Lehigh Valley Sierra Club Report - Metals in the Lehigh Tributaries, Final Report
Prepared by Matt MacConnell, PE. Co-Chair/Conservation Chair LV Sierra Club
18April2020

The Lehigh Valley Group conducted a study in 2019/2020 to determine the magnitude of heavy metal contamination in the Lehigh River Carbon County area, the extent of impairment and to outline status of remediation facilities in place and outline opportunities to enhance the treatment systems. The Lehigh River has the unfortunate history where it was once a private river, owned by the Lehigh Coal Navigating Company and provided the means for transporting untold quantities of coal to market. As a result, the river is tainted with the vestiges of the coal mining industry, including numerous abandoned mine drainage site. Funding for this study was awarded from a 2019 Huplits Wildlife Grant.

This study measured metal levels in the associated tributary stream and the Lehigh River at each of the 4 top ranked mine drainage discharges in the Lehigh Water shed that have been identified and ranked by PA DEP. These are Lausanne Tunnel, Owl Hole Tunnel (Sandy Run), Quakake Tunnel and Buck Mountain #2 Tunnel. In addition, the zinc impaired site in Palmerton (not a AMD site) will also be included in the study. In most of these locations remediation systems have been installed to try to reduce the discharge of metal to the river. This provides an independent check on the current amount of the metals we are seeing in the Lehigh river at these locations. In addition, the superfund site about 5 miles downstream from the mine drainage impacted area that is impaired from zinc pollution from a zinc smelting operation that had existed in Palmerton and this study will measure zinc levels in the water in this area. Further study is needed to assess the impact of the 0.3 ppm Zinc in the surface waters of Aquashicola Creek.

Table 1 - Results of Data Collected by Sierra Club (ground zero tunnel outflow samples highlighted in yellow, toxic Al level is highlighted in red and dangerously low pH values in magenta)

ID No.	Date	Sample Location	Sp Cond, uS/cm	pH	DO, %Sat	Temp, F	Al ppm	Fe, ppm	Mn, ppm	Zn, ppm	NO3, ppm
1	4Aug19	Lausanne Tunnel Outflow to wetland treatment area	823	5.06	55.2	54.2	0.277	3.8	3.1		
13	4Aug19	Lehigh River Upstream of Nesquehoning Ck					0.121	0.25	0.5		
14	8Sep19	Aquashicola Creek, near Lehigh River	222	7.66	99.1	60.4				0.35	0.45
15	8Sep19	Lehigh River upstream of Aquashicola	111	7.43	101	63.4				0.0	0.45
2	21Sep19	Buck Mountain #2 Tunnel Outflow	276	3.55	72.8	48.5	6.87	0.41	2.5		0.02
16	21Sep19	Quakake Tunnel Outflow	310	3.72	92.2	51.1	5.24	0.55	2.6		0.07
17	21Sep19	Sandy Run at strip mine	248	3.6	87.9	50.4	3.27	2.06	2.0		0.05
3	12Jan20	Buck Mountain Creek at Rockport	64	6.56	96.1	46.3	0.289	0.92	0.0		0.68
4	12Jan20	Lehigh River above BM Creek	119.7	6.74	98.2	44.3	0.042	0.13	0.2		0.57
5	12Jan20	Black Creek after confl. w/ Quakake	63.9	6.6	96.0	46.3	0.135	0.46			0.69
6	11Mar20	Aquashicola Creek near Lehigh								0.22	
7	21Mar20	Wetzel Run at nearest bridge	263.9	4.0	111.9	48.5	3.195	0.05	1.9		0.37
8	21Mar20	Quakake Creek after Wetzel Confl	116.9	5.16	114.2	47.8	0.915	0.12	0.7		0.81
9	5Apr20	BM2 Tunnel Outflow (Sulfur Creek) at BM Road	258	3.74	112.1	49.3	5.92	NA	NA	NA	0.33
10	5Apr20	Sulfur Creek at 10 points Rd	162.7	4.32	108.7	49.4	2.39	NA	NA	NA	0.44
11	5Apr20	BM Creek after confl w Sulfur Creek	120.2	5.02	120.2	49.5	1.82	NA	NA	NA	0.56
12	5Apr20	BM Crk at Lehigh Gorge Road	87	5.51	110.2	48.9	0.5	NA	NA	NA	0.82

The PA DEP BAMR organization is organizing a mine drainage remediation system at the Quakake Tunnel site. The remediation will involve an active treatment system where alum slurry will be fed to the tunnel discharge to raise the pH of the stream. The resulting water will go to a clarifier that will separate the suspended alum and most importantly, the aluminum precipitate. It is intended to remove manganese although some may drop out. The data in this study will help to provide pre-remediation status. The project is expected to cost $2,000,000 and be completed in the next two years. This information was gathered in phone interview with Todd Wood, an engineer involved with the project at BAMR. There are currently no plans for remediation upgrades at Buck Mountain #2.

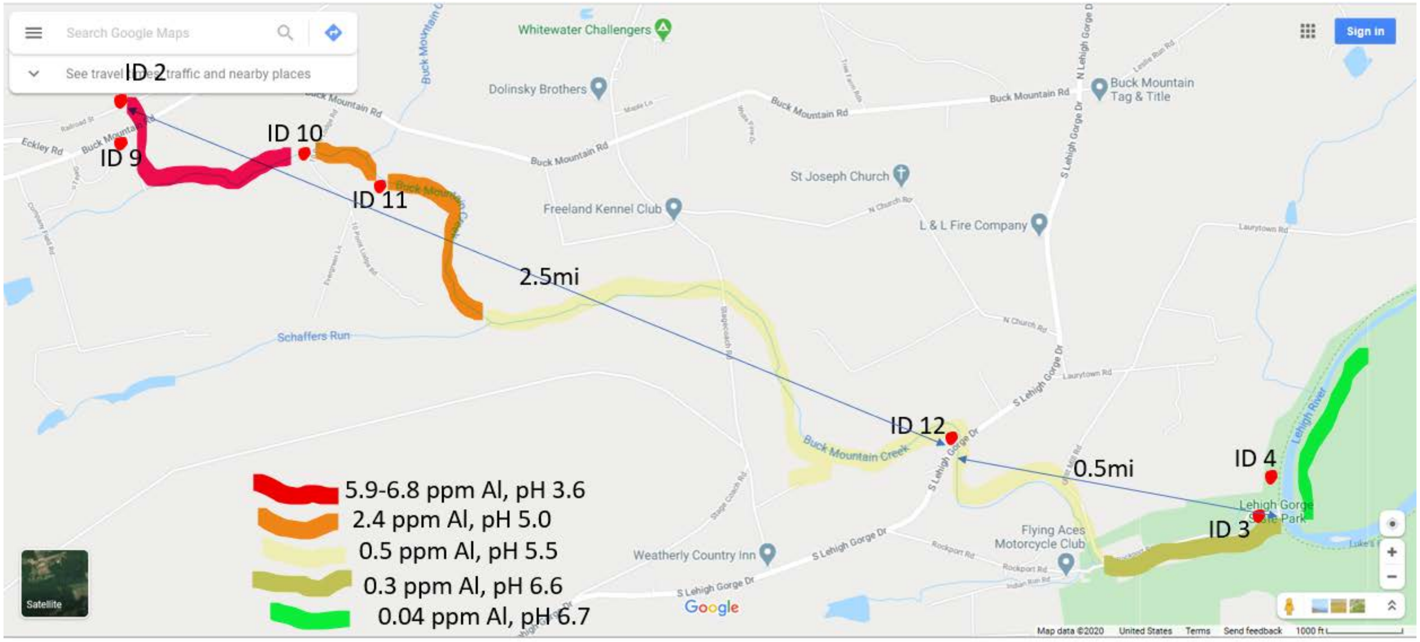
The Aluminum concentration is the highest at the Buck Mountain discharge. The flow is highest at the Quakake discharge. The outflow of the Buck Mountain discharge, Sulfur Creek, was measured and concentrations monitored along the way to the Lehigh River to characterize the extent of toxic water. The Lehigh itself was also measured. These results are illustrated in Figure 1 where the most acute toxicity (~6ppm Al) occurs before the discharge is diluted in a marshy area (!3 ppm) and then is diluted further by Buck Mountain Creek (~1.5 ppm Al) and then again by Schaffers Run before entering the Lehigh at 0.3 ppm Al.

Table 2 for a comparison of the EPA's 1988 criteria and the updated 2018 criteria for aluminum. It is unclear why Trump's EPA relaxed the criteria for toxicity, but it is not surprising given their anti-environment agenda and track record (VOTE!). Note the ug/l units equals parts per billion or ppb. 1000 ppb = 1 ppm (parts per million or mg/l).

EPA aquatic life criteria for aluminum	**Freshwater acute [a] (1-hour, total recoverable aluminum)**	**Freshwater Chronic [a] (4-day, total recoverable aluminum)**
2018 Updated Criteria (Vary as a function of a site's pH, total hardness, and DOC)	1-4,800 µg/L [b]	0.63-3,200 µg/L [b].
1988 Criteria (pH 6.5-9.0, across all total hardness and DOC ranges)	750 µg/L	87 µg/L.

The recommended acute criteria (known as the criteria maximum concentration or CMC) duration is a one-hour average and the recommended chronic criteria (criteria chronic concentration or CCC) duration is a four-day average. The EPA recommends that the CMC and CCC not be exceeded more than once every three years

Figure 1 Satellite View showing Buck Mountain #2 Tunnel Discharge as it heads to Lehigh River. Toxicity level is color coded to show extent of Acute toxic level in the first 0.8 mile and Chronic Toxic level in 1.5 miles prior to the Lehigh Confluence.



It is noteworthy to point out the abundance of wildlife in the area of Buck Mountain. There have been mountain lion sightings and reportedly there are wildlife cam photos of mountain lion cubs. There are also black bears, coyotes, red fox, racoons, fishers and raptors. The wildlife seems to thrive notwithstanding the pollution from the mine drainage sites.

Figure 2 From Top Left to Right - Lausanne Tunnel Outflow at aerators, Aluminum measurement at Lausanne Tunnel, Google Map pin at Lausanne and Lehigh Sampling points, Aerial view of inlet to Lausanne wetland, Aerial view of outlet of Lausanne Wetland, Zinc Measurement at Aquashicola, at bottom a panoramic view of Black Creek (far left) fed after Quakake Creek (center) merges with an unnamed tributary (right)

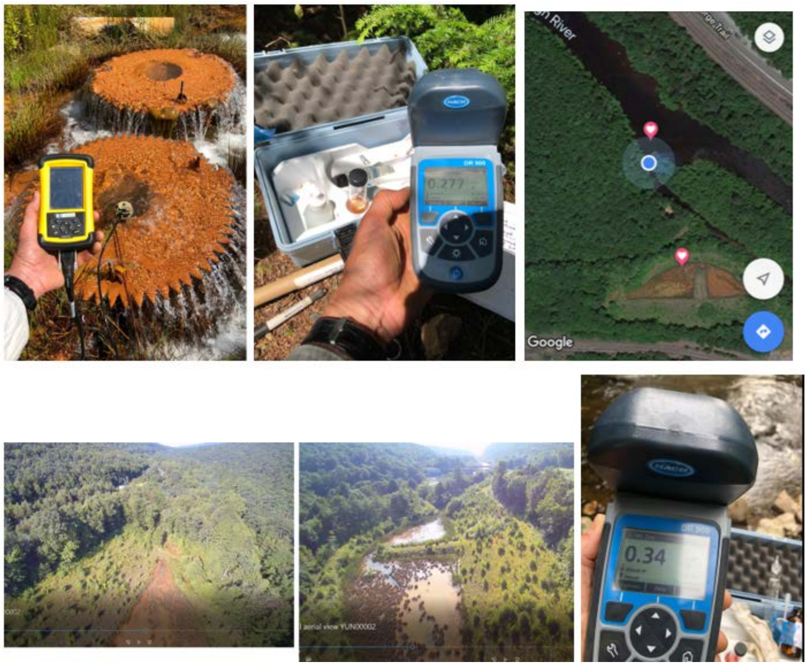
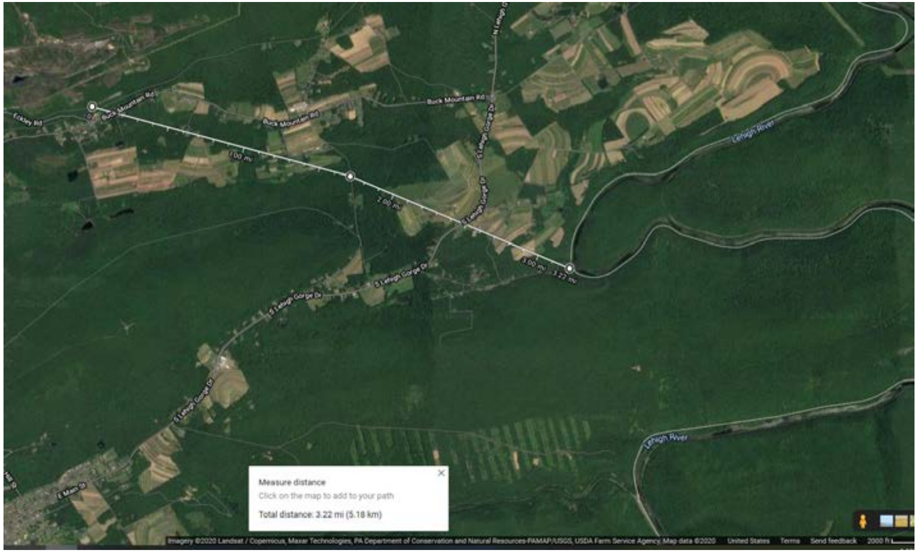


Figure 3 - Panoramic view of Quakake creek heading toward Lehigh River at left and the two merging streams: Quakake Creek at center and Black Creek at right

Figure 4 - Aerial View showing about 3-mile distance from Buck Mountain 2 Tunnel to the Lehigh Confluence at Rockport



Measure distance
Click on the map to add to your path
Total distance: 3.22 mi (5.18 km)

Figure 5 captions from top left to right. Sampling for Zinc on the Aquashicola, The Quakake Tunnel Outflow, the Sandy Run Outflow, Sandy Run with Probe, BM Creek at Rockport, Lehigh River above BM Creek confluence in the Distance, BM2 Tunnel, Pin at Quakake and sampling point, M. MacConnell sampling manganese level on Wetzel Run (Quakake tunnel receiving stream)

Figure 6 - The two points where Aluminum discharge tributaries meet the Lehigh River

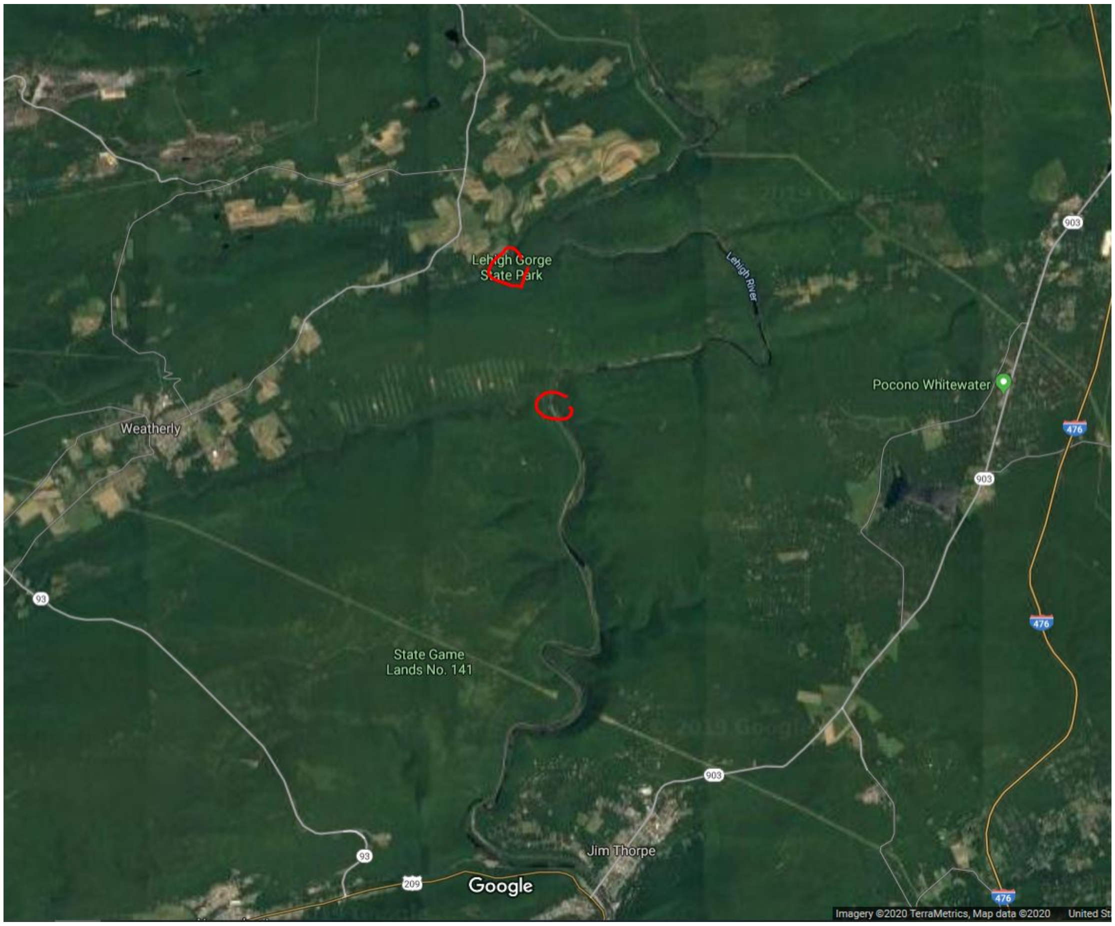
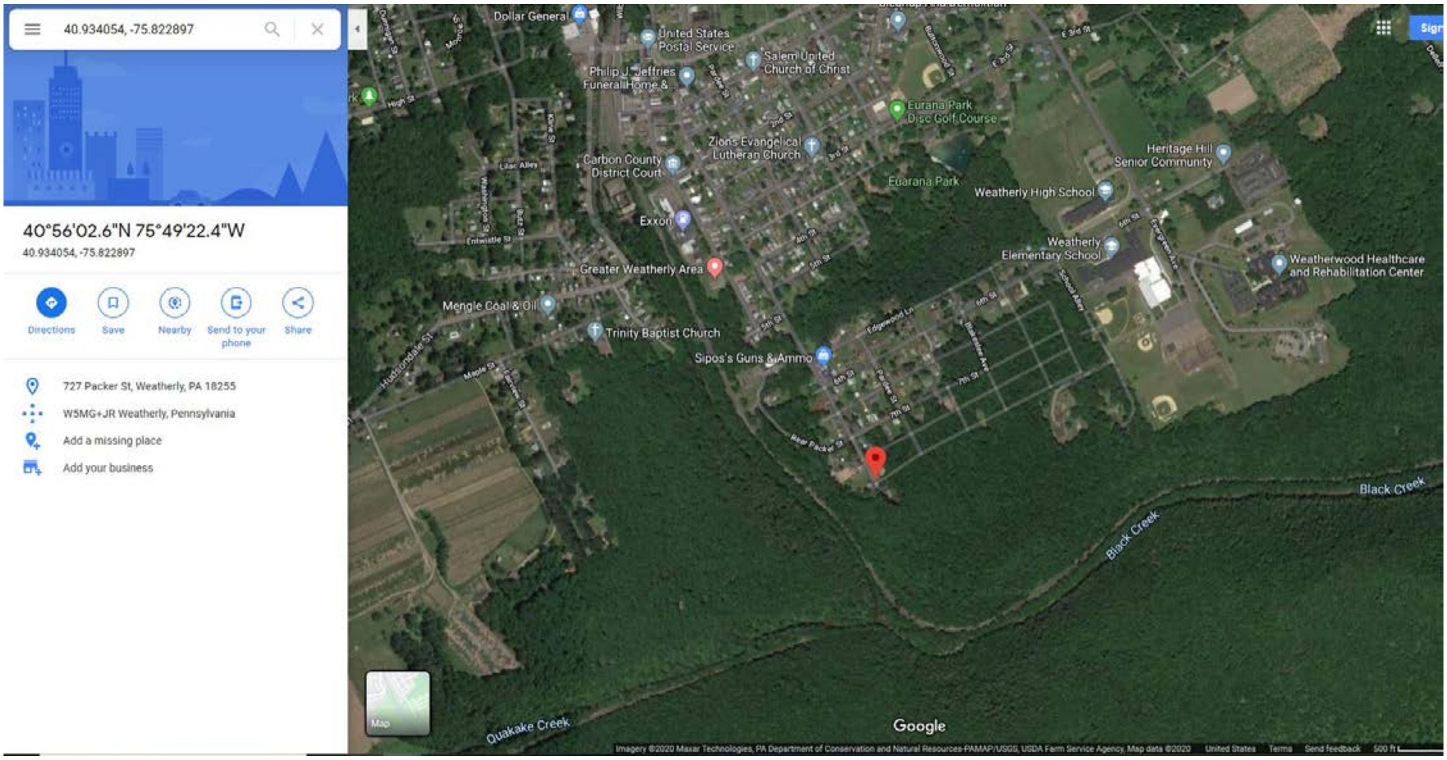


Figure 7 - Location of Quakake Tunnel indicated with Pin

Figure 8 - Aerial view showing Confluence of Quakake Creek with Black Creek (this confluence is shown in the panoramic shot in figure 3). The Pin indicates closest location from which to park car and hike into this spot.



40.934054, -75.822897

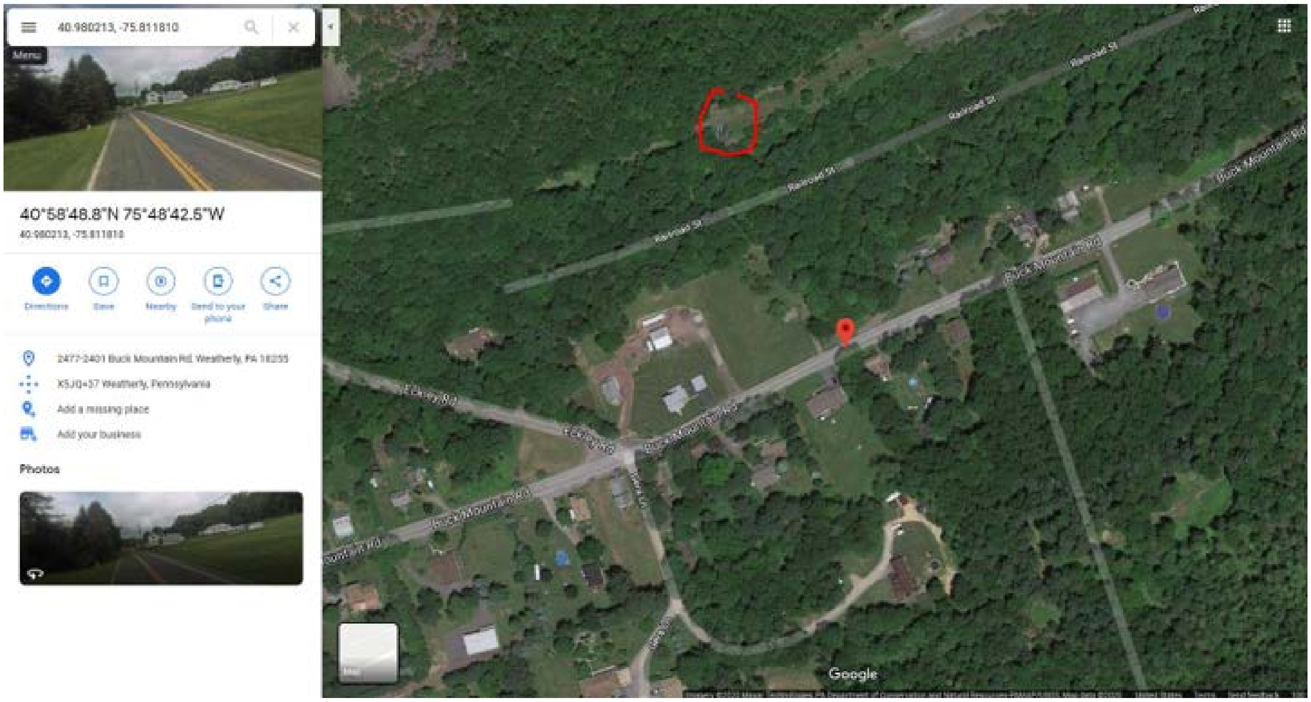
40°56'02.6"N 75°49'22.4"W

40.934054, -75.822897

727 Packer St, Weatherly, PA 18255

W5MG+JR Weatherly, Pennsylvania

Figure 9 - Buck Mountain 2 Tunnel discharge area Circled and sampling ID 9 noted with Pin



40.980213, -75.811810

40°58'48.8"N 75°48'42.5"W

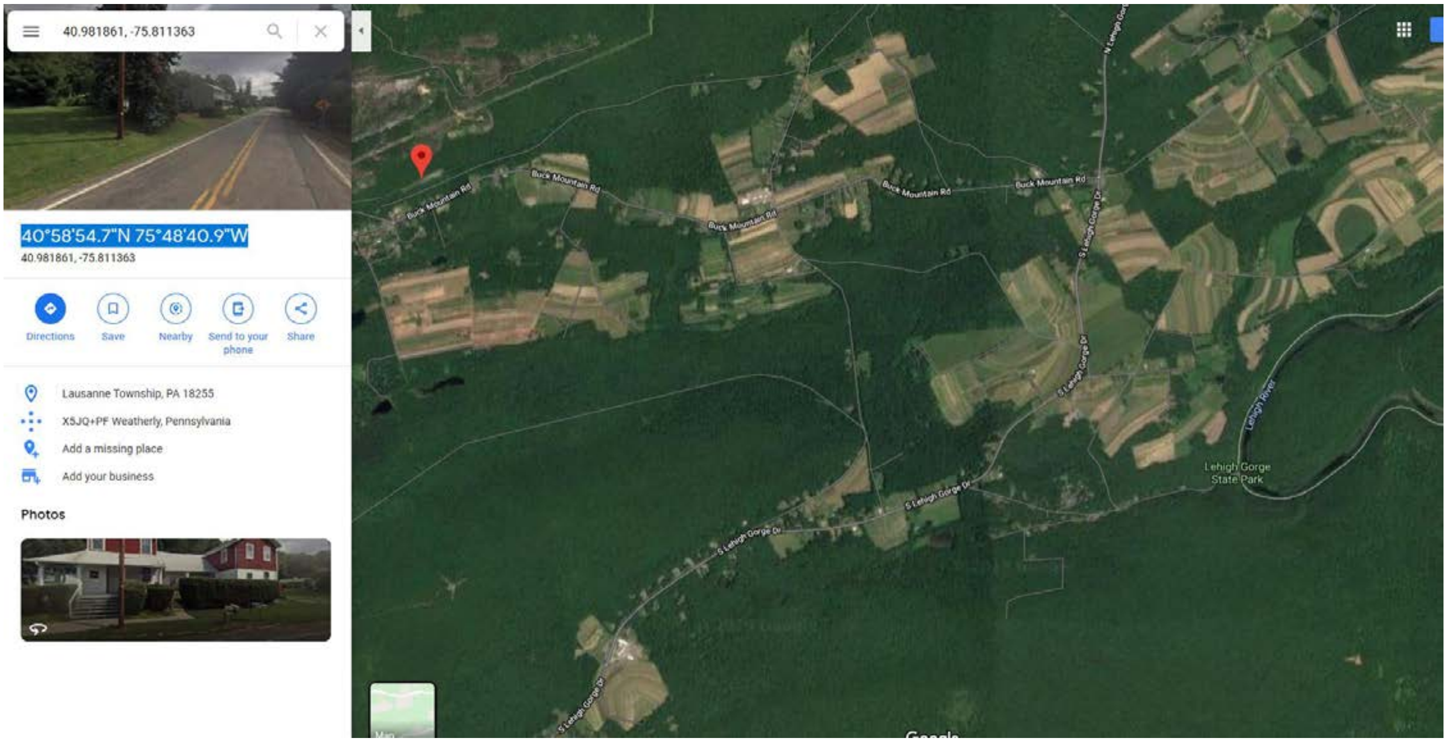
40.980213, -75.811810

2477-2401 Buck Mountain Rd, Weatherly, PA 18255

X5JQ+37 Weatherly, Pennsylvania

Figure 10 - Location of Buck Mountain 2 Tunnel Limestone treatment area indicated with Pin

Figure 11 - The BM2 tunnel site indicated with pin and the Lehigh River Confluence at Right (confluence of BM Creek with Lehigh is noted with label for Lehigh Gorge State Park on image

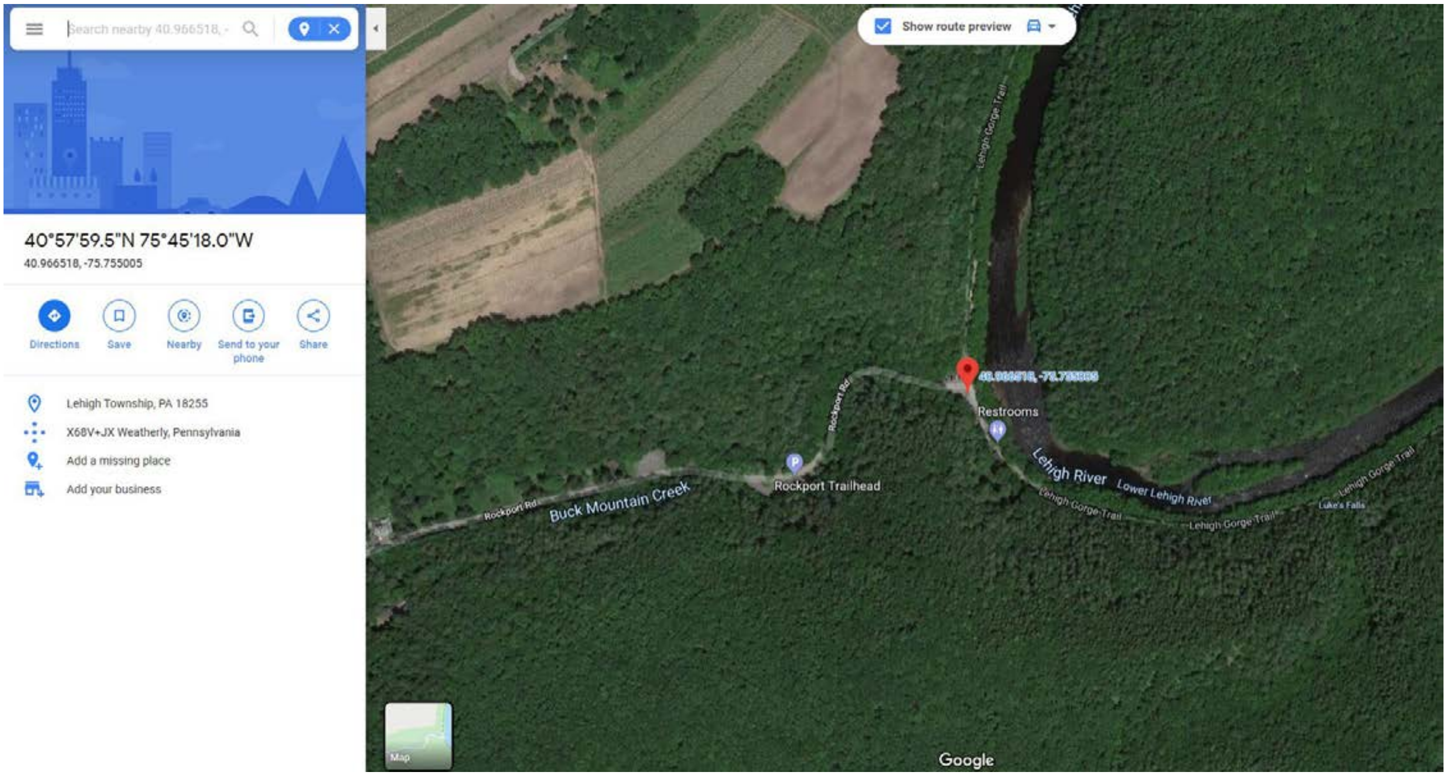


40.981861, -75.811363

40°58'54.7"N 75°48'40.9"W
40.981861, -75.811363

Lausanne Township, PA 18255
X5JQ+PF Weatherly, Pennsylvania

Figure 12 - Pin Marks Confluence of Buck Mountain Creek with Lehigh River at the Rockport DNL Trail head

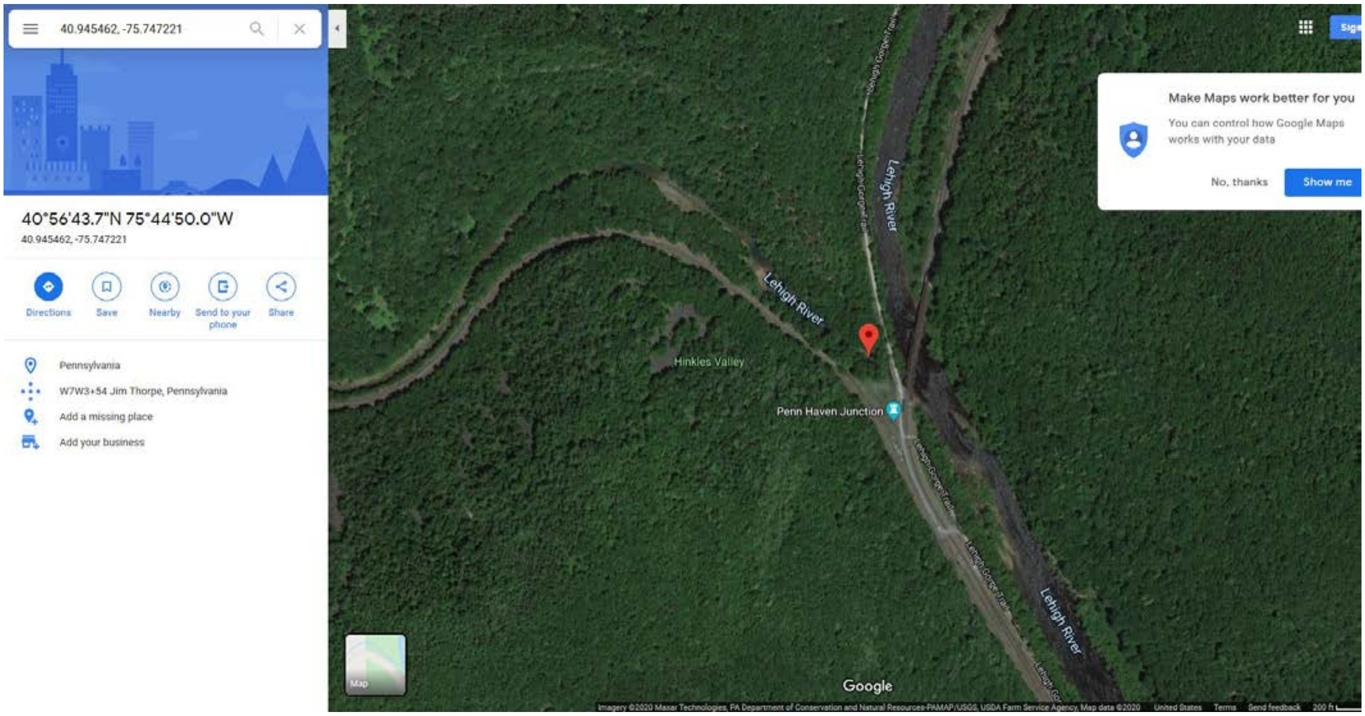


Search nearby 40.966518, -

40°57'59.5"N 75°45'18.0"W
40.966518, -75.755005

Lehigh Township, PA 18255
X68V+JX Weatherly, Pennsylvania

Figure 13 - Pin Marks Confluence Location of Black Creek with the Lehigh River



40.945462, -75.747221

40°56'43.7"N 75°44'50.0"W

40.945462, -75.747221

Pennsylvania

W7W3+54 Jim Thorpe, Pennsylvania

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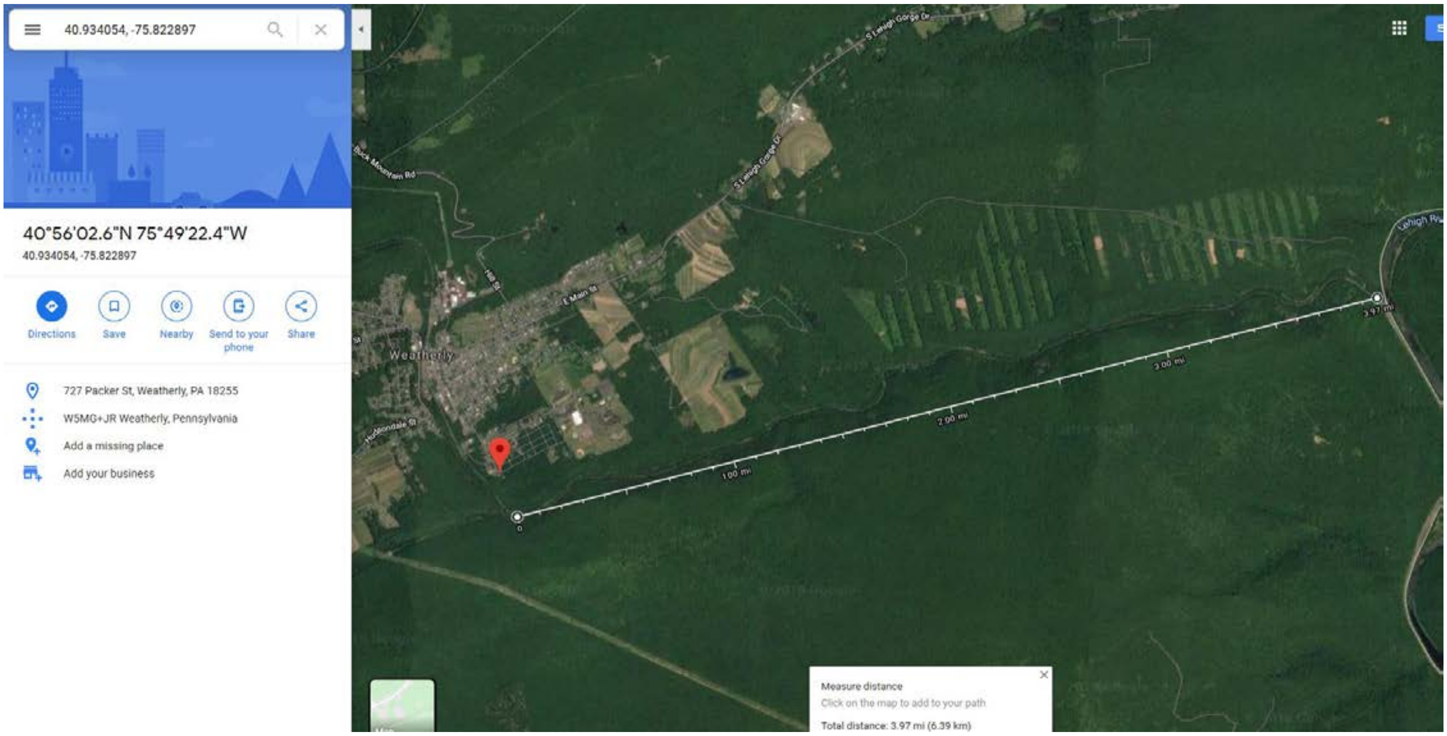
Figure 14 Pin Marks Parking Spot near Confluence of Quakake Creek and Black Creek and Marks the Distance to the Lehigh Confluence at 4 mi



40.934054, -75.822897

40°56'02.6"N 75°49'22.4"W

40.934054, -75.822897

727 Packer St, Weatherly, PA 18255

W5MG+JR Weatherly, Pennsylvania

Measure distance

Click on the map to add to your path

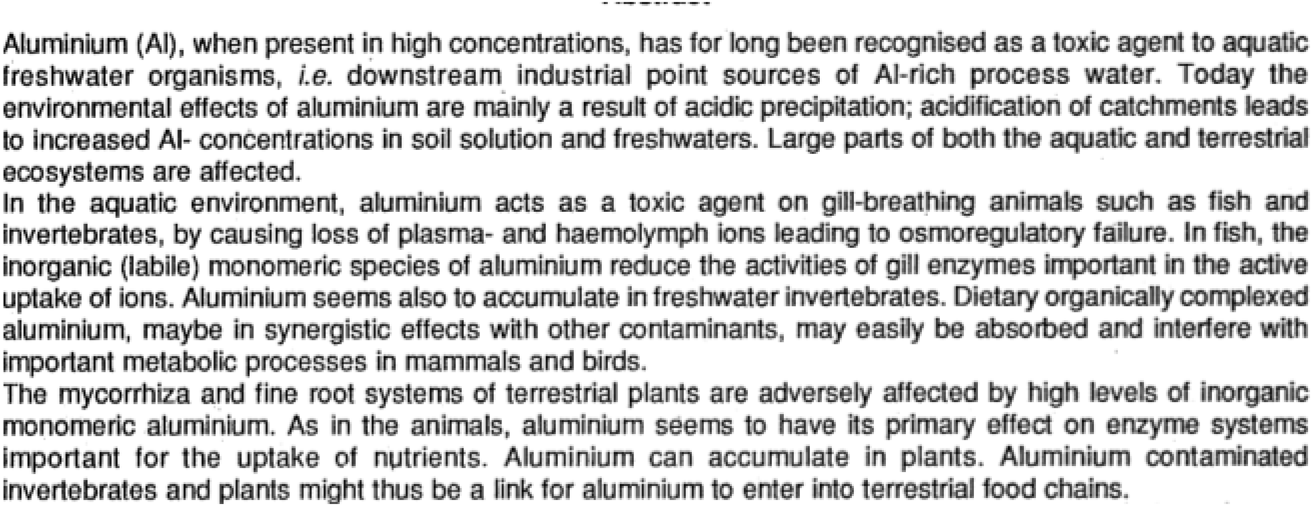
Total distance: 3.97 mi (6.39 km)

The Buck Mountain #2 Tunnel, located between Weatherly and the Eckley Mining Village, has a low pH of about 3.6 and very low alkalinity, or buffering capacity. With the high levels of aluminum in this water it is extremely toxic to aquatic organisms and fish. This site began operations in 1837 and shipped about 3.5 million tons of anthracite, which was considered the cleanest coal available. It is reported that this coal was used in the civil war where the Monitor was fueled by this coal in the battle with the Merrimac. The mine stopped operations in 1883 due to water problems and the dewatering tunnel was installed in 1895. This tunnel is what we are dealing with here today. In 2009 Wildlands Conservancy installed a limestone pond to raise the pH where the aluminum will precipitate out of solution. The hydraulics of this system are not working well. However, this system replaced an older system that had a mechanized method for adding limestone but was not successful and removed about 20 years ago.

APPENDIX - LITERATURE SEARCH on Al Toxicity

Environmental Effects of Aluminum -

Figure 15 - Abstract from Environmental Geochemistry and Health, B.O. Rosseland et al, 1990



Aluminium (Al), when present in high concentrations, has for long been recognised as a toxic agent to aquatic freshwater organisms, *i.e.* downstream industrial point sources of Al-rich process water. Today the environmental effects of aluminium are mainly a result of acidic precipitation; acidification of catchments leads to increased Al- concentrations in soil solution and freshwaters. Large parts of both the aquatic and terrestrial ecosystems are affected.

In the aquatic environment, aluminium acts as a toxic agent on gill-breathing animals such as fish and invertebrates, by causing loss of plasma- and haemolymph ions leading to osmoregulatory failure. In fish, the inorganic (labile) monomeric species of aluminium reduce the activities of gill enzymes important in the active uptake of ions. Aluminium seems also to accumulate in freshwater invertebrates. Dietary organically complexed aluminium, maybe in synergistic effects with other contaminants, may easily be absorbed and interfere with important metabolic processes in mammals and birds.

The mycorrhiza and fine root systems of terrestrial plants are adversely affected by high levels of inorganic monomeric aluminium. As in the animals, aluminium seems to have its primary effect on enzyme systems important for the uptake of nutrients. Aluminium can accumulate in plants. Aluminium contaminated invertebrates and plants might thus be a link for aluminium to enter into terrestrial food chains.

II. What is aluminum and how does it affect aquatic life?

Aluminum is found in most soils and rocks and is the third most abundant element and the most common metal in the earth's crust. Aluminum can enter the water via natural processes, like weathering of rocks and as a result of human based activities, such as drinking and wastewater treatment and mining. Aluminum is considered a non-essential metal because fish and other aquatic life do not need it to function. Elevated levels of aluminum can affect some species' ability to regulate ions and inhibit respiratory functions. Aquatic plants are generally less sensitive than fish and other aquatic life to aluminum.

III. What are EPA's updated recommended criteria for aluminum in freshwater?

The recommended criteria concentrations for aluminum in freshwater to protect aquatic life depends on a site's water chemistry parameters. Bioavailability is the measure of whether a substance in the environment is available to affect living organisms like fish. The bioavailability of aluminum is dependent on specific water chemistry parameters. The more bioavailable the aluminum is, the more likely it is to cause a toxic effect. The water chemistry parameters that have the greatest impact on aluminum's bioavailability are pH, dissolved organic carbon (DOC) and total hardness.

The final 2018 recommended national criteria are based upon Multiple Linear Regression (MLR) models for fish and invertebrate species that use pH, DOC, and total hardness to quantify the effects of these water chemistry parameters on the bioavailability and associated toxicity of aluminum to aquatic organisms. The MLR models are used to normalize the available toxicity data to reflect the effects of the water chemistry (pH, hardness, DOC) on the toxicity of aluminum to tested species. These normalized toxicity test data are then used in a criteria calculator to generate criteria for specific water chemistry conditions, yielding the water chemistry specific acute and chronic criteria concentrations. This flexible approach is based on the latest science and allows users to develop site-specific aluminum criteria for freshwaters that appropriately reflect important water chemistry parameters. The recommended acute criteria (known as the criteria maximum concentration or CMC) duration is a one-hour average and the recommended chronic criteria (criteria chronic concentration or CCC) duration is a four-day average. The EPA recommends that the CMC and CCC not be exceeded more than once every three years.

These final 2018 recommended national aluminum criteria are expressed as total recoverable metal concentrations. The use of total recoverable aluminum includes monomeric (both organic and inorganic) forms, polymeric and colloidal forms, as well as particulate forms and aluminum sorbed to clays. However, toxicity data comparing toxicity of aluminum using total recoverable aluminum and dissolved aluminum demonstrated that toxic effects increased with increasing concentrations of total recoverable aluminum even though the concentration of dissolved aluminum was relatively constant. If aluminum criteria were based on dissolved concentrations, toxicity would likely be underestimated, as colloidal forms and hydroxide precipitates of the metal that can dissolve under natural conditions and become biologically available would not be measured. The criteria document contains more discussion of the studies that informed the choice to use total recoverable aluminum as the basis for the final 2018 recommended national criteria. The current EPA-approved Clean Water Act Test Methods [1] for aluminum in natural waters and waste waters measure total recoverable aluminum.

The numeric outputs of the 2018 recommended National Aluminum Criteria Calculator will depend on the specific pH, DOC, and total hardness concentrations entered into the models. The model outputs (CMC and CCC) are numeric values that are protective for the set of input conditions. Criteria can be determined in two ways: Use the provided Aluminum Criteria Calculator V.2.0 to enter the pH, DOC, and total hardness conditions at a specific site to calculate the numeric aluminum CMC and CCC corresponding to those local input water-quality conditions, or (2) use the look-up tables provided in the criteria document, developed using the calculator, to find the numeric aluminum CMC and CCC most closely corresponding to the local conditions for pH, DOC, and total hardness. In order to calculate numeric water quality criteria for aluminum that will protect the aquatic life designated uses of a site over the full range of ambient conditions and toxicity, multiple model outputs will need to be considered.

See Table 1 for a comparison of the EPA's 1988 criteria and the updated 2018 criteria for aluminum.

EPA aquatic life criteria for aluminum	Freshwater acute [a] (1 hour, total recoverable aluminum)	Freshwater Chronic [a] (4-day, total recoverable aluminum)
2018 Updated Criteria (Vary as a function of a site's pH, total hardness, and DOC)	1-4,800 µg/L [b]	0.63-3,200 µg/L [b].
1988 Criteria (pH 6.5-9.0, across all total hardness and DOC ranges)	750 µg/L	87 µg/L.

[a] Values are recommended not to be exceeded more than once every three years on average.

[b] Values will be different under differing water chemistry conditions

Table 1—Summary of the EPA National Recommended Aquatic Life Criteria for Aluminum

IN THIS SECTION OF THE APPENDIX, WE SEE THAT EPA AND THE PA DEP HAVE DELISTED SECTIONS OF THE LEHIGH RIVER AS NO LONGER IMPAIRED BASED ON AQUATIC LIFE. THIS REPORT WILL HELP TO ASSESS THE CURRENT LEVELS OF METAL CONCENTRATIONS.

Pennsylvania AMD Report from EPA
Problem
The headwaters of the Lehigh River flow from the Lehigh Marshes just north of Gouldsboro, Pennsylvania. The river then meanders 103 miles through eastern Pennsylvania, draining an area of approximately 1,363 square miles before flowing into the Delaware River near Easton, Pennsylvania (Figure 1). The Lehigh River is the second largest tributary to the Delaware River—its watershed comprises 11 percent of the Delaware River drainage basin. The upper and middle portions of the Lehigh River watershed, including portions of Carbon, Luzerne, Monroe, Schuylkill, Lackawanna, and Wayne counties, support high-quality trout fisheries. A 32-mile stretch of the Lehigh River (from the Francis E. Walter Dam to the borough of Jim Thorpe) is designated as a Pennsylvania Scenic River. This section of the river flows through Lehigh Gorge State Park and Pennsylvania State Game Lands, and it is a popular Class II and III whitewater recreational resource.

Coal mining first began in the Lehigh River watershed in 1792, and it continues today. Deep coal mining, which involves the extraction of coal from deep deposits hundreds to thousands of feet below the surface, was prevalent until the 1940s, at which time surface mining became the primary mining method. A number of abandoned coal mining sites (of both types) in the watershed, dating back to the 1800s, have contributed nonpoint source pollution to nearby waterbodies.

As rainwater and snowmelt flow through surface mines and spoil piles (excavated soils that were removed during mining), they become laden with metals and acidity. Most of this water percolates down through the depressions left by the abandoned surface mines and then flows down into subterranean deep mine pools, where ground water has accumulated after mining operations ended. The runoff leaches additional acidity and metals as it passes through underlying sulfur-rich strata and into deep mine pools, thereby significantly compounding the toxicity and volume of the abandoned mine drainage (AMD) discharges associated with the legacy deep mine pools.

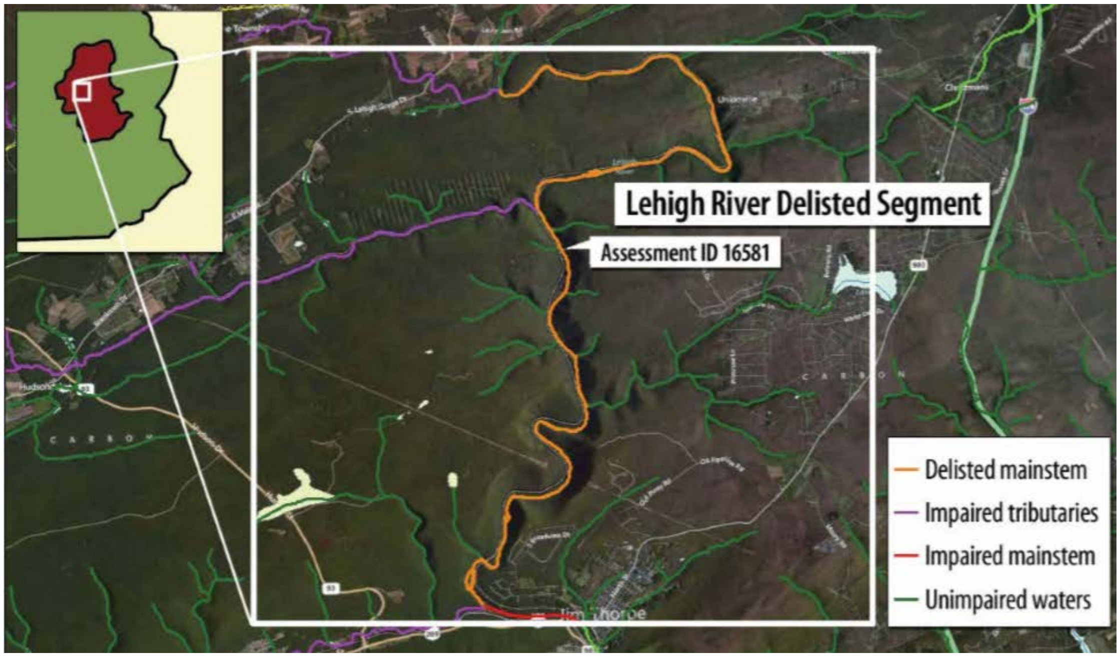
Over the years, polluted runoff from a number of abandoned surface coal mines and AMD from deep mines in the watershed delivered high loads of metals and acidity to the Lehigh River and its tributaries. A stream survey conducted by PADEP in 1998 showed that the Index of Biotic Integrity (IBI) scores for the Lehigh River fell below the state's numeric water quality criterion, a minimum IBI score of 63. The IBI is a multimetric index that measures different aspects of the biological communities.

Lehigh River WatershedPA
Figure 1. The Lehigh River watershed (red) is in a portion of eastern Pennsylvania underlain by coal fields.
Metals and acidity in runoff from abandoned surface mines and discharges from abandoned deep mines impaired Pennsylvania's Lehigh River and some of its tributaries, prompting the Pennsylvania Department of Environmental Protection (PADEP) to add 25.1 miles of watershed streams to the state's Clean Water Act (CWA) section 303(d) list of impaired waters in 2002. Project partners reclaimed and treated 297.9 acres of abandoned mine lands to address pollutant loadings. Water quality improved downstream of the reclamation sites, allowing PADEP to remove a 14.7-mile-long segment of the Lehigh River from the list of impaired waters in 2012. Reclaiming Abandoned Mine Lands Improves the Lehigh River Waterbody Improved
For additional information contact: Scott N. Heidel Water Program Specialist Pennsylvania Department of Environmental Protection 717-772-5647 • scheidel@pa.gov
U.S. Environmental Protection Agency Office of Water Washington, DC
EPA 841-F-14-001H February 2014
Figure 2. A 14.7-mile segment of the Lehigh River mainstem was removed from the impaired waters list in 2012 after restoration projects improved water quality and aquatic habitat.
present to distinguish between reference conditions and stressed aquatic ecosystem conditions. The 1998 stream survey also found high levels of metals and acidity (indicated by low pH values) in the Lehigh River, which the state attributed to AMD. Based on these data, in 2002 PADEP included 25.1 stream miles of the mainstem of the Lehigh River on the state's CWA section 303(d) list of impaired waters for not meeting the aquatic life designated use because of metals and acidity from AMD. The 25.1 stream miles added to the list were later broken into two segments—a 14.7-mile segment and a 10.4-mile segment.

In 2009 PADEP developed a total maximum daily load (TMDL) for the impaired segments of the Lehigh River in the upper and middle portions of the watershed. The TMDL set limits for the metals (aluminum, iron, and manganese) and acidity loads at stations on the Lehigh River. These limits, which vary from station to station depending on the site-specific existing pollutant loads, serve as remediation goals. The limits are intended to allow each site to meet water quality criteria 99 percent of the time.
Project Highlights
The federal Office of Surface Mining and the PADEP Bureau of Abandoned Mine Reclamation partnered to address the water quality problems identified in the TMDL. The partners designed and implemented 11 abandoned mine reclamation projects, which restored 297.9 acres of abandoned mine lands in the Lehigh River watershed through grading and revegetation. The projects aimed to reduce metals and acidity in surface and ground water while improving aquatic habitat. Results PADEP conducted aquatic habitat assessments in the Lehigh Gorge in 2008 and 2011 to quantify the recolonization of aquatic life in the waterway. The data showed IBI values of 87.4 and 88.8, respectively. Both values exceeded the minimum IBI score of 63, indicating that the aquatic ecosystem is healthy and unimpaired. On the basis of these data, PADEP removed a 14.7-mile-long segment (Assessment ID 16581) of the middle mainstem of the Lehigh

River (from Buck Mountain Creek downstream to the confluence with Nesquehoning Creek) from the list of impaired waters in 2012 (Figure 16).

Figure 16 - Image of impaired streams include the two studied in this report, Buck Mountain Creek and Black Creek



Project partners attribute the delisting of this segment to the abandoned mine land reclamation projects upstream in the watershed. The remaining 10.4 miles of the mainstem remain listed as impaired. Partners and Funding The Lehigh River Watershed is large and contains numerous impaired segments both upstream and downstream of the restored segment. As such, restoration efforts have occurred both upstream and downstream of the restored segment. Partners such as Eastern Pennsylvania Coalition for Abandoned Mine Reclamation have received 319 funds to analyze the legacy mining issues within the watershed which has helped guide watershed restoration efforts. PADEP's TMDL section has also received 319 funds, which were partly used to collect and analyze water quality data for development of the model used for the Lehigh River TMDL, which in turn was used to help steer restoration efforts.

The federal Office of Surface Mining (OSM) and PADEP's Bureau of Abandoned Mine Reclamation had direct roles in restoring this segment as outlined within the success story. Restoration work completed downstream will contribute to further restoration of the greater watershed but did not contribute to restoring this segment. Additionally, with funds from an EPA CWA section 104(b)(3) grant, the Wildlands Conservancy conducted a comprehensive assessment of the Lehigh River in 1998 to prioritize the watershed areas affected by mining. Finally, PADEP used $3,121,000 from the OSM from 1986 to 2006 to reclaim 297.9 acres of abandoned mine lands.

For additional information contact: Scott N. Heidel Water Program Specialist Pennsylvania Department of Environmental Protection 717-772-5647 • scheidel@pa.gov