WATER RESOURCES ASSESSMENT

Overview

The Buffalo Creek watershed is a DEP-designated High Quality watershed, a designation ascribed to the watershed in 1979 after the passing of the Clean Water Act. However, little water quality monitoring has been conducted to investigate trends in water quality. The intent of this chapter is to provide a comprehensive source of past and present water quality information that can be used in restoration and protection activities and can form the basis for continued monitoring. This chapter discusses some important components affecting water quality; describes federal, state, and local laws that exist to protect the watershed; gives an overview of past water quality information collected within the watershed; and presents the results of stream assessments conducted by Western Pennsylvania Conservancy (WPC).

Important Components of Water Quality

Floodplains

Floodplains refer to areas of land adjacent to a stream onto which water spills when the water level in the stream rises. Floodplains increase the capacity of a stream to handle flood events by dissipating energy from high flows. Building on floodplains, or other alterations, can increase flooding downstream, cause bank failures, and be dangerous for residents.

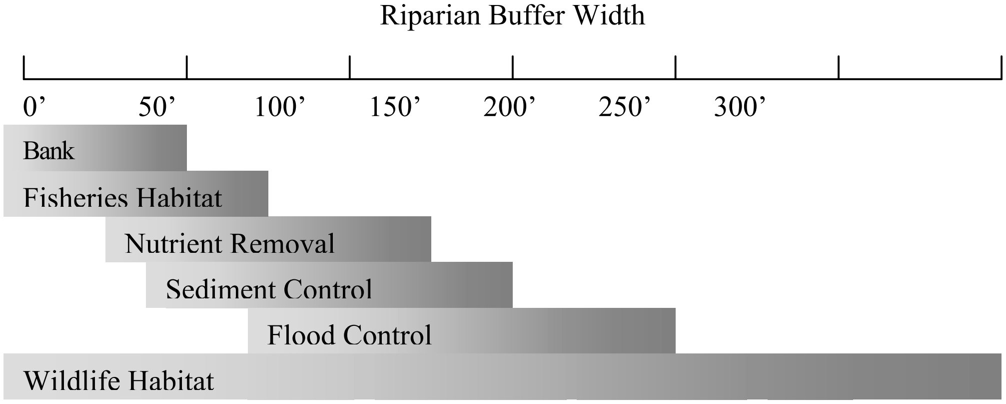
The National Flood Insurance Program (NFIP) was established in 1968 with the National Flood Insurance Act (NFIP 2002). This act enables property owners to purchase insurance as a protection against flood loss in exchange for communities agreeing to adopt ordinances that reduce flood damage, including limited building in floodplain areas. Only property owners living in such communities can purchase flood insurance. In communities that adopt such ordinances, building in Special Flood Hazard Areas may only occur if the owner agrees to purchase flood insurance. These hazard areas are areas within the 100-year flood zone, meaning that there is a one percent chance of a flood reaching this zone each year. Special subsidies are available for existing structures. Future structures built in 100-year floodplains must meet certain requirements. During declared national disasters, FEMA may also make grants and loans available to those not participating in the program (NFIP 2002). Floodplains can be considered "sensitive" areas because they are both inappropriate for building purposes and important for protection of streams and wildlife. Chapter 1 discussed such sensitive areas, and 100-year floodplains are depicted in Figure 1-13. Currently, most municipalities within the watershed have floodplain ordinances, though these provisions may not be adequately enforced.

The riparian zone along Narigan Run provides important filtering functions and supports salamander populations

Riparian Zones

Riparian zones are vegetated buffers along streams, rivers, and lakes that filter runoff and provide a transition zone between water and land. A functioning riparian zone can reduce flooding by retaining water in its vegetation and soil. This also promotes retention of groundwater during dry periods. Vegetated riparian zones prevent soil loss and bank failures by holding soil in plant roots. They also provide important corridors for wildlife, enhance recreational activities, and provide fish habitat. Studies have shown that the wider and more substantial a riparian zone is, the better it can perform these functions (Klepproth 2000). Figure 3-1 shows recommended riparian zone widths for bank support, fisheries habitat, nutrient removal, sediment control, flood control, and wildlife habitat.

Figure 3-1. Recommended Riparian Buffer Widths



Groundwater

Groundwater refers to water stored beneath the land surface in the pores and openings of soil and rock formations. It is estimated that at least 95 percent of residents within the Buffalo Creek watershed rely on groundwater as their drinking water source.

Because water is constantly interchanged between ground and surface waters, surface water quality is often indicative of groundwater quality. Also, increases in groundwater withdrawals can lead to lower stream flows. Some common pollutants of surface waters that can lead to groundwater contamination include sewer and agricultural contamination (nutrients, bacteria), mining (metals, low pH), and abandoned oil and gas wells (chlorides). Iron (from mining) is the most common groundwater pollutant in Washington County.

Groundwater within the watershed is primarily held in larger openings consisting of sandstone fractures. Because of the scarcity of small openings, drinking water yields are low to moderate in Washington County (Table 3-1). Only alluvium, or materials deposited by streams (clay, silt, sand, gravel) during past storm events, have the potential for high yields. Therefore, the best groundwater yields are from wells near stream riparian zones (Newport 1973).

Table 3-1. Approximate Groundwater Yields of Washington County Geologic Formations (Source: Newport 1973)

Geologic Formation	Characteristics	Approximate yields (may vary)
Alluvium	clay, silt, sand, gravel	~200 gallons per minute (gpm)
Monongahela	limestone, shale, coal, sandstone	.1-5- gpm
Greene	sandstone	2-35 gpm
Washington	soft shale	1-70 gpm
Conemaugh	sandstone, shale	5-50 gpm

Stormwater

The water running off streets, buildings, and land during storm events is referred to as **stormwater**. Besides causing flooding, stormwater can contribute a significant amount of pollution to waterways. Much of the unhealthy bacteria that enters streams from manure lots and faulty sewage systems enters during storm events. Many of Pennsylvania's urban areas have ordinances that include stormwater management. This involves activities such as regulating the size of culverts and ditches through which water travels to prevent flood events, and requiring the use of more pervious materials for sidewalks and parking lots to prevent ponding of water.

Pennsylvania's Stormwater Management Act of 1978 requires each county in Pennsylvania to develop stormwater management plans for each of its watersheds. As of May 2005, Washington County is in the initial stages of developing such a county-wide stormwater management plan. The development of such plans is usually considered more relevant to urban areas than to rural areas such as the Buffalo Creek watershed. However, stormwater management, especially for flood regulation purposes, may become more of an issue as development continues in the watershed. The DEP provides model stormwater management ordinances and funding options for stormwater management plans on its website, http://www.dep.state.pa.us (Keyword: stormwater). Municipalities may choose to adopt any one of these ordinances in order to prevent flooding and maintain safety for residents. None of the municipalities within the watershed currently have stormwater management provisions.

Surface Water

Surface water refers to water found above the land surface during all or some parts of the year, in rivers, streams, lakes, ponds, and wetlands. Many of the streams within the Buffalo Creek watershed are small streams originating from seepage areas in hillsides that fill up during storm events. Larger streams within the watershed, including Buffalo Creek, are "flashy" in nature, quickly reaching high flows during rain events and nearly drying up during warm summers.

Due to the lack of glacial history in the region, there are no natural lakes in the watershed (NLCD 2003). Wetlands in the watershed consist mainly of current and past river floodplains, where river particles have been deposited, and temporary wetlands. Temporary wetlands contain water during only part of the year, usually during wetter months. **Vernal pools** are temporary wetlands in which the only source of water is rainwater. They are important ecological systems and often have high biodiversity. Because they do not contain fish, vernal pools support species that could not survive in permanent pools of water. These species include spotted and Jefferson salamanders, wood frogs, and fairy shrimp. As of 2005, Western Pennsylvania Conservancy is developing a volunteer monitoring program to identify and track these important wetlands in Pennsylvania.

Hillside seep entering a tributary of Buffalo Creek

Dutch Fork Lake, located in the southern portion of the watershed, was a 91-acre impoundment created from Dutch Fork Creek in 1958 by the Fish and Boat Commission to provide additional recreational fishing opportunities. The reservoir was drained in 2004 with the idea that another reservoir will be established when there are enough funds to repair the dam.

Watershed Protection Laws

Intermittent, Ephemeral, and Perennial Streams

Not all streams flow year-round. However, all streams within Pennsylvania are protected under the Pennsylvania Clean Streams Law of 1931, which gave the state of Pennsylvania the power to enact legislation and regulations pertaining to the protection of streams.

According to the Pennsylvania Code:

An *intermittent stream* is a, "body of water flowing in a channel or bed composed of substrates primarily associated with flowing water, which during periods of the year is below the local water table and obtains its flow from both surface runoff and groundwater discharges."

An *ephemeral stream* is a, "water conveyance which lacks substrates associated with flowing waters and flows only in direct response to precipitation in the immediate watershed or in response to melting snowpack and which is always above the local water table."

A *perennial stream* is a, "body of water flowing in a channel or bed composed primarily of substrates associated with flowing water and is capable, in the absence or pollution or other manmade stream disturbances, of supporting a benthic macroinvertebrate community composed of two or more recognizable taxonomic groups of organisms which are large enough to be seen by the unaided eye and live at least part of their life cycles within or upon available substrates in a body of water or water transport system." Streams that flow year-round are perennial streams.

Point discharge limits (as described later in this chapter) are estimated at the point where the stream supports a benthic macroinvertebrate community characterizing a "perennial stream."

In the past, mining operations in Pennsylvania could get streams to be reclassified as intermittent or ephemeral, classifications requiring no special protections under state mining regulations. In particular, longwall mining under these streams was thought to have no long-term impact because of the depth of the mines. However, recent findings have suggested that these streams are affected. As a result, DEP is shifting its policy to require detailed biological assessments before approving longwall mining operations. Under this new policy, non-permanent intermittent and ephemeral streams receive the same protections as permanent, perennial streams before mining can proceed.

Protection of intermittent and ephemeral streams is also included for logging and other earth-moving activities, although permitted activities may differ from those involving perennial streams. In cases where there is some question over what protections are in place for an activity, DEP's Southwest Regional Manager or Washington County Conservation District office should be consulted.

Clean Water Act

The 1972 amendments to the Clean Water Act gave the United States Environmental Protection Agency the authority to regulate pollution to waterways of the United States. This includes issuing permits for any point source pollution to a waterbody, setting water quality standards, and implementing point source control measures. The Clean Water Act works to enforce these requirements by enacting existing and designated uses on a waterbody. **Existing uses** are defined as any use that has been attained or has occurred in a waterbody since November 1975. **Designated uses** (Table 3-2) are those that are currently recognized by the state, regardless of whether they have been attained since 1975 (Elder et al. 1999).

Table 3-2. DEP Waterbody Designated Uses

DEP designated Uses	Description
Aquatic Life	The waterbody provides suitable habitat for survival and reproduction of desirable fish, shellfish, and other aquatic organisms
Fish Consumption	The waterbody supports a population of fish free from contamination that could pose a human health risk to consumers
Shellfish Harvesting	The waterbody supports a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers
Drinking Water Supply	The waterbody can supply safe drinking water with conventional treatment
Primary Contact Recreation (swimming)	People can swim in the waterbody without risk of adverse human health effects (like catching waterborne diseases from raw sewage contamination)
Secondary Contact Recreation	People can perform activities on the water (such as canoeing) without risk of adverse human health effects from occasional contact with the water
Agriculture	The water quality is suitable for irrigating fields or watering livestock

Discharges are not permitted to streams or lakes if they violate the existing uses for that stream or lake. They may violate designated uses, but only if the use cannot be obtained through reasonable enforcement or without causing widespread social and economic costs. For instance, a stream may have "drinking water supply" as an existing use and not a designated use (it is currently not safe to drink). In this case, the state must take steps to restore the stream so that it can be used as a water supply. If a point source will violate a designated use, a public hearing must be held to inform the public before a permit can be issued. Citizens and non-profit organizations can gather information about their watersheds' existing uses, including pictures, newspaper articles, and personal letters, so that a stream can be protected for those uses. According to the Clean Water Act, point sources may not occur that degrade the Buffalo Creek watershed below its designation as a High Quality watershed, unless a special exception is granted. A high Quality watershed is considered to satisfy all designated uses.

Buffalo Creek is designated a High Quality watershed by DEP

The entire Buffalo Creek watershed is protected by DEP under the classification *High Quality Warm Water Fishery* (HQ-WWF), given to the watershed in 1979 (PA Code[1]). Though based largely on mere observation and not scientific data (Pers. Comm., D. Bogar), subsequent water quality information has supported this classification.

Table 3-3. DEP High Quality Watershed or Stream Qualifications (Chapter 93)	
Chemistry (meet at least one condition)	The water has long-term water quality, based on one year of data, including being better than the water quality criteria in Chapter 93.7 at least 99 percent of the time.
	Additional chemical and toxicity information, which characterizes or indicates good water quality.
Biology (meeting at least one condition)	The surface water supports a high quality macroinvertebrate community, as determined by biological and physical habitat procedures outlined in EPA's "Protocols for Use in Streams and Rivers" and has a score of at least 83 percent when compared to a reference stream or watershed of high quality.
	The surface water supports a high quality aquatic community based on information gathered using approved biological assessment procedures.
	The surface water has been designated a Class A wild trout stream.

Currently, "high quality" is the highest designation that can be given to a warm-water stream. A high quality waterway meets a number of criteria, including specific water quality and biological standards (Table 3-3). "Warm water" is described as a stream that has, "fish species and flora and fauna which are indigenous to a warm water habitat." Scientifically, in Pennsylvania, a Warm Water Fishery satisfies certain temperature requirements, including a maximum healthy water temperature of 87º F in August (versus 66º F for a Cold Water Fishery) (PA Code[1]). Typically, Warm Water Fisheries have more exposed surface and therefore receive more light than Cold Water Fisheries. However, Warm Water Fisheries often are often able to support species that are considered cold-water fish.

In order to satisfy the requirements of the Clean Water Act, DEP must report to the EPA every two years on the state of its waterways and provide a list of waterways either meeting or not meeting their EPA designated uses. Currently, this list is called the Integrated Waterbody List (PA DEP[3]) (Table 3-4). Streams are assigned five categories based on their status on the Integrated Waterbody List. DEP is required to develop a Total Maximum Daily Load (TMDL) assessment for all streams that are not meeting their designated uses, except when better enforcement of point source pollution can alleviate the problem. These streams are placed in category 5 of the Integrated Waterbody List.

Table 3-4. Sections of the Integrated Waterbody List (PA DEP)

Category	Classification Description
1	Streams in which all uses are attained
2	Streams in which at least one use is attained
3	Unassessed streams
4	Streams impaired for one or more designated use, not requiring TMDL Assessment
5	Impaired Streams requiring a TMDL

A TMDL is an analysis of the maximum level of pollutants that can enter a waterbody while still meeting water quality standards and existing uses for that stream under the Clean Water Act. TMDLs must be developed for streams in category 5 of the Integrated Waterbody List. Currently, Dutch Fork Lake is the only stream or lake within the watershed for which a TMDL has been completed. The Integrated Waterbody List shows that four sections of the watershed are not meeting their aquatic life use

(PA Code[1]). This is discussed later in the chapter under Previous Studies, DEP Unassessed Waters Assessment (page 3-11). Within the West Virginia portion, Buffalo Creek is a Warm Water Fishery but does not have a high quality designation. No streams are listed as impaired in the West Virginia section.

The ultimate goal should be to have the entire watershed reflect a high quality designation. Despite impairments, the Buffalo Creek watershed is still granted the protection of its high quality designation within the Pennsylvania portion.

NPDES Permits

State governments are required to enforce the requirements of the Clean Water Act. One of the ways that this is done is through the National Point Discharge Elimination System, or NPDES, whereby Pennsylvania DEP issues permits for point source discharges (PA DEP[4]). Point sources refer to discharges that enter a stream or lake directly via a pipe, culvert, container, or other means, whereas non-point sources do not have a defined source. In Pennsylvania, the DEP and local conservation districts are responsible for issuing point source permits to industrial operations, municipal wastewater treatment plants, concentrated animal feeding operations, and households. In addition, any disturbance of land from one to five acres requires an NPDES permit, whether it is a point source or not. The exception is for tilling and agricultural practices that are not part of a Concentrated Animal Feeding Operation (CAFO) and most logging disturbances less than 25 acres. However, any logging disturbance over 25 acres requires an NPDES permit. Eight NPDES permits are currently active, or have recently been active, in the Pennsylvania portion of the Buffalo Creek watershed (Table 3-5; Figure 3-1). NPDES permits in the West Virginia portion of the watershed are listed in Appendix G. Active NPDES permits may be found at the EPA Envirofacts website (http://www.epa.gov/enviro/index.html).

Soil and Erosion Control

Pennsylvania's Clean Streams Act and regulations under the Pennsylvania Code create a role for local governments in protecting streams by developing Erosion and Sediment Control Plans, which include sediment control Best Management Practices, or BMPs. BMPs are practices that help protect the quality of the land and the environment by preventing erosion and pollution. They include such activities as contour farming, filter strips, and silt fences. Even though most agricultural and logging operations under 25 acres are exempt from NPDES permits, they still require a type of Erosion and Sediment Control Plan (PA Code [2]). Disturbances greater than 5,000 acres must have the plan on site. Farm operations must have either a Conservation Plan or Erosion and Soil Control Plan and can receive fines for either not having plans or being in non-compliance with a plan. Conservation plans are also required for farmers wishing to take part in incentive programs. The Washington County Conservation District assists in development of Erosion and Sediment Control Plans and Conservation Plans.

Concentrated Animal Feeding Operations

In addition to these regulations, the Pennsylvania Nutrient Management Act requires agricultural operations called Concentrated Animal Feeding Operations (CAFOs), where there are more than two animal equivalent units per acre (or more than 2,000 pounds), to also develop nutrient management plans through the local Natural Resources Conservation Service (NRCS) office (PA DEP[5]). Nutrient management plans involve applying nutrients in such a way as to avoid over-application and pollution to water resources.

Table 3-5. NPDES Permits in the Pennsylvania Portion				
Facility	**Location**	**Description**	**Permitted Time**	**Receiving Waters**
Blaine Township Wastewater Treatment Plant	Taylorstown, PA	sewer systems	12/13/2001 to 12/13/2006	Buffalo Creek
Claysville/Donegal Jt. Municipal Authority	Claysville, PA	sewer systems	11/22/2002 to11/22/2007	Dutch Fork
Consolidated Truck Stops, Inc.	Interstate 70 Exit Claysville, PA	gasoline service stations	1/18/2001 to 1/18/2006	Dutch Fork
Green Valley Packing	Buffalo Township, PA	meat packing plants	3/27/1998 to 3/27/2003	UNT to Buffalo Creek
Grose Catering	Taylorstown, PA	private households	6/28/2004 to 6/30/2009	Wolf Run
Interstate RV Center, Inc.	Claysville, PA	RV sales	1/23/2004 to 1/31/2004	Dutch Fork
Interstate Village Mobile Home Park	Claysville, PA	mobile home dealers	1/17/2003 to 7/15/2003	UNT to Bonar Creek
McGuffey High School and Middle School	Claysville, PA	school	11/18/2003 to 11/30/2008	UNT to Buffalo Creek

537 Municipal Sewage Plans

Act 537, the Pennsylvania Sewage Facilities Act, requires that all municipalities develop and implement an official sewage plan addressing present and future sewage disposal needs. DEP reviews official plans and revisions and issues necessary construction permits. DEP also provides grants and reimbursements for up to 50 percent of costs associated with Act 537 planning and permitting (PA DEP[6]).

Act 537 plans vary by municipality and may include plans for municipal sewage treatment facilities and upgrades to on-lot systems. Sewage Enforcement Officers within each municipality are responsible for issuing permits for new systems and repairs to old systems. All homes not serviced by a sewage treatment facility are required to have a functioning on-lot system that does not create an "obvious" discharge. Malfunctioning systems can be reported to DEP, as well as failure of municipalities to follow 537 plans (PA DEP[6]). PENNVEST, the Pennsylvania Infrastructure Investment Authority, offers loans, and some grants, to municipalities developing sewage treatment facilities. Loans are also available to individuals for development or improvements to on-lot systems.

Previous Water Quality Sampling

USGS chemical sampling: 1965-1969, 1983-1985

United States Geological Survey (USGS) undertook some of the first chemical sampling of the Buffalo Creek watershed during the 1960s and 1980s (USGS). This involved sampling of five locations within the watershed: Buffalo Creek, Brush Run, Sugarcamp Run, Upper Dutch Fork, and Dunkle Run. Some select results are given in Table 3-6. USGS maintained a stream flow gauging station along Brush Run from 1960 until 1985. More information can be found at http://waterdata.usgs.gov.nwis.

Parameter	Minimum	Maximum	Average
conductivity (uS)	303	650	440.5
alkalinity (mg/L CaCo3)	120	190	156
chloride (mg/L)	0	40	14.1
sulfate (mg/L)	40	79	55.28
total iron (mg/L)	0.13	3.1	0.555
total manganese (mg/L)	0.01	0.13	0.061

Pennsylvania Fish and Boat Commission Fish Surveys

The Pennsylvania Fish and Boat Commission's 1992 assessment of habitat quality and fish abundance in Buffalo Creek stated that, "the excellent warm-water fishery described by DER has been degraded in some way," and that further measurement of water quality was needed (Miko and Lorson 1992). This conclusion was formed after noting a decrease in fish abundance and size compared to sampling done in 1983 (from 22 to 17 species), as well as high erosion. The 1983 assessment had deemed the watershed an excellent Warm Water Fishery worthy of special protection (Lorson 1983). The decline in fish population (primarily noted in Buffalo Creek near the West Virginia border) was attributed to increased sedimentation or possible decrease in the amount of fish entering the creek from Dutch Fork Lake due to low conditions (as most of the absent fish were lake species). The 1992 study also concluded that hardness and alkalinity had increased in Buffalo Creek since 1983 (Table 3-7). This assessment did not survey any other streams within the watershed.

Table 3-7. Water Chemistry Measured in Buffalo Creek by Fish and Boat Commission

	Site 1 (near Taylorstown)		**Site 2** (near WV border)	
	1983	1992	1983	1992
Chemical				
pH	7.9	7.9	7.9	7.9
Conductivity (uS)	N/A	470	N/A	433
Alkalinity (mg/L)	120	158	130	155
Hardness (mg/L)	85	194	145	193
Temperature °C	N/A	25	N/A	23

California University of Pennsylvania—graduate projects

Two graduate student projects, under the supervision of Dr. David Argent, studied the water quality of Buffalo Creek. Romanchak et al. documented the chemistry, as well as macroinvertebrate and fish assemblages, of five sites upstream and downstream of streambank fencing projects (Romanchak and Argent 2001). McCone et al. examined fish, macroinvertebrates, and water quality data from sections of Buffalo Creek (all near Camp Buffalo) with both high streambank erosion (reference sites) and minimal erosion (experimental sites) to see if they differed in water quality (McCone 2003). It was found that reference sections contained significantly higher macroinvertebrate and fish diversity than experimental sections. However, results varied between sites in both sections. For instance, reference reaches ranged from approximately 10 percent for percent Diptera to over 60 percent (possible impairment), while experimental reaches ranged from approximately 40 percent to over 70 percent (Figure 3-3). The percent EPT was over 10 percent in all cases, which is considered by most standards to indicate no impairment.

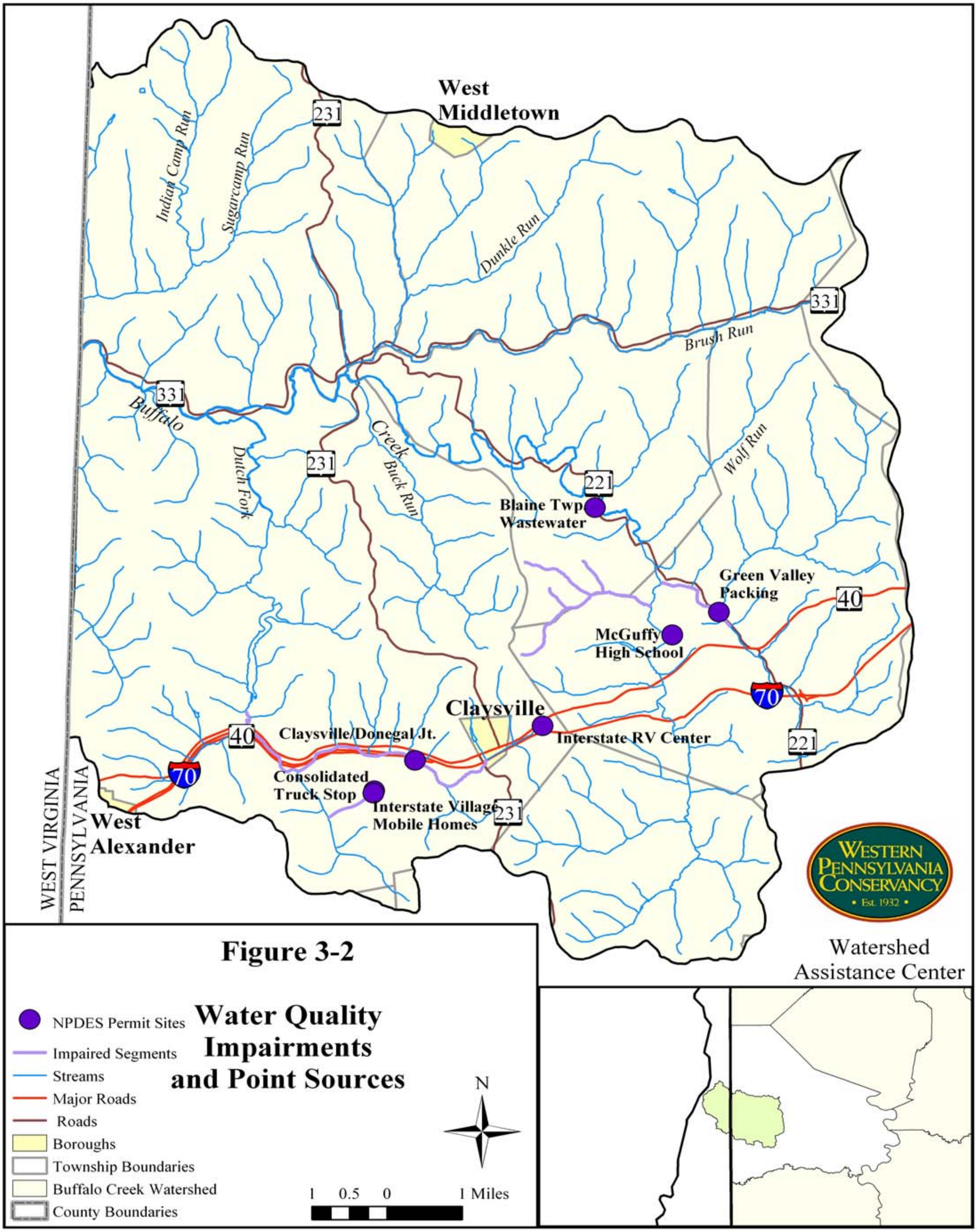


Figure 3-2

Water Quality Impairments and Point Sources

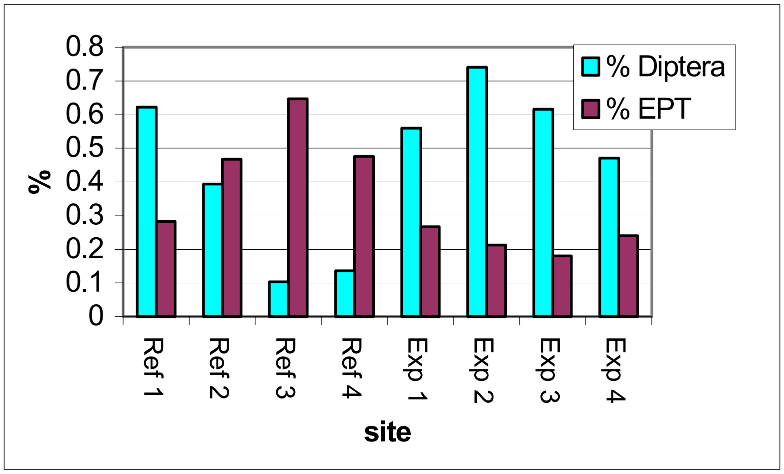


Figure 3-3. Results of California University of PA Assessment.

A total of 24 species of fish were identified in Buffalo Creek during the McCone et al. study, including seven species of darters—banded, blackside, fantail, greenside, Johnny, variegate, and rainbow.

DEP Unassessed Waters Assessment

Investigations by DEP in 2001 during a "wadeable streams survey" placed four sections of the Buffalo Creek watershed on the 2004 list of impaired waterbodies reported to EPA, or Integrated Waterbody List (Table 3-8, Figure 3-2). Conducted in 2001, and based on habitat and the macroinvertebrate assemblage (not chemical data), this sampling was done to determine whether streams were meeting their Aquatic Life uses. Impaired sections of Type 5 are due to non-point sources and require a TMDL (Pers. Comm., A. Falcone).

Table 3-8. Buffalo Creek Watershed Integrated Waterbody List Impaired Sections

DEP Type	Location	Description
2	Dutch Fork Creek, from Bonar to 32875 Trib	Suspected Impairments, but not significant
4	Trib 32867 to Bonar Creek	Municipal Point Source/Organic Enrichment/ Low D. O.
5	Trib 32967 to Buffalo Creek south and tribs	Grazing Related Agriculture/Siltation/Removal of Vegetation
5	Buffalo Creek-S Bridge to Taylorstown	Habitat Modification/Nutrients/Siltation

PAGWIS Groundwater Sampling

The Pennsylvania Groundwater Information System (PAGWIS) is a database managed by the USGS containing information about private and public water supplies. Information for the database was obtained by sources such as Pennsylvania DEP, USGS, Pennsylvania Department of Agriculture, private well water drillers, and others.

A review of the database found 14 wells within the Buffalo Creek watershed for which water quality information is available (PAGWIS). Records from Washington County indicate that wells in the Pittsburgh and Uniontown formations can be of poor water quality, containing iron and manganese. Because mining is minimal within the watershed, this contamination is not common. An exception to this was a record from 1983 showing iron concentrations as high as 17 mg/L compared to normal levels of less than 1 mg/L. This record was from the northeastern portion of the watershed, where previous mining has occurred. However, the exact source of the high iron level is unknown.

In general, groundwater yields within the watershed are poor to moderate because of the scarcity of fractures in bedrock material, consisting primarily of shale and sandstone. They are also prone to excessive mineralization if drilled too far below the surface, because water at this depth moves slowly and has had more time to dissolve minerals from rocks. Records also show that there may be numerous abandoned oil and gas wells within the watershed, which have the potential to cause pollution from chloride, iron, and other contaminants. However, no tests of groundwater to date have found chloride concentrations above the drinking water standard of 250 mg/L. Much more up-to-date information is needed on groundwater within the watershed, since all available data is from the 1980s.

West Virginia DEP Sampling

In July 2000, the West Virginia Department of Environmental Protection (WVDEP) conducted water quality sampling at eight sites in the West Virginia portion of the Buffalo Creek watershed. Water quality standards were met for most parameters. However, four of the eight sites exceeded standards for fecal coliform, including two sites on Castleman Run and sites on Lazear Run and Pierce Run. In addition, though not exceeding standards, Grog Run and Titt Run had conductivity levels indicating possible water quality problems. Titt Run, Pierce Run, Lazear Run, and one of the Castleman Run sites also had nitrate levels of 1.5 mg/L or higher, indicating possible impairment due to agricultural run-off or faulty septic systems. Sedimentation was found to be a significant source of water quality impairments, especially at Titt Run, Grog Run and the two Castleman Run sites (WVDEP). Appendix O. shows results of these sampling efforts.

Dutch Fork Lake

The water quality of Dutch Fork Lake reservoir reflected the water quality of Dutch Fork Creek upstream, as nutrients and pollution upstream came to make up the resulting characteristics of the reservoir. Though the reservoir was drained in October 2004 and its future is questionable, past water quality of the reservoir provides useful information about the status of Dutch Fork Creek.

Canoers enjoy Dutch Fork Lake

Dutch Fork Lake was included on Pennsylvania's 1996, 1998, and 2002 303(d) list of impaired waterbodies for not meeting its Aquatic Life use. Aquatic life was threatened due to excess productivity related to the phosphorous load to the reservoir. This productivity contributed to fish abundance, because the basis for the food web was algae. However, eutrophication (the process by which excess nutrients cause plants to take over a pond and eat up oxygen) can ultimately impair or kill fish and other organisms, which need oxygen for survival. In 2003, a TMDL study was completed for Dutch Fork Lake (PA DEP[7]). This study involved field and computer methods to estimate total loading and make recommendations for improvement, including regulation of point source permits and suggestions for elimination of non-point source pollution.

Lakes naturally evolve towards eutrophic, or "nutrient rich" conditions, such as those that existed in Dutch Fork Lake, as nutrients and sediment collect over time. However, Dutch Fork Lake, as a reservoir, did not meet the standard definition of a "lake" because it emptied into Dutch Fork Creek and was formed from the creek. According to the DEP definition, lakes have a retention time greater than 14 days, while Dutch Fork Lake only had a retention time of nine days. This means that if no water entered the lake, it would have been dry in nine days. Because water flowed through Dutch Fork Lake faster than a normal lake and water discharged from the dam at the epilimnion (top), some of the nutrients and algae entering Dutch Fork Lake traveled downstream. For these reasons, the highly productive nature of Dutch Fork Lake reservoir was largely attributed to pollution, not natural eutrophication.

When total phosphorous, a determinant of lake productivity, was measured in 1987 by DEP, the mean concentration of total phosphorous in Dutch Fork Lake was 112 ug/L. Average concentration decreased to 65.6 ug/L in 2003, suggesting that agricultural or other improvements were made upstream of the reservoir. A chlorophyll value over 20 ug/L is considered eutrophic, or high in nutrients. Chlorophyll a, which is a pigment in plants directly related to productivity, was nearly 30 ug/L in 2003. DEP estimated that chlorophyll a would need to be at 20 ug/L in order to meet water quality standards for the lake. Accordingly, phosphorous loads would have had to be decreased by 667 kg/yr in order to meet these standards (PA Code[1]).

Modeling efforts by DEP in 2003 pointed to direct runoff into the reservoir from cropland and pastureland as the biggest source of phosphorous pollution, and suggested BMPs were needed to improve the reservoir. However, the land immediately surrounding Dutch Fork Lake is mostly forested. If agricultural inputs were entering the reservoir, then Dutch Fork Creek and other tributaries, rather than direct runoff, were likely contributors. DEP suggests that BMPs, such as the following, would have improved conditions of the reservoir:

- reduction of excess fertilizers to row crops;
- streambank fencing to reduce the amount of organic matter entering the stream (which breaks down into phosphorous); and
- riparian revegetation to act as a buffer against phosphorous entering the stream.

Groundwater pollution from agricultural sources was considered another large contributor of phosphorous to Dutch Fork Lake in DEP's recent study. It is possible that other contributors, such as faulty sewer systems, are contributing a large proportion of phosphorous through groundwater that the model failed to show. Both the Claysville Mobile Home Park and Donegal Joint Municipal Authority had permits to discharge into either Dutch Fork Creek or one of its tributaries upstream of the reservoir. However, DEP considered contributions of phosphorous to be minimal.

Since the time that the reservoir was drained in 2004, sediment and nutrients that had built up in the reservoir have been traveling downstream into Dutch Fork Creek and eventually Buffalo Creek. This has degraded the quality of life in the stream, although some efforts have been made by DEP to use sediment and erosion controls to limit this degradation.

Recent Water Quality Improvement Activities

Buffalo Creek Watershed Restoration Project

The Buffalo Creek Restoration project is a partnership among numerous conservation organizations to reduce agricultural non-point pollution by fencing livestock from streams, restoring wetlands, and establishing warm-season grasses. Partners include California University of Pennsylvania, Tri-County Chapter of Pheasants Forever, Washington County NRCS, Ducks Unlimited, U. S. Fish and Wildlife Service, the Pennsylvania Game Commission, the Washington County Conservation District, the Pennsylvania Fish and Boat Commission, and the National Fish and Wildlife Federation. Pennsylvania DEP has also contributed funding through the Growing Greener Program (Pers. Comm., J. Teracido 2004).

The NRCS and cooperating agencies developed an assessment of water quality problems, determining that pasture and cropland erosion, animal waste, nutrient pollution, and stream erosion from livestock were the major natural resource concerns. They determined that there was a need to treat

10,000 acres of pasture, 1,000 acres of riparian corridor, and stabilize 40 miles of streams in the northern portion of the watershed. To date, the project has fenced over 27 miles of streams, protected over 90 acres of wetlands, created 45 livestock crossings, and planted over 311 acres of warm-season grasses within Buffalo Creek watershed (Pers. Comm., J. Teracido 2004).

Partners for Fish and Wildlife Stream Stabilization

The Partners for Fish and Wildlife Stream Stabilization project, summer 2004, addressed fish habitat and stability of the streambank area of Buffalo Creek 5.2 miles downstream from Taylorstown. The project was designed to demonstrate the benefits of bank protection by installing rock vanes and root wads to protect from erosion and divert energy from the streambanks. Trees were planted to provide long-term stability. Pennsylvania DEP, NRCS, the National Fish and Wildlife Foundation, and the Fish America Foundation provided funding for this project (Putnam and McCone 2002).

Dirt and Gravel Roads Program

The Pennsylvania State Conservation Commission Dirt and Gravel Road Pollution Prevention Program provides training and funding to local road-owning entities, mainly municipalities, to correct pollution problems on dirt and gravel roads. Sediment entering streams from roads can cause such negative consequences such as disrupting flow, suffocating organisms, accelerating filling up of dams and reservoirs, and decreasing spawning areas for fish (Penn State).

The Task Force on Dirt and Gravel Roads, including public and private agencies such as Trout Unlimited, Penn State University, and Pennsylvania DEP, created the commission and continues in an advisory capacity to the program. Pennsylvania's conservation districts administer the program. Municipalities may apply for funding after completing a two-day workshop. In 1996-1997, the Task Force developed a list of healthy streams (High Quality and Exceptional Value), being negatively affected by dirt and gravel roads. The Buffalo Creek watershed had the highest density of priority dirt and gravel roads in Washington County (Penn State).

An inadequately designed culvert and endwall from a Buck Run tributary filled with sediment after a flood in 2004.

Examples of improvements made through the Dirt and Gravel Road Program include grade breaks, french mattresses, headwall and endwall construction or improvements, and use of driving surface aggregate. Grade breaks increase the road elevation on a downhill slope, causing water to flow off the road surface and preventing erosion of road material. French mattresses are structures built under a roadway through which water can fully pass, allowing a non-erosive discharge of water. Headwalls and endwalls are walls built around culvert openings that can be modified to withstand higher flow capacities. Driving surface aggregate is a road surface containing fine particles that can be used in place of more common applications containing silt and clay. Unlike silt and clay, the fine particles settle out and can have less negative effects on aquatic life (Penn State). Figure 3-4 shows priority dirt and gravel roads within the Buffalo Creek watershed.

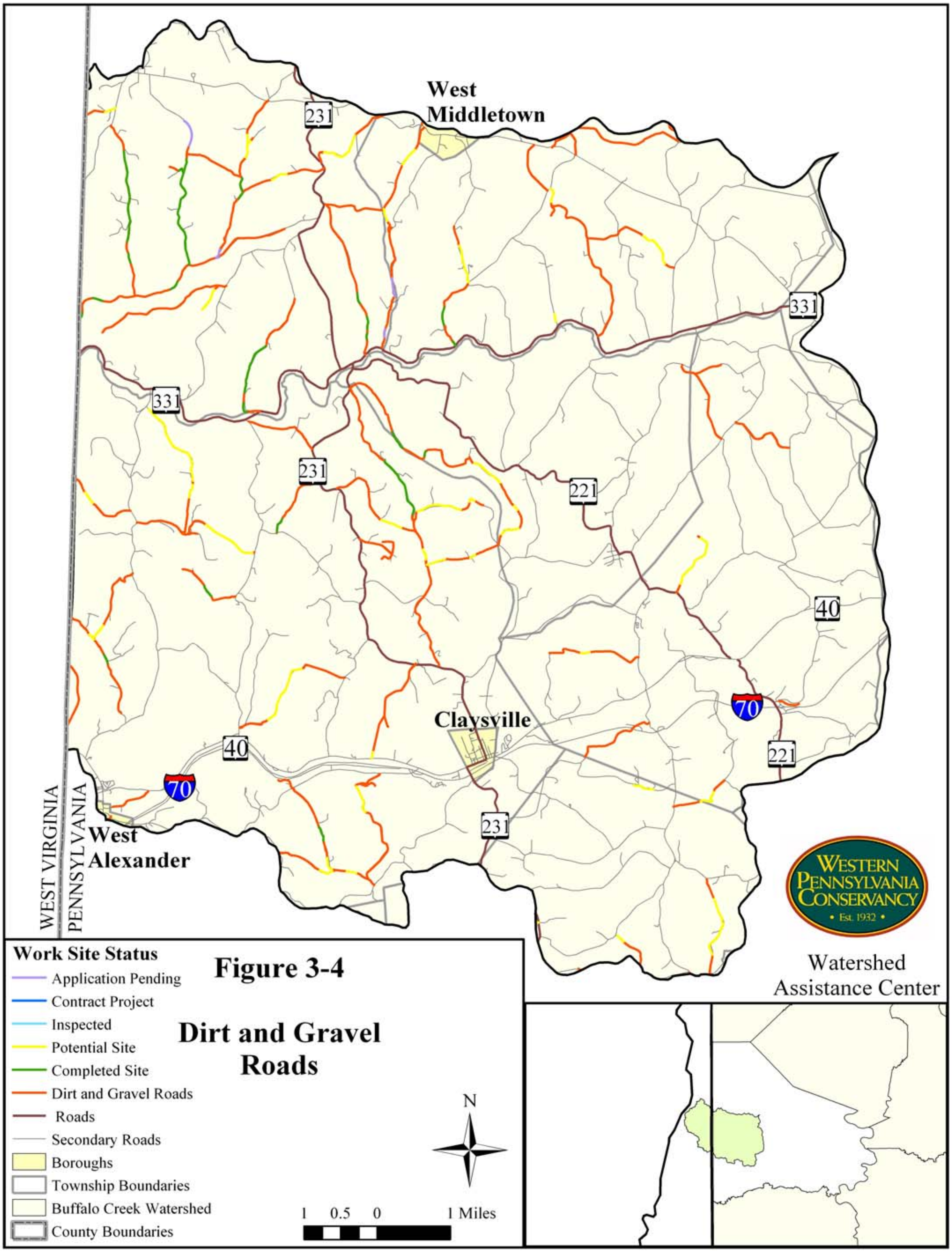


Figure 3-4

Dirt and Gravel Roads

WPC Assessment

Overview

To investigate the current health of the streams within the Buffalo Creek watershed, WPC collected data on the chemical, biological, and physical aspects of water quality. Stream flow estimates were made within major tributaries of Buffalo Creek. Chemical sampling was done using both test kits and laboratory analysis and conducted based on subwatershed boundaries. Macroinvertebrate sampling was done using EPA's rapid bioassessment protocol adapted for WPC use. A visual assessment was performed on every accessible stream within the watershed using the USDA protocol adapted for use in the Buffalo Creek watershed. The visual assessment results were used to determine whether streams exhibited excellent, good, fair, or poor quality based on a minimum of 10 variables. Recommendations based on findings are given at the end of each section.

Stream Flow

Objective

To quantify stream flow, or discharge, as measured by cubic feet/second of water in Buffalo Creek and its tributaries during low- and high-flow situations.

Methods

A cross-sectional area of each selected stream was determined by measuring width and depth of the stream at various intervals. An FP 100 Global Flow Probe was used to measure stream flow in feet/second at each of these intervals. This information was used to estimate total discharge by summing the product of velocity and area of each interval.

Results

Stream discharge varied greatly throughout the sampling period. This coincided with residents' reports of extremely low flow during dry, summer months of high evapo-transpiration and high flow during storm events. Because of dangerous flow, discharge was estimated for a spring storm event by using past estimates of the cross-sectional area and using the flow probe from the streambank. This may be an underestimate of flow. Table 3-9 shows stream flow estimates for major tributaries.

Table 3-9. Stream Flow at Select Locations

Stream	Flow (cubic feet/second)		
	8/1/2003	10/23/2003	4/2/2004
Sugarcamp		3.92	
Buffalo Creek East	12.15	5.71	*78.29
Buffalo Creek South		7.83	*76
Buffalo Creek (Taylorstown Gazebo)	21.79		
Buck	2.87		*75
Buffalo Creek (mouth of Middle section)	39.96	25.12	*218.50
Dunkle	7.04	3.60	*50.63
Dutch Fork (mouth)	5.18	17.5	*193.60
Upper Dutch Fork (mouth)	6.08	3.68	*133.950
Buffalo Creek (near WV border)	27.31	36.8	too high
Brush	12.79	8.16	*148.5

*estimated because of dangerous sampling conditions

Discussion

Stream discharge is one of the most useful parameters measured in streams. Extreme changes in flow over time can indicate alterations in watershed hydrology due to such factors as well-water withdrawals, riparian buffer removal, and mining activities. Because of a lack of flow information collected in the watershed in the past, few conclusions can be drawn from the data collected in this study. Efforts should be made to continue monitoring stream flow into the future to look for changes that may be indicative of stream health.

Unnaturally low flows can decrease the capacity of a stream to buffer changes in temperature that can affect aquatic organisms. Low flows may also cause aquatic animals to be stranded in pool areas or have negative effects on organisms because of low oxygen levels. The same land-use activities that cause low flows during dry months can contribute to high flows during rain events, especially alterations occurring in floodplain areas. Floodplains are one of the most important places where stream water is transferred to groundwater. Instead of water being stored in groundwater, vegetation, and soil, floodplain alterations can cause water to be lost to a stream and increase flow during rain events.

Stream discharge can also be used in conjunction with pollution concentrations to estimate locations of pollution loading. In most cases, discharge can be roughly estimated by volunteers by measuring the time it takes to float a symmetrical object downstream a certain distance or by using a flow probe. Unfortunately, discharge is most difficult to measure during high storm events when it can be the most useful. "Dimensionless ratios" are sometimes used to estimate stream discharge during flows below the bankfull stage by estimating the probable discharge for different stream types at specific cross-sectional areas. The term **bankfull** describes the point at which a stream discharge begins to overflow onto its floodplains (Rosgen 1996). Dimensionless ratios are currently not available for most of Pennsylvania but are being developed by USGS and may one day be useful in estimates of stream flow.

Another useful way to measure stream flow, which is actually utilized in the development of dimensionless ratios, is the use of stream gauges. The USGS maintains permanent stations across the United States to monitor instantaneous stream flow, which is transmitted via satellite to the USGS office every four hours and then made available to the public on the USGS website. Stream discharge information provided through these gauges can help provide information to properly design dams, bridges, and wastewater treatment plants, as well as warn of flood events. From 1960 to 1985, USGS maintained a gauging station within the watershed on Brush Run (USGS). Due to budget constraints, the gauging station was eliminated.

Recommendations

- Continue to monitor and record stream discharge in Buffalo Creek and its tributaries.
- Develop a relationship between water height and stream discharge in major tributaries using dimensionless ratios, so that discharge can be estimated more easily and be used more readily to estimate flood levels and sediment loads.
- Encourage the re-establishment of a USGS gauging station within the watershed.

Chemical Assessment

Objective

To evaluate water quality within the Buffalo Creek watershed by acquiring existing chemical data and conducting new investigations using test kits and laboratory analysis.

Methods

All known chemical data from studies within the Buffalo Creek watershed was collected, with emphasis on data collected within the last five years. WPC staff conducted further investigations using

Lamotte test kits and laboratory analysis (Table 3-10). New stream sites were chosen based on the following priorities:

(1) Sites on Buffalo Creek itself, based on changes in land use and accessibility.
(2) Sites at the mouths of major tributaries of subwatersheds entering Buffalo Creek in Pennsylvania.

(3) Smaller order streams that enter Buffalo Creek and its major tributaries.
(4) Sites on tributaries of major subwatersheds that enter Buffalo Creek in West Virginia.

Types of Analysis Performed	How Performed	Dates of Sampling	Sites
conductivity, total dissolved solids, pH, sulfates, iron, nitrates, phosphates	test kits	quarterly (August 2003-2004)	Buffalo Creek mainstem and subwatersheds, a total of 13 sites
conductivity, total dissolved solids, pH, sulfates, iron, nitrates, phosphates	test kits	1-3 times during 1 year period (August 2003-2004)	smaller tributaries, a total of 20 sites
TSS, chlorides	laboratory	October 2003	9 sites=TSS; 7 sites=chlorides
TSS, TP, some nitrates	laboratory	March 2004	9 sites=TSS, TP; 4 sites=nitrate
fecal coliforms	laboratory	August, October 2004	8 sites in August and 8 in October

Chemical sampling results were compared to water quality standards to determine sites at which water quality standards were not being met. Results were compared to past data to estimate water quality trends over time and make recommendations. The following is a description of the chemical parameters measured during the study. The majority of sampling was done using test kits, which were adequate to determine whether water quality standards were being met. Further laboratory tests were used to investigate some of the sources of pollution.

pH: This measure of the number of hydrogen ions in solution is affected by natural geologic conditions as well as pollution. Higher pH may indicate nutrient and sediment pollution while lower pH may indicate acid rain or mine drainage. High pH's may result in algae blooms. Natural pH conditions often range from 5.5 to 8.5.

Iron: Naturally occurring iron may show up as red deposits in streams in Pennsylvania where iron has come into contact with oxygen and forms a rust-like precipitate. Processes used in mining and oil and gas well drilling can contribute to unnaturally high amounts being released into streams, which is toxic to wildlife.

Temperature: The temperature of a stream may affect dissolved oxygen concentrations (higher temp=lower DO), rates of photosynthesis, effects of pollutants, and aquatic species composition; removal of vegetation along the stream is the biggest contributor to increased temperature.

Dissolved Oxygen: Aquatic organisms require oxygen for survival. Factors such as high temperatures and algal growth can decrease the amount of oxygen available and decrease health of aquatic organisms.

Conductivity: This measure of electrical current carried by ions in solution is dependent on both natural and man-made sources; high conductivity or increases in conductivity can indicate faulty septic systems, or high urban or agricultural runoff, but often further investigation is needed. Total Dissolved Solids (TDS) is a comparable measurement, equal to roughly half the conductivity concentration.

Total Suspended Solids (TSS): This measure of large particles suspended in solution can indicate soil erosion, waste system effluent, agricultural runoff, and soil erosion; particles can carry harmful bacteria and nutrients, block photosynthesis, and clog the gills of aquatic insects and fish.

Phosphates: This measurement of the phosphorous available to plants often is the key factor contributing to algal growth in streams, which can cause low oxygen concentrations; a measurement of phosphate at any one time may not yield valuable results because phosphate is quickly produced and utilized. Therefore, total phosphorous (TP) may be a more important measure.

Nitrates: A valuable component of amino acids necessary for life, high levels of nitrates may cause increased algal growth and low oxygen levels. This measurement of the nitrogen available for plants is, like phosphates, primarily caused by agricultural runoff and faulty sewer systems.

Sulfates: High levels of sulfate may be indications of sewer pollution or mine drainage pollution; natural sources may include naturally occurring sources found in gypsum within limestone rock.

Chlorides: High levels of chloride may be caused by abandoned oil and gas wells, agricultural runoff, and road salt.

Fecal Coliforms: This group of bacteria found in the intestinal tracts of humans and other warm-blooded animals may carry harmful micro-organisms. High levels may indicate faulty sewer systems and runoff from farm animal operations.

Total Nitrogen and Total Phosphorous: This measure of the total amount of phosphorous and nitrogen, including that which is not yet available to plants, can be helpful in estimating sources of nutrient loading.

Results

The highest temperature recorded within the watershed during the sampling period was 74.2° F at the exit of Dutch Fork Reservoir in August 2002. Other sampling points with temperatures 70.0° F or higher included Buffalo Creek at the West Virginia border, Dutch Fork Creek at its mouth, and Dutch Fork Creek immediately before it enters Dutch Fork Lake. The lowest temperatures recorded during summer sampling were 68.1° F at the mouth of Buck Run and 67.3° F at the mouth of the south branch of Buffalo Creek. The Buffalo Creek watershed met the requirements of a Warm Water Fishery with respect to temperature according to these results.

ents and sediment during a storm

The lowest pH recorded within the watershed was a pH of 7.3 for Dutch Fork Creek before entering Dutch Fork Lake (summer). The highest reading was a pH of 8.8 for Dutch Fork Creek below the truck stop on Route 70 (spring). The average pH recorded within the watershed was 8.18.

Conductivity averaged 474 microsemens (uS). A conductivity reading from 550 to 600 uS was considered a possible sign of a water quality problem, while a reading above 600 uS was considered a more definite sign of a problem. Probable water quality problems were identified at the following sites: Upper Buffalo Creek, S bridge (spring 2004), Mouth of Dunkle Run (summer and fall 2003), a tributary to Brush Run (fall 2003), and Dutch Fork Creek before entering Dutch Fork Lake (summer 2003). A more definite problem was identified on Buffalo Creek at the gazebo area in Taylorstown in summer 2003, but no other readings at this site reached such levels.

Nitrate levels averaged about 0.25 mg/L in any stream within the watershed on any given sampling day. Highest levels were observed during spring runoff. Although no measurements exceeded water quality standards, levels over 1 mg/L were considered to be possible symptoms of a water quality problem. These levels were observed at the following sites: mouth of Upper Buffalo Creek, S Bridge (March 2004), Buffalo Creek at Taylorstown Gazebo (March 2004), Brush Run tributary along Hickory Run Road (March 2004), the mouth of Brush Run (March 2004), and a tributary to Dunkle Run (Spring 2004). A level of 4 mg/L in an agricultural tributary of Brush Run was the highest observed.

Sulfate levels ranged from 0-60 mg/L, and all were below the water quality standard of 250 mg/L. Chloride, measured at eight sites in 2003, remained far below the water quality standard of 250 mg/L. The highest chloride concentration measured was 66.5 mg/L at the mouth of Lower Dutch Fork subwatershed. Iron approached the water quality standard of 1.5 mg/L in a tributary to Brush Run along Maple Run Road and exceeded standards in a tributary to Buffalo Creek in Buffalo Township. No specific reason for this high iron level could be identified.

Total nutrient and suspended solid loading measurements made during a spring storm event were used to look for sources of sediment and nutrients within the watershed. Loading was estimated using the units commonly used in such studies of kilogram per day (kg/day) and kilogram/day/hectare. One hectare is equal to approximately 2.47 acres, and approximately 453.59 grams are equal to one pound.

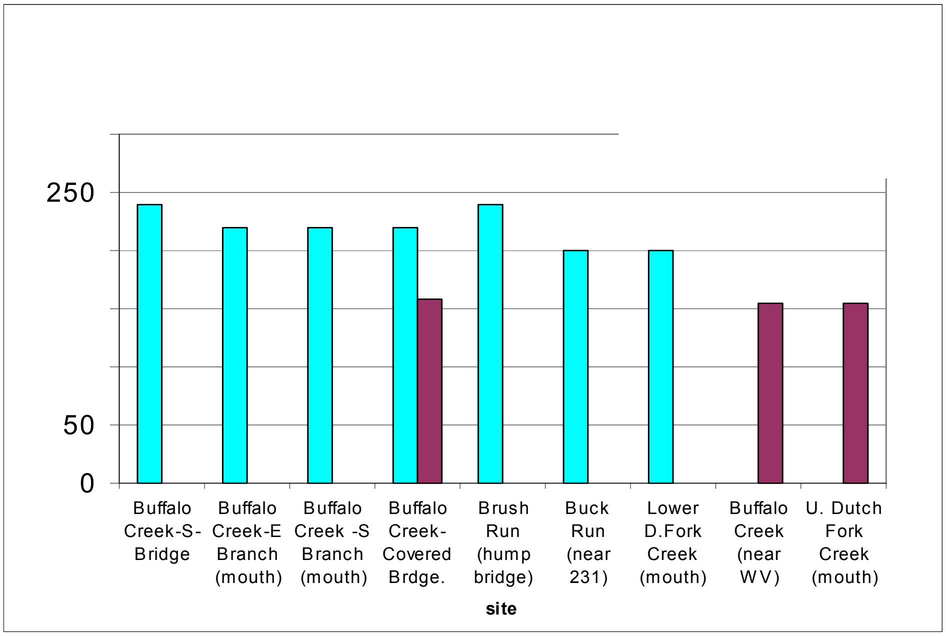
Table 3-11. Net Contribution of Sediment and Phosphorous to Buffalo Creek (storm event)

Subwatershed	**Area (hectares)**	**Phosphorous**			**Total Suspended Solids**		
ID	hectares	kg/day	rank	g/day/ha	rank	kg/day	g/day/ha
Buffalo East	3,283	18	5	1	5	12,545	627
Middle Buffalo Creek *	3,012	4	7	0	1	22,249	1,212
Brush Run	3,267	68	1	4	2	17,840	896
Buffalo Creek South	3,865	26	4	1	3	15,586	662
Dutch Fork mouth *	1,660	-17	9	-2	8	896	89
Buck Run	1,460	33	3	4	7	4,456	501
Dunkle Run	2,061	12	6	1	6	6,016	479
Dutch Fork upper	4,566	43	2	2	4	12,642	454
Lower Buffalo Creek*	2,550	-130	8	-9	9	-232	-15

* These subwatersheds were adjusted for contributions from subwatersheds upstream, and values only represent the net gain or loss of sediment in that subwatershed.

Middle Buffalo Creek and Brush Run contributed the highest amounts of sediment to the mainstem of Buffalo Creek in terms of both total contribution and contributions/acre (Table 3-11). Lower Buffalo Creek served more as storage for sediment than a source, with less sediment leaving the subwatershed than entering it. The highest contributors of phosphorous were Buffalo Creek South and Upper Dutch Fork subwatersheds. On a per/area basis, Brush Run and Buck Run were the highest contributors. Lower Dutch Fork Creek and Lower Buffalo Creek served more as storage areas than source areas for phosphorous.

Alkalinity sampling done by the Buffalo Creek Watershed Association found that alkalinity averaged 220 mg/L over eight sites throughout the watershed (Figure 3-5). This appears to be an increase in the average of 155 mg/L during Fish and Boat Commission sampling in 1996, though few sites were looked at during that evaluation.



Fecal coliform sampling undertaken during rain events in swimming (August) and non-swimming (October) seasons exceeded water quality standards for the majority of the samples. Results are shown in Table 3-12. In August, eight out of nine samples exceeded standards of 200 mg/L, and the sample below standards was thought to be the result of a laboratory error. The maximum value that could be obtained during this first sampling was 200 mg/L because of the constraints of the laboratory test. In October, six out of eight samples exceeded standards of 2,000 mg/L. The sites with the highest levels were the mouth of Dunkle Run and Buffalo Creek at Taylorstown. Sites with the lowest levels and not exceeding standards were Buck Run and Buffalo Creek South.

(units: coliform colonies/100 mL)		
Site	**8/18/2004**	**10/19/2004**
Buffalo Creek East, S Bridge	>200*	2540
Buffalo Creek, Taylorstown	>200*	3600
Buffalo Creek, Route 3003 Bridge	>200*	3100
Dunkle Run, mouth	0**	3760
Buck Run, near mouth	>200*	1430
UNT, Newman Road	>200*	2460
Upper Dutch Fork, before reservoir	>200*	2340
Upper Buffalo Creek, softball fields	not sampled	1560
UNT, Hickory Nut Road.	>200*	not sampled
* 200 mg/L was the maximum value that could be obtained **suspected error in analysis values in red exceed the water quality standard		

Water quality standards are set by DEP for the most common types of pollution to streams. Based on the water quality sampling done by WPC, water quality standards were exceeded very few times for most parameters (Table 3-13; Figure 3-6). Alkalinity may have been considered to impair water quality at the levels found based on other sources, but DEP does not set a maximum value for alkalinity. Fecal coliform was the exception, exceeding water quality standards the majority of the time. Though sampling was not done over a period of 30 days, which is required by the water quality standard requirements for fecal coliforms (Table 3-13), values could be expected to exceed standards at least during rain events, which normally occur at least five times per month. Figure 3-6 shows the results of sampling efforts. Sites that exceeded water quality standards for a standard parameter at least one time during the study are shown in red.

Table 3-13. Number of Samples Exceeding Water Quality Standards			
Parameter	**Units (mg/L)**	**Source**	**# Exceeding Standards**
Alkalinity	x>20	PA Code 25, Chapter 93.7	0/8
Iron	1.5	PA Code 25, Chapter 93.7	1/48
Nitrates	10	PA Code 25, Chapter 93.7	0/55
pH	6.0<x<8.5	PA Code 25, Chapter 93.7	4/51
Phosphate	0.1	EPA Water Quality Standards	0/46
Sulfates	250	PA Code 25, Chapter 93.7	0/36
Chloride	250	PA Code 25, Chapter 93.7	0/7
TSS	500 avg; 750 max	PA Code 25, Chapter 93.7	0/10
Parameter	**coliforms/100mL**	**Source**	**# Exceeding Standards**
Fecal Coliform	200 during swimming season, based on 5 samples over 30 days	PA Code 25, Chapter 93.7	7/8
Fecal Coliform	2,000 during non-swimming season, based on 5 samples over 30 days	PA Code 25, Chapter 93.7	6/8

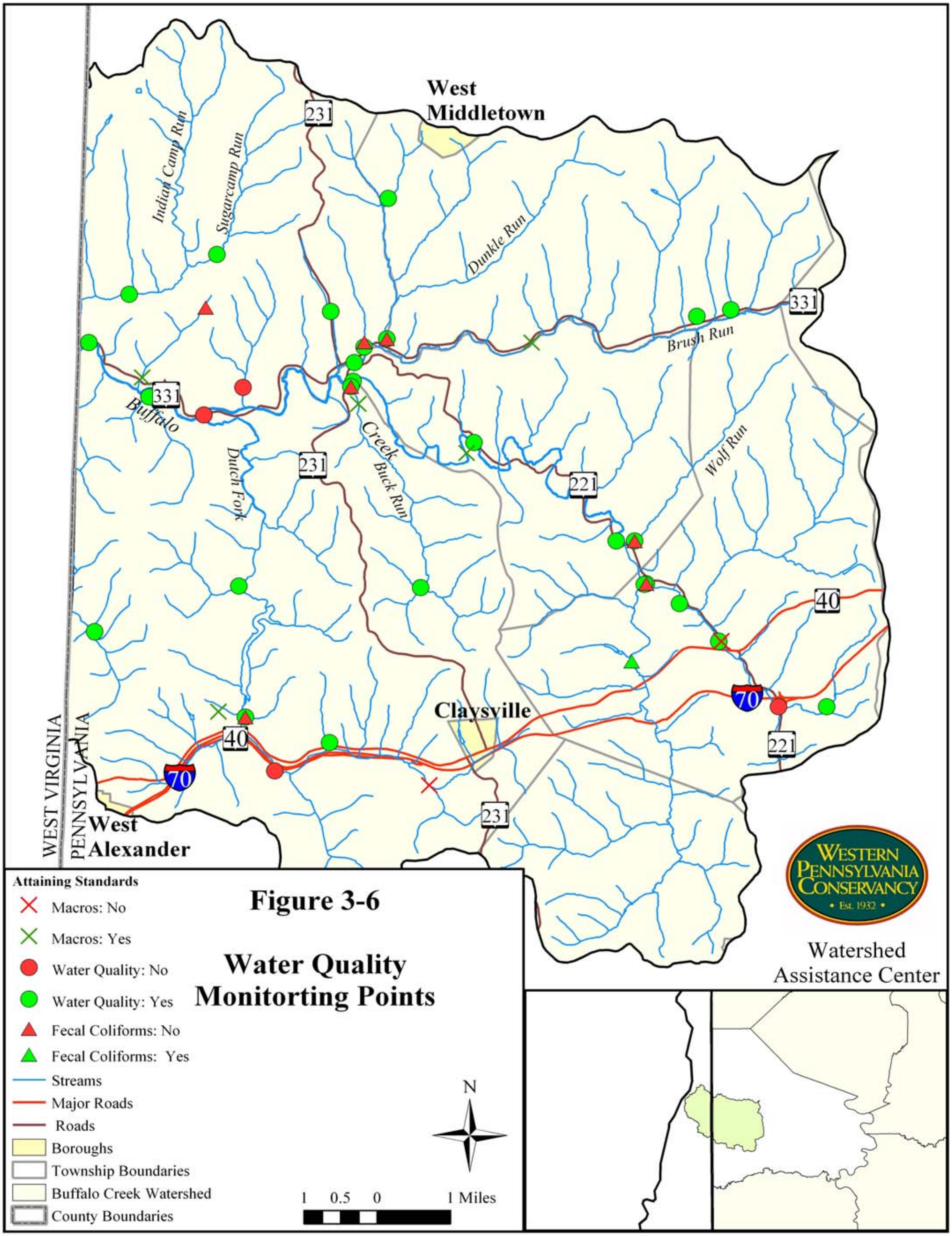


Figure 3-6

Water Quality Monitorting Points

Discussion

Results support observations made by WPC and residents that faulty sewage septic systems and agricultural runoff are probably the two major problems affecting water quality in Buffalo Creek. Suspended solids are largely comprised of sediment from streambank erosion, manure and crop runoff, and solids from faulty septic systems. Not surprisingly, areas of high total suspended solids were also some of the areas with the highest fecal coliform counts, which are symptoms of septic problems and agricultural runoff. These included Dunkle Run, Middle Buffalo Creek (Taylorstown), and Upper Dutch Fork Creek.

Though fecal coliform bacteria are not inherently harmful, they can be a symptom of other disease-causing bacteria. Drinking water standards are 200 mg/L, while standards for surface waters are much higher. Typically, streams carry the highest levels of fecal coliforms after storm events, when runoff enters streams. Levels were not measured during normal flow periods, when bacterial counts may have been lower. Though the high levels do not necessarily indicate that streams within the watershed are not safe for recreation purposes, efforts should be made to monitor coliform levels regularly and to determine sources of high levels. Septic system upgrades and additional streambank fencing efforts could help reduce fecal coliform counts.

Though standards were generally met for other parameters, levels may still be high enough that impairments to wildlife exist. For instance, studies have shown that nitrate levels below water quality standards may not kill amphibians and fish, but may cause other less notable impairments, such as nervous system dysfunctions. Additionally, nitrate and phosphate levels are constantly changing in response to storm events and natural processes. Sampling four times during one year may not have given a true picture of nutrient levels. Even small amounts of phosphate can contribute greatly to algal growth and potentially affect stream health.

Alkalinity in streams varies greatly based on the natural geology of an area and the presence of calcium carbonate and other alkalinity producing compounds. Though high alkalinity can benefit a stream by preventing the negative effects of acid rain and acid mine drainage, it can also have negative effects if combined with high nutrients. This is because carbonate and bicarbonate ions that make up alkalinity increase the amount of phosphorous utilized by plants, increasing primary production and algal blooms. Alkalinity in Buffalo Creek has increased by approximately 27 percent since 1996. Increases in alkalinity can occur as a result of anthropogenic inputs such as agricultural runoff and faulty septic systems, or any ion that increases buffering capacity.

Severe erosion along a section of Buffalo Creek, resulting in significant loss of streambank each year

Of the areas sampled, Buck Run continually presented itself as one of the higher quality streams within the watershed. The exception was that it had the highest total phosphorous load on a per acre basis. This suggests that there may be a substantial source of phosphorous in the subwatershed. The fact that fecal coliforms and suspended sediment were substantially lower than other areas suggests that the source may not solely be attributed to septic systems or animal waste. However, nutrient interactions in streams can be complicated and further study is needed to determine the source of phosphorous loading.

Water quality standards were exceeded approximately 10 percent of the time during the sampling period. High quality streams are expected to meet water quality standards at least 99 percent of the time. The foremost parameters that exceeded water quality standards were pH and fecal coliforms. Though there is a water quality standard for pH of 8.5, it is possible that natural conditions in a high quality stream could be near that level. More investigation would be needed to determine whether the high levels are normal or due to agricultural and other impacts. Additionally, there is no direct evidence that fecal coliforms exceeded water quality standards by being over 2,000 colonies during five sample periods in a month. Samples were not collected five times within a month and it can only be assumed that water standard levels are exceeded every time there is a medium to high rain event, which may occur at least five times in a month. What is known is that any efforts to reduce fecal coliforms would greatly benefit streams for humans and wildlife. Finally, only one site exceeded water quality standards due to iron levels, a possible indicator of abandoned mine drainage (AMD) or abandoned oil and gas well impacts. However, this 1.5 mg/L reading is much lower than many other AMD-impacted streams and there is no evidence of high iron levels elsewhere within the watershed.

n
these areas may receive financial incentives

Though there are no water quality standards for suspended solids (an indicator of sedimentation), sediment pollution can pose a serious threat to stream health. The lack of standards simply reflects the complicated nature of determining what levels should be considered harmful. Some streams received high suspended sediment loads but are able to transport this sediment downstream, where it is not deposited on streambeds. It is the natural meanders, or bends in the stream, that provide the energy for this transfer of the sediment. Streams that have been altered from their natural state due to building or roads, altered riparian zones, or other factors, often retain sediment on the streambed, which can smother aquatic organisms. This sediment deposited on the streambed is immobilized during high storm events, causing bank failures downstream and ultimately increasing flooding potential, which also poses problems for humans.

Results suggested that the Middle Buffalo Creek and Brush Run subwatersheds contributed the most sediment in total and on a per acre basis during a storm event. These may be the watersheds with the highest levels of streambank erosion and other sources of sediment. Both need further study and would be some key areas to benefit from additional streambank fencing, septic system upgrades, and streambank improvements to reduce sediment loads, though Brush Run already has the highest levels of streambank fencing within the Buffalo Creek watershed. Also notable was the use of marginal lands (steep slopes and floodplains) for grazing and cropland within many of the subwatersheds. These areas are priorities for the Conservation Reserve Enhancement Program (CREP) and other programs that pay farmers to keep these lands out of production. Best management practices such as streambank fencing and rotational grazing may reduce sediment loads in agricultural areas.

Fluvial geomorphology studies can investigate a stream's ability to transport sediment and make recommendations for improving sediment transport. Because of the and cost associated with these studies, conducting them is often unrealistic, especially in rural areas. However, Buffalo Creek and its tributaries would benefit from any further studies of sediment dynamics and improvements to both reduce sediment loads and increase the ability to transport sediment downstream through repairing riparian areas and improving passage of sediment through culverts and bridges.

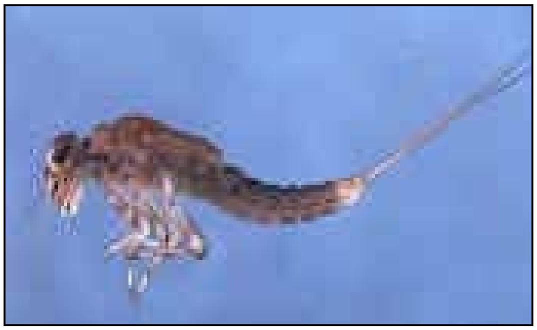
Recommendations

- Conduct further chemical monitoring within the Buffalo Creek watershed to look for potential problems and trends in water quality.
- Establish regular monitoring of fecal coliforms.
- Continue and expand BMPs within the watershed, including streambank fencing, the limiting of disturbances (mowing, agricultural, logging, etc.) in riparian zones, and discontinue agricultural activities on steep and other marginal areas; this can be done through landowner participation in CREP and other programs.
- Enforce Act 537, which requires all on-lot systems to have functioning sewage systems, and encourage municipalities to follow their Municipal Sewage Plans.
- Conduct more detailed analyses of fecal coliforms and other bacterial measures (such as Escherichia coli- E. coli) as technology becomes available that is able to determine the sources of bacteria in streams (human, livestock, wildlife).
- Conduct detailed studies on the transport of water and sediment within the watershed, based on the principles of fluvial geomorphology, to determine areas that could best benefit from restoration activities such as riparian plantings and the installation of root wads and crossvanes, in order to alleviate pressure on streambanks and reduce stream widening.

Macroinvertebrate Assessment

Background

Aquatic macroinvertebrates include animals without backbones that are big enough to see with the naked eye and live in waterways such as streams, lakes, and wetlands. They include aquatic insects, snails, and crayfish. Macroinvertebrates are important indicators of health in aquatic ecosystems, often depending on unique habitat requirements to complete their life cycles. Physical characteristics such as external gills, siphons, and streamlined shapes are special adaptations to the aquatic environment. Typically, aquatic insects make up the majority of the macroinvertebrate assemblage. Larval, or immature, insects emerge as adults to lay their eggs on, or in close proximity to, streams and lakes. Common aquatic insect orders include mayflies, dragonflies, stoneflies, beetles, flies, and true bugs. Snails, clams, and worms are also common.



This mayfly of the family Baetidae has a streamlined shape designed for maneuvering in running waters. (photo courtesy New York State Department of Environmental Conservation)

Because a waterbody's chemistry can change from one day to the next, biological indicators such as macroinvertebrates are often better indicators of aquatic health than chemistry, especially in streams. Aquatic insects have life cycles of varying durations and unique tolerances to pollution, so that the presence and abundance of a group can say much about past and present stream health. Aquatic insect life cycles range from less than two weeks (some species of chironomids and other fly families) to several years (some species of stoneflies). Higher quality waters often have a larger proportion of longer-lived, more intolerant species (indicating a consistent period of good water quality). As a result of differences in geologies and background water chemistry, tolerance levels to pollution can also vary by geographic area. See Appendix K for a family level tolerance listing used by the Pennsylvania DEP.

Objective

To use the quantities and identities of macroinvertebrates and their varying tolerances to pollution to evaluate water quality within the Buffalo Creek watershed.

Methods

The sampling protocol used in collection was “Western Pennsylvania Conservancy’s Standard Operating Procedure for Macroinvertebrate Sampling Using a D-Frame Net,” which involves vigorously collecting debris 20 times (kicks) within a 100-meter sample reach, using a special net and dislodging debris .5 meters upstream of the net (Appendix I). Sorting and identification utilized “Western Pennsylvania Conservancy’s Laboratory Macroinvertebrate Sample Sorting and Identification,” which involves identifying a subset of the entire sample down to the genus or species level (the lowest level of identification). One additional site sampled by the Buffalo Creek Watershed Association during a macroinvertebrate training was sampled using only five kicks.

WPC macroinvertebrate sample sites identified to the lowest possible taxa included Buffalo Creek (S Bridge), Buffalo Creek (Covered Bridge), Welch Run, Dutch Fork North at SR 3019, Buck Run, and Brush Run at Coon Hunt Club. An additional site identified to family by the Buffalo Creek Watershed Association was the mouth of Upper Dutch Fork Creek.

DEP’s Wadeable Streams Survey (Appendix J) was used to determine whether a site was impaired in order for results for the six sites to be compared with DEP’s macroinvertebrate survey results obtained in 1999. Indices of Biological Integrity used to further evaluate stream health included Hielsenhoff Index of Biological Integrity, percent Diptera (fly) larvae, percent EPT (Ephemeroptera, Plecoptera, and Tricoptera), and Total Number of Taxa, as described below.

Hilsenhoff Index of Biological Integrity: This index measures stream health by considering the tolerances to pollution of the members of the macroinvertebrate community. Each family receives a specific tolerance score, and the tolerances are averaged to get an index score. A value of 7 or higher is considered impaired, 6-7 is possibly impaired, and less than 6 is unimpaired.

Percent Diptera larvae: Dipterans, or flies, are an important part of the stream community. However, many dipterans can withstand polluted conditions of low oxygen. The following gauge of stream health was used in this study: <15% or >50% dipterans = impaired; 15%-20% or 45%-50% dipterans = possibly impaired; 20%-45% dipterans = unimpaired.

Percent EPT: Most species of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Tricoptera) require gravelly stream bottoms with good oxygen and high water quality. The presence of these groups indicates good habitat and water quality. In general, < 5% EPT species is impaired, 5%-10% EPT species is possibly impaired, and >10% EPT species is unimpaired.

Total Number of Taxa: If the site has a high number of taxa (in this case, families), then habitat and water quality can support a variety of life. Nutrients (such as from sewage) decrease the ability of the stream to support aquatic insect life. Generally, less than 13 families is considered impaired and greater than 13 is considered unimpaired.

A stream was considered impaired if it had an impaired score on two or more of the above indices or if it failed DEP's Wadeable Streams Evaluation, which considers various indicators of stream health (Appendix J).

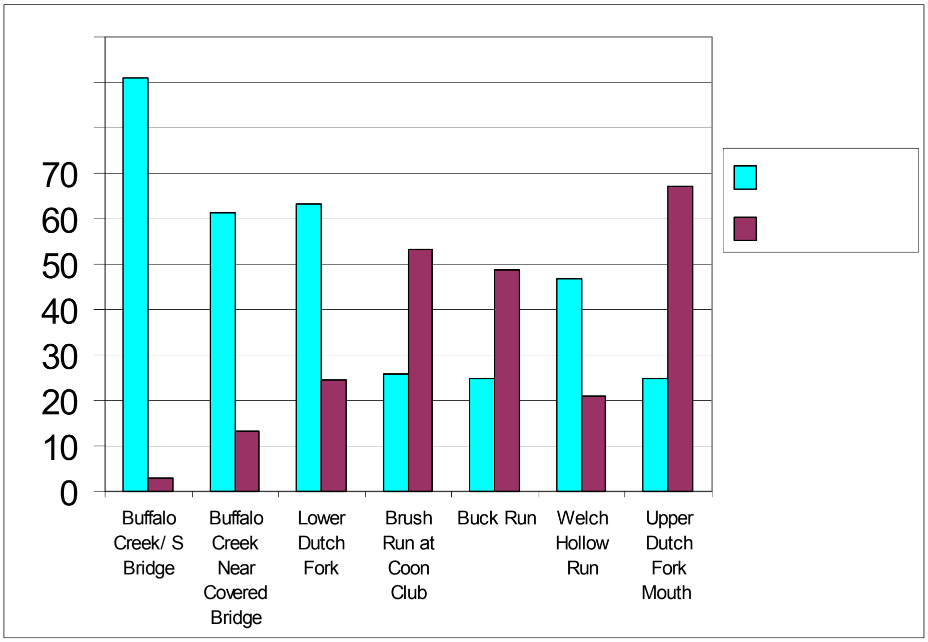


Figure 3-7. % Diptera and % EPT at WPC macroinvertebrate sites

Results

Figure 3-7 shows percent Diptera and percent EPT scores for each of the sites. The streams showing the greatest habitat quality and least amount of agricultural impacts, Buck Run and Welch Hollow Run, had the highest percent EPT scores and lowest percent Diptera scores. Upper Dutch Fork had a high percent EPT species but most of the sample was comprised of a tolerant mayfly taxa, heptagenidae. Sites with possible impairment according to percent Diptera included Buffalo Creek-S Bridge, Buffalo Creek-Covered Bridge, and Lower Dutch Fork. Brush Creek had a marginal percent Diptera score, which means that it scored between impaired and unimpaired.

A site was ultimately considered impaired if it received a negative in two or more of the four index categories (percent Diptera, percent EPT, Hilsenhoff, and Diversity) or if it failed DEP's Wadeable Stream Survey, which is an alternative method of evaluating stream integrity that is used by DEP (Appendix J). Table 4-14 shows the final results. The Upper Dutch Fork site (Route 3019) not only failed one of the indices, percent Diptera, but also failed the DEP survey and was therefore considered impaired. The Buffalo Creek East site failed all of the indices and was also considered impaired.

Table 3-14. Results of Macroinvertebrate Survey

Biological Index	Buffalo East (S Bridge)	Dutch Fork at Rt. 3019	Dutch Fork (at lake inlet)	Buffalo Creek (near covered bridge)	Buck Run	Welch Hollow Run	Brush Run (near Coon Hunt Club)
Hilsenhoff Score	I	marginal	N	N	N	N	N
Percent Diptera	I	I	N	I	N	N	marginal
Percent EPT	I	N	N	N	N	N	N
Diversity	I	N	I	N	N	N	N
DEP Survey	I	I	N	N	N	N	N
Considered Impaired	I	I	N	N	N	N	N

I=impaired, N=not impaired

Discussion

Macroinvertebrate Communities

Specific taxa of macroinvertebrates tend to occur together as a result of water quality and environmental characteristics. WPC, The Nature Conservancy, and other partner agencies have recently been working on a community classification system that will help determine what species most occur together within certain environments. Data collected for this plan was used in developing the classification. The study found that community "3" is a common community type characteristic of lower gradient, less forested streams containing the stonefly family Perlidae. A large percentage of streams with these characteristics contained members of this family. Community type "5" streams, usually containing Emidae, Hydrophilidae, and Empididae families, are associated with agricultural land use, and most of these streams are considered impaired. It was found that most streams in Buffalo Creek were type "3" streams, while Buffalo Creek also contained category type "5" streams. Community types in Buffalo Creek were fairly common throughout Pennsylvania (Nightingale 2004).

Impaired Stream Sections

In conjunction with its sampling done in 2001, as part of the Unassessed Waters Assessment, DEP used macroinvertebrates sampled at 42 sites within the watershed to determine whether water quality standards for aquatic life were being met yet. WPC sampling at different sites suggested that additional sections are impaired in addition to what was determined by DEP.

DEP has recognized a sewage problem at Taylorstown and the development of a sewage plant in the area is intended. However, the findings in this study suggest that the problem may extend far upstream of the 303(d) listed area, given that a poor macroinvertebrate score was found at the S Bridge. Raw sewage entering Buffalo Creek has been reported in the vicinity of the S Bridge. Consequently, the impaired section of Buffalo Creek near Taylorstown should likely be extended west along Buffalo Creek to the S Bridge, and potentially even farther upstream of this site. In addition, the eastern branch of Buffalo Creek, which impacts the downstream S Bridge site, should be a high priority for streambank fencing and other BMPs, as it has minimal fencing compared to other portions of the watershed, but has a high level of agricultural land use that may be contributing to the degradation.

An additional impaired site identified by WPC was upstream of the 303(d) section along Dutch Fork Creek. The source of water quality problems within the impaired portion of Dutch Fork Creek has yet to be identified, but has previously been attributed by DEP to point source pollution from the Route 70 truck stop. Though the truck stop may be contributing to the poor environmental quality, sampling suggested that problems may partially originate upstream of the truck stop and some non-point sources are contributing. For these reasons, it is recommended that this section be scheduled for a TMDL (which it currently is not).

There may be other impaired sites that were not sampled. The chemical and visual assessments assessed many areas that were not covered by the macroinvertebrate sampling. However, because of the importance of macroinvertebrate sampling in finding longer-term problems in water quality, the watershed group and other organizations should consider conducting more intensive macroinvertebrate sampling efforts in the future.

Recommendations

- Develop a regular macroinvertebrate monitoring program for the Buffalo Creek watershed.
- Consider Buffalo Creek near the S Bridge and Dutch Fork Creek along Route 3019 as priorities for monitoring and future restoration activities, and expand streambank fencing programs to these portions of the watershed.

Visual Assessment

Background

There is often a need to assess a stream quickly without the need for large amounts of scientific data. One way to do this is through a visual assessment of stream health, which can give a general overview of problems that might be occurring within a stream reach. Streams are complex systems where a variety of biological, physical, and chemical processes interact, and a visual assessment cannot begin to predict these interactions. However, it may give a general view of both negatively impacted and healthy areas and aid in developing monitoring, protection, and restoration efforts.

Changes in physical structure often affect the health of a stream. Increases in sediment load beyond the transport capacity of a stream results in deposition, stream widening, and cutting into streambanks. This can be made worse by the alteration of the channel, such as roads too close to the stream and removal of the riparian zone. Often, these activities increase flooding and problems downstream. By looking at the characteristics of the channel and activities around it, one can begin to interpret the physical health of the stream. Chemical pollution is another factor influencing stream health. Though only directed chemical sampling can determine specific types of pollution, visual indicators of pollution may include high algal growth, water odors, and effluent pipes going into the stream. The presence and types of macroinvertebrates found by briefly picking up rocks and debris can indicate pollution problems. Less tolerant stoneflies, mayflies, and caddisflies are preferable to large numbers of tolerant species such as fly larvae and leeches.

Objective

To estimate the health of streams within the Buffalo Creek watershed, by visually assessing components of stream health, in order to determine priority streams for restoration, protection, or further research.

Methods

The health of all accessible streams within the Buffalo Creek watershed was evaluated using USDA's Stream Visual Assessment Protocol adapted for WPC use. Accessible streams were those that could be evaluated from nearby roadways or through permission granted by landowners. If a stream was only partially evaluated and a score could not be formulated, it was given a "no score" rating. If a stream could not be identified at all due to landowner permission issues, it was considered "unassessed." The assessed streams were given a score from one to 10 based on an average of scores in 10 different categories related to stream health. The composition of land use and stream substrate was also estimated for each stream evaluated. The following stream parameters were evaluated:

Channel Condition: Channel alterations may increase the probability of flooding and bank erosion downstream and cause habitat loss for aquatic animals. Signs of channel alteration or straightening include an unnaturally straight stream, high banks, dikes, lack of riffles and pools, missing or altered vegetation, culverts, bridges, and riprap.

Riparian Zone: The riparian zone, or vegetated area along the stream from the active channel throughout the floodplain, keeps the stream cool, helps reduce erosion, dissipates energy during flood events, and provides woody debris for stream animals. A small or absent amount of vegetation in this area can be unhealthy for a stream.

Bank Stability: Excessive bank erosion occurs when riparian zones are degraded, hydrology is altered, sediment load is increased, or the floodplain is changed. Some streambank erosion is natural, but severe erosion on outside bends or erosion on inner bends of banks can be indicative of a problem.

Water Appearance: Turbid or green water can indicate sediment and nutrient impacts. Clarity can be estimated by looking at objects at different depths, and should never be estimated during a rain event (unless impacts during a rain event are being determined).

Nutrient Enrichment: High levels of nutrients promote overabundance of algae. Intense algal blooms and thick mats of algae may indicate nutrient problems.

Fish Barriers: Barriers that block the movement of fish or other organisms may affect survival and reproduction of these species. These include dams and raised culverts. Large culverts with little drop usually do not cause a problem for fish.

Instream Fish Cover: The potential for the maintenance of a healthy fish community and its ability to recover from disturbance can be estimated by looking at the number of habitat types available, including woody debris, deep pools, overhanging vegetation, and others.

Embeddedness: This measurement of the degree to which cobble and gravel are covered by fine sediment within a riffle or run is directly related to the suitability of substrate for macroinvertebrates, fish spawning, and egg incubation. It is influenced by stream erosion and other causes of sedimentation.

Invertebrate Habitat: The number of habitat types available for invertebrate colonization of the stream substrate can be related to the regularity of stream flows and other indicators of stream health. These include woody debris, submerged logs, leaf packs, boulders, and coarse gravel.

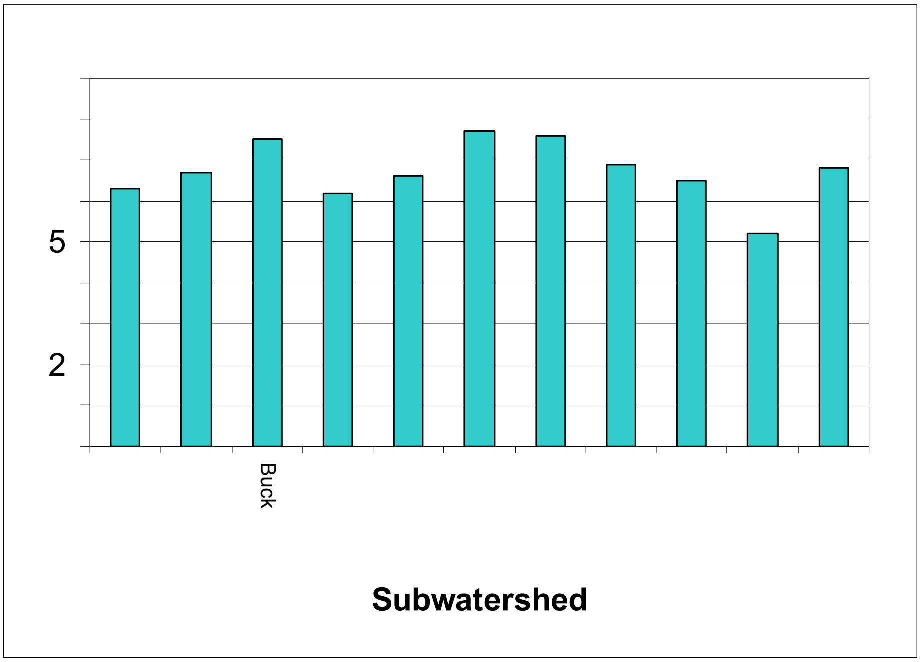
Canopy Cover: The amount of stream shaded when the sun is high and leaves are full can help determine the temperature and algal growth in a stream, which affects a stream's status as a Cold Water or Warm Water Fishery.

In addition to these 10 parameters, a stream was given an added negative score if sewage or manure presence was noted.

Results

Figure 3-9 shows the streams sampled during the visual assessment survey. Each stream assessed is given a different color based on its rating. Figure 3-8 shows the average stream score within each subwatershed. Scores within many of the subwatersheds varied greatly, and percentage area of each stream scored was not considered in the averaging. The subwatershed with the lowest average score was Buffalo Creek East, and the subwatershed with the highest score was Lower Buffalo Creek.

The lowest scoring category was "embeddedness," an indicator of sedimentation. Of the 11 subwatersheds, six had embeddedness as the lowest scoring category and two had embeddedness as the second lowest scoring category. The most common second lowest scoring categories were "instream fish cover" and "bank stability." Table 3-15 gives results for each parameter.



ithin each subwatershed. A higher score indicates better stream health.

Table 3-15. Results for Lowest Scoring Visual Assessment Parameters				
Subwatershed	Lowest Category	Average Score	Second Lowest Category	Average Score
BC South	Bank Stability	5.1	Embeddedness	5.2
Brush	Embeddedness	6.2	Instream Fish Cover	6.3
Buck	Water Appearance/Nutrient Enrichment	6.5	Bank Stability/Embeddedness	6.6
Castleman	Nutrient Enrichment/Riparian Zone	5.0	Canopy Cover	5.1
Dunkle	Embeddedness	5.4	Instream Fish Cover	5.8
Lower BC	Embeddedness	6.8	Nutrient Enrichment	6.9
Lower D. Fork	Embeddedness	6.7	Fish Barriers	7.2
Middle BC	Instream Fish Cover	5.8	Water Appearance	6.2
Sugarcamp	Embeddedness	5.8	Embeddedness	5.8
BC East	Embeddedness	4.3	Bank Stability	4.4
Upper D. Fork	Embeddedness	5.5	Instream Fish Cover	6.1

The following gives a brief description of observations during visual assessment surveys:

Buffalo Creek South: The biggest apparent land use was agricultural/grazing. However, there were clusters of residential development in the portion south of Route 40. North of Route 40, reverting old fields surrounded the mainstem of South Buffalo Creek. Septic system problems were expected in the residential areas south of Route 40 due to the small size of lots and room for leach beds. Several septic discharges to streams were found. Many homes are built in floodplains and residents have removed riparian zones, mowed to streams, or in some instances actually dredged and straightened streams. Most livestock grazing areas are near small streams and streambank fencing efforts are greatly needed.

Brush Run: The biggest land use is agricultural, and Brush Run and Dunkle Run have the highest levels of agriculture within the watershed. However, streambank fencing efforts have been strong and appear to be greatly improving the conditions of many of the streams in Brush Run subwatershed. One of the bigger problems is that Route 331 is extremely close to Brush Run, which has contributed to flooding problems and streambank erosion due to straightening of the stream. In the upstream section and in some of the headwaters, the riparian zone has been removed, causing a reduction of debris to the stream and reducing habitat. In addition, there is still need for fencing in some areas.

Buck Run: Buck Run was observed to one of the highest scores in the visual assessment, receiving high scores for riparian zone and aquatic habitat. Much of the mainstem is under Pennsylvania Game Commission control, and the northern portion is highly forested. Despite this, sewage smells were observed along several of the headwater tributaries. Livestock access to streams and the use of lawn fertilizers were also noted. These impacts may have contributed to the lower scores given for water appearance and nutrient enrichment. In addition, the close proximity of Buck Run to the road appears to be contributing to sedimentation, and more efforts are needed to keep dirt and gravel out of the stream. Culverts of tributaries also did not appear to be adequate in accommodating sediment flows. Poorly maintained gas well roads crossed streams, and vehicle tracks caused considerable damage to stream riparian zones within these crossings.

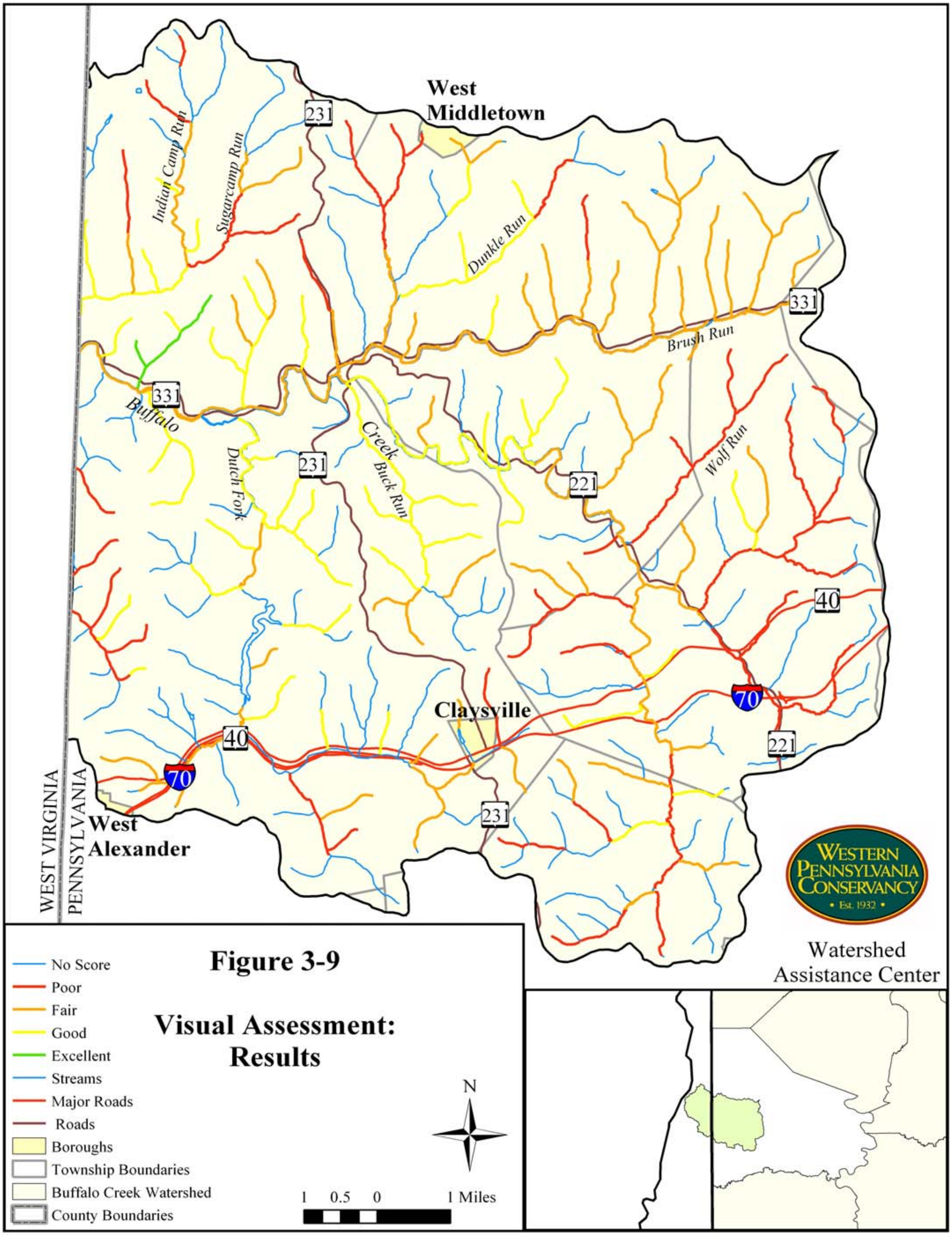


Figure 3-9

Visual Assessment: Results

Castleman Run: Castleman Run, which enters West Virginia, was observed to be a highly agricultural subwatershed. One stream received a "good" score and the others were considered impaired. In general, rocks were coated with algae, water was turbid, and riparian zones were lacking. Livestock had access to streams, and sewage smells were noted in several cases.

Dunkle Run: Dunkle Run had similar characteristics to Brush Run. Grazing-related agriculture dominated, but streambank fencing efforts were strong. However, a number of farms still in need of streambank fencing were noted. A section of Poplar Road poses a serious safety issue and is in need of repair. In several areas, livestock were being grazed along extreme slopes and severe erosion was noted.

Lower Buffalo Creek: Lower Buffalo Creek subwatershed received the highest overall stream score. However, this was primarily due to the quality of the tributaries and not of the mainstem. Several tributaries were located within State Game Lands; additional tributaries had been left forested by landowners. In general, the mainstem had high levels of streambank erosion and appeared to be widening in many areas because of sediment loads and lack of a riparian zone. In several areas, such as near the intersection of Lower Dutch Fork, the creek had better habitat quality for fish, with alternating pools and riffles. However, in most cases, these habitat types were not observed. Tributaries generally had good to excellent water quality, including Narigan Run and Welch Run. Extensive logging was observed in several areas along Narigan Run, possibly contributing to sedimentation. The proximity of the road to Narigan Run also appeared to be causing some channelization problems. Dog Run Road was found to be in disrepair, and the road crossed the stream many times, indicating that the road should be considered for closure or repair.

Lower Dutch Fork: This subwatershed generally exhibited good water quality and stream habitat. In several cases, houses on Dutch Fork Creek were built within the floodplain, but in most cases the mainstem was set far back from disturbance and surrounded by scrub/shrub and forest. The tributaries were generally of good quality and were highly forested, such as along Chapel Hill Road. However, culverts were found to be inadequate and residents had altered streams to accommodate water and sediment during floods. Small animal and horse farms were observed near the mainstem and often lacked streambank fencing or other best management practices.

Middle Buffalo Creek: This subwatershed contains a multitude of land uses, including agricultural, public (State Game Lands), and residential (Taylorstown). The Pennsylvania DEP has found high concentrations of fecal coliforms in the stream below Taylorstown and the township (Blaine) is considering building a sewage treatment facility. The subwatershed also likely receives agricultural inputs from the tributary of Wolf Run, where some streambank fencing is needed. Downstream from Taylorstown, riffles and pools in the mainstem of Buffalo Creek are evident and streambank erosion decreases, providing a good fishing area. Several smaller, good condition tributaries enter Buffalo Creek. However, above Taylorstown, erosion is a serious problem and the mainstem is widening. This is especially evident through Taylorstown, where it is expected that several feet of streambank is lost from Buffalo Creek each year. Residents mow along stream banks streams, and riparian zones are removed, contributing to the widening of the creek.

Sugarcamp Run: This subwatershed is comprised mainly of agricultural lands, but residential development and forest are also important land use types. The most striking observation was the need for streambank fencing along nearly every stream with agriculture, especially portions of Sugarcamp Run where the riparian zone was absent and streambank erosion was extreme. As Sugarcamp Run entered West Virginia, a forested, floodplain forest was observed and stream habitat improved. Most of Indian Camp Run was observed to be of good habitat quality, with natural meanders. Japanese knotweed was observed near the headwaters of Indian Camp Run by a golf course, one of the few places where it is beginning to enter the watershed.

Buffalo Creek East: This subwatershed, along with Castleman Run, was the most impacted within the watershed. It is evident that developmental pressures are emerging in this area, and there are few measures towards conservation planning. Streambank fencing and other BMPs are sorely needed throughout the subwatershed. Sewage smells and effluent into the stream were observed. Tributaries, such as along Gorby Road, have been essentially turned into ditches. The best quality tributary observed was along a reverting field on Reese Road.

Upper Dutch Fork: Though embeddedness and instream fish cover were the lowest scoring categories, this section is ultimately affected, physically and chemically, by Route 70. It very closely follows the highway and has been altered to cross under the road many times. A conductivity of nearly 1000 uS was found in a tributary near the road, possibly caused by road salt or another pollutant. Agriculture and clusters of residential development dominate the subwatershed. After a TMDL of Dutch Fork Lake revealed high nutrients, residents were required to implement BMPs, and streambank fencing is now evident throughout the subwatershed. However, faulty septic systems continue to be a primary source of nutrient additions to the stream. Invasive species, such as multiflora rose, were found to be significant surrounding many fenced streams. Higher quality areas included a tributary along Hicks Road and the trout-stocked area near the former reservoir. Many areas of this subwatershed were difficult to assess because of Route 70 and landowner access problems.

Discussion

Though visual assessments can only give a basic overview of stream health, they can be used to make general recommendations about stream improvements and the focus of restoration efforts. In nearly every subwatershed, embeddedness was one of the lowest scoring categories. Any effort to decrease sediment loads will improve this aspect of stream health. Several areas of Buffalo Creek are high priorities under CREP, due to the proximity to streams and steep slope. This program may provide funding for streambank fencing or taking marginal land out of production. Other funding opportunities may be available through NRCS.

Landowner awareness was another big issue. Many landowners thought that removing riparian zones and straightening streams would improve conditions during flooding, when these activities usually make conditions worse by reducing the capability of the stream to handle the energy of flood events. Though mowed streambanks may look better to many people, mowing has an extremely negative impact on wildlife and contributes to flooding Municipalities could encourage maintaining riparian zones by providing some type of incentive to landowners who retain riparian zones. Additionally, many landowners said that they did not understand why protecting streams was important, yet groundwater issues were the biggest worry of respondents of the public survey. However, groundwater and surface water are constantly interchanging and affect each other.

Recommendations

- Develop tax incentives or other incentives for landowners that maintain riparian zones and do not build within the 100-year floodplains.
- Encourage municipalities to follow local 537 Sewage Plans and to enforce upgrades to on-lot systems.
- Encourage farmers to use BMPs and to participate in USDA, CREP, and Partners for Wildlife streambank fencing programs.

Recommendations (summary-all sections)

Stream Flow

- Continue to monitor and record stream discharge in Buffalo Creek and its tributaries.
- Develop a relationship between water height and stream discharge in major tributaries using dimensionless ratios, so that discharge can be estimated more easily and be used more readily to estimate flood levels and sediment loads.
- Encourage the re-establishment of a USGS gauging station within the watershed.

Water Quality

- Conduct further chemical monitoring within the Buffalo Creek watershed to look for potential problems and trends in water quality.
- Establish regular monitoring of fecal coliforms.
- Continue and expand BMPs within the watershed, including streambank fencing, the limiting of disturbances (mowing, agricultural, logging, etc.) in riparian zones, and discontinue agricultural activities in steep and other marginal areas; this can be done through landowner participation in CREP and other programs.
- Enforce Act 537, which requires all on-lot systems to have functioning sewage systems, and encourage municipalities to follow their Municipal Sewage Plans.
- Conduct more detailed analyses of fecal coliforms and other bacterial measures (such as Escherichia coli- E. coli) as technology becomes available that is able to determine the sources of bacteria in streams (human, livestock, wildlife).
- Conduct detailed studies on the transport of water and sediment within the watershed, based on the principles of fluvial geomorphology, to determine areas that could best benefit from restoration activities, such as riparian plantings and the installation of root wads and crossvanes, in order to alleviate pressure on streambanks and reduce stream widening.
- Be informed about construction, logging, and other earth-moving projects in the watershed and verify that Erosion and Soil Control or other necessary permits have been obtained for these activities.

Water Quality (macroinvertebrates)

- Develop a regular macroinvertebrate monitoring program for Buffalo Creek watershed.
- Consider Buffalo Creek near the S Bridge and Dutch Fork Creek along Route 3019 as priorities for monitoring and future restoration activities, and expand streambank fencing programs to these portions of the watershed.

Water Quality (visual assessment)

- Develop tax incentives or other incentives for landowners that maintain riparian zones and do not build within 100-year floodplains.
- Encourage municipalities to follow local 537 Sewage Plans and to enforce upgrades to on-lot systems.
- Encourage use of BMPs and participation in CREP, NRCS, and Partners for Wildlife streambank fencing programs.