Three Fork Creek Watershed Restoration Project

Preston County, WV

Submitted by:

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Project Completion Date: April 15, 2011

Initial Construction Cost: $750,491.15

Responsible Agency for Reclamation:

West Virginia Department of Environmental Protection
Office of Abandoned Mine Lands and Reclamation

Contractor: Breakaway, Inc.

Design Engineer: WV Department of Environmental Protection
Office of Abandoned Mine Lands and Reclamation

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Introduction

Three Fork Creek is situated in West Virginia's Preston and Taylor counties, with a drainage area of 103 square miles (Map 1). The headwaters are predominantly located in Preston County, with minor contributing tributaries originating in Monongalia and Taylor counties at elevations exceeding 2,200 feet. The mainstem is located in both Preston (7.5 miles) and Taylor (11 miles) counties, formed by the confluence of Birds Creek, Squires Creek, and Fields Creek in western Preston County. The stream then flows southwest before emptying into the Tygart Valley River (in the Monongahela River basin) in the city of Grafton, Taylor County, at an elevation of 1,000 feet. The chief tributaries of Three Fork Creek are Birds Creek (consisting of the North and South Fork), Fields Creek, Raccoon Creek, Squires Creek, and Laurel Run.

With the exception of Laurel Run and Fields Creek, acid mine drainage (AMD) generated from extensive pre-SMCRA underground mining had degraded the chief tributaries of Three Fork Creek. As a result, the entire length of the Three Fork Creek mainstem was mostly devoid of aquatic life. The effects of AMD impairment extended from Three Fork Creek downstream into the Tygart Valley River. In 2004 the West Virginia Division of Natural Resources (WVDNR) determined that Three Fork Creek was the second highest contributor of AMD in the Monongahela River basin. When localized rain storms occurred in the Three Fork Creek watershed during low flow conditions, acid slugs were pushed downstream, sometimes causing fish kills in the Tygart Valley River. High concentrations of acid and iron carried by Three Fork Creek from abandoned coal mines created a plume in the river through the town of Grafton.

Three Fork Creek flows into the Tygart Valley River at Grafton, approximately 2.25 miles downstream of Tygart Lake, a 1,750-acre reservoir managed by the U.S. Army Corps of Engineers (USACOE). Both the lake and the lake tailwaters are used extensively for boating and fishing. Additional recreational facilities in the vicinity of Tygart Lake include Tygart Lake State Park and Grafton City Park (located immediately below Tygart Lake Dam and includes a boat launch). Each attraction draws recreational users to the vicinity, providing a boost to the economy of Grafton, as well as providing high visibility of the confluence of Three Fork Creek with the Tygart Valley River to those passing by. WVDNR regularly stocks trout in the tailwater section, and stocks various other fish species in the lake and tailwater section.

In addition to the information detailed below, the high visibility, impact to aquatic life, recreation, and local economy, and increased loadings for water treatment facilities downstream made Three Fork Creek a prime candidate for restoration by the West Virginia Department of Environmental Protection, Office of Abandoned Mine Lands (AML).

Plume from Three Fork Creek in Tygart Valley River at Grafton

Background/Site Description

Official coal mining records for Preston County were first recorded in Annual Reports of West Virginia in 1883. During this period, fewer than five mines reported producing coal in the county. Expansion of the Baltimore and Ohio Railroad allowed for the development of its coal fields. Production records for underground mines were first recorded for the county in 1895. Since that time, the peak years for pre-SMCRA underground coal production in Preston County were in 1925 (2.7 million tons), 1948 (2.5 million tons) and 1965 (2.5 million tons). Production data during the same time period follows the same general trend, with peak production occurring in 1925 (174 million tons) and 1947 (154 million tons).

The extensive underground coal mining within the headwater tributaries of Three Fork Creek prior to the enactment of SMCRA had left approximately 9,100 acres of untreated and discharging mine pools throughout its headwaters. In the Three Fork Creek watershed, the majority of pre-SMCRA mining was conducted in the headwater section in the Upper Freeport coal seam, though mining has also been conducted in the Middle Kittanning and Bakerstown seams (Map 2). Very few pre-SMRCA surface coal mines, and no known pre-SMCRA underground mines, exist within the Three Fork Creek drainage of Monongalia and Taylor counties.

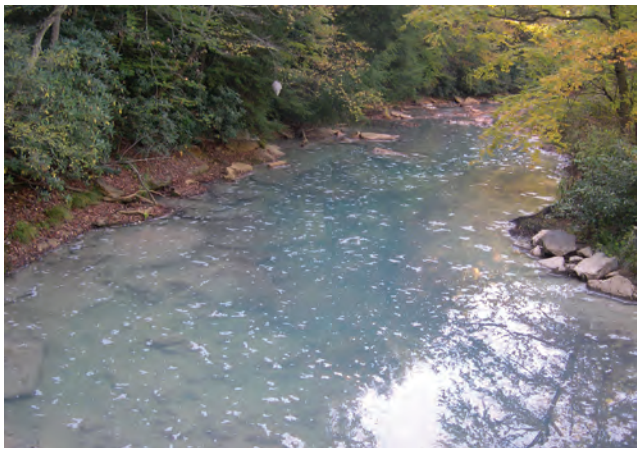
Mine drainage associated with Upper Freeport and Middle Kittanning seams in the headwater tributaries of Three Fork Creek is characteristically low in pH and high in metals. The Bakerstown seam produces higher pH discharges, but is also high in metals. The table below summarizes 106 water quality samples collected at 26 seep and portal discharge locations.

Table 1. Sampling results prior to dosing

	pH (Standard Units)	Aluminum (Al, mg/L)	Total Iron (Fe, mg/L)
Median/Average	2.9	15.2	21.5
Maximum	5.2	64	145
Minimum	2.4	0.12	0.0

Aluminum-laden tributary

Iron-laden tributary



Three Fork Creek downstream of aluminum and iron-laden tributaries

Restoration Goal

The Three Fork Creek Watershed Restoration Project was initiated through a combined effort of AML, West Virginia University (WVU) and the Save the Tygart watershed group. The goal of the project was to return the Three Fork Creek mainstem to its designated stream usage by decreasing the water quality impairment of multiple pre-SMRCA coal mine discharges within the watershed. Objectives for obtaining this goal were to:

- Improve water chemistry and aesthetics to support recreational water activities in the Three Fork Creek mainstem, and
- Restore benthic macro-invertebrates and fish in the Three Fork Creek mainstem.

WVU conducted an in-depth study to determine feasible alternatives to reach the established goal based on pre-SMRCA mine discharge information and water quality/quantity data collected and provided by AML. The Save the Tygart watershed group collected additional water quality data. Options included both passive and active treatment, and "at-source" and "in-stream." Various forms of at-source AMD treatment have been constructed throughout the state in the past. While many of these resulted in small localized AMD reductions, none produced measureable watershed-wide water quality improvements. In addition, most forms of at-source AMD treatment failed after a few years due to armoring eliminating contact with limestone, or clogging restricting the hydraulic flow through a treatment system. Based on historical attempts and conditions within the Three Fork Creek watershed, (numerous discharges with high metals and low pH, steep topography, and narrow valleys), achieving successful results with the traditional approach of applying at-source AMD treatment to individual pre-SMCRA mine discharges was questionable. A new cost-effective approach to treating multiple discharges was necessary to achieve the desired watershed improvement.

Ultimately, it was determined that in-stream, active treatment was the most viable option for treating Three Fork Creek. Although the most expensive alternative because of the high level of acidity on the mainstem, an active treatment system using in-stream lime dosers was determined to be the preferred alternative. For the purpose of this project, AML described a doser as:

An in-stream water powered mechanism that relays an alkaline material from an attached storage silo into a discharge channel, where the material is added to the receiving stream to increase alkalinity.

The study also recommended the number and location of dosers required to neutralize the acid load in the watershed. Water quality sampling of Three Fork Creek identified Raccoon Creek, North Fork Birds Creek, South Fork Birds Creek and Squires Creek as the major contributors of acid mine drainage (AMD) to the stream. To neutralize the acid load in the Three Fork Creek mainstem, dosers were recommended on each of these tributaries in locations as far into the headwaters of these tributaries as possible, while maintaining adequate year-round flow.

Construction/Operation

Construction of the dosers was initiated in July 2010. Each doser includes an intake located on the edge of the stream that diverts water from the stream to the doser via an underground pipe, the actual doser mechanism enclosed in a steel building, a steel lime storage silo, and an outlet leading to the stream. Two types of dosers were utilized: one using a water-powered tipping bucket to dispense lime at each tip, and three using a water wheel to turn an auger, dispensing lime. Each system was completed and actively treating water by April 2011.

The majority of on-site difficulties surfaced following the completion of the construction phase of the project. Utilizing in-stream treatment requires constant maintenance and adjustments due to the dynamic conditions of the individual tributaries. AML conducts routine sampling and adjustments of the doser systems twice per week, while volunteers from the Save the Tygart watershed group partner by sampling the stream once per week. On-site difficulties include:

- Types of treatment material to utilize: AML tried three types of material: granulated lime (CaO), a smaller diameter granulated lime, and hydrated lime (Ca(OH)2). Each reacted differently depending on the site and weather conditions. Ultimately, the smaller diameter granulated lime worked best.
- Stream Flow: The constant fluctuations in stream flow require routine adjustment to the treatment systems to maintain steady water quality downstream.
- Major storm events: Swift, high streams move sediment, boulders, and debris changing the stream channel and at times damaging the doser system.

Squires Creek doser

- Intakes and Lines: Leaves, sediment and other debris, normally carried through the stream channel, can clog the intake, not allowing enough water to flow into the system. Iron buildup in the lines themselves has created water flow issues as well.
- Mine Discharges: It appears that the flow from mine discharges peak two to three days after a storm event due to the water infiltrating into and out of the mine workings.
- Cold Weather: The granulated lime initially utilized during warmer seasons does not provide the same amount of neutralization/chemical reaction when the water temperature drops. AML utilized hydrated lime during the winter months, though this material is much more difficult to handle than granulated lime. Another problem experienced during the winter months is freezing, which shut systems down on occasion.
- Health and Safety: During treatment, the hydrated lime created a dust plume inside the doser enclosure. Respiratory and eye protection was required during entry into the building to check, make adjustments, and clean the system.

Results

WATER CHEMISTRY

Pre-construction stream sampling was conducted by AML staff, WVU and the Save the Tygart watershed group, while post-construction sampling is conducted by AML staff and the local watershed group. The WVDEP's Office of Water Resources Watershed Assessment Branch (WAB) also placed continuous monitors in the mainstem to record pH values. Pre-construction lab analyses of water samples showed that acidity gradually decreased and alkalinity increased toward the mouth of Three Fork Creek, probably due to the influx of good quality streams. However, the average alkalinity never exceeded the acidity prior to dosing. After dosing began, the reverse was observed (Table 2). The median pH increased at each sampling point (Map 3).

Additional variables analyzed include: Total Iron, Total Aluminum, Total Manganese, Total Magnesium, Total Suspended Solids, Total Dissolved Solids, Calcium, Conductivity and Sulfates. A post-construction decrease was observed for all measured variables with the exception of Iron, Calcium and Total suspended solids.

Table 2. Data from 13 pre-construction samples and 8 post construction samples

Site Description/Location	Median pH	Average Hot Acidity (mg/l as CaCO3)	Average Alkalinity (mg/l as CaCO3)
South Fork Birds Creek near mouth	3.8	95.56	0.82
South Fork Birds Creek near mouth	7.32	12.69	31.02
North Fork Birds Creek at mouth	3.9	55.05	0.90
North Fork Birds Creek at mouth	4.93	15.69	18.20
Birds Creek at mouth	3.9	85.07	0.80
Birds Creek at mouth	6.67	10.54	18.80
Squires Creek at mouth	3.35	101.58	0.82
Squires Creek at mouth	6.45	16.94	25.74
Raccoon Creek upstream of Little Raccoon Creek	3.3	134.37	0.82
Raccoon Creek upstream of Little Raccoon Creek	4.74	34.69	12.23
Raccoon Creek at mouth	4.1	96.15	1.71
Raccoon Creek at mouth	6	9.77	7.78
Three Fork Creek downstream of Birds Creek	4.4	52.86	1.07
Three Fork Creek downstream of Birds Creek	7.03	6.79*	15.83
Three Fork Creek downstream of Raccoon Creek	4.8	30.69	3.07
Three Fork Creek downstream of Raccoon Creek	6.9	7.62*	15.88
Three Fork Creek at Thornton	4.9	28.87	3.68
Three Fork Creek at Thornton	7.1	3.69*	17.75
Three Fork Creek near mouth	5.1	21.87	2.30
Three Fork Creek near mouth	7.08	5.36*	19.59

Net of fish captured during 2012 fish survey

AQUATIC SURVEYS

Pre-construction benthic macro-invertebrate and fish surveys were conducted by WAB in September 2010. Post-construction surveys were conducted in September 2012, approximately 17 months after the dosers officially started treating water. Benthic surveys consisted of the kick-net sampling method and fish surveys used the electroshocking method. Pre-construction and post-construction surveys were conducted at the same four locations along the mainstem of Three Fork Creek.

The benthic macro-invertebrate survey found diminished populations at all four locations during the pre-construction survey. The number of benthic taxa (or benthic groups) and EPT taxa (Ephemeroptera-mayfly, Plecoptera-stonefly, and Trichoptera-caddisfly, each of which are sensitive to pollution) is indicative of the water quality. During the 2010 survey, WAB identified eight taxa and three EPT species. Both improved during the 2012 survey: 15 total taxa and eight EPT taxa were identified.

Results of the pre-construction and post-construction fish surveys are even more dramatic. The 2010 sampling of four sites along the mainstem of Three Fork Creek resulted in a total of one fish: a green sunfish caught 0.4 miles from the confluence with the Tygart Valley River. Less than two years later, the sampling conducted in 2012 resulted in 1,605 fish caught, representing 21 species of predator and prey species at the same four sample locations. Of additional surprise was the presence of numerous young fish, showing natural reproduction within the watershed.

AESTHETICS AND EMBEDDEDNESS

During weekly pH checks through the watershed, AML staff noticed that the iron staining found on most rocks in the stream has slowly been disappearing from the both the tributaries and the mainstem of Three Fork Creek, improving the aesthetics of the stream. Embeddedness, which can be defined as the degree to which fine sedi-

ments surround the larger substrate material, increased in the upper reaches of the watershed, but decreased in the lower 9.6 miles. The embedded material consists of a mixture of algal growth, organic debris, metal precipitate, and inorganic silt particles.

RECREATIONAL OPPORTUNITIES

In the two years since the dosers began treatment in the Three Fork Creek Watershed, local residents have begun to once again utilize the stream for recreation. Camping and swimming have resumed along portions of the stream. Recreational fishing on the stream has also increased, with local residents reporting success while fishing throughout most of the stream.

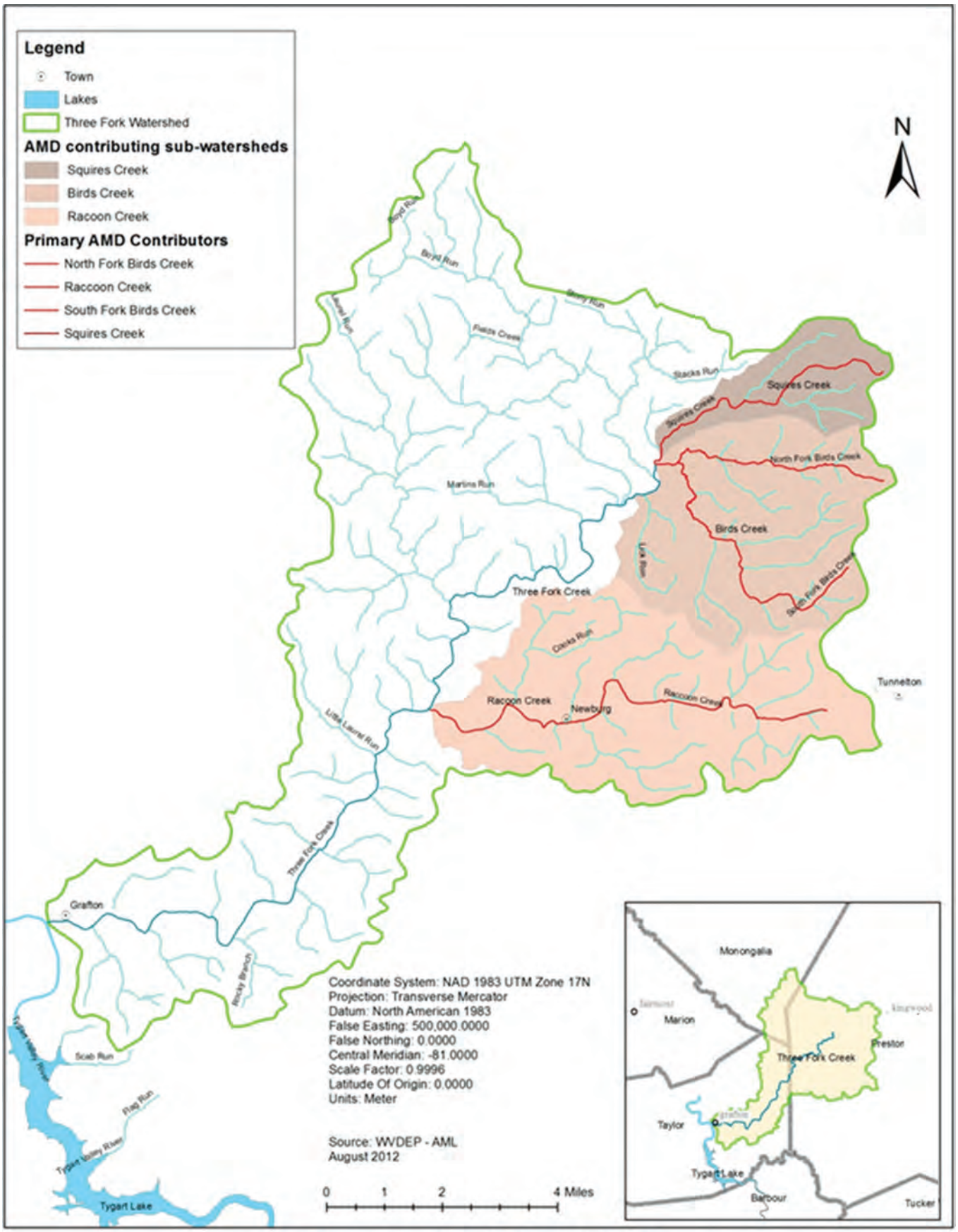
Summary

The headwaters of the Three Fork Creek watershed were extensively mined throughout the last century. Drainage from the Pre-SMCRA mines had severely impaired the stream since the mid-1950s. Approximately 9,100 acres of untreated mine pools discharged acid, iron and aluminum into the headwater tributaries, leaving Three Fork Creek discolored and lifeless. Due to the high visibility of the stream and the impact to aquatic life, recreation, and local economy, a partnership between AML, WVU, and a local watershed group was developed to restore Three Fork Creek to its pre-mining conditions.

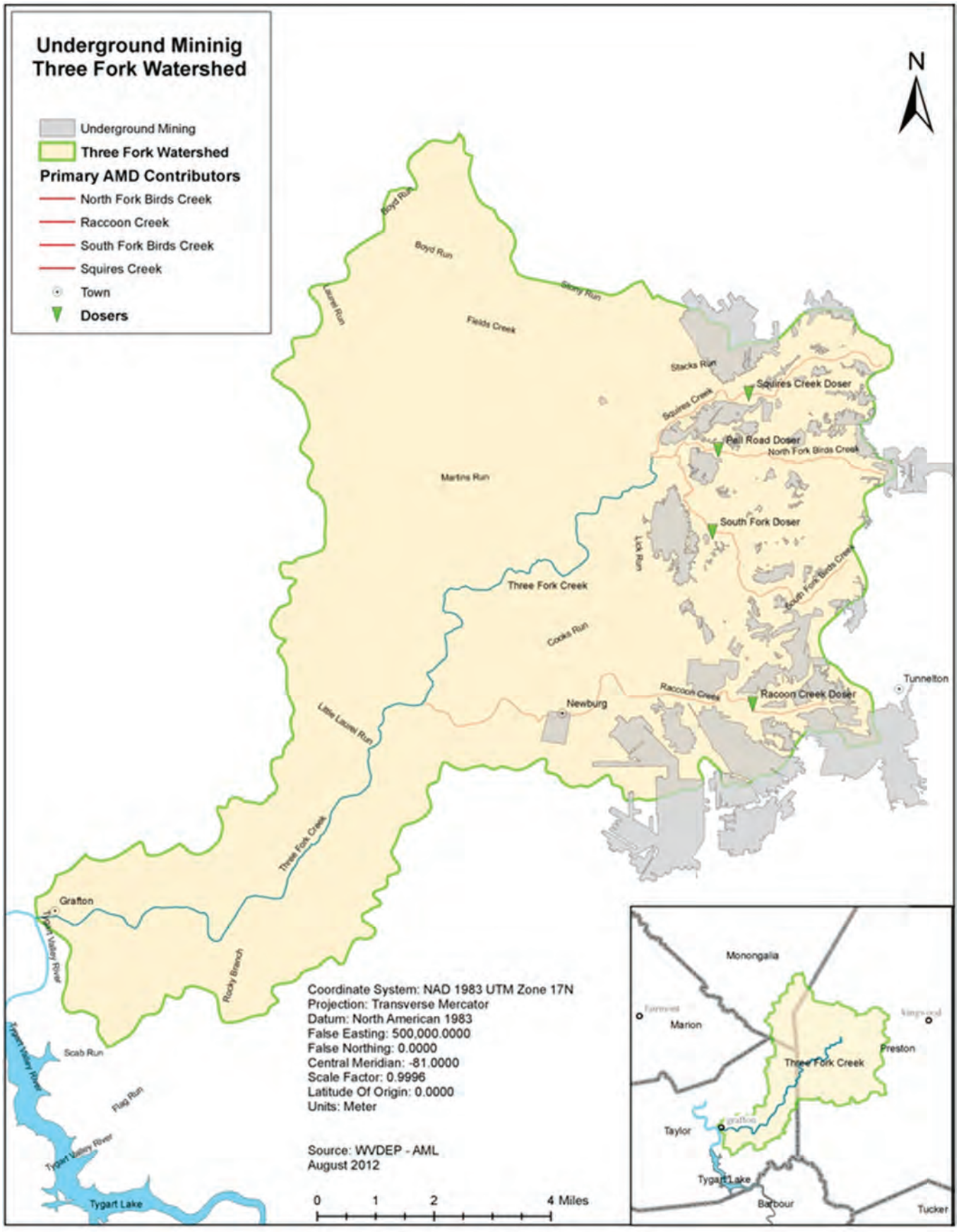
The restoration objectives of the partnership were to improve water chemistry and aesthetics in the Three Fork Creek mainstem to conditions that could support recreational water activities, while restoring benthic macro-invertebrates and fish. Previous AML projects completed in the watershed did not produce measureable watershed wide water quality improvements. Based on a study of mine discharge and stream quality and quantity, "in-stream" lime dosing was selected as the most effective treatment.

Four lime dosers were placed in headwater tributaries of Three Fork Creek. Positive results were evident almost immediately following start-up of the lime dosing. AML personnel, Save the Tygart watershed group, and local residents began noticing aquatic life returning in the stream. Follow up benthic macro-invertebrate and fish surveys showed the stream had improved immensely when compared to pre-dosing surveys.

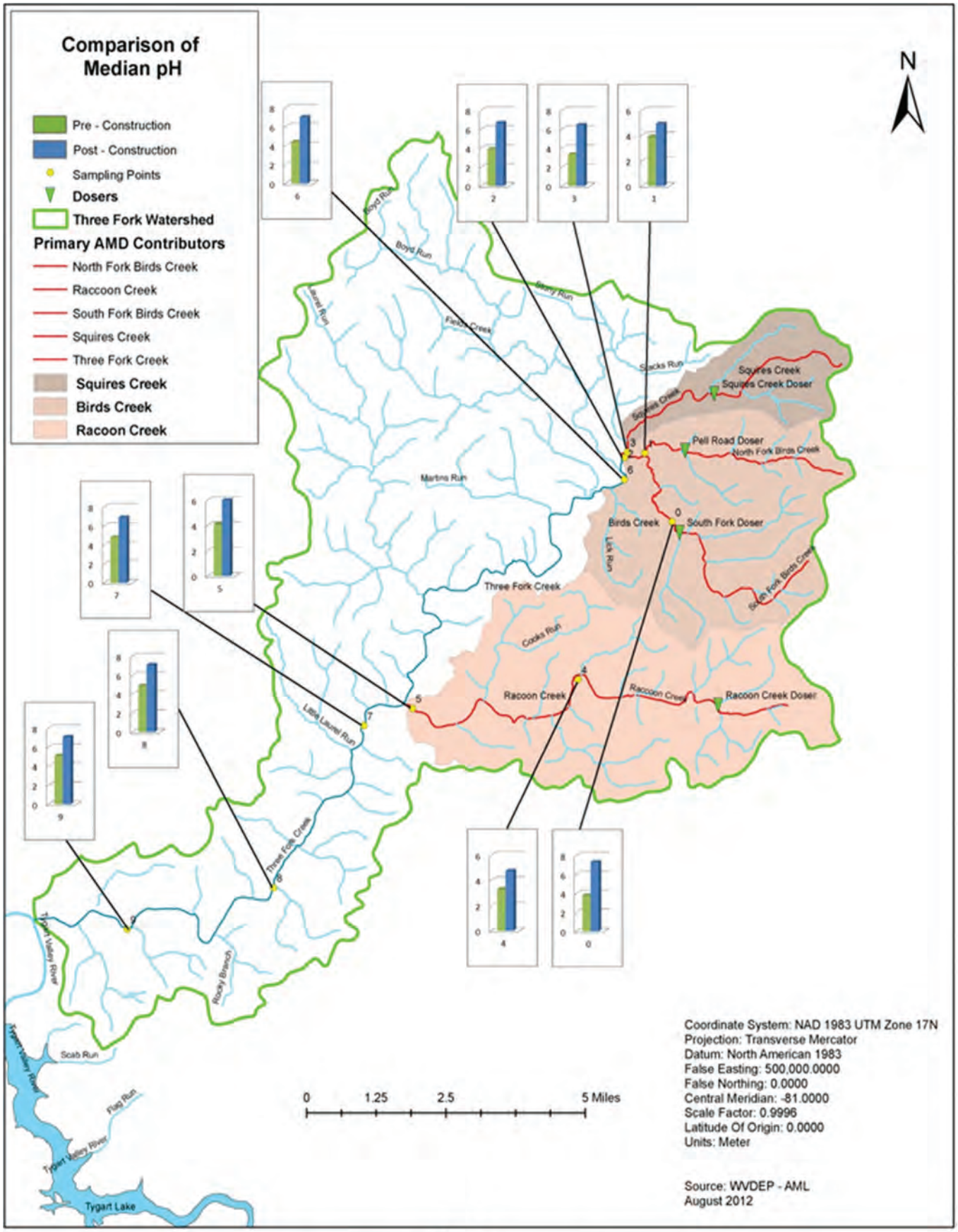
According to older local residents, Three Fork Creek was once known as a premier trout stream in the state. However, due to the Pre-SMCRA mining in the watershed, the stream was nearly devoid of aquatic life. During a fish sampling conducted in 2010, only one fish was caught. A second fish sampling conducted two years later, only 17 months after the official treatment of water commenced, resulted in 1,605 total fish captured and released. Three Fork Creek is once again alive!



Map 1 - Three Fork Creek Watershed and AMD Contributing Sub-Watersheds



Map 2 - Pre-Law Deep Mines within Three Fork Creek Watershed



Map 3

In-Stream Dosing for Treatment of AMD

On-site difficulties

Squires Creek doser after flood

Ice on tip bucket of doser

On-site difficulties cont.

Undissolved lime downstream of the North Fork doser

Debris clogging intake of the North Fork doser

Dosing Success

Birds Creek prior to dosing

Birds Creek after dosing

Dosing Success cont.

Raccoon Creek prior to dosing

Raccoon Creek after dosing

Benthic Macro-invertebrate Survey

Save the Tygart Watershed Group assists WVDEP with 2012 benthic macro-invertebrate survey

Stonefly captured during 2012 survey

Fish Survey

WVDEP personnel partner with Save the Tygart Watershed group on 2012 fish survey

Small Mouth Bass caught during 2012 fish survey