THE STATE OF THE CREEK, 2005

The Clean Creek Program Annual Report

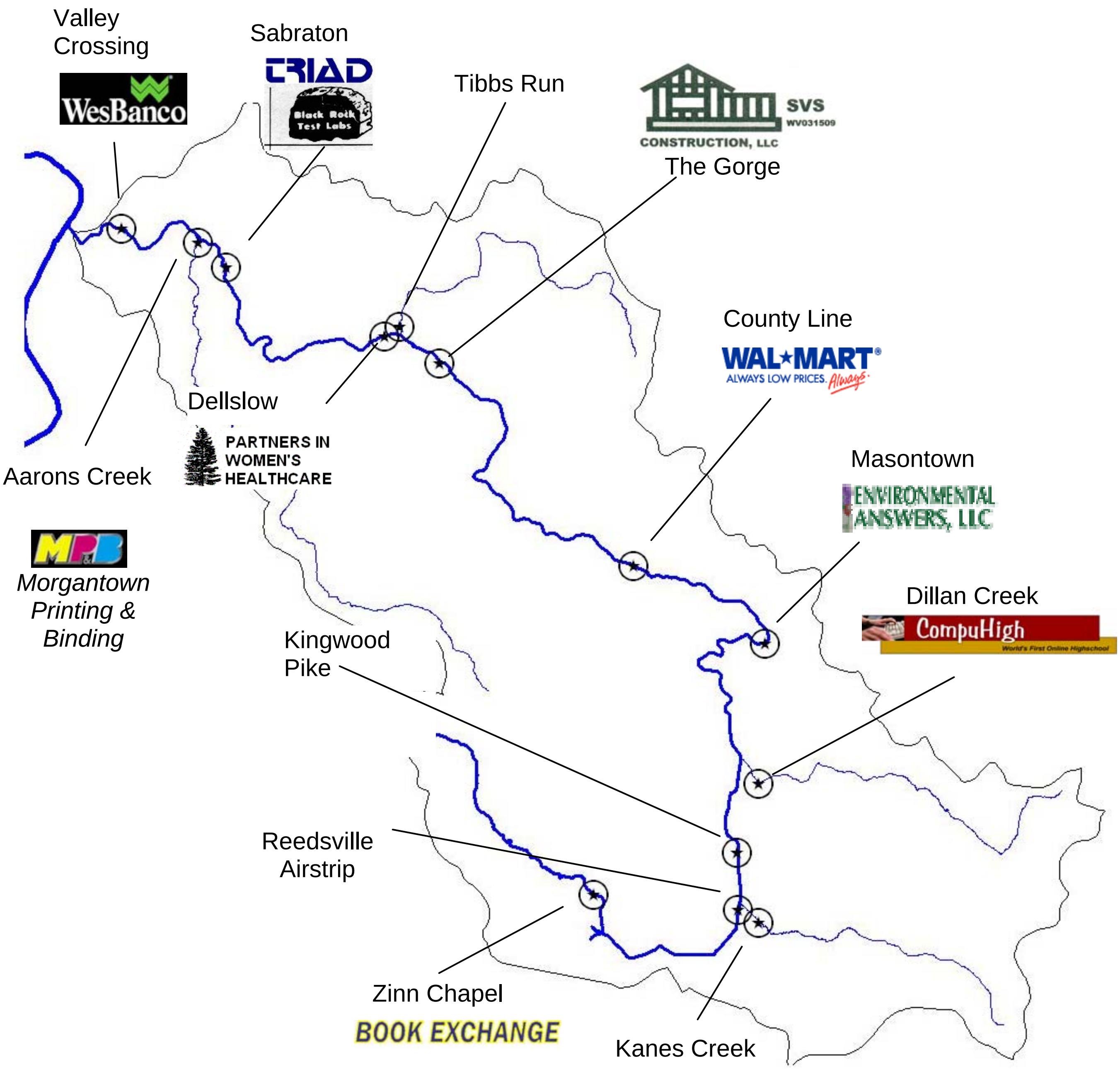
FRIENDS OF DECKERS CREEK

Compiled by

Friends of Deckers Creek

CLEAN CREEK PROGRAM

SAMPLING SITES AND SPONSORS, 2005



EXECUTIVE SUMMARY

Friends of Deckers Creek sampled the creek and four tributaries quarterly during 2005, the third year of the Clean Creek Program. Patterns in water quality matched previous results. Acid mine drainage (AMD) is the most harmful pollution found in Deckers Creek. There is a small amount of AMD in the uppermost segment of the creek, but the impact of AMD becomes clear at Kanes Creek, which carries AMD from a large number of abandoned mines. Deckers gathers additional AMD between Kanes Creek and Masontown, and then improves in water quality as it flows through a region with limestone bedrock. Five miles from its mouth, a single abandoned mine, the Richard mine, delivers a large amount of AMD to the creek, and severely degrades it for the rest of its length.

Although the spatial pattern of damage by AMD remained the same, concentrations of pollution were lower than in previous years. In the first year of the Clean Creek Program, extremely high flows apparently flushed large amounts of AMD from abandoned mines into the upper portion of the watershed. In 2005, however, extremely dry conditions decreased the amount of AMD flowing into the creek. Chemical measurements and fish surveys indicated the potential for rapid recovery, once AMD decreases or is eliminated.

Several groups have begun projects to eliminate AMD, to protect the creek and its communities as rains return and flows from mined areas increase. Friends of Deckers Creek secured funding for and contracted with an engineering company to build a passive remediation project near the headwaters of Kanes Creek. The Natural Resources Conservation Service is designing remediation projects near Masontown and Dillan Creek.

The Deckers Creek Restoration Team, which includes Friends of Deckers Creek, several state and federal agencies, local governments, and individuals, continues to implement a watershed based plan to address AMD throughout the watershed. The Richard mine, however, discharges too much water to be treated with the passive treatments proposed for other sites. The Deckers Creek Restoration Team continues to work with all parties to identify a source of operation and maintenance funding for this site.

Front cover:

Top—Deckers Creek at Dellslow in low-flow conditions in summer 2005. Office of Surface Mining Summer Intern James Robert Mitchell is measuring streamflow.

Bottom—Comparison of the appearance of the water in summer 2004 (bottom center) and 2005 (bottom right) at the same location near the mouth of Deckers Creek (at the Valley Crossing site).

ACKNOWLEDGEMENTS

Friends of Deckers Creek relies on the support of foundations, agencies, local businesses, and volunteers.

The NiSource Environmental Challenge Fund supported this project through a generous grant.

Nine businesses from the watershed and surrounding areas supported the project by sponsoring sampling at monitoring sites:

Deckers Creek at Valley Crossing	**WesBanco, Monongalia County**
Aarons Creek	**Morgantown Printing & Binding**
Deckers Creek in Sabraton	**Triad/Black Rock Test Labs**
Deckers Creek in Dellslow	**Partners in Women's Health Care** Tom Harman, Patsy Harman, Jane Koch and Julie Armistead
Deckers Creek at Blue Hole	**SVS Construction**
Deckers Creek at the County Line	**Wal-Mart**
Deckers Creek in Masontown	**Environmental Answers, LLC**
Dillan Creek	**CompuHigh**
Deckers Creek at Zinn Chapel	**The Book Exchange**

Additional information about these sponsors can be found at www.DeckersCreek.org.

A number of volunteers participated in gathering the data.

Jeffrey Atkinson, Sarah Bitter, Chris Campbell, Alina Chitac, Seth Davis, Nathan Fazio, Danny Feuillet, Lee Haggerty, Lara Hedrick, Mark Hepner, Heather Hildebrand, Christ Horn, Meghann Kent, Zack Liller, Chad Lykins, Roy Martin, Sarah McClurg, George Merovich, Travis Metcalf, Robert Miller, Megan Moyers, Lindsay Pierce, Ira Poplar-Jeffers, Dustin Smith, Garrett Staines, Tim Szczypinski, Derek Tettenburn, Christina Venable, Logan Wamsley, and Aaron Yeager surveyed fish communities.

James Robert Mitchell and Meredith Pavlick assisted with the benthic macroinvertebrate surveys. Several staff and students at West Virginia University, Division of Forestry and Natural Resources assisted with invertebrate identification.

Alina Chitac, James Robert Mitchell, Erin Shultz, Rob Stenger, Hanna Wheeler, and Jessica Zamias assisted with quarterly water sampling trips.

The Clean Creek Program was created by Friends of Deckers Creek (FODC). The mission of FODC is to improve the natural qualities of, increase public concern for, and promote the enjoyment of the Deckers Creek Watershed. Evan Hansen provided a helpful review of this report.

For further information about FODC and its Clean Creek Program, or to sponsor a monitoring site, contact

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(304) 292-3970		(304) 292-2450

Friends of Deckers Creek contact information:

www.DeckersCreek.org
Friends of Deckers Creek
P.O. Box 877
Dellslow, WV 26531

THE DECKERS CREEK RESTORATION TEAM

These groups meet quarterly to discuss ways to improve
the natural qualities of Deckers Creek, especially
by eliminating sources of acid mine drainage.
Meetings are open to the public.

Friends of Deckers Creek

Greer Industries

Monongalia Soil Conservation District

Monongalia County Commission

Morgantown City Council

Masontown Town Council

Reedsville Town Council

USDA Natural Resources Conservation Service

USDI Office of Surface Mining

WVDEP Office of Abandoned Mine Lands and Reclamation

WVDEP Division of Water and Waste Management

WVU Division of Forestry

WVU Division of Plant and Soil Sciences

West Virginia Conservation Association

ABBREVIATIONS AND TECHNICAL TERMS

Acidity	The ability of water to maintain low pH levels when basic chemicals are added. Acidity is quantified as the amount of base (measured as milligrams of calcium carbonate) required to raise the pH of a liter of water to a pH of 8.3.
Alkalinity	The ability of water to maintain high pH levels when acidic chemicals are added. Alkalinity is quantified as the amount of acid required to lower the pH of a volume of water to a pH of 4.5. Alkalinity is expressed as milligrams per liter of calcium carbonate.
AMD	Acid mine drainage
AML	Abandoned mine lands. Areas mined before 1977, not subject to rules outlined under SMCRA.
AMLIS	Abandoned Mine Land Inventory System (information system maintained by OSM of abandoned mine land problems across the U.S.)
Anticline	A fold in bedrock with the concave part of the fold facing downwards
Benthic macroinvertebrates	Animals that inhabit stream sediments that have no backbone and are large enough to be seen with the naked eye. Assemblages of such creatures may be used to judge water quality.
$CaCO_3$	Calcite, the most common mineral in limeststone
cfu/100 mL	Colony-forming units per 100 milliliters. A unit for enumerating levels of bacteria, especially fecal coliforms, in water.
DWWM	Division of Water and Waste Management, within WVDEP
Fecal coliform bacteria	Bacteria that normally live in digestive tracts of animals, including humans. Their presence in surface water indicates pollution by sewage, farm runoff, or wildlife.
FODC	Friends of Deckers Creek
mg/L	milligrams per liter
MUB	Morgantown Utility Board
Net alkalinity	Alkalinity minus acidity
OAMLR	Office of Abandoned Mine Lands and Reclamation, within WVDEP
OSM	U.S. Department of the Interior Office of Surface Mining, Reclamation and Enforcement
PAD	Problem Area Description (file describing abandoned mine lands, used by OSM and OAMLR)

pH	A measure of how acidic water is. Water at pH 7 is neither acidic nor basic. pH levels below 7 indicate that water is acidic.
Pyrite	A mineral with the chemical formula FeS_2 that occurs in coal and that oxidizes in the presence of air and water to form dissolved iron and sulfuric acid. The oxidation of pyrite generates acid mine drainage.
SMCRA	Surface Mining Control and Reclamation Act. Law passed in 1977 regulating coal mines and establishing the Abandoned Mine Land Trust Fund to reclaim abandoned mines.
SOS	Save Our Stream. A method for evaluating water quality using benthic macroinvertebrates that was developed by the Izaak Walton League.
SRG	Stream Restoration Group (data-gathering group within OAMLR)
RAPS	Reducing and alkalinity producing system. A form of passive AMD treatment where water is passed through a layer of compost and then through a layer of limestone. Bacteria in the compost consume oxygen and prevent the iron from becoming oxidized to the ferric state. Iron in that state will armor limestone with iron hydroxide, and slow down its reaction with acid.
USGS	United States Geological Survey
Water quality standard	A concentration set by West Virginia as a threshold for the designation of impairment. When the concentration of a pollutant exceeds the water quality standard, the water is considered impaired.
WVDEP	West Virginia Department of Environmental Protection
WVU	West Virginia University

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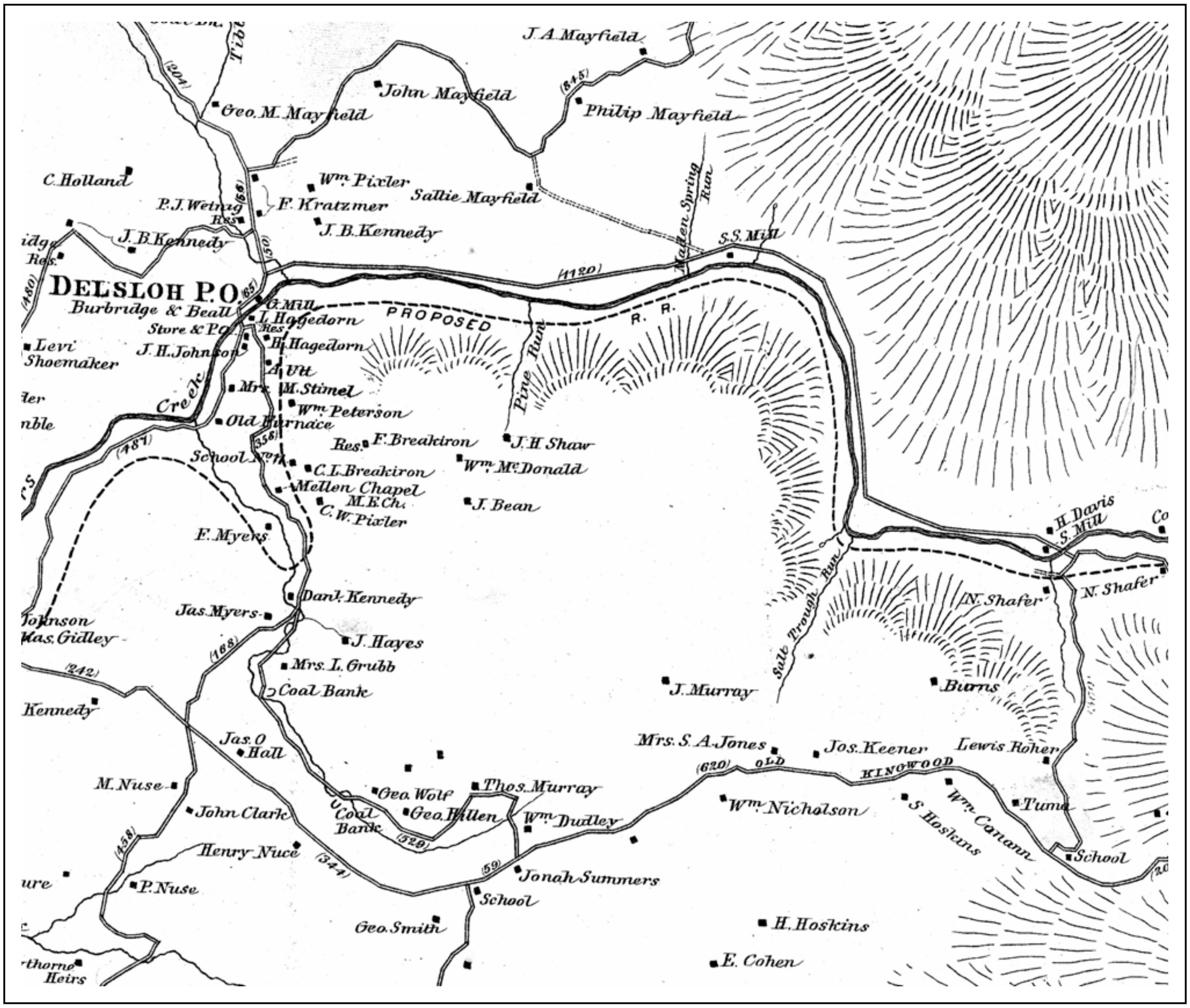
Suggested Reference:

Christ, M.J. 2006. The State of the Creek, 2005: The Clean Creek Program Annual Report. Friends of Deckers Creek. Dellslow, West Virginia. April.



Detail of an 1886 map of Morgan District of Monongalia County, showing terrain, roads and landowners between Dellslow and the location of Deckers Creek Limestone mine. Deckers Creek flows from right to left. (Lathrop et al., 1886)

West Virginia and Regional History Collection, West Virginia University Libraries

INTRODUCTION

Purpose

This is the final report of the third year (January through December, 2005) of the Clean Creek Program of Friends of Deckers Creek. This report gives the most recent water quality and biological survey results, and also compares them to earlier results, both from the Clean Creek Program and from other data sources.

This report also provides context for these data, including information about the geography and geology of Deckers Creek and its watershed, and about the groups that are working to solve its pollution problems.

At the first sight of the steep sections of Deckers Creek, many people assume that this steep, rocky stream represents the clean, wild whitewater of West Virginia. Unfortunately, that is not the case. Deckers Creek reflects the impact of extraction of natural resources. In particular, coal mining through most of the 20th century has left Deckers Creek with a legacy of acid mine drainage that can be read in its turbid waters, its red rocks, and its impoverished insect and fish communities.

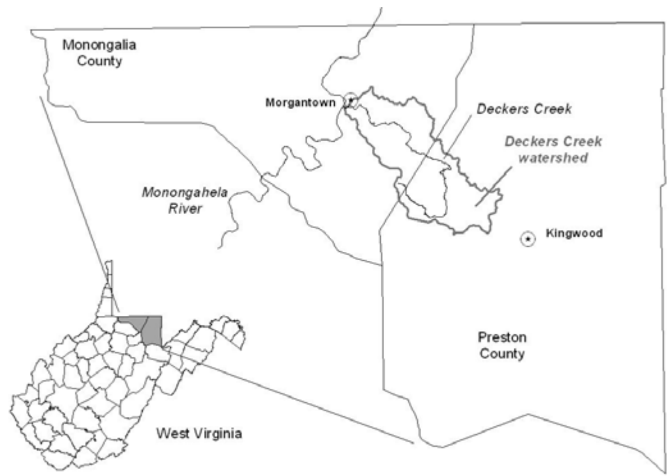


Figure 1: Location of the Deckers Creek watershed

About Deckers Creek

Geography

Deckers Creek flows into the Monongahela River at Morgantown, West Virginia (Figure 1). The features of the creek are becoming more well-known through a popular rail-trail, the Deckers Creek Trail, which runs beside the creek.

Deckers Creek, however, is not in a city for its entire 23 miles (Figure 2). It begins on the southeast facing slope of a ridge as a small woodland brook. It sweeps to the north and flows through a long flat valley as a straightened ditch among pastures and fields. It then turns to the northwest and cuts a steep gorge down to Morgantown, plunging over falls and rapids on the way. It also runs strong and fast through Morgantown, but is often constrained by steep walls of either creek-cut bedrock or human-built stone.

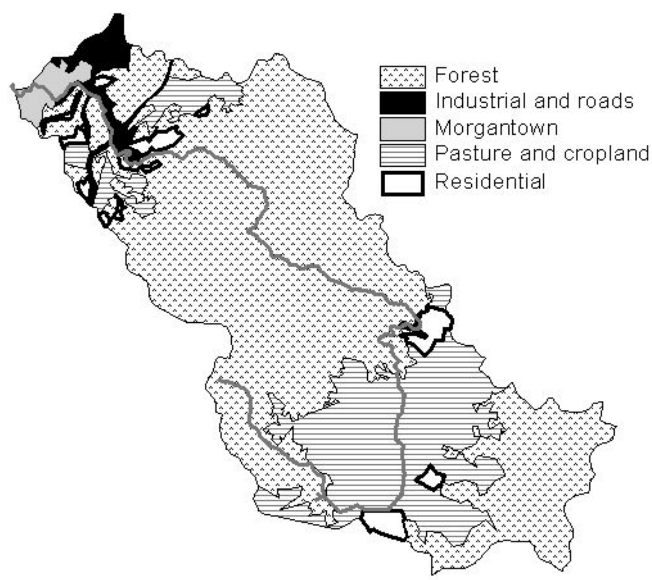


Figure 2: Land-use in the Deckers Creek watershed

Its watershed includes most of Valley District in Preston County, including Arthurdale, Reedsville and

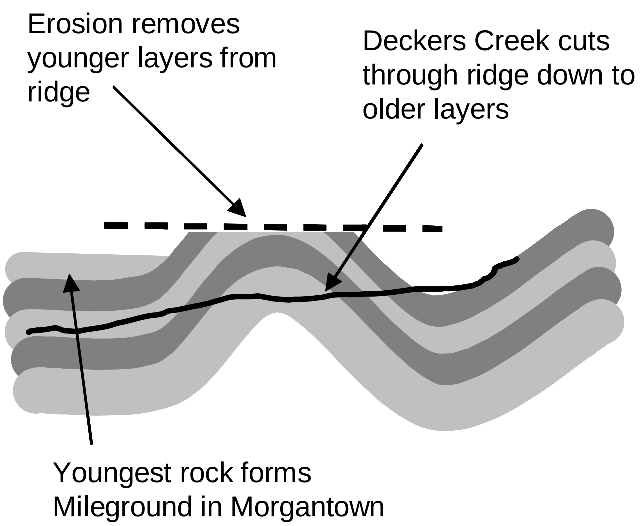


Figure 3: General geological profile of the Deckers Creek watershed (looking towards NNE)

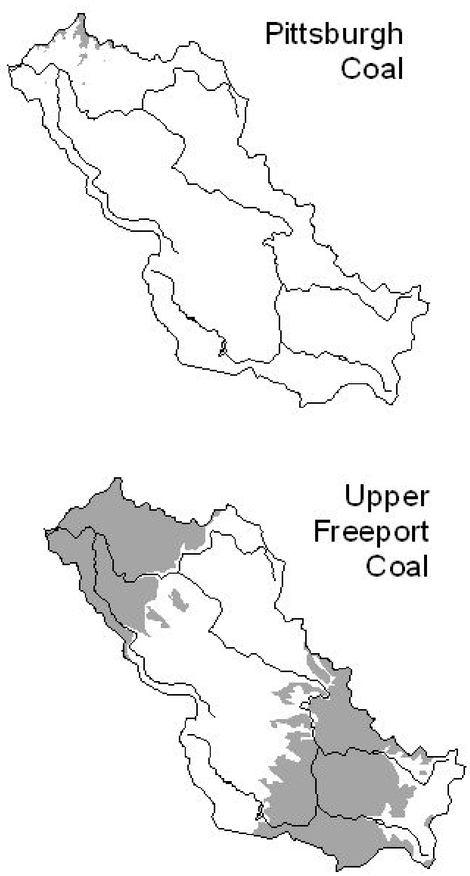


Figure 4: Distribution of major coal seams in the Deckers Creek watershed

Masontown, and most of Morgan District in Monongalia County, including the towns of Sturgisson, Brookhaven, Dellslow, Richard, Sabraton, and a substantial part of Morgantown.

Geology

An orientation to the geology of Deckers Creek is useful for understanding both its scenic beauty and its challenges. The bedrock layers of the Deckers Creek watershed generally slope down from the southeast to the northwest, but there is one large fold, or anticline, in the rocks (Figure 3). In the center of this fold, older bedrock is pushed up through younger bedrock. The oldest bedrock appears where Deckers Creek has cut a gorge through this fold. Younger bedrock lies on the ridge formed by the fold, and even younger bedrock appears at either end of the gorge. The youngest bedrock is found at the western end of the watershed, on the Mileground in Morgantown.

These rocks are important. In the Deckers Creek watershed, the coal seams are in the younger bedrock. The Upper Freeport Coal covers the entire watershed except where the anticline has pushed up into it, and where a few of the major tributaries have eroded it away. The Pittsburgh seam occurs only near Morgantown (Figure 4). The oldest rock with substantial exposure is the Greenbrier Limestone, which is found and mined where the creek cuts through the center of the anticline at Greer. The Bakerstown Coal is found between the Upper Freeport and Pittsburgh seams, but a map of its extent has not been compiled.

The coal and pyrite, a mineral in the coal, are responsible for the most devastating pollution in Deckers Creek: acid mine drainage (AMD). Mining coal exposes pyrite to oxygen and water. Pyrite consists of iron and sulfur. Oxygen reacts with the sulfur to form sulfuric acid, and also reacts with the iron to form iron hydroxide, or yellowboy, releasing additional acidity. AMD is destructive because of both the acidity (Box 1) and the dissolved metals in solution. The many forms of solid and dissolved metals and acidity make the task of solving AMD problems complicated (Box 2).

Past water quality information

A number of long-time residents have stories about anglers catching trout from Deckers Creek. Many more people, however, remember Deckers Creek being much more polluted than it is today. Although there are few data with which to construct a complete picture of the history of the creek, the data confirm that the creek has improved.

With regard to sewage, the creek improved drastically after the construction of a sewer main along the creek. There has also been improvement with regard to AMD. A WVU Master's thesis (Henson, 1950) records pH values close to 4 at several sites as high up in the watershed as Masontown. Such low values indicate severe impact from AMD and make the creek uninhabitable for fish. Another student performed a similar investigation of Deckers Creek approximately 25 years later (Teti, 1975). Jason Stewart conducted a third study in 1999 and 2000 and compared it with earlier results (Stewart, 2001). The trajectories illustrate general improvement in the pH levels of the creek, although low pH values continue to occur in many locations (Figure 5).

Long-term water-quality changes stem from the changes in coal mining in north-central West Virginia. Mining in the Upper Freeport seam, which contributes the most acidity to Deckers Creek, has become rare because permits for mining this high-sulfur seam are difficult to obtain. In addition, the high sulfur level in the coal lowers the quality and the profitability of the coal by causing higher pollution control costs to those who burn it.

Shorter-term trends in water quality may reflect reclamation projects, mine management and weather patterns. The Office of Abandoned Mine Lands and Reclamation (OAMLR) within the West Virginia Department of Environmental Protection (WVDEP) has conducted reclamation on several sites, including Upper Deckers Creek Impoundment #5, Kanes Creek South, Elkins Coal and Coke, Dillan Creek, Tibbs Run Portals, Masontown Refuse and many others. AMD still flows from many of these sites, especially from the portals of deep mines. Nevertheless, isolation of acid-forming materials from water percolating through the soil may have eliminated substantial AMD loads to the creek. OAMLR has also added limestone fines to the creek in a number of locations to determine whether the water in the upper part of the gorge could

Box 1: Water and acid

Water, H_2O, naturally splits up to form two ions, which are pieces with opposite electrical charges. H^+ has a positive charge and OH^- has a negative charge:

$$H_2O \rightarrow H^+ + OH^-$$

In a solution that is neither acidic nor basic, the numbers of H^+ and OH^- are equal. Such a solution would have a pH value of 7. In an acidic solution, the H^+ ions far outnumber the OH^- ions. pH values for these solutions are lower than 7. A solution at a pH of 4 has one million H^+ ions for every OH^- ion. The imbalance is greater at lower pH values.

As the pH in a solution changes, many of the chemical reactions that take place in it change as well. Materials that are solid at one pH may dissolve at another. Other materials may be dissolved in water at one pH, and bubble out of solution as a gas at other pH values. Fish in water and cells inside organisms exist in solutions, and changes in pH affect them. A change in pH may cause toxic chemicals to dissolve into a solution, or life-sustaining chemicals to become unavailable. Such changes may also slow down or stop many of the chemical reactions that are part of living, growing and reproducing.

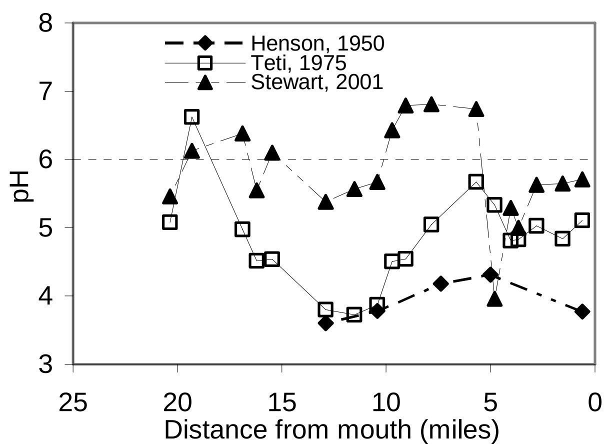


Figure 5: Comparison of pH profiles along Deckers Creek at roughly quarter-century intervals. See the "Sampling sites" section to relate distance from mouth to well-known landmarks.

Box 2: The chemistry of acid mine drainage

In the first step of AMD production, the sulfur in pyrite is oxidized to form iron sulfate and sulfuric acid.

$$FeS_2 + (7/2)\ O_2 + H_2O = FeSO_4 + 2H^+ + SO_4^{2-}$$

Both the iron sulfate and the acid are soluble, and both add acidity to the solution. To understand how the iron sulfate makes acid, it is important to understand the forms that acidity takes. The first form is the excess of H^+ ions. H_2SO_4 makes acidity by dividing into H^+ and SO_4^{2-}. The second form is dissolved metals, especially aluminum and iron, which contribute H^+ to solution as they become insoluble:

$$Al^{3+} + 3H_2O \rightarrow Al(OH)_3 + 3H^+$$
and
$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$$

where Al^{3+} and Fe^{3+} are dissolved forms of aluminum and iron, respectively, and $Al(OH)_3$ and $Fe(OH)_3$ are solids that precipitate out of solution. Therefore, in a solution with a pH value of 4 and a high concentration of aluminum, adding OH^- to fix the million-fold imbalance will not completely eliminate the acidity, because some of the neutralized acidity will be immediately replaced by the dissolved aluminum.

AMD often contains yet more acidity in a different form of dissolved iron, and in dissolved manganese. Ferrous iron (Fe^{2+}) does not immediately release H^+ into solution in the same way as ferric iron (Fe^{3+}). But in the presence of oxygen, it will turn into ferric iron, and release H^+.

$$Fe^{2+} + \tfrac{1}{4}O_2 + 2.5H_2O \rightarrow Fe(OH)_3 + 2H^+$$

Manganese undergoes similar reactions as it changes from Mn^{2+} to Mn^{4+} and then to $Mn(OH)_4$.

be kept neutral and habitable by fish. Changes in water levels prevented before-and-after measurements from showing the effects of these efforts precisely. In no case is there a consistent regime of measurements that proves or disproves the efficacy of any particular measure. This lack of consistent monitoring at regular intervals is an important motivation for FODC's Clean Creek Program.

Deckers Creek benefits from several mining or former mining operations that carefully treat mine runoff. International Coal Group treats acid water in two large mines by adding quicklime and then allowing the water to run through several settling ponds before releasing it to Kanes Creek. CoalTrain Corporation has used alkaline shale from a bedrock layer adjacent to the Bakerstown coal seam to treat runoff. Decondor Coal Company treats mine drainage with anhydrous ammonia before discharging it.

A graph of pH values taken at the USGS gauging station at the base of Kingwood Street in Morgantown indicates that not all perceived improvements are supported by data (Figure 6). Although there was a general improvement in pH from 1950 to the 1970s, there was little additional improvement until approximately 2000: pH values continued to swing between neutral (near 7) and acidic (below 7). The neutral to alkaline (above 7) measurements taken most recently may be an artifact of recent flow conditions (see "Relating Streamflow and Chemistry," below).

Biological trends are more difficult to document than chemical trends. This report provides information on fish and benthic macroinvertebrate communities in the creek and its tributaries. Communities of benthic macroinvertebrates can be used to assess water quality in streams. Like the chemical measurements, these communities indicate that streams in the Deckers Creek watershed are impaired.

About Friends of Deckers Creek

Deckers Creek has long attracted groups who have wanted to improve the environment and benefit the human communities nearby. Residents in Richard and Dellslow celebrated annual "Deckers Creek Valley Days" from 1968 to 1979. A clean-up in 1993, before FODC started, was coordinated by the Monongalia Friends Meeting, the Unitarian Fellowship, the Baha'i

Community, Sigma Gamma Epsilon, National Small Flows Clearinghouse, National Drinking Water Clearinghouse, Monongahela Chapter of the Sierra Club, and Morgantown's Board of Parks and Recreation (BOPARC).

FODC was started in 1995 by outdoor enthusiasts, especially rock climbers and kayakers. People from these groups agreed that Deckers Creek was worth restoring, and that it would only happen through grassroots efforts. The mission of the Friends of Deckers Creek is to improve the natural qualities of, increase public concern for, and promote the enjoyment of the Deckers Creek Watershed.

Friends of Deckers Creek carries out its mission through a wide variety of activities (Box 3).

About the Clean Creek Program

FODC identified water-quality monitoring in the creek as one of its central activities. Dependable water quality data allow FODC and its partners to target the most important sites for remediation, and to track improvements over time. There is a lack of long-term data measured with consistent methods in the same places. FODC therefore developed a program in which local businesses can collaborate on long-term monitoring. The key features of the program include:

- *Monitoring water chemistry at 13 sites four times a year*
- *Monitoring fish and benthic invertebrate communities once a year*
- *Inviting businesses to sponsor each site*
- *Presenting results to watershed residents and community leaders*
- *Involving volunteers*
- *Publishing annual "State of the Creek" reports*

The desire to improve Deckers Creek is widespread among Morgantown area and Valley District residents. All those who wish to work on the creek should have clear information about the conditions of the creek at all its locations and in all its seasons.

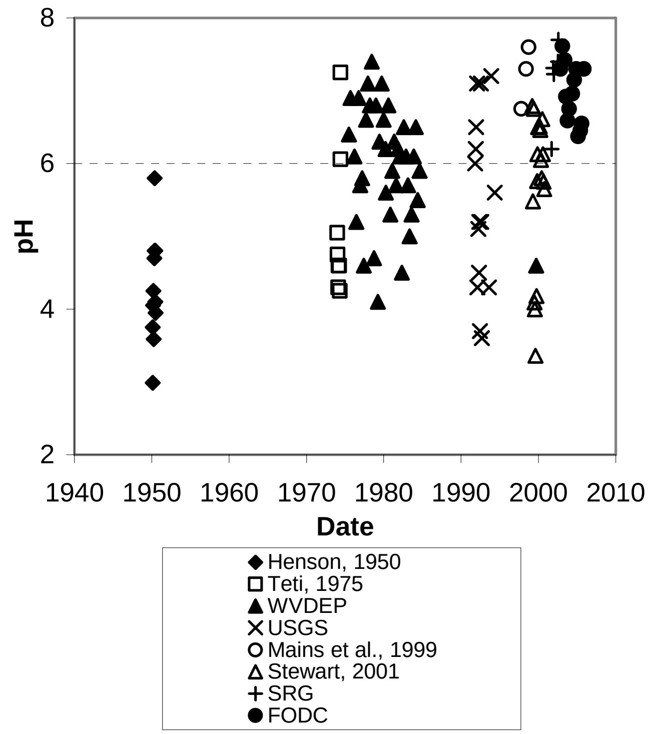


Figure 6: pH readings in Deckers Creek near the Valley Crossing site. The dashed line at a pH value of 6 is the minimum pH of unimpaired waters, according to WVDEP.

Box 3: Activities of Friends of Deckers Creek

Improving natural qualities:
- Coordinating state and federal efforts to clean up Deckers Creek
- Raising funds for building and maintaining remediation projects
- Picking up trash
- Monitoring to identify pollution problems
- Devising solutions

Increasing public concern:
- Leading a campaign to address stormwater pollution in the watershed
- Publishing reports and newsletters
- Maintaining a website
- Making presentations to those interested in the creek
- Communicating with community leaders about Deckers Creek's potential and its problems
- Holding educational meetings that rotate to sites all across the watershed

Promoting enjoyment:
- CarpFest! An annual festival celebrating Deckers Creek
- Supporting rail-trail events, such as the Deckers Creek Half Marathon

Box 4: Internet resource for the Deckers Creek watershed

FODC's website contains information about clean-ups and meetings, PDF files of many of our reports, and links to additional watershed information:
www.DeckersCreek.org

USGS reports height and streamflow measured at the bottom of Kingwood Street in Morgantown:
waterdata.usgs.gov/nwis/nwisman/?site_no=03062500

EPA allows you to find information on watersheds, such as that of the upper Monongahela River:
cfpub.epa.gov/surf/huc.cfm?huc_code=05020003

The Monongahela River Trails Conservancy has information on the Deckers Creek and Caperton Trails:
www.MonTrails.org

Arthurdale Heritage maintains a site about the first New Deal community. It is in the Deckers Creek watershed:
www.ArthurdaleHeritage.org

Digital images of USGS topo maps are available from WVDEP. The Deckers Creek watershed is on the Kingwood, Lake Lynn, Masontown, Morgantown North, Morgantown South, Newburg and Valley Point quadrangles:
gis.wvdep.org/data/drgs.php

Color-infrared aerial photos for the same quadrangles are also available from WVDEP:
gis.wvdep.org/data/doqq.php

The inventory of abandoned mine lands can be found through an interactive server at OSM. The system does not have the resolution to query sites for the Deckers Creek watershed, but a query of Monongalia and Preston Counties is informative:
ismhdqa02.osmre.gov/OSM.HTM

Water pollution discharge permits can be searched by USGS quad, county, permit number or permittee:
www.wvdep.org/WebApp/_dep/search/Permits/OWR/OWRPmtsearchpage.cfm?office=OWR

There are also search tools for coal mining permits:
www.wvdep.org/WebApp/_dep/search/Permits/Omr/Permitsearchpage.cfm?office=OMR

And for coal-related water pollution discharge permits:
www.wvdep.org/WebApp/_dep/search/Permits/HPU/HPUPmtsearchpage.cfm?office=HPU

The TMDL document for the Upper Monongahela, watershed outlines pollutant reductions needed in Deckers Creek:
www.wvdep.org/alt.cfm?asid=46

WVDEP lists impaired waters, including several in the Deckers Creek watershed:
www.wvdep.org/item.cfm?ssid=11&ss1id=720

Jason Stewart and Jeff Skousen published a peer-reviewed article on long-term changes in Deckers Creek:
www.wvu.edu/~agexten/landrec/decker25.pdf

Those wishing to sponsor a sampling site in the Clean Creek Program should contact FODC using the information on Page iii.

Sampling sites

The 13 Clean Creek Program sites were chosen according to several criteria. The sites document the changes in the creek up- and downstream from sources with major effects on the water quality in the creek. For example, a comparison of the results from Dellslow and Sabraton illustrate the effect of the Richard mine. Second, sites where people encounter the creek, especially on the Deckers Creek Trail, were prized. Finally, tributary sites were chosen based on their potential for holding fish at times when water quality drops in the mainstem of Deckers, as well as for their effects on the mainstem.

Deckers Creek at Valley Crossing (Photo 1). This site is representative of the lower reaches of Deckers Creek, where its waters are not far from the Monongahela River. Users of the rail-trail frequently mention seeing large fish in this segment of the creek. A USGS gauging station at this site records water height and posts it to the Web at half-hour intervals (Box 4). When it rains, a combined sewer overflow discharges to Deckers Creek in this stretch, and often provides a dramatic demonstration of bacterial sources that enter Deckers Creek in its lowest three miles. Data from this site also reveal what the creek contributes to the Monongahela River.

Aarons Creek at the mouth (Photo 2): Aarons Creek generally has water with low pollutant concentrations, and benthic macroinvertebrate and fish communities indicating good water quality. There is some evidience of sediment problems at this site, however. Sediments are often embedded in sand, eliminating some of the interstitial spaces for invertebrate communities, and probably indicating poorly controlled construction practices or collapsing banks upstream. This site is an index of the care with which the land along the northern part of Greenbag Road is being developed.

Deckers Creek in Sabraton (Photo 3): This site represents a long segment of the creek that is degraded by the water from the abandoned Richard mine. Water at this site is often red, sometimes green, and almost always turbid. Metals coming out of a dissolved form and turning into solid particles account

Photo 1: Deckers Creek at Valley Crossing. Gray, upright cylinder at left is USGS gauge. Rail-trail fence is in the background.

Photo 2: Aarons Creek next to Greenbag Road near its confluence with Deckers Creek. A pool at the bend in the creek in this picture holds the most diverse group of fish in the watershed.

Photo 3: Deckers Creek in Sabraton, just upstream from the rail-trail bridge. Iron from the Richard mine colors the creek most when streamflow is low.

Photo 4: Deckers Creek under the Dellslow bridge. This area below the steep terrain of the gorge but above the Richard mine holds the richest fish community in the mainstem.

Photo 5: Tibbs Run just downstream from the lower bridge on Tyrone Road

Photo 6: Rapids just upstream from Blue Hole in the gorge segment of Deckers Creek

Photo 7: Deckers Creek at the County Line. It flows out of Preston and into Monongalia County

Photo 8: Deckers Creek looking upstream from Masontown. The rock pile appeared in late 2002 or early 2003, and is diverting water to the the bank on the right of the photograph.

for much of this turbidity. FODC hopes that those crossing the creek on the rail-trail at this site will witness improvement in the creek rapidly, once the problem of the Richard mine is solved.

Deckers Creek at the Dellslow Bridge (Photo 4): This site is usually one of the best sites for fish in the watershed. The creek at this point is large enough to hold a sizable community of sizable fish. It is cool and aerated after passing through a long, steep, rocky gorge. Its water is also well buffered after passing an area with limestone bedrock, limestone mines, and no AMD. Large boulders and exposed bedrock make pools and riffles, providing the “structure” important for fish habitat.

Tibbs Run at the crossing of Tyrone Road (Photo 5): Tibbs Run flows into Deckers Creek just upstream from Dellslow. It is one of the four largest tributaries of Deckers, but it is also important as a possible fish refuge when occasional surges of acidic water come down Deckers Creek past Pioneer Rocks. It is not a spacious refuge, however. It is steep and rocky, and there are a number of small falls in its first quarter mile. It sometimes carries large loads of bacteria from residential areas.

The Deckers Creek Gorge (Photo 6): This site was chosen as the hallmark site of the Deckers Creek at its wildest. The segment is of special interest to anglers because it physically resembles trout habitat, even though the creek gets too warm to sustain reproducing trout populations. This gorge section has a gradient of 200 feet in 0.7 mile. The creek itself winds past and pours over car- to house-sized rocks and bedrock ledges.

Deckers Creek at the Monongalia/Preston County Line (Photo 7): This site shares many of the physical characteristics of the site in the gorge. It differs in that the water at this point has not passed the limestone mines. This area is thus more likely to experience episodes of acidic or metal-laden water. The streambed is dominated by softball- to car-sized rocks rather than the larger rocks in the lower gorge.

Deckers Creek at Masontown (Photo 8): This segment occurs at the downstream end of a calm, three-mile wooded segment. It is also at a parking area for the rail-trail. The field at this site is a large reclaimed area. A layer of coal spoil is visible where Deckers Creek has eroded the bank over the last few years. Sediment in the water just upstream from Masontown makes a reddish cloudiness when disturbed, suggesting decades of metal deposition. At Masontown the slope and current pick up, and gravel and pebbles cover the streambed.

Figure 7: Deckers Creek and major tributaries with distance to mouth noted for monitoring locations. Distances are used in x-axis of many of the following water quality graphs.

Dillan Creek at Burke Road (Photo 9): Dillan Creek is a large tributary with severe AMD in its upper reaches. Its acidity is neutralized, however, before it reaches Deckers Creek. We monitor in a channelized section next to Burke Road.

Deckers Creek at Kingwood Pike (Photo 10): This site represents the channelized, low-gradient portions of Deckers Creek after it has received the input of one heavily impacted AMD stream, Kanes Creek. The streambed there is mostly sandy, but there is usually soft mud at the edge of the stream.

Kanes Creek at Route 92 (Photo 11): The Kanes Creek watershed contains a large number of AMD sources. It is the watershed with the most remediation targets in the Deckers Creek watershed. This stream extends the Deckers Creek watershed to within about three miles of Kingwood. The ridges where it rises also hold the origins of Greens Run and Morgan Run of the Cheat River, and Squires Creek of Threeforks Creek, all of which are polluted by AMD.

Deckers Creek at the airstrip (Photo 12): Although it is marked on the USGS 7.5 minute topographical map, there is no airstrip at this site now. The stream at this site is physically similar to Deckers Creek at Kingwood Pike. It is channelized and has a sandy bottom. Water quality is usually better at this site than at the Kingwood Pike because it is upstream from Kanes Creek, a source of AMD.

Deckers Creek near Zinn Chapel (Photo 13): This site represents the headwaters of Deckers Creek and its tributaries, which rise on sandstone ridges and carry water from soils with little capacity to buffer either AMD or acid rain. The water in this stream indicates mild acidification. There is one abandoned mine land site upstream where drainage has been documented.

In many of the graphs that follow, the mainstem sites have been arranged according to distance from the mouth of Deckers Creek (Figure 7). Graphs show the change in the water quality from the highest elevation site, Deckers near Zinn Chapel (20 miles from the mouth), to Valley Crossing (one mile from the mouth).

Sampling periods

This report summarizes the Clean Creek Program dataset according to calendar years. In 2005, our physical and chemical sampling seasons extended from February 25 to March 18 for winter, from June 9 to 10 for spring, from August 1 to 5 for summer, and from November 17 to 18 for fall.

Photo 9: Dillan Creek, just upstream from Burke Road

Photo 10: OSM Summer Intern Lina Bird monitoring conditions in Deckers Creek at the Kingwood Pike

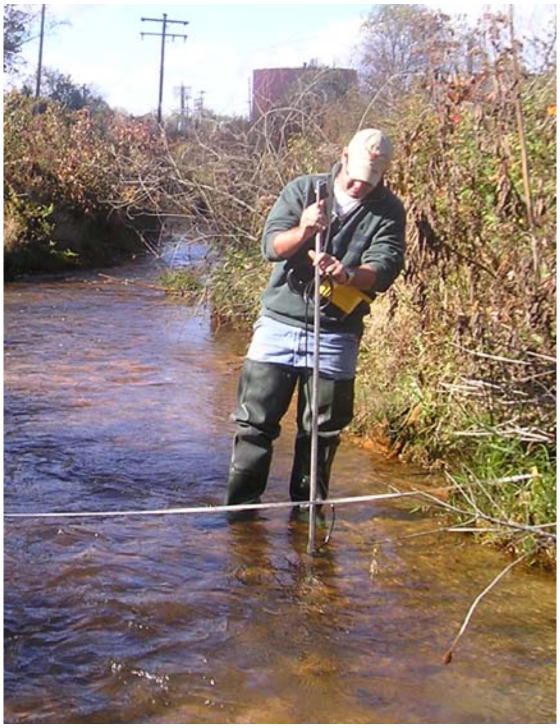


Photo 11: A volunteer makes a measurement of flow in Kanes Creek just downstream from Route 92

Photo 12: George Merovich and natural resource students from WVU prepare to survey the fish community at the Reedsville airstrip.

Photo 13: Deckers Creek near Zinn Chapel: Rocks at lower right come from a causeway for trucks servicing natural gas wells.

Specific methods

Quarterly physical and chemical sampling at the 13 sites included the measurements in Box 5.

FODC obtained a scientific collecting permit from the West Virginia Division of Natural Resources for benthic macroinvertebrate and fish community surveys. We sampled benthic invertebrates using the Save Our Streams (SOS) method. A sampling net approximately one square yard in size was held with one edge against the stream bottom, perpendicular to the flow, and the opposite edge above the surface of the water. A second worker rubbed larger rocks and kicked through smaller sediments in an approximately one square yard area upstream of the net. The workers transferred benthic macroinvertebrates and stored them in alcohol until identification in the FODC office. Stream scores were calculated from the numbers and kinds of organisms using spreadsheets provided by the WVDEP (WVDEP, 2005).

Fish were surveyed using a backpack shocker, a device which sends pulses of electrical current through the water. The pulses stun the fish, allowing them to be collected, identified, weighed, measured, and returned to the stream. Survey lengths ranged from 48 to 185 meters.

Box 5: Field and laboratory methods used in the Clean Creek Program

Field measurements

pH: Field pH was measured with a handheld pH meter with a glass combination electrode.

Conductivity: Field measurements of specific conductance were made with a handheld conductivity meter (Oakton Con 100).

Dissolved oxygen (DO): DO was measured using a Hach Sension 6 portable oxygen meter.

Flow: Measurements of flow were taken at 10 to 15 locations on a transect across the stream. At each location, water velocity was measured with a Rickly "Pygmy" flow meter. Meter malfunctions prevented many of the flow measurements.

Laboratory analyses

Total iron, aluminum and manganese: These metals were measured by atomic absorption spectro-photometry.

Hot acidity: Hot acidity was measured by adding base (titrating) until the solution reached a certain, slightly alkaline pH. The sample was treated with hydrogen peroxide first to convert any iron and manganese to forms which could be titrated.

Alkalinity: Alkalinity was measured by adding acid (titrating) until the solution reached a certain, slightly acidic, endpoint.

Sulfate: The water sample was mixed with chemicals that make sulfate come out of solution as a fine powder. Sulfate concentration was measured as the turbidity of that powder.

Fecal coliform bacteria: Bacteria were enumerated by diluting the sample many times, and determining which dilutions still contained enough bacteria to establish new colonies in new media.

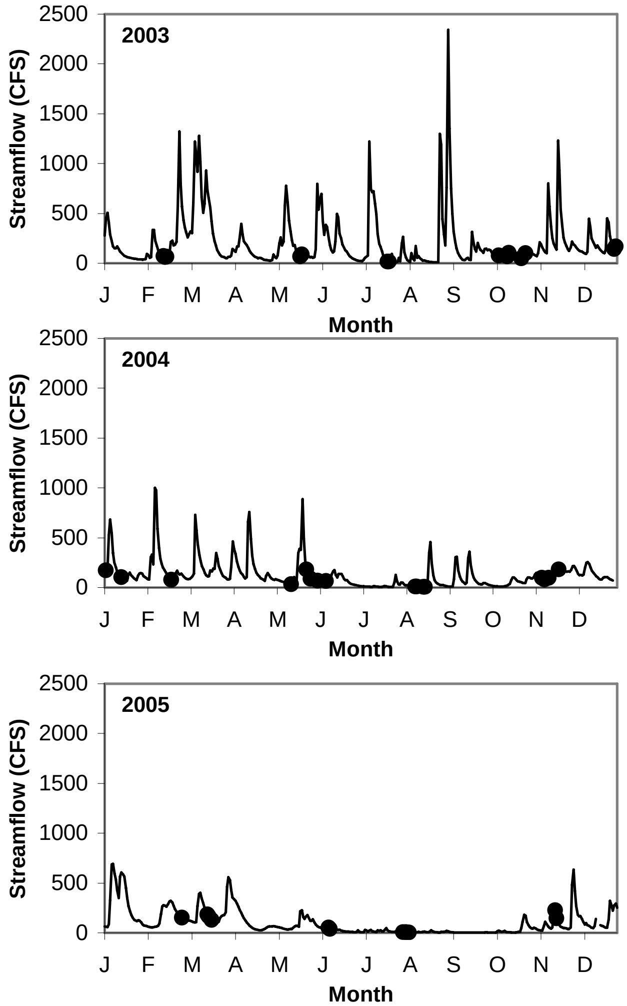


Figure 8: Daily flow for Deckers Creek measured near Valley Crossing. Black circles indicate flows at that site when sampling took place.

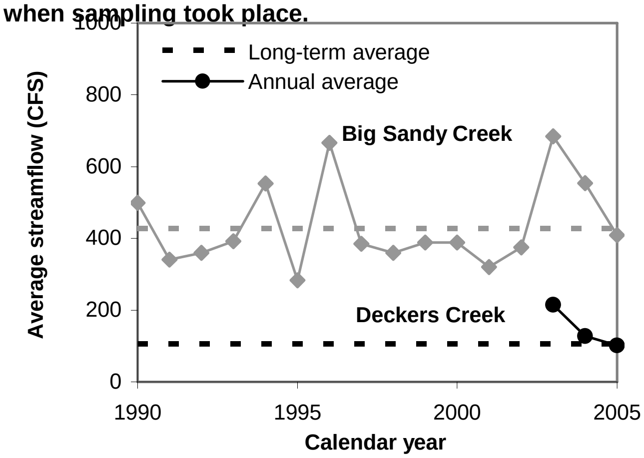


Figure 9: Average streamflow for recent calendar years on Deckers and Big Sandy Creeks

RESULTS

Hydrology

To understand the water quality in the creek, one must understand how much water is going by. Measurements of flow in conjunction with measurements of pollutant concentrations are necessary for calculating the amount of a pollutant passing a particular point in the stream during a period of time. This amount is known as the pollutant load. Pollutant loads are obtained by multiplying the concentration of a pollutant (usually measured in milligrams per liter) by the water flow (usually measured in gallons per minute, which can be converted to liters per second). If a pollution source contributes a pollutant load to a segment that is similar to the load in the entire segment, then eliminating that one source may solve the segment's pollution problems.

Flow measurements are made with most of the observations for the Clean Creek Program. These measurements require wading across the creek and making 10 to 15 water velocity measurements. At peak flows, this task becomes difficult or dangerous.

The USGS maintains a stream-height gauge on Deckers Creek at the bottom of Kingwood Street in Morgantown, near the Valley Crossing site. This gauge records stream height every half hour, and electronically conveys the value to USGS, which publishes it on the Web (Box 4).

Figure 8 compares streamflow during the three Clean Creek Program years with streamflow on sampling dates. The y-axis represents the average flow measured at Valley Crossing on that day. Sampling occurred mostly at relatively low flows. This may because some pollutants reach their highest concentrations when it rains.

The hydrological data can also be used to understand longer term changes in streamflow. USGS did not operate the Deckers Creek stream gauge between 1969 and 2002. A stream gauge on Big Sandy Creek, however, a nearby tributary of the Cheat River, indicates the regional patterns of high and low flows over the last 15 years (Figure 9). The five years before the Clean Creek Program started had average to below average streamflow. 2003 had extremely high streamflow. The transition from low to high flows probably affected water quality in Deckers and in other creeks. 2004 and 2005 have had average flows closer to the long-term average.

Temperature

Water temperature is an extremely important measurement. It helps determine what fish communities might inhabit a stream if it were not polluted. Reproducing native trout populations, for example, are seldom found in waters where the temperature climbs above 18.3°C or 65°F (PFBC, 2006).

FODC has placed temperature loggers at two sites: one in Masontown at the top of the gorge, and one in Dellslow at the bottom. In 2005, temperatures at both sites exceeded 20ºC. During the warmer months, temperatures in Dellslow were slightly lower than those in Masontown (Figure 10).

At both sites, the average temperatures during July, the hottest month, were slightly higher in 2005 than in 2004. The average July temperature rose from 20.2 to 21.5ºC in Dellslow, and from 22 to 23.1ºC in Masontown

Water quality in the mainstem

Chemical measurements confirm that AMD harms the life of the creek. Its signature, however, is complex. AMD has differing effects on the water quality in Deckers Creek in different segments and in different times.

On average, Deckers Creek has a pH close to or greater than 6 through most of its length (Figure 11). At certain times, however, readings fall below 6. In the Clean Creek Program dataset, seven of the nine sampling sites on the mainstem have given at least one pH value below 6. These values indicate that water is becoming too acidic to support rich aquatic life.

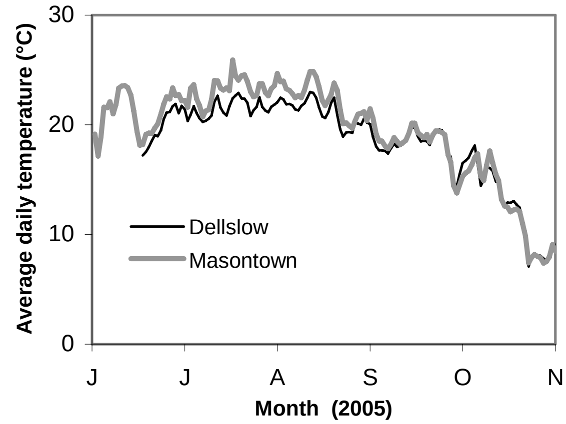


Figure 10: Temperature in Deckers Creek at the top (Masontown) and bottom (Dellslow) of the gorge in 2005.

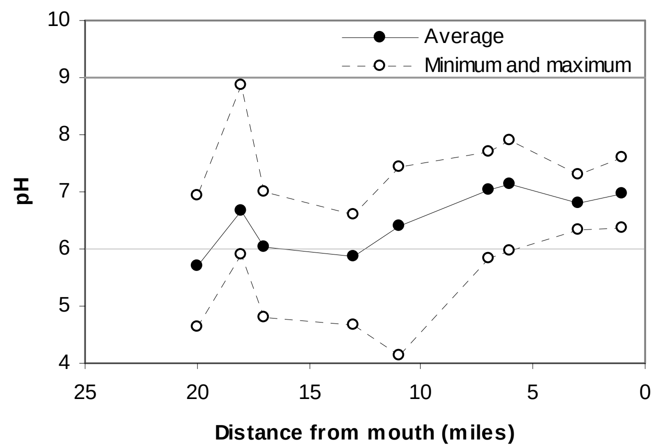


Figure 11: Average, minimum and maximum pH values measured at mainstem sampling sites from October 2002 to December 2005

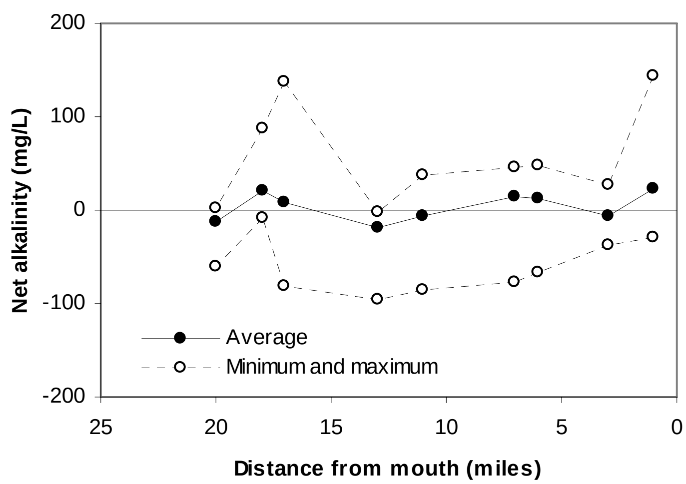


Figure 12: Average, minimum and maximum net alkalinity concentrations in the mainstem of Deckers Creek from October 2002 to September 2004

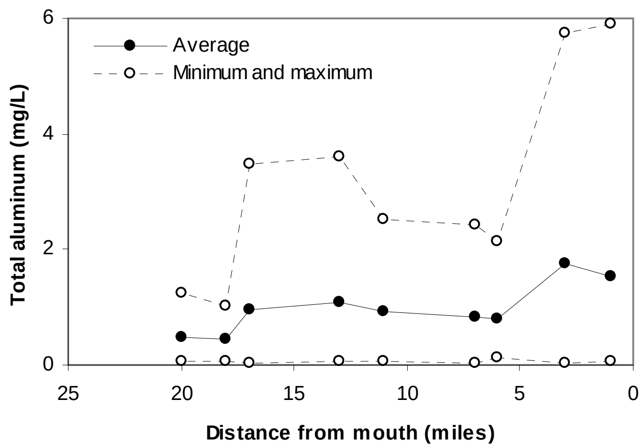


Figure 13: Average, minimum and maximum aluminum concentrations in the mainstem of Deckers Creek

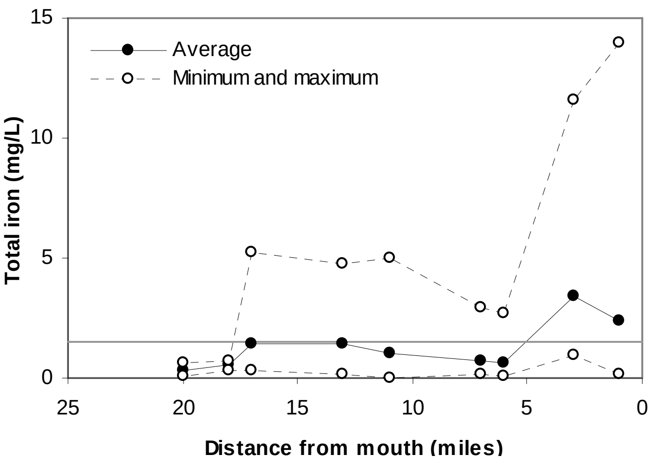


Figure 14: Average, minimum and maximum iron concentrations in the mainstem of Deckers Creek, compared to the water quality standard (dotted line)

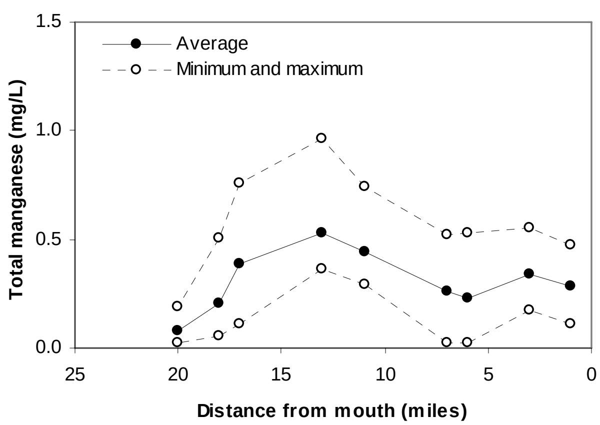


Figure 15: Average, minimum and maximum manganese concentrations in the mainstem of Deckers Creek

The lowest pH values have been found at the County Line, downstream of all the AMD sources in Valley District, but upstream of the limestone mines. Although the Clean Creek Program sampling program has not detected it, pH in Sabraton and Morgantown may also fall below 6 at very low flows. Samples taken at CarpFest (late summer and early fall) have had pH values less than 5, which are the lowest values for the segment below Richard in any year.

Although pH values are, on average, less than 7, the creek often maintains some alkalinity (Figure 12). Net alkalinity in the creek is, on average, very close to 0 mg/L as $CaCO_3$.

Concentrations of metals also indicate that areas with pH values consistently above 6 are not free of AMD. Concentrations of aluminum and iron increase, on average, in two regions of the creek: just below Kanes Creek, and just below the Richard mine (Figure 13 and Figure 14). Concentrations of manganese have remained below 1 mg/L during the Clean Creek Program sampling periods, even in the most AMD-impacted areas (Figure 15). The pattern in the concentration of this metal differs from that of other metals in that manganese reaches its highest concentration in the upper part of the watershed, rather than below the Richard mine.

Sulfate is another chemical that is added to streams by AMD (Box 2). The role of AMD in polluting the creek is confirmed by sulfate concentrations, which also spike downstream from Kanes Creek and from the Richard mine (Figure 16).

Fecal coliform bacteria also occur in Deckers Creek. In the three years of the Clean Creek Program, however, concentrations at sampling times have seldom exceeded 400 cfu/100 mL, which is the level that raises concern about a rarely-sampled body of water, according to the WVDEP (Figure 17). Bacteria in Deckers Creek may come from homes and businesses with inadequate sewage treatment, from sewer overflows during rainy periods, or from wildlife or livestock.

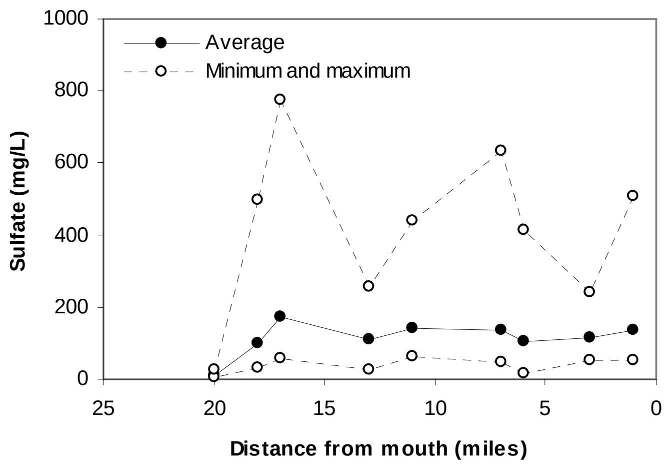


Figure 16: Average, minimum and maximum sulfate concentrations in the mainstem of Deckers Creek

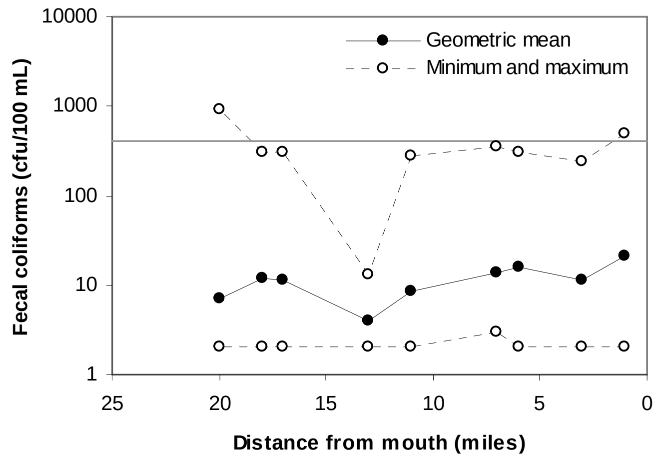


Figure 17: Geometric mean, minimum and maximum fecal coliform counts in the mainstem of Deckers Creek, compared with the water quality standard

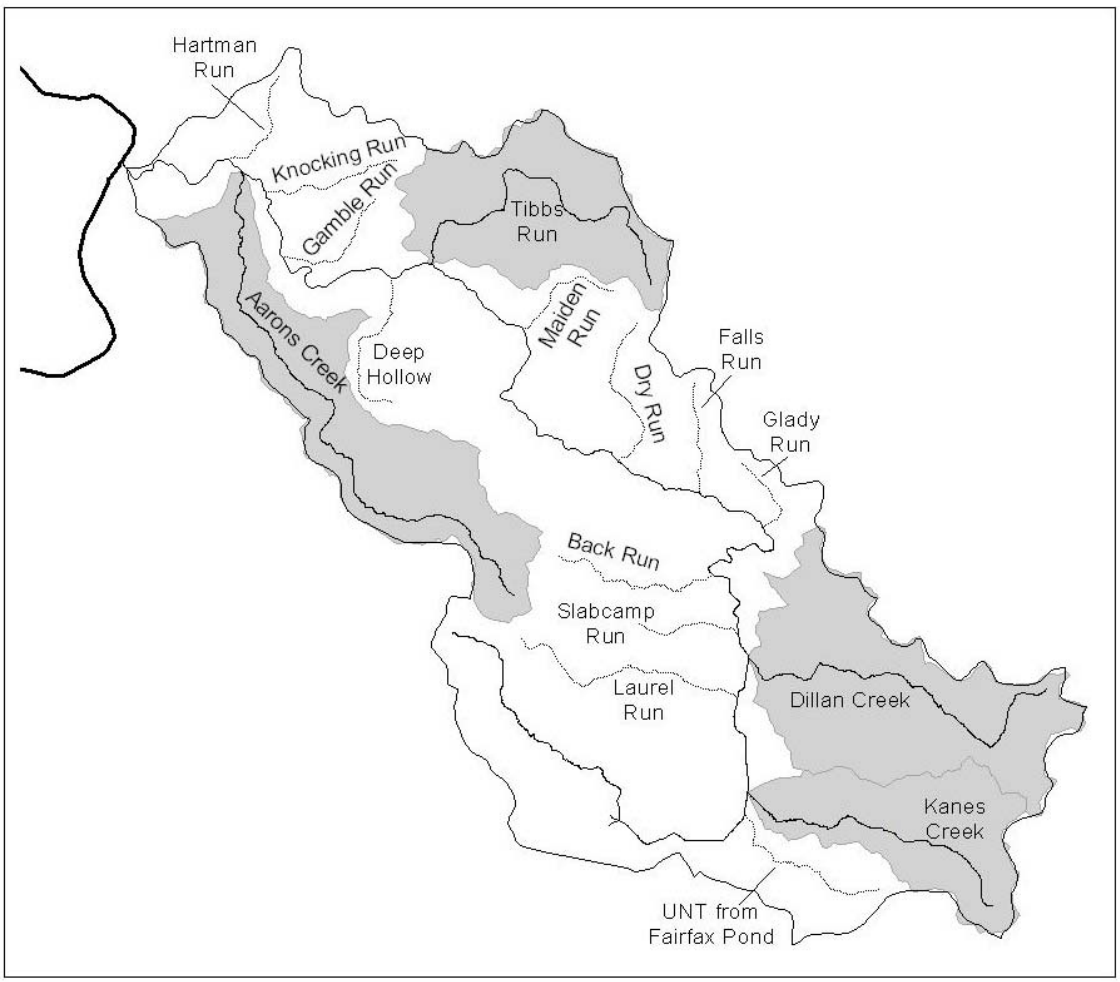


Figure 18: Tributaries of Deckers Creek. Gray watersheds are those with monitoring sites.

Box 6: Tributaries to Deckers Creek. Numbers in parentheses indicate the distance from the mouth of each tributary to the mouth of Deckers Creek.

Hartman Run (1.9) Often acidic from abandoned Pittsburgh seam mines

Aarons Creek (2.2) Large tributary with little AMD, some high bacteria counts

Knocking Run (2.7) Little AMD, some high bacteria counts

Gamble Run (3.6) Little AMD, some high bacteria counts

UNT from Deep Hollow (5.7) Carries AMD, but not enough to degrade Deckers Creek

Tibbs Run (6.3) Some AMD, some high bacteria counts

Maiden Run (7.8) Little data, probably mildly acidic from acid precipitation

Dry Run (11) Little data, usually good water quality

Falls Run (12.2) Not acidic but high conductivity. Greer maintains facilities in this watershed.

Glady Run (13.2) Acidic tributary from a heavily mined watershed

Back Run (14.9) Good water that feeds an impoundment supplying water to Masontown

Slabcamp Run (15.9) Small stream, severely polluted with AMD

Dillan Creek (16.3) Severely degraded by AMD in its headwaters, but more or less neutralized by its own tributaries

Laurel Run (16.8) Impaired by AMD at its mouth, and possibly a large source to Deckers. Upstream portions probably impaired by acid precipitation.

UNT from Zinn Chapel (17.3) Impaired by AMD in headwaters, but neutral at its mouth

Kanes Creek (18.2) Severely impaired by AMD, although water at mouth is sometimes neutral due to the Morgan Mine treatment plant

UNT from Fairfax Pond (18.5) Not acidic, although manganese loads may come from abandoned mines. Water contains lead from foundry waste used as fill in the watershed.

Water quality in the tributaries

Some of Deckers Creek's tributaries are its worst problems, while others are the safest places for fish to stay when water quality in the mainstem goes bad (Box 6). The Clean Creek Program monitors the four largest tributaries to Deckers Creek, and may expand to more in the future.

Dillan Creek drains 11.8% of the Deckers Creek watershed, the largest fraction of any tributary. Aarons Creek, which drains 11.3% of the watershed, is only slightly smaller. Tibbs Run and Kanes Creek drain 8.5 and 6.8% of the Deckers Creek watershed, respectively (Figure 18).

Aarons Creek is similar to Deckers Creek in that it has eroded a gorge through the anticline in the middle of the watershed (Figure 3). It differs in that none of the low area to the southeast of the ridge drains to it. Deckers is therefore much larger. It also encounters the Upper Freeport coal seam in its upper reaches, while Aarons Creek does not. The lowest reaches of this tributary, however, are undergoing extensive development, which may harm the creek through changes in the stormwater and sediment regimes. The flat land in the lower reaches of Aarons Creek also supports a small amount of cattle farming.

Tibbs Run also has its origins on the Chestnut Ridge anticline. Unlike Aarons Creek, it joins the mainstem of Deckers on the edge of the ridge, and is steep and rocky for most of its length. A number of housing developments have been built in this subwatershed.

Dillan Creek flows towards Deckers Creek from the ridge that separates the Cheat River and Deckers Creek watersheds. Much of its watershed is forested, but pastureland occupies its northernmost corner, and Reedsville is growing along its southwestern edge. Upper Freeport and Bakerstown coal have been mined from this watershed. A number of mine portals were established in the valley that Dillan Creek cut.

Kanes Creek is dominated by woodland and abandoned mine sites, with some residential development along the major roads, especially Route 7. Like Dillan Creek, underground mines flank Kanes Creek, which eroded a valley through the Upper Freeport seam.

Water quality measurements are consistent with the settings of these tributaries. Aarons Creek has the highest pH and net alkalinity values, while Kanes Creek has the lowest (Figure 19 and Figure 20). Tibbs Run has higher pH values but lower net alkalinity than Dillan Creek. Ordinarily, water with a higher pH would be expected to carry more alkalinity, but these two creeks do not show the expected relationship. Dillan Creek contains substantial levels of sulfate, while Tibbs Run contains very little. The presence of higher concentrations of solutes, especially sulfate, in Dillan Creek is consistent with its impairment by AMD in its upper reaches: the AMD adds the sulfate, but the acidity is neutralized by tributaries. One of the tributaries, Swamp Run, contains carefully reclaimed mines of Bakersfield coal. This coal seam is overlain by a geologic layer containing abundant limestone, and the high alkalinity in Swamp Run probably comes from those reclaimed mines.

Among the metals, concentrations of aluminum and iron are much greater in Kanes Creek, as expected (Figure 21 and Figure 22). Manganese concentrations do not exceed 1 mg/L at any site (Figure 24). They are highest in Kanes Creek, the tributary most impaired by AMD. Patterns of sulfate concentrations also indicate that Kanes Creek carries AMD (Figure 23)

During the time of this study, only Tibbs Run violated the 400 cfu/100 mL level, indicating impairment by fecal coliform bacteria (Figure 25). Aarons Creek, however, had a higher average geometric mean concentration: 92 cfu/100 mL. Because fecal coliform levels depend so much on the weather near the sampling time, the behaviors of the tributaries is difficult to interpret. The AMD-impaired tributary, Kanes Creek, always had very low bacteria counts.

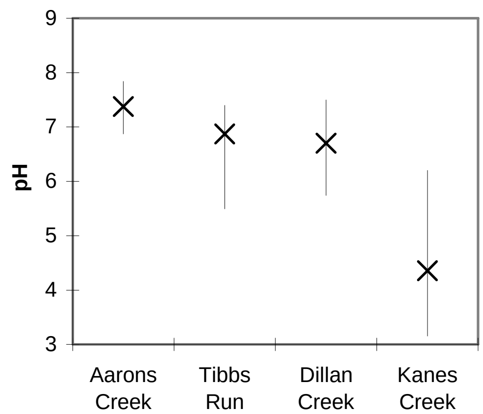


Figure 19: Average, minimum and maximum pH values in four tributaries from October, 2002 to September, 2004, for Aarons Creek and Tibbs Run, and from October 2003 to September 2004 for Dillan and Kanes Creeks

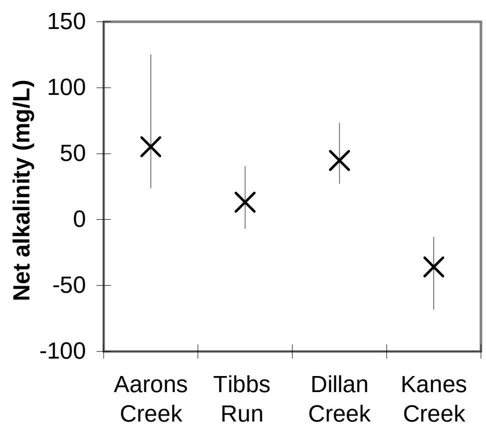


Figure 20: Average, minimum and maximum net alkalinity in tributaries

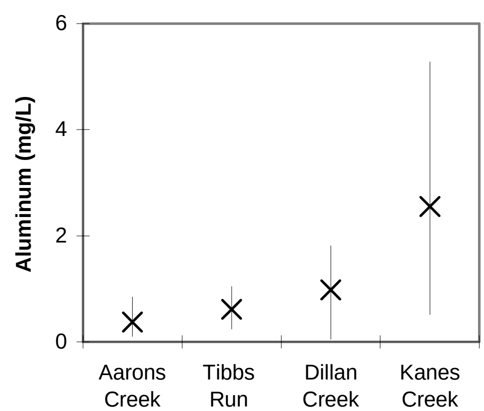


Figure 21: Average, minimum and maximum aluminum concentrations in tributaries

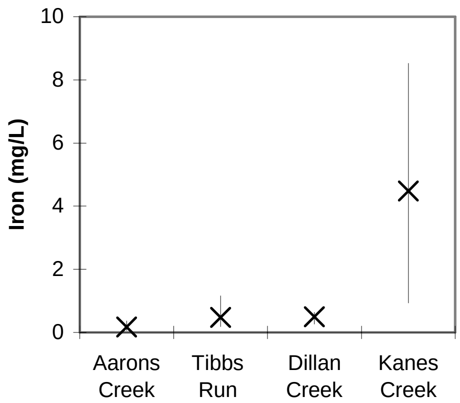


Figure 22: Average, minimum and maximum iron concentrations in tributaries

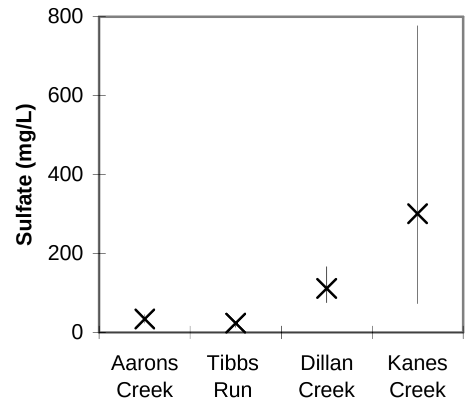


Figure 23: Average, minimum and maximum sulfate concentrations in tributaries

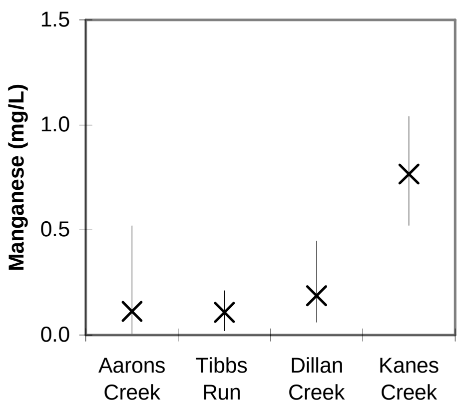


Figure 24: Average, minimum and maximum manganese concentrations in tributaries

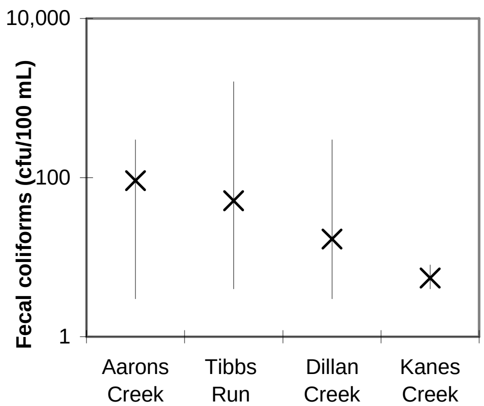


Figure 25: Geometric mean, minimum and maximum fecal coliform counts in tributaries

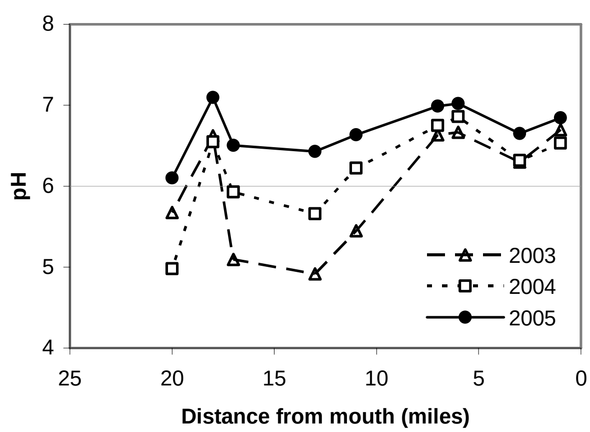


Figure 26: Comparison of average pH values in the mainstem for the three monitoring years

Changes from year to year

Water quality in Deckers Creek was better in 2005 than in 2003 and 2004. Average pH values were greater than the state criterion minimum level of 6 at all sampling sites (Figure 26). Net alkalinity was higher at all sites except Valley Crossing (Figure 27).

Aluminum (Figure 28), iron (Figure 29) and manganese (not shown) concentrations are generally lower in 2005 than in 2003 or 2004. Iron concentrations exceeded the standard in Valley District (at Kingwood Pike, Masontown and the County Line) in 2003, but have stayed below that level in 2004 and 2005. The Richard mine, however, caused iron concentrations in Sabraton to violate the criterion in all three years. The patterns of sulfate concentrations, which has no water quality standard, indicate less pollution in the Preston County portion of Deckers Creek in 2005, but an unexplained increase in sulfate concentrations in Morgantown (Figure 30).

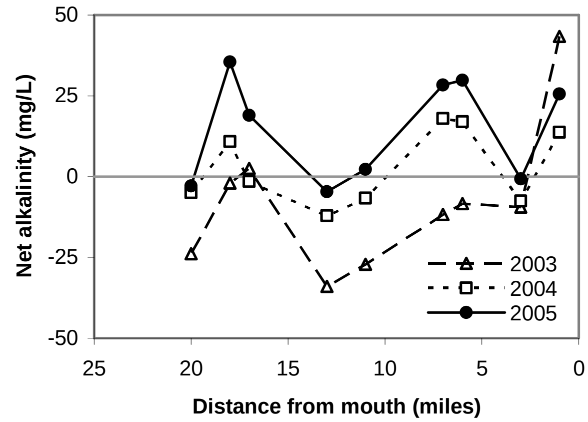


Figure 27: Average mainstem alkalinity concentrations in the three monitoring years. Alkalinity levels below zero support few fish species.

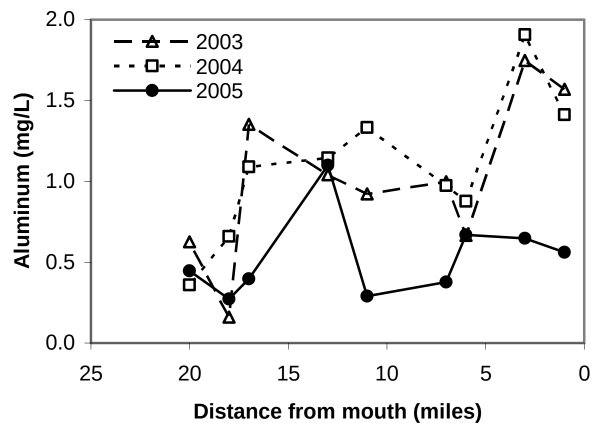


Figure 28: Average aluminum concentrations in mainstem in each monitoring year

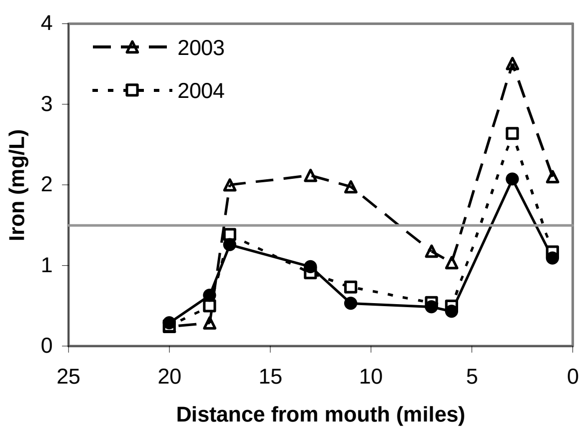


Figure 29: Average iron concentrations in mainstem in each monitoring year, compared to the water quality standard for total iron

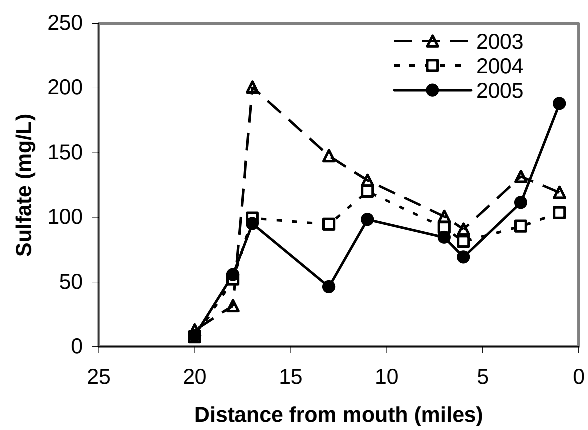


Figure 30: Average sulfate concentrations in the mainstem in each monitoring year

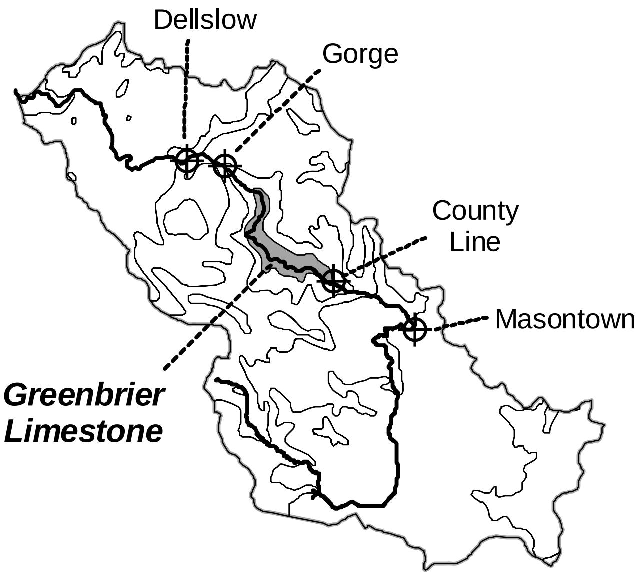


Figure 31: Geological formations, especially the Greenbrier Limestone formation in the Deckers Creek watershed, along with monitoring points just up- and downstream from the area with limestone bedrock

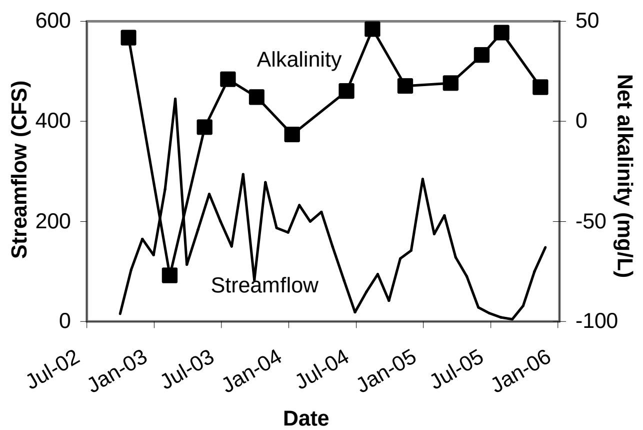


Figure 32: Streamflow (averaged by month) and alkalinity measured in the gorge segment throughout the study period

Relating streamflow and chemistry

The Clean Creek Program started at the end of a few relatively dry years (Figure 9). The increase in flows that began in November 2002 took place at the same time as some dramatic changes in water quality. Those changes have some important implications for plans to neutralize acidity in the creek.

As Deckers Creek flows past the section of the gorge with limestone bedrock (Figure 31), including the limestone mines, it increases in alkalinity. According to the average values in our three-year dataset, the water changes from net acidic to net alkaline in this region (Figure 12). The limestone improves the water and protects the biological communities found downstream.

The behavior of the water following the increase in flow late in 2002, however, indicates that this protection is delicate. Figure 32 compares streamflow patterns over more than three years with measurements of net alkalinity in the gorge.

High flows in December 2002 through March 2003 occur at the same time as and probably caused a large drop in net alkalinity not only in the upper watershed, but through the gorge and even past the limestone bedrock area. In fact, there was a large decline in the fish population between fall 2002 and fall 2003 (see below).

The average data confirm that the limestone in the Deckers Creek watershed improves the creek and offers some protection from AMD. The protection, however, is inadequate during the more powerful swings in water quality.

Benthic macroinvertebrates

Benthic invertebrates, creatures that live in the sediments at the bottom of the stream, are good indicators of stream water quality. If the water is good, there will be many individual organisms, many different kinds of organisms, and certain sensitive organisms that only survive in relatively good water. In water of poor quality, there will be fewer organisms, fewer kinds, and no sensitive species.

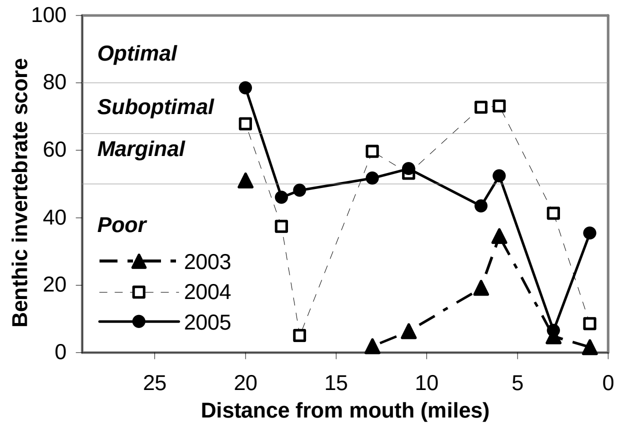


Figure 33: Benthic invertebrate community scores for the mainstem of Deckers Creek in each year

WVDEP has provided watershed groups several ways of integrating the information about different organisms and their numbers into scores that reflect water quality. More than 100 organisms must be found, however, in order for these scores to indicate water quality accurately. The accompanying graphs present scores that were calculated using a WVDEP spreadsheet, but those scores were multiplied by a factor that discounts the score for samples with less than 100 individuals. The factor is the number in the sample divided by 100. While this method may not be comparable with other indices of water quality, it indicates accurately the portions of the creek where low numbers mean low quality water.

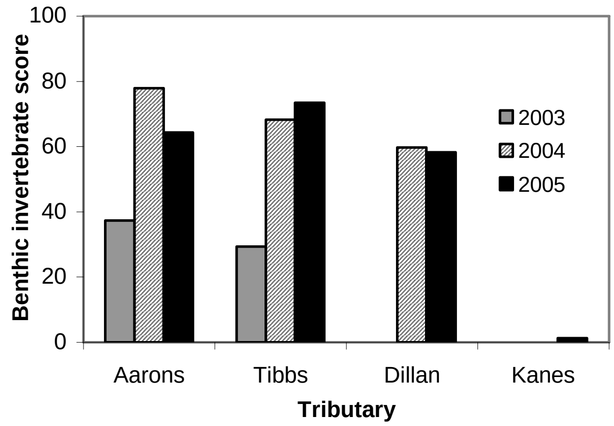


Figure 34: Benthic invertebrate scores in tributaries. Dillan and Kanes Creeks were not sampled in 2003.

Water quality in the mainstem of Deckers Creek is poor to suboptimal (Figure 33). The Zinn Chapel site at mile 20 has good water, but the quality drops as Deckers passes Kanes Creek and flows to Masontown. Past Masontown, there is some improvement in the gorge, especially below the limestone mines at Greer (mile 10). The gains are lost as Deckers passes the Richard mine between Dellslow and Sabraton.

Water quality has improved dramatically since 2003. Low numbers of organisms from Masontown to Dellslow suggested a very poor stream in 2003. In 2004 and 2005, numbers and scores were higher. Nevertheless, these scores indicate that much of the creek supports only marginal communities.

Benthic invertebrates scores in the tributaries also improved since 2003 (Figure 34). Aarons Creek and Tibbs Run were sampled all three years and improved in the second. Both were in the suboptimal range in 2004 and 2005. Dillan Creek was not sampled in 2003, but yielded communities indicating marginal conditions in 2004 and 2005. Kanes Creek was not sampled in 2003, but no organisms were found there in 2004, and only four were found in 2005.

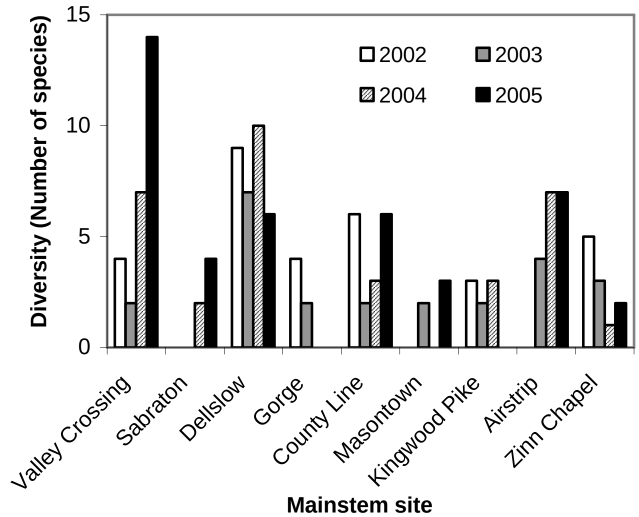


Figure 35: Numbers of fish species found at mainstem sites during annual surveys. Reedsville airstrip was not sampled in 2002.

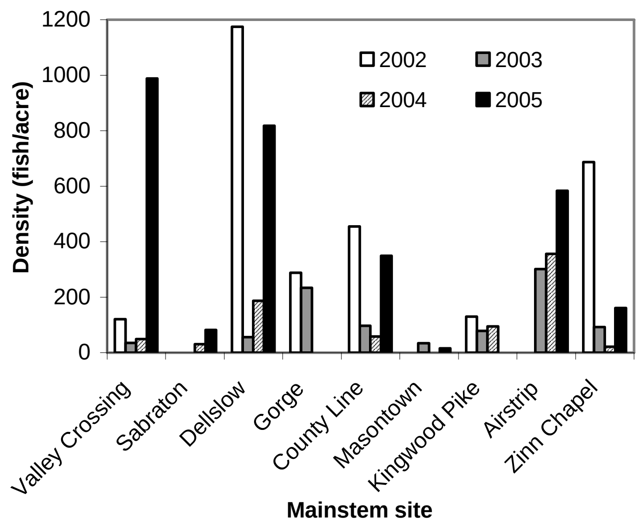


Figure 36: Numbers of individual fish found during annual surveys

Fish

Fish communities in Deckers Creek are volatile. A site that teemed with fish in one year may have only a few in the following year. Nevertheless, certain patterns appear as the data accumulate. The fish data consistently indicate which sites in the creek will not support fish. The Sabraton, Masontown and Kingwood Pike sites consistently contain the smallest, least diverse communities.

We quantified diversity using the number of fish species present (Figure 35). Fish species disappear as conditions worsen, but they may be regained as new fish enter a site. Proximity to the Monongahela River, a river with improving water quality and its own diverse array of fish, explains the wide changes in diversity at the Valley Crossing site. Water at this site is often extremely polluted, and iron precipitates can coat every surface (see front cover). Yet when pollution is more moderate, fish readily swim in from the river. Many of the species that appear and disappear from this site are small minnow species common to larger rivers (Table 1). In contrast, the species that occur at Dellslow change little from year to year.

The effect of the wide swings in water quality and of the proximity of the Monongahela River is even more pronounced for numbers of fish per acre (Figure 36). In 2003 only 35 fish occurred in an acre of stream near Valley Crossing. In 2005, that number jumped to 988. Numbers at other sites, notably in Dellslow, have also increased dramatically over this period.

The number of larger fish that might be caught with fishing tackle is an index of how much that site can support fishing. Figure 37 depicts the numbers of fish longer than 6" per acre at each of the mainstem sites. In 2004 and 2005, Deckers Creek next to the Reedsville Airstrip has been the most fishable site. This site, which is just upstream from Kanes Creek, contrasts with Deckers Creek at the Kingwood Pike, where no large fish has yet been found.

Fish communities may also be assessed using biomass, or the total weight of all the fish in a certain area. Biomass numbers identify the two most productive sites in the watershed: Dellslow and the Reedsville Airstrip (Figure 38Figure 38). The Zinn Chapel site yielded fish >10" in length during the first two years of the program, but has since yielded only small numbers of creek chub.

Table 1 records the fish species that were found at each site in the mainstem in each monitoring year. Table 2 records fish species found in the tributaries.

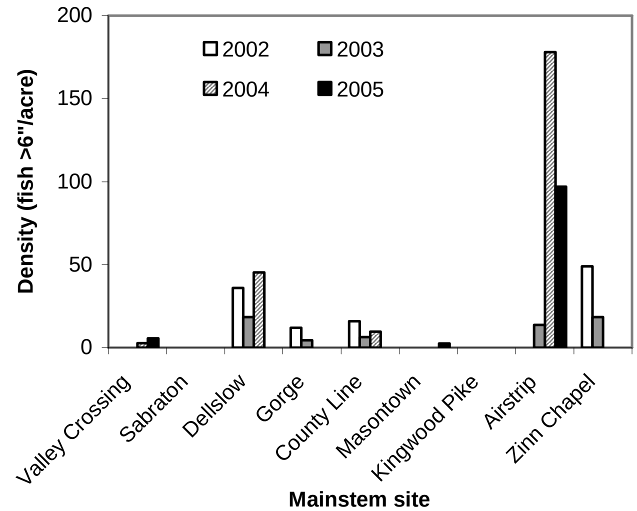


Figure 37: Numbers of large fish in each annual survey

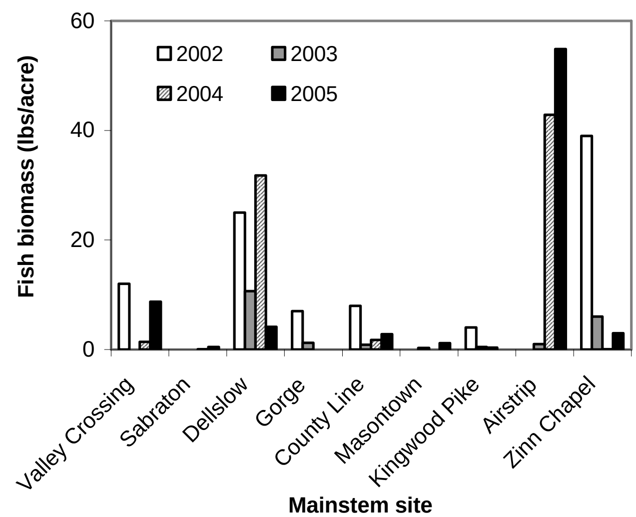


Figure 38: Total weights of fish caught at each site during each annual survey

Table 1: Fish species found in the mainstem of Deckers Creek. Shaded cells indicate a site was not sampled in that year.

Common name	Scientific name	Valley Crossing				Sabraton				Dellslow				Gorge				County Line				Mason-town				Kingwood Pike				Reedsville Airstrip				Zinn Chapel			
		02	03	04	05	02	03	04	05	02	03	04	05	02	03	04	05	02	03	04	05	02	03	04	05	02	03	04	05	02	03	04	05	02	03	04	05
Blacknose dace	*Rhinichthus atratulus*			X				X	X	X	X	X	X																								
Black bullhead	*Ameiurus melas*																			X																	
Black crappie	*Pomoxis nigromaculatus*																				X																
Blotchside logperch	*Percina burtoni*				X																																
Bluegill	*Lepomis macrochirus*									X	X	X			X			X										X				X	X	X	X		X
Bluntnose minnow	*Pimephales notatus*			X	X																																
Brown bullhead catfish	*Ameiurus nebulosus*				X																		X									X		X			
Central stoneroller	*Campostoma anomalum*			X	X				X	X			X								X												X				
Common carp	*Cyprinus carpio*										X																										
Creek chub	*Semotilus atromaculatus*		X		X			X	X	X		X	X	X	X			X	X		X				X						X	X	X	X		X	X
Fantail darter	*Etheostoma flabellare*																																				
Golden redhorse	*Moxostoma erythrum*																																				
Golden shiner	*Notemigonus crysoleucas*																	X																			
Green sunfish	*Lepomis cyanellus*	X								X	X	X	X								X					X		X					X				
Johny darter	*Etheostoma nigrum*																																				
Largemouth bass	*Micropterus salmoides*				X					X		X													X	X		X			X				X		
Least brook lamprey	*Lampetra aepyptera*																				X																
Margined madtom	*Noturus insignis*																																				
Northern hog sucker	*Hypentelium nigricans*			X							X	X																									
Pumpkin-seed	*Lepomis gibbosus*									X	X			X				X		X			X									X	X	X			
Rainbow darter	*Etheostoma caeruleum*				X																																
Redbreast sunfish	*Lepomis auritus*													X																							
River chub	*Nocomis micropogon*																																				
Rock bass	*Ambloplites rupestris*											X																									
Rosyface shiner	*Notropis rubellus*	X		X																																	
Sand shiner	*Notropis ludibundus*				X																																
Sauger	*Sander canadense*			X	X																																
Silver shiner	*Notropis photogenis*				X																																
Silverstrip shiner	*Notropis stilbius*			X																																	
Smallmouth bass	*Micropterus dolomieu*	X			X				X			X	X																			X					
Spotfin shiner	*Cyprinella spiloptera*	X	X		X							X													X												
Spotted bass	*Micropterus punctulatus*																	X															X				
White sucker	*Catostomus commersoni*				X					X	X	X	X														X				X	X					
Yellow bullhead catfish	*Ameiurus natalis*									X				X				X	X		X					X	X				X	X	X	X	X		

Table 2: Fish species found in tributaries. Shaded cells indicate a site was not sampled in that year

Common name	Scientific name	Aarons Creek				Tibbs Run				Dillan Creek				Kanes Creek			
		02	03	04	05	02	03	04	05	02	03	04	05	02	03	04	05
Blacknose dace	*Rhinichthus atratulus*			X		X	X		X								
Black bullhead	*Ameiurus melas*											X					
Black crappie	*Pomoxis nigromaculatus*																
Blotchside logperch	*Percina burtoni*																
Bluegill	*Lepomis macrochirus*	X	X	X				X	X		X	X					
Bluntnose minnow	*Pimephales notatus*			X	X												
Brown bullhead catfish	*Ameiurus nebulosus*												X				
Central stoneroller	*Campostoma anomalum*	X	X	X	X												
Common carp	*Cyprinus carpio*																
Creek chub	*Semotilus atromaculatus*	X	X		X	X	X	X	X		X		X				
Fantail darter	*Etheostoma flabellare*	X	X	X	X												
Golden Redhorse	*Moxostoma erythrum*			X													
Golden shiner	*Notemigonus crysoleucas*												X				
Green sunfish	*Lepomis cyanellus*	X							X			X	X				
Johny darter	*Etheostoma nigrum*	X		X													
Largemouth bass	*Micropterus salmoides*										X						
Least brook lamprey	*Lampetra aepyptera*	X		X													
Margined madtom	*Noturus insignis*		X														
Northern hog sucker	*Hypentelium nigricans*	X	X	X	X												
Pumpkin-seed	*Lepomis gibbosus*	X							X		X		X				
Rainbow darter	*Etheostoma caeruleum*																
Redbreast sunfish	*Lepomis auritus*																
River chub	*Nocomis micropogon*																
Rock bass	*Ambloplites rupestris*																
Rosyface shiner	*Notropis rubellus*																
Sand shiner	*Notropis ludibundus*																
Sauger	*Sander canadense*																
Silver shiner	*Notropis photogenis*																
Silverstrip shiner	*Notropis stilbius*																
Smallmouth bass	*Micropterus dolomieu*	X	X	X	X							X					
Spotfin shiner	*Cyprinella spiloptera*																
Spotted bass	*Micropterus punctulatus*	X			X								X				
White sucker	*Catostomus commersoni*	X			X						X						
Yellow bullhead catfish	*Ameiurus natalis*	X									X						

PLANS FOR REMEDIATION

The first part of FODC's mission is to improve the natural qualities of the Deckers Creek watershed. FODC's strategic plan envisions a creek that is fishable by 2010 and swimmable by 2015. While the Deckers Creek watershed is now polluted by AMD, bacteria, heavy metals, sediment and trash, FODC and the Deckers Creek Restoration Team have made the most progress toward addressing AMD. A plan is presented below. This section summarizes FODC's watershed-based plan (Christ, 2005).

AMD sources to Deckers Creek will be eliminated using both passive and active methods. This section describes the team that will bring the projects about, the funding resources to be used, and the most promising technologies.

Box 7: Reclamation funding sources

Section 319 funds – Provided by the USEPA to the WVDEP for addressing nonpoint source pollution. 319 funds are available for constructing passive AMD treatment systems on abandoned mine lands (AMLs).

AML Trust Fund – Funding made available by SMCRA. Monies are generated from a tax placed on every ton of coal mined in the U.S., and are distributed to the coal mining states to address AMD from AMLs. Funding can only be used for treatment system construction.

10% AMD Set-Aside Fund - Program allows states to reserve up to 10% of their annual AML Trust Fund as an endowment for use on water quality projects. Monies can be spent on operations and maintenance costs associated with AMD treatment systems on AML sites. Funding is very limited at this time.

Watershed Cooperative Agreement Program – Program sponsored by OSM that provides grants to watershed groups to treat AMD from AMLs.

Natural Resources Conservation Service Public Law 566 funds – Program that supports projects addressing watersheds. It requires a 50% match from a state agency.

Deckers Creek Restoration Team

In 2002, organizations and government agencies that were already planning AMD elimination projects declared the existence of the Deckers Creek Restoration Team (DCRT). This new group, which is roughly modeled on the Cheat River group "River of Promise," is a forum to discuss, plan and coordinate remediation projects for Deckers Creek. Each of the organizations involved brings a number of strengths and resources to the table. All groups take part in identifying projects, developing designs, securing funding and constructing solutions. Each organization has a number of particular strengths and many have access to funding resources (Box 7).

FODC: convenes the group and takes the lead in outreach to watershed residents about Deckers Creek and its journey toward remediation. FODC also secures Watershed Cooperative Agreement Program (WCAP) and 319 funds.

OAMLR: is the state agency responsible for solving AML problems in the state. They have access to annual disbursements from the Abandoned Mine Lands Trust Fund, and approximately 20 years experience in planning and executing projects.

The WVDEP Division of Water and Waste Management (DWWM): administers a program to eliminate nonpoint source pollution. They provide personnel with technical and project management expertise, as well as access to funding through the United States Environmental Protection Agency (USEPA), through Section 319 of the Clean Water Act.

The Natural Resources Conservation Service (NRCS): addresses a number of water pollution problems at a watershed scale. They work in the Deckers Creek watershed through the Public Law 566 program. This program requires a state sponsor with a 50% financial match. WVDEP, through OAMLR, has agreed to be that sponsor. The combination of OAMLR and NRCS is a crucial tool for remediation of Deckers Creek. NRCS is part of the United States Department of Agricuture.

The Office of Surface Mining (OSM): is charged with overseeing state programs related to reclaiming abandoned mine lands and bond forfeitures sites as well as regulating permitted mines. They also provide expertise in a number of important fields. The WCAP is a crucial tool for giving watershed groups power to initiate projects by matching other sources of funding. OSM is part of the United States Department of the Interior.

Local governments: The Monongalia and Preston County Commissions, the City Council of Morgantown, and the Town Councils of Masontown and Reedsville all have designated correspondents for the DCRT. Their participation is crucial for linking the efforts of other groups with local citizens and landowners.

Businesses: Greer Industries is also a correspondent on the DCRT, and may participate in restoring Deckers Creek as an owner of former minelands, an owner of stream bank, and as a supplier of limestone.

DCRT meetings are open to the public. FODC and DCRT invite all interested parties to attend its meetings.

The regulatory context for stream remediation

The power of watershed groups to clean up creeks stems not only from widespread public concern for natural areas and resources, but also from the law of the land. The Clean Water Act (CWA) of 1972 dedicated the country to eliminating discharges of pollutants to surface waters by 1985. The CWA and USEPA established a number of rules and procedures to make sure that states protect clean streams and clean up polluted streams.

Table 3: Summary of load estimates and allocations for subwatersheds of the Deckers Creek watershed

Subwatershed	Metal	Loads (lbs/year)	
		Estimated	*Target*
Kanes Creek	Al	12,000	2,400
	Fe	53,000	7,500
	Mn	2,600	2,600
Laurel Run	Al	42,000	3,200
	Fe	198,000	11,000
	Mn	6,900	4,200
Dillan Creek	Al	8,000	1,650
	Fe	41,000	8,600
	Mn	2,000	1,600
Slabcamp Run	Al	42,000	42,000
	Fe	200,000	7,000
	Mn	7,000	2,200
Deckers Creek, Slabcamp to Back Run	Al	400	400
	Fe	1,600	1500
	Mn	500	500
Deckers Creek Back Run to Glady Run	Al	5,000	5,000
	Fe	190,000	4.500
	Mn	3,300	3,300
Glady Run	Al	3,400	600
	Fe	15,000	2,700
	Mn	1,000	700
Deep Hollow	Al	9,000	1,600
	Fe	66,000	6,400
	Mn	2,700	2,300
Deckers Creek, Deep Hollow to Aarons (including Richard mine)	Al	19,000	3,000
	Fe	70,000	7,500
	Mn	3,300	3,300
Hartman Run	Al	9,900	1,800
	Fe	46,000	5,800
	Mn	3,700	1,900

Source: USEPA, 2002.

First, the state must establish water quality standards for a variety of pollutants. If the streams do not attain the standards, they are considered impaired.

Next the state must report to the USEPA a list of all the impaired water bodies in the state. The list is called the 303(d) list. AMD impairs a number of Deckers Creek watershed streams according to the list, including Hartman Run, the unnamed tributary from Deep Hollow, Glady Run, Slabcamp Run, Dillan Creek, Laurel Run and Kanes Creek, as well as Deckers Creek itself. The unnamed tributary from Fairfax Pond in Arthurdale is on the list for impairment by lead.

For waters that are impaired, the state must prepare a clean-up plan. These plans are known as “total maximum daily loads” (TMDLs). The TMDL for the Monongahela River encompasses its tributaries, including Deckers Creek (USEPA, 2002). TMDLs break larger watersheds down into subwatersheds, estimate the total amount of a particular kind of pollution (e.g., iron) that is discharged in it, and then calculate a target: the maximum amount that could be discharged without impairing that subwatershed’s streams. Table 3 shows these target values for the Deckers Creek watershed.

If the TMDL determines that pollution must be reduced, the state must find a way to achieve those reductions. If the pollution is from a point source, such as an active coal mine, and more importantly if some party has a permit to discharge the pollution, then the state can reduce pollutant loads by adjusting the amounts that the point source is allowed to discharge. If, on the other hand, the pollution is from a nonpoint source, which includes sources farming and forestry as well as abandoned mines, then the state must find other ways to solve the problem.

Fortunately, the USEPA provides funds to states that must clean up nonpoint source pollution. These are known as “319” funds because they are described in Section 319 of the CWA. In order to use these funds, a watershed based plan (WBP) must be approved, which demonstrates that projects supported by the funds will

- *Achieve the load reductions described in the TMDL*
- *Improve water so that water quality standards are met*
- *Remove the stream from the list of impaired water bodies.*

A two-pronged plan

FODC completed a WBP for the entire watershed in 2005 (Christ, 2005). The plan, which has been accepted by both WVDEP and USEPA, provides information on nonpoint source pollution entering Deckers Creek. This baseline information will help track the improvements in the creek's water quality as projects are designed and executed.

Eliminating AMD from Deckers Creek will require both active and passive treatment. AMD from abandoned mine lands is usually treated using passive methods, whereas mines that release water during current mining operations treat it actively (Box 8). In active treatment, an alkaline material is mixed with AMD (Photo 15), which is then conveyed to a settling pond where metal oxides come out of solution and settle to the bottom of the pond as sludge. This kind of treatment needs ongoing inputs of money, materials and energy. In passive treatment, on the other hand, water is conveyed through one or more structures that treat the water. These structures usually include limestone to neutralize acidity, and some means to exclude or consume oxygen (Box 9). When AMD is treated in the presence of oxygen, limestone gets covered with an iron oxide "armor" that slows down acid neutralization. Until recently, it was assumed that after installation, passive treatment measures would need little monitoring or upkeep. Current practitioners are now researching how long the various treatment techniques will remain effective, and what sort of maintenance plans can keep the acid neutralization rate high.

In the Deckers Creek watershed, most of the AMD sources can be treated using passive methods. The most important exception is the Richard mine. The drainage from the Richard mine is too voluminous and too concentrated to be treated passively in the small area where it comes out of the mine and travels to Deckers Creek.

The two kinds of AMD sources—those that can be treated passively and those that cannot—are the two paths in the plan to solve the AMD problems in Deckers Creek.

Box 8: Types of coal mines in the Deckers Creek watershed

Permitted mines – Mine sites that began operation post-1977, after SMCRA was put into law. Operators are required to post bonds for each mine as an incentive to reclaim the site to pre-existing conditions. Bonds are held by the state if a mine is abandoned, and are used to fund reclamation projects on these sites.

Bond forfeiture sites (BFS) – Permitted mines that have been abandoned before all bonds were released. Bonds are forfeited when post-mining reclamation standards required by SMCRA are not met by the operator. AMD is often found at these sites.

Abandoned mine lands (AMLs) – Sites mined and abandoned pre-1977. These mines are not subject to SMCRA. Funding to reclaim these sites is generated from a tax placed on mined coal and from other state and federal grant programs.

Box 9: Common methods for passive treatment of AMD

Aerobic Wetland: A shallow wide area, usually with plants, spreads water out and slows it down. Oxygen diffuses into the water and oxidizes iron and manganese and metal oxides settle out of solution. These require neutral or net-alkaline water.

Anoxic Limestone Drain: Anoxic water is kept anoxic as if flows through a limestone passage. Neutralization takes place without oxidized iron coating the limestone.

Compost Wetland: This is a shallow area where water movement slows. This form of wetland is loaded with compost and usually limestone. The compost prevents iron oxidation and sometimes turns oxidized iron back to the reduced form. It may also neutralize AMD with the alkalinity formed by sulfate reduction.

Grouting: Mine voids are occasionally filled back up, often with some kind of combustion ash that sets up like concrete. Grouting can divert water from acid-forming material.

Manganese Reduction Bed: Leading AMD through limestone beds after aluminum and iron have been removed can cause manganese to precipitate out of solution.

Open limestone channel: Simple vee-shaped channels with limestone are frequently used to convey water from one place to another on reclamation sites. These channels neutralize some acidity, but are equally important for keeping water from eroding away the soil that covers acid-forming material.

Reducing and alkalinity producing system: These systems are similar to compost wetlands, but they force the water to drain through the compost and then allow it to interact with limestone (Photo 14).

Sulfate-reducing bioreactor: These pass water through an organic layer similar to the one in RAPS. The layer is deeper, and the oxygen demand should be stronger, so that sulfate is reduced.

Wet seals: Portals where water drains from a deep mine must be sealed so that the path the water takes is controlled, and so that no one can get into the mine.

Passive treatment projects

The DCRT will carry out passive treatment projects starting at the headwaters of Kanes Creek and moving downstream to the confluence with Deckers Creek, and then downstream on Deckers. Sources in other tributaries will be addressed as confluences are encountered. Passive treatment projects are split into high and low priority groups to give flexibility in planning. If small amounts of funding are available, smaller projects may be executed out of order. The major sources are mapped in Figure 39.

Drainage from Upper Freeport mines usually contains acidic water with substantial concentrations of iron, aluminum, and dissolved oxygen. Reviews of AMD treatment methods generally suggest reducing and alkalinity producing systems (RAPS) for this kind of AMD (e.g., Watzlaf et al., 2004). The sulfate-reducing bioreactor (SRB) is a recent modification of RAPS.

A computer program, “AMDTreat,” can be used to calculate the size of the installation that will be needed to treat the water (OSM, 2005). If a RAPS (called a “Vertical Flow Pond” in AMDTreat) is sized according to the amount of acidity from the Valley Point #12 site, for example, it would take up an area 270’ by 147’, or about 0.9 acres.

Constraints related to the layout of sites and the desires of landowners frequently affect the exact size and nature of the treatment measures. Designers continue to innovate to devise better and more predictable systems.

The first project on the list is Valley Point #12. FODC has secured 319 funds from WVDEP and WCAP funds from OSM, and has hired an engineering firm to design a system to treat this water. The final design is expected in late spring or summer 2006, with construction expected late summer 2006.

The next two projects are Kanes Creek South Site #1 and Valley Highwall #3, which are also likely to employ SRBs. After these three sites are addressed, there will be no large AMD sources to Kanes Creek above mile 2.6, where Sandy Run contributes AMD from an impaired watershed.

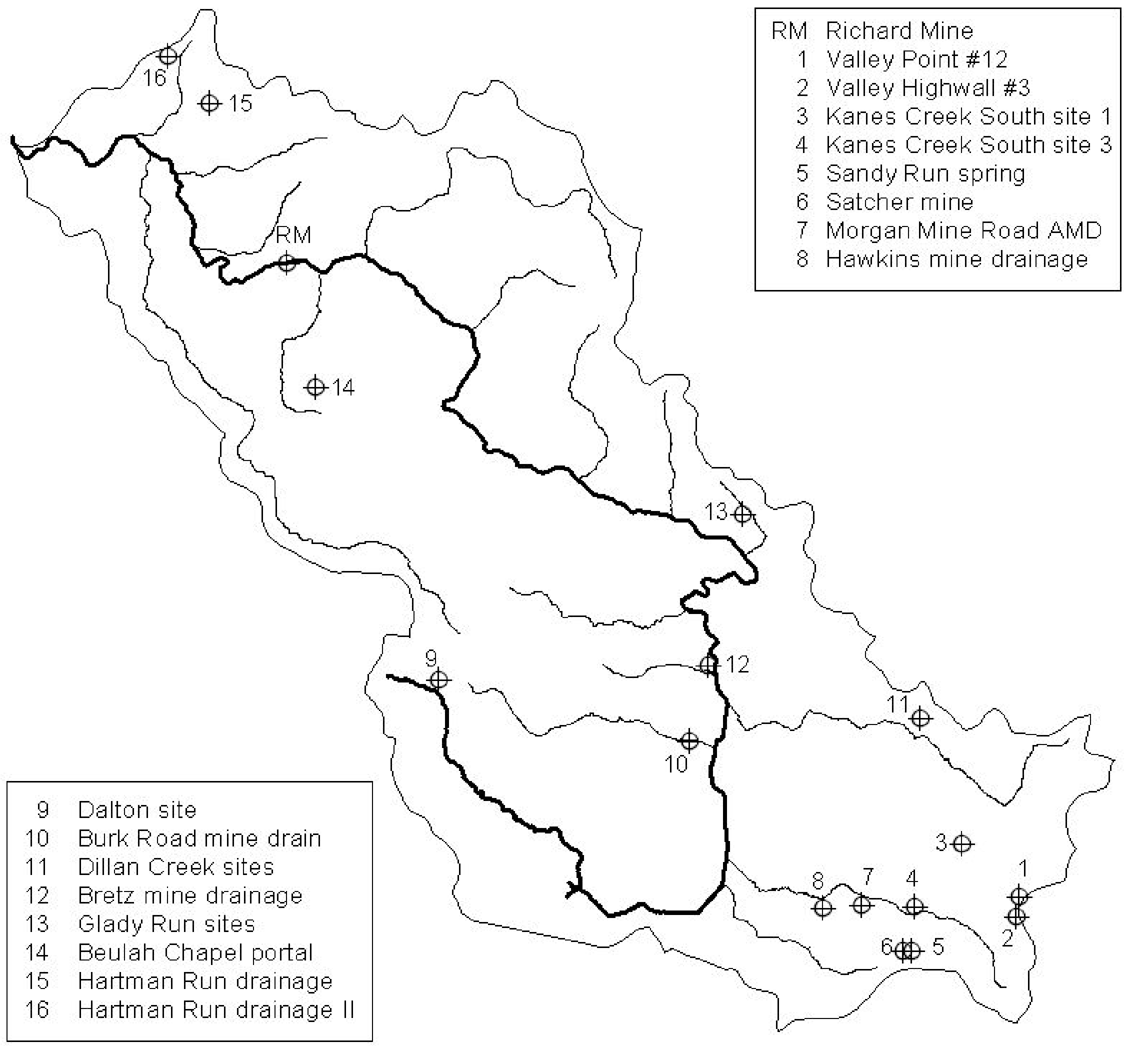


Figure 39: Location of the 17 high-priority AMD sources in the Deckers Creek watershed, listed in the order they are to be addressed

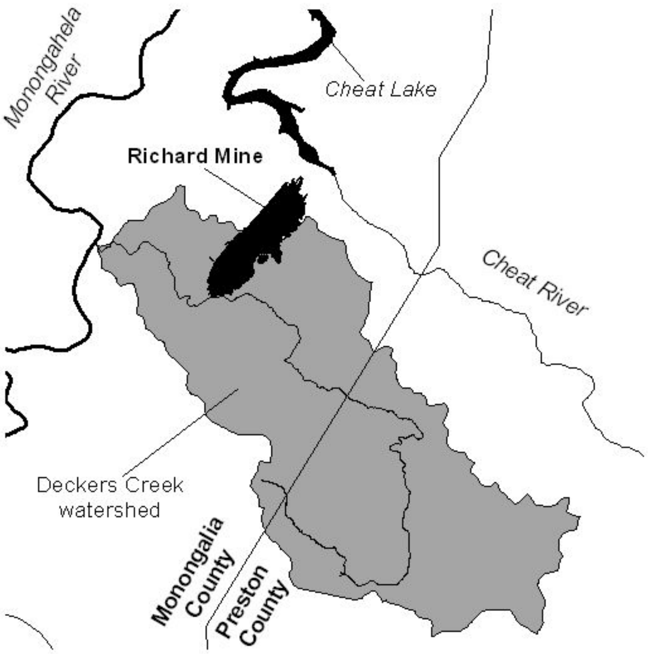


Figure 40: Location of the Richard mine relative to Deckers Creek and Cheat Lake

Active treatment: the Richard mine

The drainage from the Richard mine will require a bigger, more complex project. This mine occupies approximately three square miles underneath Brookhaven, and reaches nine tenths of the distance from Deckers Creek to Cheat Lake (Figure 40). FODC currently envisions using active treatment. Funding for the capital and ongoing costs of that treatment might be paid by a trust fund to be raised through a combination of sources, including but not limited to government, foundations, businesses, and individuals.

The Richard Mine discharges approximately 200 gpm of water carrying roughly 1000 mg/L acidity, enough acid to dissolve 760,000 pounds of limestone each year.

The annual cost of an active treatment system for the Richard mine is difficult to determine. According to preliminary calculations by WVDEP, treatment might cost as much as $160,000 per year. The largest proportion of that cost is the chemical agent, either pebble quick lime or hydrated lime, for neutralizing the AMD. That amount also includes electricity for mixing the AMD and the chemicals and for pumping sludge out of the settling ponds, maintenance, monitoring and other labor costs. Community, business and government support will be necessary to maintain such a project.

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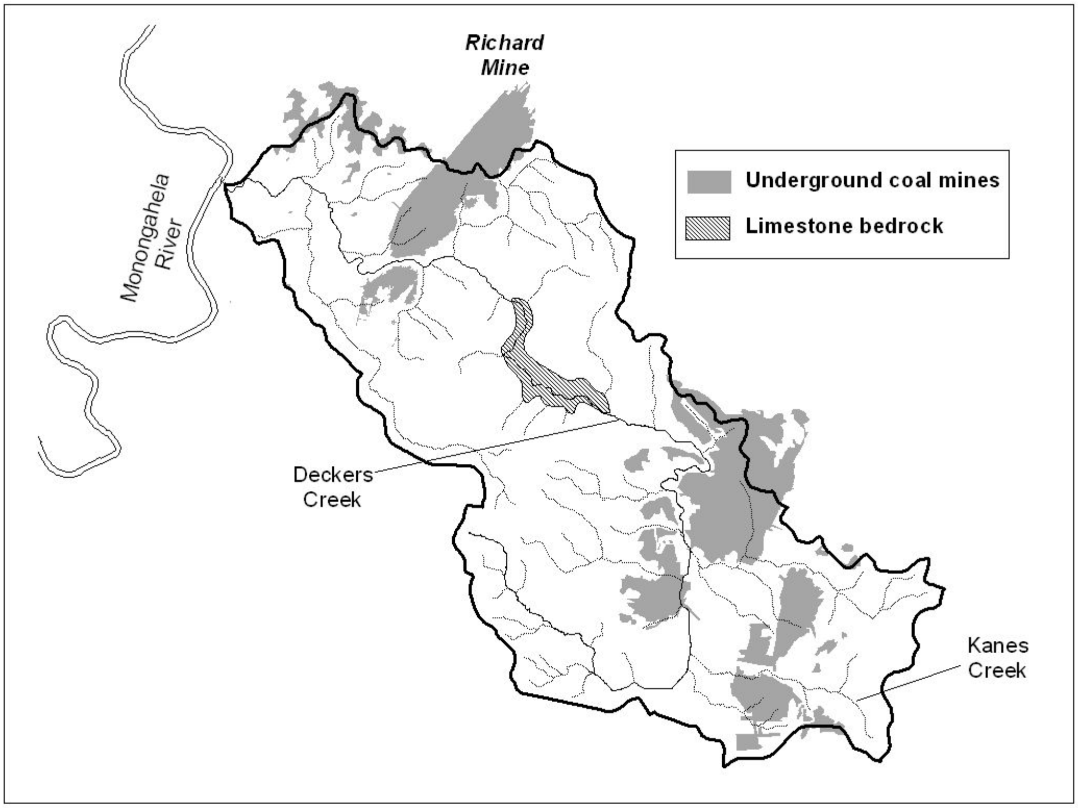

Deep mines in the Deckers Creek watershed

Photo 14: Reducing and alkalinity producing system installed near Kanes Creek. The lower left pool contains a compost layer covering limestone, and the other basins are settling ponds.

Photo 15: Part of an active AMD treatment plant on Kanes Creek, run by International Coal Group . Hydrated lime is mixed with AMD just before it enters the mixing chamber. A large propeller under the metal walkway mixes air into the AMD to oxidize iron. After mixing, AMD flows into several large settling ponds.

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