creek watershed, it was possible to elevate the alkalinity and increase the pH of the streams.

By middle 2016, Legislative revision to the water quality standards for LFLS Creek and Maple Run were passed by WV Legislature.

Upon USEPA approval in 2018, the design of permanent in-stream dosers commenced for LFLS Creek and Maple Run, with construction completed in 2019.





LFLS In-Stream Doser

- 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 feet downstream.

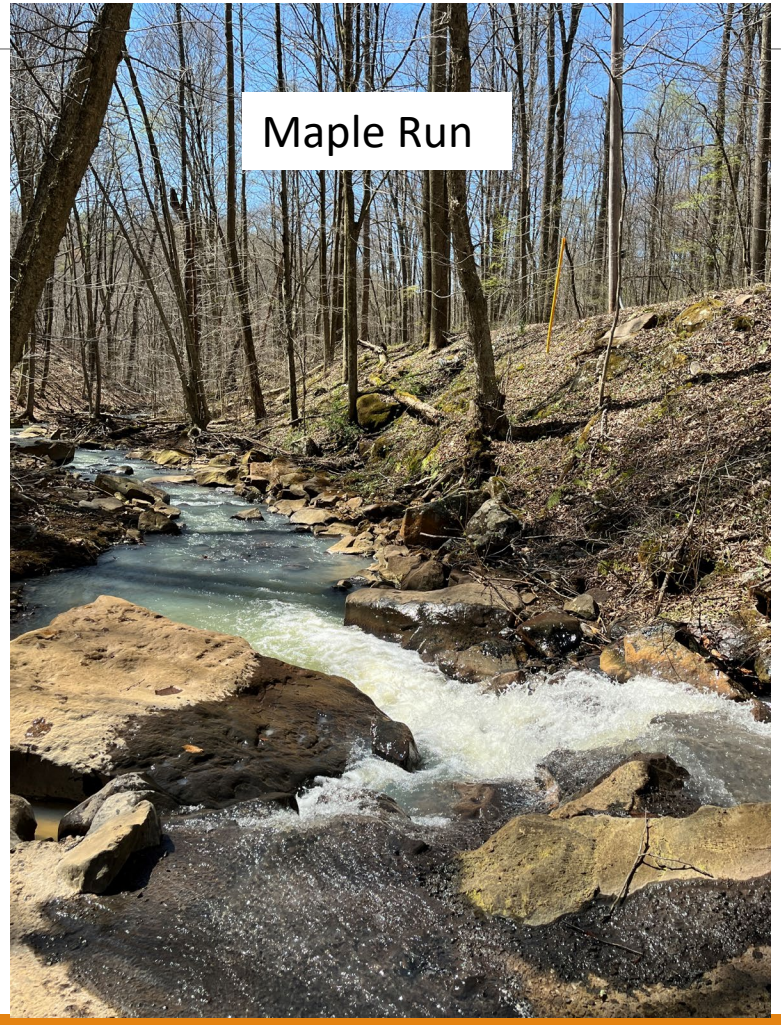
Maple Run In-Stream Doser

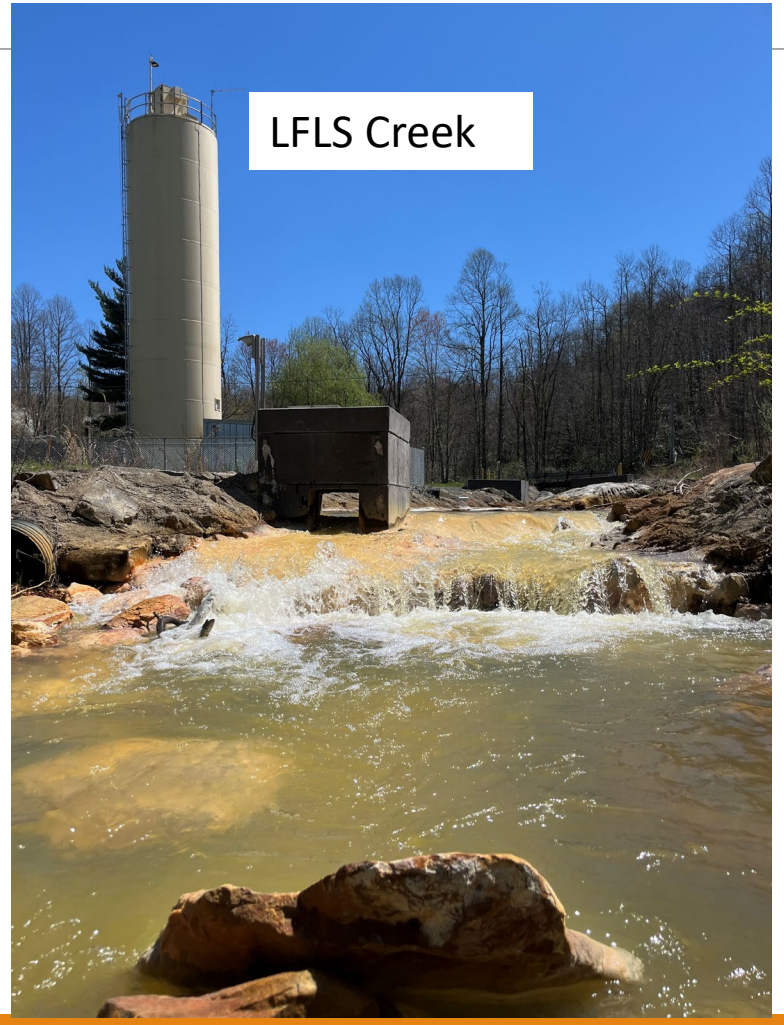
- The Maple Run in-stream doser is a hydrated lime mechanical feed system with a smaller silo.
- The chemical is fed directly into the stream, concentrating the flow for efficient mixing. Downstream, the pH-controlled system mirrors the LFLS in-stream doser.

Results - Water Quality Improvements

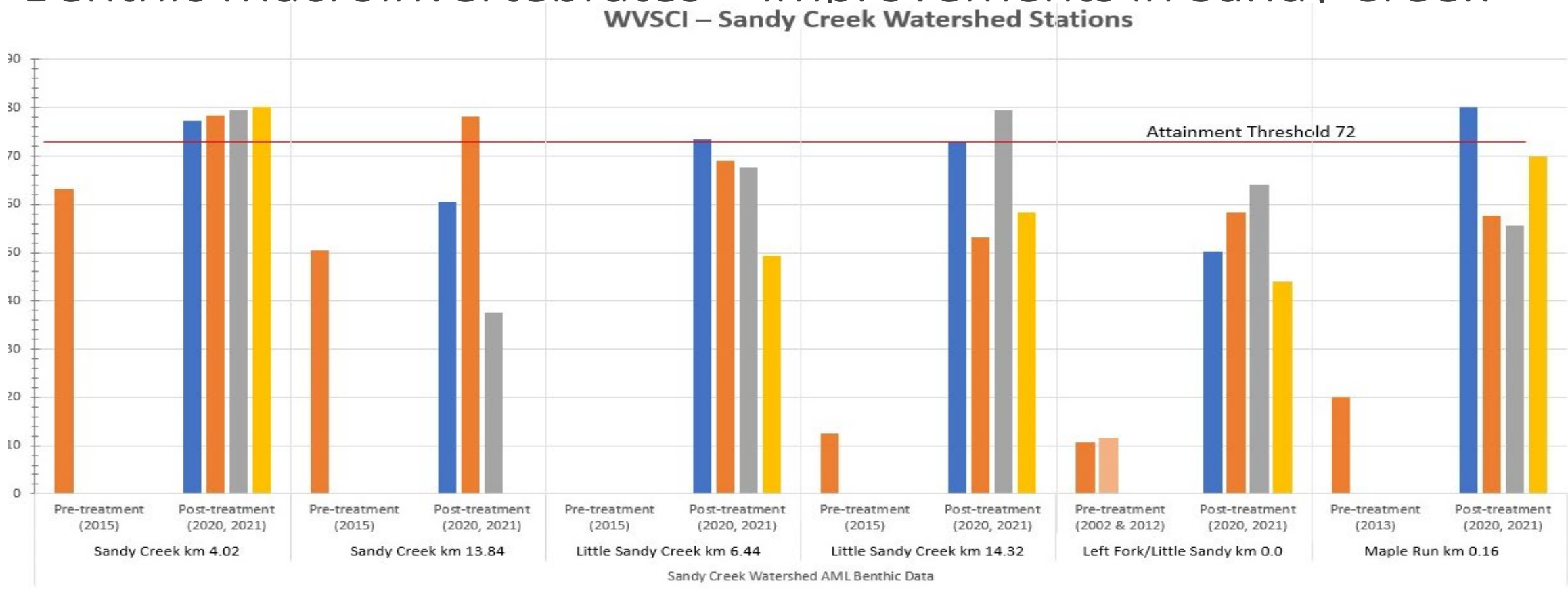
- The primary aim of in-stream treatment was to neutralize high acidity in Left Fork Sandy Creek, Left Fork Little Sandy Creek, and Maple Run. Thereby elevating pH to near neutral levels in the main stem Sandy Creek and Little Sandy Creek. This initiative aimed to restore and support diverse wildlife within the Sandy Creek watershed as outlined within the watershed-based NPDES permit's plan.
- Water treatment facilities at F&M Coal, operational since spring 2020, consistently discharge below NPDES limits.
- 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. 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 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 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.
- Correspondence between OSR and WAB highlights improved water quality facilitating fish species recruitment and the rising benthic macroinvertebrate population of previously impaired waterways.

Neutralized pH and in-stream metals precipitate below Dosers





Benthic Macroinvertebrates – Improvements in Sandy Creek



- **WVSCI** is an Index of Biotic Integrity (IBI) that summarizes the health of the aquatic life community using samples of the benthic macroinvertebrate community.
- 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, the watershed exhibits enhanced ecological attributes.
- Data collected by WVDEP WAB and prepared by Jeff Bailey.

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		
Mile Point	2.5			8.6	4	8.9			0			0.1		
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**

Fish Species – Improvements in Sandy Creek

- Significant fish community improvements have been demonstrated at all sample stations when comparing pre- and post-treatment samples.
- No fish were observed at any sample station in 2013 and 2015 except for Sandy Creek at Mile 8.6. That sample station was surveyed as a baseline control because it is upstream of the Little Sandy Creek watershed AMD sources.
- 2023 data from Sandy Creek at mile 2.5 has not been fully identified and is highlighted in blue. Only field data is displayed in the table.

Fish of Sandy Creek and LFLS Creek

Discussion - Problems/Improvements/Future

The USEPA's watershed-based NPDES variance for Left Fork Little Sandy Creek and Maple Run aims to restore 14.8 km (9.2 miles) of Little Sandy Creek and 8.05 km (5.0 miles) of Sandy Creek.

- Visual challenges persist in these streams due to sludge embeddedness from in-stream dosing.
- A known issue of in-stream treatment is the precipitation of metals with the stream channel below the dosers.
- Not anticipated as the high flow events to periodically flush out the stream are as variable through each season, specifically during the summer when the lowest stream flows occur.

OSR, in collaboration with WVDEP AML&R, is constructing an in-stream water treatment facility to address this issue. The facility will settle sludge and return clear water to the stream. Sludge will be disposed of in underground mine workings.

Discussion - Problems/Improvements/Future con’t.

The ongoing need for re-evaluating the watershed-based variance with the USEPA every five years underscores its dynamic nature and the long-lasting affects of AMD within watersheds.

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.

Rectangular clarifiers at Buffalo Coal (S-2003-88) which is like the design for LFLS clarifier.

Conclusions

- 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 and the installation of in-stream dosers have demonstrated positive results. Monitoring efforts by the LMFACWA and the WVDEP WAB and OSR indicate considerable improvements in benthic macroinvertebrates and fish populations in Sandy Creek. While challenges remain, such as the increased stream embeddedness of LFLS Creek due to sludge precipitation and aesthetics in certain areas.
- The USEPA-approved watershed-based NPDES variance for Sandy Creek represents a pronounced step toward restoring water quality standards for a historically AMD impaired stream. 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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