Chapter 3. Water Resources


Connoquenessing Creek looking upstream from the mouth

Water resources provide a vital lifeline for communities throughout western Pennsylvania. Historically, communities formed near these sources to sustain their needs for drinking water, provide transportation of goods, power mills, and irrigate agricultural lands. As time went on and the railroad industry enabled the transportation of goods and people, waterways gave way to recreation, but still maintain the purpose of providing drinking water. Throughout the Connoquenessing area, creeks and streams still provide local residents with drinking water, businesses with water for their operations, outdoor recreation enthusiasts with a place to paddle or fish, and wildlife with an essential element of their habitat needs. This chapter will cover the basic elements of water resources, their purpose, function, and the challenges facing the Connoquenessing community in conserving this crucial natural resource.

Location

Drainage

The Connoquenessing Creek watershed is located within the 203,940-square-mile Ohio River drainage basin. The headwaters of Connoquenessing Creek, along with the headwaters of the Slippery Rock Creek subwatershed, originate in Butler County, encompassing a majority of its land area. Connoquenessing Creek flows into the Beaver River, west of Ellwood City in Lawrence County, western Pennsylvania. The Beaver River continues on its southern course to Rochester, Pennsylvania, where it enters the Ohio River. The Ohio River, flowing southwest, drains parts of 11 states before it joins the Mississippi River, which ultimately empties into the Gulf of Mexico.

Watershed Address

The United States Geological Survey (USGS) has developed a system in order to better catalog and describe the location of surface water resources in the United States. This system divides and subdivides the U.S. into successively smaller units of water drainage, with the result being a specific Hydrologic Unit Code (HUC) that is essentially a watershed's address. Major watersheds in the U.S. are described as one of eighteen Water Resource Regions by the USGS. Each is given a name and two-digit number (Seaber et al., 1987). Pennsylvania is drained by three of these regions: Great Lakes, Ohio, and Mid-Atlantic. The USGS further divides these regions into subregions, then accounting units, and finally into cataloging units. The HUC code for the Connoquenessing Creek watershed, including the Slippery Rock Creek portion, is **05030105**, which can be described as follows:

Region 05: All waterways draining into the Ohio River Basin, excluding the Tennessee River Basin
Subregion 03: Upper Ohio
Accounting Unit 01: Upper Ohio-Beaver
Cataloging Unit 05: Connoquenessing

The Pennsylvania Department of Environmental Protection (DEP) uses a different cataloging system, which delineates six drainage basins within the state that are further divided into watersheds, each named for their major streams. The Connoquenessing Creek watershed (referred to as the Slippery Rock Creek watershed by DEP) is located in the Ohio sub-basin (20), which comprises the Pennsylvania portion of the Ohio River. Within this sub-basin, the Connoquenessing Creek, including Slippery Rock Creek is considered to be watershed C. Therefore, DEP classifies it as watershed 20C.

Major Tributaries

Upper Connoquenessing Watershed

The headwaters of the Connoquenessing Creek originate about 10 miles northeast of Butler, Pa. The upper portion of the mainstem of the Connoquenessing Creek generally flows south until it reaches the city of Butler. Route 38 runs adjacent to this upper portion of the mainstem for the majority of its length. The Oneida and Boydstown dams, which control flow, can be found along this stretch of the creek. Bonnie Brook, a headwater tributary, originates near the small town of North Oakland, Butler County, and flows through East Butler before entering the Connoquenessing Creek upstream of Butler.

Thorn Creek

Middle Connoquenessing Watershed

Thorn Creek stems from two reservoirs near Herman, Pa. It flows south to a bend around Frazier Mill, then continues in a northwest direction until it enters the mainstem slightly upstream of Renfrew, Pa. Glade Run, Breakneck Creek, and Little Connoquenessing Creek, respectively, spill into the Connoquenessing before its waters flow through Zelienople, Pa. Glade Run begins near the Glade Mill Airport, is impounded to form Glade Run Lake, then continues northwest until it enters the Connoquenessing Creek downstream of Ribold. The headwaters of Breakneck Creek originate just across the county line in Allegheny County. It then flows north through Valencia, Mars, and Evans City, before entering the Connoquenessing Creek upstream of Harmony. While all of the major tributaries to this point have entered from river-left, the Little Connoquenessing Creek enters from river-right. The Little Connoquenessing flows southwest from the area about one mile south of Unionville, and enters the Connoquenessing Creek at Harmony Junction (formerly Eidenau), just downstream of where Breakneck Creek enters.

Lower Connoquenessing Watershed

The Connoquenessing Creek then borders Harmony and Zelienople, primarily traveling west. Brush Creek, which begins near Interstate 76 on the border of Butler and Allegheny counties, flows northwest, traveling through Brush Creek Park and under a historic covered bridge before entering the Connoquenessing Creek on river-left near the town of Hazen. Through its final six-mile portion, the Connoquenessing Creek drops 100 feet in elevation down a gorge between the Frisco Railroad Bridge and its confluence with the Beaver River at Rock Point. This entire stretch winds through Ellwood City and provides up to Class III rapids for whitewater enthusiasts to enjoy. One mile below the Frisco Bridge, the Slippery Rock Creek subwatershed merges in Ellport, typically doubling water flows for the final five-mile run.

Little Connoquenessing Creek

Table 3-1. Major Tributaries

Tributary	% Area	Drainage Area (square miles)	
Upper Connoquenessing Creek			**136.43**
Thorn Run	**1.63**	**7.69**	
Bonnie Brook	**4.33**	**20.44**	
Middle Connoquenessing Creek			**147.99**
Thorn Creek	**8.95**	**42.22**	
Glade Run	**8.65**	**40.79**	
Breakneck Creek	**8.83**	**41.64**	
Lower Connoquenessing Creek			**187.21**
Little Connoquenessing Creek	**13.67**	**64.49**	
Camp Run	**3.14**	**14.80**	
Brush Creek	**11.89**	**56.10**	
Slippery Rock Creek (subwatershed)		*366.12*	

Important Components of Water Quality

Surface Water

Surface water refers to water found about the land surface, in rivers, streams, lakes, reservoirs, ponds, wetlands, and seeps. Surface water is in constant interaction with groundwater, which is stored below the surface within openings in rock material. Therefore, it is influenced by the quality of the groundwater, as well as inputs from land-use practices associated with farming, forestry, mining, and other activities.

Streams and Rivers

As water drains from ridges and higher-elevation wetlands that are created from depressions in the topography, tributaries form and grow in size and volume as the water flows to lower elevations. Larger streams are influenced by the water quality of these wetlands and tributaries from which they originate, as well as pollution from acid precipitation and land-use activities.

One human practice affecting water flow and quality is stream **channelization**. For a variety of reasons, humans have altered natural stream channels to straighten, widen, deepen, divert, and otherwise modify the physical characteristics of the stream. Streams may be channelized to purposefully drain wetlands, improve navigation, control flooding or divert the flow to a reservoir for agricultural use or construction of a road, dam, bridge, or other structure. The negative consequences of stream channelization include aquatic and terrestrial habitat alteration, wetland loss, streambank destabilization, erosion, and sedimentation. In urban areas, the city of Butler for example, where the floodplains have already been developed, streams may be channelized to increase the volume of water it is capable of holding to aid in flood control. However, when the stream channel is straightened, the velocity of the water flowing within it greatly increases, scouring the stream bed and eroding streambanks. The sediment is carried downstream to deposit and accumulate once the flow slows down sufficiently, which then can lead to increased flooding in downstream areas, causing the opposite effect for which it was originally intended.

Lakes, Ponds, and Reservoirs

Lakes are inland bodies of water that form through natural processes. These processes include geologic events, such as the movement of tectonic plates, which disrupt the flow of a river to form a lake. In the United States, most natural lakes were formed by glaciations thousands of years ago, when the advance of the glaciers caused great depressions to form and fill with water. Natural lakes are uncommon in Pennsylvania, and occur only in the northwestern and northeastern parts of the state. Lakes differ from ponds in that they have more visible waves, are deeper, have rooted plants that are only able to grow close to the shore, and have water temperatures that vary with depth. Ponds, natural and man-made, are present throughout the state, though their locations are not well documented.

Thorn Reservoir

Reservoirs, or impoundments, are common throughout Pennsylvania. Reservoirs are created when a body of water is detained by a structure, such as a dam. These reservoirs of water behind the dams, sometimes referred to as "lakes," are often utilized for recreational activities, such as fishing, swimming, and boating. They also may provide flood control or water supply for nearby communities. Some industries create reservoirs to contain waste water, which often contains pollutants, discharged after use in their operations. Several notable reservoirs exist within the watershed, including Glade Run Lake, Lake Oneida, Thorn Run Reservoir, and the Hereford Manor Lakes.

Along with the reservoir of water impounded by a dam, wetlands are often formed on the marginal areas surrounding them. Some tree species within those wetlands die and remain standing when inundated with the backed-up water. These wetlands provide valuable wildlife and fisheries habitats, and the dead, standing trees provide nesting habitat for waterfowl, such as wood ducks, and other wildlife. More will be discussed on wetlands later in this chapter.

Groundwater

Water stored beneath the land surface in pores and openings of soil and rock formations is referred to as groundwater. Although groundwater is commonly considered a separate entity from surface water found in streams and lakes, the two are constantly interchanging. Groundwater emerges at the surface in valleys and seeps, and surface water percolates downward into underground storage areas of rock and soil, called aquifers. As a result of this dynamic, the quality of streams and lakes can directly impact the quality of groundwater, and vice versa.

The pattern of water movement in the Connoquenessing watershed is controlled primarily by topography, which is highly dissected by major and minor valleys into isolated bedrock "islands." Water moves from areas of high elevation to lower elevation and from shallow to deeper aquifers. Water levels are most affected by precipitation patterns, with levels generally highest in early spring and fall and lowest during the late spring, summer, and early winter.

The yields of wells depend upon the ease of water movement through rock and the amount the rocks release. Groundwater is found in two types of openings in rock—primary and secondary. Primary openings are spaces between fine mineral grains. Though the space between grains may be small, cumulatively they are capable of generating large amounts of water. In contrast, secondary openings occur from fractures in the geology of rocks. Any one fracture will likely generate more water than a primary opening, because secondary openings are usually less abundant and are not capable of yielding much water. Types of deposits that generate the most water are alluvial deposits, which are formed from the movement of rivers.

The quality of groundwater in an area can generally be determined by sampling streams at base flow, which are flows low enough that all of the flow can be considered to come from groundwater. The average percentage of stream flow from groundwater is around 50 percent. In streams that are greatly affected by mine drainage, sulfates and metals, such as iron and manganese, can be found at unnaturally high levels, particularly at base flows. Similar to abandoned mine drainage (AMD), acid from precipitation is able to dissolve the metals found in bedrock, causing those metals to be leached out into groundwater and streams.

The majority of residents throughout the Connoquenessing watershed get their water from public water suppliers. Most of the public water is obtained from streams and reservoirs. Therefore, these public water sources are affected by groundwater quality and quantity. Water suppliers within the project area may struggle to find clean drinking water free of contamination from AMD and other pollutant sources. Thus, treatment costs increase in order to meet drinking water standards, which translates to higher water costs for the municipalities and consumers.

Floodplains

The area of land adjacent to a river, stream, or lake that absorbs the occasional overflow of water beyond the banks of those waterbodies is known as the floodplain. Floodplains and wetlands dually act to absorb flood waters during high-flow events. When structures, houses, buildings, and impervious surfaces impact a floodplain or eliminate a natural wetland, the ability of those areas to dissipate flood waters is diminished. In addition, the likelihood of property damage and human health and safety risk increases when development occurs within a floodplain area susceptible to occasional flood events. Figure 2-8 (Chapter 2) shows significant floodplain areas.

The National Flood Insurance Program (NFIP), administered through the Federal Emergency Management Agency (FEMA, 2002), was established in 1968 with the National Flood Insurance Act. Property owners can purchase insurance as a protection against flood loss if communities agree to adopt ordinances that reduce flood damage, including limiting building in floodplain areas. Ordinances must meet minimum regulatory standards of NFIP and the PA Floodplain Management Act (PA Act 166). Residents from non-participating communities can still purchase insurance, but at a much higher rate (FEMA, 2002).

Houses built in the floodplain

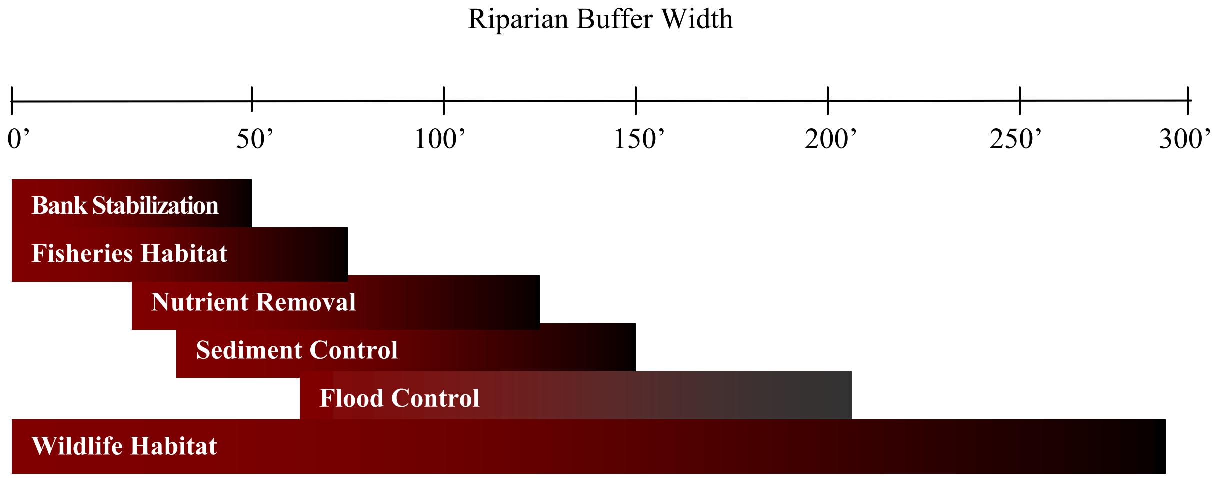
In communities that adopt such ordinances, building in Special Flood Hazard Areas (SFHA) may occur only if the owner agrees to purchase flood insurance. SFHAs are areas within the 100-year flood zone, which means that there is a one percent chance of a flood reaching this zone each year. Special subsidies are available for existing structures built before the adoption of ordinances. 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 (FEMA, 2002). Many communities in Pennsylvania have adopted a riparian buffer approach to floodplain management. These “total prohibition” ordinances encourage the reduction of construction and development in the floodplain.

Floodplains can be considered “sensitive” areas because they are both inappropriate for building purposes and important for protection of streams and wildlife. Currently, most municipalities have floodplain ordinances, though these provisions may not always be adequately enforced. Harmony, Ellwood City, and Zelienople have been identified as areas particularly prone to flooding occurrences. Special attention to these issues should be addressed when development projects are being considered.

Riparian Zones

Riparian zones or buffers are vegetated areas along streams, rivers, and lakes that filter pollutants and sediment from runoff and provide a transition between water and land. A functioning riparian zone can reduce flooding and erosion by retaining water, slowing its velocity, and stabilizing soil. This also promotes groundwater retention during dry periods. Riparian zones also provide important corridors for wildlife, regulate water temperature, enhance recreational activities, and create fish habitat. Studies have shown that the wider and more substantial a riparian zone is, the better it can perform these functions (Klapproth, 2000). Some of the agricultural streams and developed areas of the watershed do not have adequate riparian zones. This has created severe bank erosion in some areas, as well as the introduction of invasive species, which thrive in disturbance. Figure 3-5 shows recommended riparian zone widths for bank support, fisheries habitat, nutrient removal, sediment control, flood control, and wildlife habitat.

Figure 3-5. Recommended Riparian Buffer Widths



Retaining existing buffers is a cost-effective method of protecting waterways from sedimentation, streambank erosion, and flooding. A number of tools are available in Pennsylvania for landowners and communities to protect and enhance these important riparian zones and other important green areas, such as:

- Pennsylvania Stream ReLeaf Plan (DEP, 1997) and forest buffer tool kit (Alliance for the Chesapeake Bay [ACB] & DEP, 1998)
- Stream corridor restoration: principles, processes, and practices (Federal Interagency Stream Restoration Working Group, 1998)
- Chesapeake Bay riparian handbook: A guide for establishing and maintaining riparian forest buffers (Palone & Todd, 1997)
- Riparian forest buffers: function and design for protection and enhancement of water resources (Welsch)
- Pennsylvania’s Conservation Reserve Enhancement Program (U.S. Department of Agriculture Farm Service Agency)

Land Purchase

There are several avenues a community may pursue to protect, restore, and conserve riparian corridors. A municipality or conservation organization may seek the outright purchase or donation of land in a high quality riparian zone to protect it for future use, or they may seek to obtain areas in need of restoration. The municipality or conservation group then has control of the land and is responsible for all financial and maintenance obligations. Pennsylvania Department of Conservation and Natural Resources (DCNR) offers funds for land acquisition projects to protect and restore natural areas. Land acquired with these funds must be available for public use. Another option for financing the purchase of the riparian land is to subdivide the area and sell the less sensitive sections to offset the costs.

Conservation Easements

Another way to protect riparian land is through the purchase of a conservation easement, a legal agreement between a landowner and land trust or local government that permanently restricts the type of land use for that property to allow for the conservation of natural resources. The landowner maintains ownership of the land, but gives up some of the development rights. The conservation easement compensates the landowner for the economic loss resulting from these restrictions, such as limited timber harvesting or grazing. The landowner may also receive a tax credit for the reduced value of the property. Within Pennsylvania, municipalities may hold conservation easements and use various taxing schemes to raise money for the acquisition of open space and agricultural land. The Recreation Use of Land and Water Act (# 586) and the Rails to Trails Act (#188) limit liability for property owners with easements or adjoining trails (ACB, 2004).

Municipal Planning

Municipalities have several options in regards to land use planning. County Comprehensive Plans are documents that address the timing and character of development. Although non-regulatory, the Municipalities Planning Code states that zoning ordinances must be consistent with comprehensive plans, which should contain planning for natural and historic preservation (Pennsylvania Municipalities Planning Code).

An Official Municipality Map designates existing and proposed open space reservations. If a municipality wishes to set aside a landowner’s property for open space purposes, then the municipality has a legal obligation to buy the land within 12 months of the landowner’s decision to develop it.

Ordinances can restrict activities within a certain distance of a stream, based on stream size, slope of the land, wetlands, etc. This may include limiting the building of structures prone to flooding, the removal of streamside vegetation, and the amount of earth disturbance in this zone. Typically, several zones are delineated next to a stream, and restrictions increase in zones that are the closest. Structures present before the ordinance is enacted are often exempt from these restrictions. Municipalities in Pennsylvania that have riparian ordinances and can be contacted for more information include Salford and Horsham Township, Montgomery County; Kennett Township, Chester County; Warwick Township, Lancaster County; and Radnor Township, Delaware County (ACB 2004).

Transferable Development Rights

This tool, which is discussed further in the Biological Resources Chapter, compensates property owners in areas where development is restricted, by allowing them to sell development rights to increase development densities in other areas.

Density Bonuses

This tool awards developers by allowing them to increase development density in exchange for conserving natural areas or contributing to an open space fund.

Stormwater Credits

A stream buffer helps reduce stormwater runoff. Developers can receive stormwater credits, which result in construction of less costly stormwater management facilities, in exchange for maintaining or restoring riparian buffers (ACB, 2004).


Persistent stormwater

Stormwater

The water running off impervious surfaces, such as streets, buildings, and parking lots, as well as land during storm events is referred to as stormwater. Besides flooding, stormwater contributes a significant amount of pollution to waterways. Much of the unhealthy bacteria that enter streams from manure lots and faulty sewage systems do so during storm events.

In urban areas, impervious surface area is often linked to stream impacts, with significant impacts occurring at only 10 percent impervious surface according to some studies (Schueler, 1995). Impervious surfaces are areas on the landscape where water cannot pass through to be absorbed by the soil. Examples of impervious surfaces include hard surfaces, such as asphalt, concrete, rooftops, and highly compacted soils. Highly compacted soils often result from a lack of vegetation in an area, which as mentioned before, also leads to water quality degradation.

Water runs off the land until it finds a place to enter the soil, or it is incorporated into man-made systems that funnel it to a body of water. This leads to increased volume and velocity of water flowing into the stream, less groundwater flowing through the soil, and erosion of the stream bed. These changes result in flooding, loss and degradation of habitat, erosion, sedimentation, and physical changes in the stream. Small floods may increase by up to 10 times with increases in imperviousness from urbanization (Hollis, 1975), and research in Pennsylvania has shown that brook trout are absent from streams in watersheds with just four percent impervious surface.

Minimizing the amount of impervious surface is one approach to water resource protection, by using such tools as performance zoning, residential design, and open space subdivision. Reducing impervious surface not only has environmental benefits, but reduces social, economic, and development costs as well.

Pennsylvania's Stormwater Management Act of 1978 requires each county in Pennsylvania to develop stormwater management plans for each of its watersheds, though some counties have yet to comply. DEP provides model stormwater management ordinances and funding options for stormwater management plans on its website, http://www.dep.state.pa.us (Keyword: Stormwater).

Dams

Historically, dams were often installed along streams and rivers to harness the natural power of water for operating mills of varying sorts, including saw, grist, and paper mills. Dams also are utilized on rivers for navigation purposes and transportation of goods. The natural power of stream currents is still utilized for some industries today, and it can be harnessed for hydroelectric power generation. A dam along the Connoquenessing Creek mainstem in Butler is currently being utilized to retain water for use by AK Steel for its manufacturing operations. Several abandoned dams exist throughout the watershed, and residents and municipalities are weighing the options of whether or not to remove them (Figure 3-3).


Breached dam on Connoquenessing Creek

Often times, dams no longer serve a purpose, and are abandoned. If not maintained, they may fall into a state of disrepair and pose a safety risk. Dam failures may cause flooding, resulting in injury or death to humans, property damage, and interruption of transportation and emergency services. Dams obstruct migration paths of fish, and may inhibit the movement and dispersal of other aquatic life. Abandoned dams also hinder paddlers' ease of transportation down a stream.

It must be determined, based on maintenance costs, safety, and potential uses of the dams, whether or not to remove it. If a community decides to leave a dam in place, a portage trail may be constructed around the dam to allow water recreation. If it is determined that a dam be removed, a plan must be developed for the removal process and to restore the stream and its habitat afterwards.

There are a few organizations responsible for the oversight of dam maintenance, regulation, and removal in western Pennsylvania, including the U.S. Army Corps of Engineers, DEP, Pennsylvania Fish and Boat Commission (PFBC), and American Rivers. Necessary permits must be obtained prior to removing a dam, and assistance is available to support the planning and restoration process. A useful resource for additional information about the benefits of dam removal, volunteer monitoring, and references for assistance, is the *Citizen's Guide to Dam Removal and Restoration*, which can be obtained from the Pennsylvania Organization for Watershed and Rivers (POWR) at www.pawatersheds.org.

Wetlands

Lake Oneida wetland

In order for an area to be considered a wetland, it must have three components: anaerobic or hydric soils, wetland vegetation, and indications that it has been covered with water at least part of the year (Mitsch and G. Gosselink, 2000). Anaerobic or hydric soils include those that form under conditions of flooding long enough in the growing season to not contain oxygen in the upper part. It is important to note that an area does not have to be covered with water during the entire year to be considered a wetland. Wetland areas may be permanently flooded by shallow water, permanently saturated by groundwater, or periodically saturated for varying periods during the growing season.

Wetlands retain water, which is absorbed into the ground or slowly released to surface water streams. The reduced velocity of water movement allows more water to soak into the ground, supplying groundwater recharge, which eases the stress on water supply during times of drought. The absorption quality of a wetland or network of wetlands helps to reduce the severity of flooding. Wetlands also filter water by a variety of mechanisms. Wetland vegetation slows the velocity of water running through them, allowing more time for the water itself to soak into the ground and any suspended sediment to settle out. Pollutants, such as chemicals and metals, which are bound to the sediment particles also settle and separate from the flowing water. Nutrients from fertilizers, manure, and sewage are utilized by the plants growing in the wetland and are removed from the water. Wetland systems often support a variety of living organisms, termed biodiversity. The nutrient rich sediment that collects in a wetland provides abundant nutrients and food resources for plants and wildlife. The emergent vegetation and dead, standing timber provide excellent breeding and nesting habitat for insects and wildlife, especially waterfowl. Many migratory species depend on wetlands for rest and recharge during their long migratory treks.

Vernal pools are one type of wetland, where isolated ponds are created during the spring from rainwater and snow melt that has collected in depressions in the ground. These critical habitats provide breeding grounds for woodland frogs and salamanders. Vernal pools also support a variety of other floodplain, meadow, shrub lands, and woodland species.

Wetland Loss

More than half of all wetland habitats that once occurred in Pennsylvania have been lost. The major causes of wetland loss have been impoundment, drainage for agriculture and development, and conversion to other uses. The reduction of wetlands in any given area can drastically impact health and human safety by leading to increased occurrence and severity of flooding, decreased natural water quality revitalization, and exacerbated drought conditions. Loss of wetland habitats also negatively impacts wildlife, by increasing the distance between remaining wetlands, which reduces the ability of animals to move from one wetland to another and to recolonize.

The stricter environmental regulations existing today prevent major wetland drainage and impoundment. However, recent federal court decisions have reduced the protections given to smaller, isolated wetlands under the Clean Water Act. Although smaller wetlands still receive some protection under Chapter 105 of the Pennsylvania Code, permits can often be acquired for their alteration or destruction (Pennsylvania Game Commission, 2005).

It is critical to protect and maintain an abundance of wetlands in any watershed for flood protection, water quality improvement, and wildlife habitat protection. Often artificially constructed wetlands do not perform to same quality as natural wetlands, but in any case, it is important to maintain as much wetland area as possible. Ideally, wetlands that are threatened by development or conversion should be protected with a buffer surrounding them to reduce the secondary impacts.

Wetlands in Connoquenessing Watershed

Figure 3-2 delineates wetlands and hydric soils found throughout the Connoquenessing watershed. Wetlands only comprise 0.01% of the land area (Table 2-1, Chapter 2) of the Connoquenessing landscape. Swamp forests are a recognized community of the Southern Unglatiated Allegheny Plateau ecoregion (McNab & Avers, 1994). The Redwing Valley Swamp biological diversity area (BDA) is one example of the high level of biodiversity contributed by wetland habitats (Figure 4-1, Chapter 4).

Wetlands can be constructed to serve a specific purpose related to improving water quality. Wetlands can be constructed to control stormwater runoff in developed areas, remediate AMD, and treat wastewater. Several small, artificial wetlands exist throughout the study area to serve those purposes.

Passive treatment systems to abate the effects of AMD, often include a system of settling ponds and wetlands to allow metals and pollutants to drop out of the water, incorporating alkaline additions when necessary, as well. These treatment sites and wetlands offer a unique opportunity for a variety of educational workshops to teach citizens about the effects of pollution, environmental remediation techniques, water quality, and biodiversity. Lutherlyn has an effort in the Semiconon subwatershed to remediate AMD with a passive treatment system, and they offer a variety of educational programs in association with the project.

Watershed Protection Laws

Clean Water Act

The 1977 amendments to the federal Water Pollution Control Act became known as the Clean Water Act (CWA). This act establishes the basic structure for regulating discharges of pollution into waterbodies of the United States. The CWA gives the United States Environmental Protection Agency (EPA) the authority to regulate pollution discharges and set water quality standards. It also makes it unlawful for

Butler Area Sewage Treatment Plant

any person to discharge pollution from a "point source" into navigable waters without a permit. The CWA funds construction of sewage treatment plants and recognizes the need for planning to address "non-point source" pollution problems, as well (Elder et al. 1999).

Point versus Non-point Source Pollution

Point source pollution refers to discharges, or pollution inputs, that enter a stream or lake directly via a pipe, culvert, container, or other means. One of the ways the Clean Water Act is enforced is through the National Pollutant Discharge Elimination System (NPDES), whereby DEP issues permits for point source discharges (DEP[4]). 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, even if it is a non-point source. The exceptions are for tilling and agricultural practices that are not part of a concentrated animal feeding operation (CAFO), and most logging disturbances that are less than 25 acres. However, many of these activities still require a soil and erosion control permit (DEP[4]).

Connoquenessing flowing under Route 422

Non-point source pollution is pollution that enters a waterbody through an undefined source, usually in the form of runoff from places such as agricultural fields, logging operations, lawns, and city streets. Non-point sources comprise the majority of pollution, mainly because they cannot be as easily regulated. Usually, AMD is considered a non-point source because it is created in large, poorly-defined areas, often discharging into a stream in a diffuse manner. Efforts to reduce non-point source pollution are often conducted on a state or local level through programs to implement best management practices (BMPs) offered by conservation districts and other agencies and organizations. This will be discussed later in this chapter.

Impaired Waterbodies

In order to satisfy the requirements of the CWA, states must report to the EPA every two years on the status of its waterways, and provide a list of waterways not meeting water quality standards. A water quality standard is a combination of a designated use for a particular waterbody and the water quality criteria to protect that use. Typically, states now report on the status of all assessed waterbodies and this list is referred to as the Integrated Waterbody List (Pennsylvania). Streams are assigned to one of five categories based on their status on this list and are required to develop a Total Maximum Daily Load (TMDL) for streams in Category 5. These streams include those that are not meeting their designated uses, excluding those where point source pollution controls can alleviate the problem.

In Pennsylvania, the Integrated Waterbody List is developed based on the Surface Water Assessment Program. Impaired streams in the project area are shown in Figure 3-4 and described further in the "Water Quality" section of this chapter.

Thorn Creek

NPDES Permits

As mentioned above, one of the ways that the CWA is executed is through the NPDES, whereby DEP issues permits for point source discharges. 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. A list of current permits can be found in Appendix G.

In Pennsylvania, an earth disturbance activity from one to five acres requires an NPDES permit if a point source exists at the site. Any disturbance over five acres requires a permit regardless of whether or not there is a direct point source to a waterway. Farmers do not need to obtain an NPDES permit unless the farm meets the criteria to be considered a concentrated animal feeding operation (CAFO). However, they must complete a conservation plan. Timber operations fewer than 25 acres are also exempt from NPDES permits, but must complete Erosion and Sediment Control Plans. Active NPDES permits may be found at the EPA Envirofacts website (http://www.epa.gov/enviro/index.html).

Erosion and Sedimentation Control

Soil erosion is the natural process of removing soil from the land by wind or water. Though erosion is a natural process, it can be greatly worsened by a lack of vegetation, poor farming practices, stream channelization, and stormwater runoff. Sedimentation is the process by which the bottom of the stream becomes covered with eroded material from streambanks and land. This occurs if more sediment enters a stream than can be transported downstream or if hydrologic alterations reduce the capacity of the stream to transport the sediment.

Silt fence to control sediment entering stream near a construction site

In Pennsylvania, any disturbance over 5,000 square feet must have an Erosion and Sediment Control Plan on site. Earth disturbance permits must be obtained for activities disturbing an area over 25 acres, including timbering and development activities. Most agricultural operations do not need to have an earth disturbance permit, but must have a conservation plan if the farmer wishes to take part in incentive programs. Both earth disturbance permits and conservation plans require provisions for sediment control. A separate permit is required for stormwater from construction activities. Local county conservation districts assist in the development of Erosion and Sediment Control Plans and conservation plans (PA Code, 1997c). They also help fill out paperwork for earth disturbance permits. However, all permits in High Quality and Exceptional Value watersheds must be approved by DEP. It is not clear whether soil and erosion control regulations in the project area are being adequately implemented. Any efforts to improve the effectiveness of soil and erosion control measures in the project area should involve local conservation districts and state agencies responsible.

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 BMPs. These practices protect the quality of land and the environment by preventing erosion and pollution. They include agricultural practices such as utilizing contour farming and filter strips; sustainable forestry practices like limited harvesting in riparian zones and steep slopes; and wise development practices, such as maintaining vegetated zones around parking lots and buildings.

Contour farming: Tilling and planting that follows the slope of the land, creating ridges that slow the run of water

Silt fences: A temporary barrier designed to retain sediment in a construction site by slowing water flow and promoting deposition on the uphill side of the fence, also decreasing the velocity of run-off

Strip cropping: Partitioning a field into alternate bands of different crops, such as row crops, hay, and small grains, to allow infiltration and filtering of sediment

Filter strips: Areas of grass planted next to cropland to filter out sediment, organic matter, nutrients, and chemicals carried in run-off

Nutrient Management Program

The Pennsylvania State Conservation Commission, formed through the Pennsylvania Nutrient and Odor Management Act (NOMA), administers the Pennsylvania Nutrient Management Program (PNMP). The program is controlled by the commission and county conservation districts with approved delegated authority. Concentrated Animal Operations are required to participate in the program, as well as any operation that wishes to gain liability protection under the act, or has received financial assistance through NOMA for BMP installation. In addition, any agricultural operation in violation of the Pennsylvania Clean Streams Law may be required to submit a nutrient management plan that meets NOMA requirements (PNMP).

Farmers participating in NOMA must develop and implement approved nutrient management plans. Nutrient management planning is a series of BMPs designed to reduce nutrient pollution by balancing nutrient inputs with nutrient requirements. Plans must be developed by a certified Pennsylvania Department of Agriculture (PDA) Nutrient Management Specialist. The intent of NOMA is to address water quality issues from such activities as animal number and density, nutrient losses from manure storage and handling areas, nutrient runoff from animal concentrated areas, and manure fertilization. Questions about the program should be directed to the appropriate county conservation district. Financial and technical assistance is available (PNMP).

Pennsylvania Sewage Facilities Act

Sewage is a major cause of pollution in western Pennsylvania streams. Sewage pollution can come from municipal and non-municipal sewage treatment plants, as well as from private septic systems. This pollution can occur from plants that have inadequate capacity due to population growth or poor design and private systems that are not properly built or maintained. In some cases, both sewage waste and stormwater enter a municipal system through the same infrastructure, and the plant is not capable of handling all of this waste at once. The overflow waste is deposited directly into the stream. When this happens, it is called a combined sewage overflow (CSO) event.

Constructing the new Saxonburg sewage treatment facility, summer 2007

Connoquenessing Creek from Camp Kon-O-Kwee

The main type of pollution entering streams from sewage treatment plants and septic systems is inorganic and organic nutrients, sediment, and bacteria. Nutrients can lead to excessive plant growth, which depletes the oxygen levels of streams. Sediment is responsible for clogging the gills of aquatic organisms and affecting in-stream hydrology and habitat. Bacteria can be harmful, and sometimes fatal, to both stream life and humans. Elevated bacteria levels were found in Brush and Breakneck creeks by a study conducted by the Connoquenessing Watershed Alliance, which will be discussed in further detail later in this chapter.

Stream impacts caused by AMD can sometimes mask the effects of other pollutants, such as septic systems and agricultural runoff. In fact, these other pollutants can add pH and alkalinity to a stream, canceling some of the harmful effects of acidic mine drainage. Few streams in the watershed have a HQ or EV designation, which can put limitations on the types of pollutants entering a stream. Nonetheless, sewage pollution can have a significant negative impact on stream ecosystems and can affect the use of the stream for recreation and water supply. Over 15 sewage treatment plants have permits to discharge treated wastewater to local streams. Depending on the age, condition, infrastructure, capacity of the system, and treatment methods used, the amount of waste matter entering streams from each of these plants may vary greatly.

The Pennsylvania Sewage Facilities Act (Act 537) was enacted in 1966 to repair existing sewage disposal problems and to inhibit future problems. Defective sewage disposal systems can create a grave hazard to public health and the environment. They pose a risk of pollution to public and private drinking water sources, as they frequently can be directly discharged into the groundwater, and can expose various bacteria, viruses and parasites to humans and animals.

The major provisions of Act 537 are (DEP, 2006):

1. All municipalities must develop and implement an official sewage plan that addresses their present and future sewage disposal needs.

2. Local agencies are required to employ both primary and alternate Sewage Enforcement Officers (SEO), who are responsible for implementing the daily operation of that agency's onlot disposal systems (OLDS) permitting program.

3. Local agencies, through their SEO, approve or deny permits for construction of onlot sewage disposal systems prior to installation.

4. DEP provides grants and reimbursements to municipalities and local agencies for costs associated with the Act 537 planning and permitting programs.

5. An Environmental Quality Board (EQB) must adopt regulations establishing standards for sewage disposal facilities.

6. A Sewage Advisory Committee (SAC) reviews existing and proposed rules, regulations, standards, and procedures, and then advises the Secretary of the DEP.

AMD on Semiconon Run

Abandoned Mine Drainage Legislation

The Federal Surface Mining Control and Reclamation Act (SMCRA) of 1977 established mandatory uniform standards for coal mining activities on state and federal lands, including environmental performance protection standards to reduce adverse effects of fish, wildlife, and other environmental values. An important component of this legislation is that mining companies are required to conduct remediation efforts for environmental degradation caused after the Act's passage (mine discharges, coal refuse, etc.) It gives companies an incentive to reduce environmental impacts in order to avoid the high costs of remediation. The Act also created the Abandoned Mine Reclamation (AMR) fund to help pay for the clean up of mine lands abandoned before 1977, which are not covered by the new standards and regulations (Environmental Literacy Council, 2002).

This Act, along with the Clean Water Act, has important implications for mining activities throughout Pennsylvania. Future mining activities in the Connoquenessing watershed must comply with SMCRA, as well as the anti-degradation component of the Clean Water Act (Environmental Literacy Council, 2002).

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 (1997):

Dry phase of an intermittent stream

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." Streams that do not flow year-round are intermittent streams.

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 of 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. However, DEP has recently begun shifting its policy to require detailed biological assessments before approving such operations. Under this new policy, non-permanent intermittent and ephemeral streams are receiving similar protection 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 Northwest or Southwest Regional Office should be consulted.

Water Quality

Water Quality Monitoring

The Connoquenessing Watershed Alliance has a volunteer water quality monitoring program that is active throughout the watershed, including the Slippery Rock Creek subwatershed. In 2001, the Alliance was awarded $8,305 through Pennsylvania's Growing Greener program to purchase equipment and supplies necessary to expand the program (White, 2001). The monitoring is regular, systematic, and ongoing. Tests are conducted for pH, specific conductivity, dissolved oxygen, alkalinity, sulfates, nitrates, temperatures, flow volume, and macroinvertebrates.

Major Sources of Impairment

Abandoned Mine Drainage

AMD is a significant cause of impairment throughout the watershed, but in Little Connoquenessing subwatershed in particular. AMD is formed when mining activities fracture bedrock that is situated over coal seams, allowing rain, groundwater, and oxygen to come into contact with the seam and surrounding bedrock. This contact causes chemical and biological reactions resulting in water contaminated with dissolved metals, including iron, manganese, and aluminum. Acid is formed when sulfur-oxidizing bacteria in the rock helps convert inorganic sulfur to sulfate and sulfuric acid. If there are insufficient neutralizing compounds, the water will become acidic. The polluted water discharges into streams and groundwater through mine openings, springs, and seeps. When the water is exposed to oxygen in the air, the metals will precipitate, or drop out of the solution as solids, creating even more acid and coating stream bottoms with silt-like metals. High levels of iron and aluminum can poison fish and threaten drinking water supplies (Fripp, Ziemkiewicz, & Charkavorki, 2000). The siltation from the metals and the altered pH can also affect the survivability of aquatic macroinvertebrates, which form the base of the food chain, and thus the basis of a healthy, functioning stream ecosystem.

Passive AMD treatment system at Lutherlyn

Underground mining refers to practices that extract coal by tunneling into the earth. The most common underground mining method utilized is the room and pillar method. Using this method, an opening at the surface is used to reach the coal seam. Rooms are cut into the coal bed, leaving a series of pillars or columns of coal to help support the mine roof. Surface mining involves extracting deposits of mineral resources close to the surface. A common surface mining method is strip mining, which removes the layers of rock, or overburden, directly over the coal seam.

Remediation refers to activities undertaken or treatment methods used to minimize or remove pollution from a contaminated area. Regarding reducing water pollution from AMD, the goals are to reduce metal loadings and water acidity, or raise water pH to acceptable levels. AMD treatment falls into two broad categories, active and passive. Active treatment involves the physical addition of a neutralizing agent, such as chemicals and lime, to the source of the AMD or directly into the stream. Passive treatment includes a variety of techniques to raise the pH and reduce metal loading that involve a constructed treatment or containment project, such as a wetland or limestone drain. While initial costs for passive treatment can be higher, passive treatment generally requires less maintenance and attention once constructed (Turner et al.).

The type of treatment system used is highly dependent on the concentrations of metals present in the AMD and site conditions. Chemical treatment is typically implemented through passive and active methods, such as the addition of lime or the use of limestone-lined ponds. If it is necessary to reduce metal concentrations and raise the pH, then a variety of passive treatments may be used, including an anaerobic wetland, aerobic wetland, or combination of systems (Pennsylvania State University).

Previously mined areas can also be dangerous, with unstable portals and roofs associated with underground mining and dangerous high walls and spoil banks associated with surface mining. In some cases, reclamation techniques, such as removal of refuse and/or regrading and re-vegetating, can be used to make a site safer and reduce mine discharges in surface mined areas. Once an area is surface mined, its suitability for different land uses may change, because mined material can have a lower pH and different soil composition.

Some funding for mine reclamation is available through the Office of Surface Mining and other state and federal programs. See the Land Resources chapter for information about the impacts of mining on the landscape and for funding opportunities. Underground and surface mining continue to be utilized. As more profitable coal seams are mined in Pennsylvania, the reclaiming of old areas and targeting of once unprofitable coal seams may become more cost effective.

AK Steel Corporation Butler Works

Nitrates

Nitrates are commonly used in fertilizers and in industrial applications. Nitrates are easily soluble, and do not attach to soils, so their probability to migrate to groundwater is likely. Once in water, nitrates do not evaporate, and so remain in place until ingested by plants or other organisms. High levels of nitrates in a waterbody can result in eutrophication and algal blooms, which disrupt oxygen levels when the material decays, causing the death of aquatic life (EPA, 2006b).

Nitrates have also been found to contaminate unprotected wells (U.S. Agency for Toxic Substances and Diseases Registry, 2001). Other than fertilizers and industrial processing chemicals, nitrates are also found in rodenticides (pesticides used to kill rodents) and food preservatives, particularly those used for lunch meats and hot dogs (EPA, 2007). Nitrates also are a component of animal (including humans) waste.

Nitrates can pollute streams by direct discharge of industrial effluent, runoff from agricultural lands, and faulty septic and municipal sewage systems. The biggest contributor of nitrates to Connoquenessing waterways is by industrial discharge.

A water sample in October 1999, revealed that the Connoquenessing Creek was found to have particularly high levels of nitrates, especially downstream of the Butler Works Plant of AK Steel Corporation. Nitrate levels of 175 parts per million were found (ppm), well above the national health standard of less than 10 ppm for drinking water (Hopey, 2001). The borough of Zelienople, 21 miles downstream of the AK Steel discharge, utilizes water from the Connoquenessing Creek as a backup water supply in times of drought. The elevated nitrate levels caused significant concerns among residents of the borough, who rallied together with CWA to bring their concerns to EPA.

The AK Steel Corporation Butler Works Plant was responsible for most of the point source release of nitrates into the Connoquenessing Creek. Upon an EPA order to reduce nitrate discharge and provide a safe alternative of drinking water to the residents of Zelienople, AK Steel undertook efforts to greatly reduce their discharge of nitrates to the creek by limiting production and converting their pickling procedures to utilize hydrogen peroxide rather than nitric acid. They also worked with EPA and DEP to install a reverse osmosis water filtration system at the Zelienople intake on the Connoquenessing Creek, which reduced nitrate levels to an acceptable amount (Gerwig, 2002).

Infants, pregnant women, and nursing mothers are particularly at risk of adverse health effects in association with high levels of nitrates in drinking water. Methemoglobinemia, also known as "blue baby syndrome" is the most-likely adverse health effect to occur to humans. This syndrome most often occurs in infants less than four months of age, due to the unique difference between the methods by which the body metabolizes nitrate in respect to age. In an infant's system, nitrate is readily metabolized into nitrite, which robs blood cells of oxygen, thus creating a blue coloration in body tissues. The most serious consequences of this condition are coma and death (Knobeloch et al., 2000). Nitrates also have been linked to certain types of cancer in young children and adults, though research continues.

Acid precipitation

The term pH is used to quantify whether a solution is an acid or a base. Acidity is created by the concentration of hydrogen ($H+$) ions in solution, while basicity is created by the concentration of hydroxide ($OH-$) ions. A solution with an equal number of hydroxide and hydrogen ions is considered neutral. The lower the pH, the more acidic a solution is, while higher pHs are more basic.

Rainwater is already acidic, generally having a pH of around 5.6, from the reaction of carbon dioxide with oxygen in the atmosphere to form carbonic acid. However, acidity from non-natural sources has caused rainwater in some areas to have a pH of 4.9 or lower. Acidity in precipitation (rain, snow, fog, dew, etc.) that forms from the reaction of air pollutants with water in the air is called acid precipitation. These pollutants mainly include sulfur and nitrogen oxides, which turn into sulfuric and nitric acids. Other times, these pollutants fall as dry deposition, or acidic gases and particles that are blown onto buildings, cars, etc. When it rains, the particles are washed from objects and increase the pH of the rain. The sources of this pollution include vehicles and industrial and power generating plants. The effects of acid precipitation are usually felt many miles away from the source. Most pollutants in the project area come from emissions from more populated areas in the east and midwest and from coal-burning power plants to the west.

The best way to document the pH of rain is to collect rainwater by setting out containers or installing rain gauges. Rain that is not affected by pollutants will naturally be acidic, with a pH of 5.0 to 6.0. A pH below 5.0, however, may indicate acid precipitation.

The 1990 Clean Water Act Amendments include the most significant legislation that has been enacted to lessen emissions contributing to acid precipitation. The amendments promote the use of market-based approaches to reduce emissions, including pollution trading; encouraging innovative technologies to reduce sulfur and other emissions; and promoting the use of low sulfur coal. Through the use of stricter standards for the emission of sulfur and the use of innovative sulfur scrubbers, sulfur emissions are now 20 percent lower than when the legislation was enacted. This has translated to a significantly lower concentration of sulfuric acid in precipitation. Unfortunately, affordable technologies have not been developed to remove the nitrogen component. As a result, nitrogen emissions have not decreased and nitric acid precipitation is still a serious problem in the Midwest. The portion of the Midwest including western and central Pennsylvania has the highest levels of nitrogen-containing compounds in precipitation in the United States (Driscoll et. al., 2001).

Acid precipitation can have additional effects on water quality, besides the impacts of low pH. Toxic metals that have been deposited in soils are leached into streams and groundwater when they react with the anions found in acid precipitation. In some cases, the concentrations are high enough to negatively impact aquatic life. It is possible that some of these impacts are occurring in the project area. Aluminum is another common metal that amplifies in waterways that receive acid precipitation. Both aluminum and acidity disrupt the water-salt balance in fish, causing red blood cells to rupture and contributing to heart attacks. Acid precipitation can also leach important nutrients from forest soils and decrease the growth of a forest.

Fortunately, ecosystems can recover from acid precipitation impacts. Research shows that macroinvertebrate life in a stream re-establishes itself within three years of decreased acidity, whereas fish populations may take up to 10 years (Driscoll et. al., 2001). A visible lowering of sulfuric acid in streams of the project area has occurred as a result of the 1990 legislation. However, 1990 reductions were not adequate to allow for the full or even partial recovery of aquatic ecosystems. As a result, further and stricter regulatory controls are needed to reduce emissions from industrial and power plants, as well as vehicles.

The acid precipitation issue is particularly difficult because there is little that can be done locally to solve the problem. The active addition of alkalinity-producing chemicals to streams is a tactic that can be taken, but this is a temporary solution that often causes more problems for aquatic systems. Individuals interested in reducing the impacts of acid precipitation can make changes to reduce their personal contribution to emissions through activities such as driving more fuel-efficient cars and using less energy. Additionally, constituents should encourage their legislators to support stricter regulations that would further reduce the pollution from smokestacks and cars that is the source of acid precipitation.

Although evidence points to a significant decrease in water quality of the project area due to acid precipitation, more research is needed to determine normal pH reference conditions for the project area and the extent of the impact caused by low pH precipitation.

Local farm

Agricultural Practices

Agricultural pollution is the second-leading cause of water quality degradation in Pennsylvania, after AMD. Dairy and beef operations comprise a large number of farms within the project area (U.S. Census, 2000). Pollution loading increases with improper management of nutrients, such as manure and fertilizers, as well as inadequate stormwater runoff controls. These problems represent some of the most serious issues related to agricultural pollution (Swope, personal communication, 2006). BMP initiatives focus on nutrient reduction and proper storage of manure. Farmers that develop nutrient management plans can participate in cost-incentive programs, such as Environmental Quality Incentives Program and Conservation Reserve Enhancement Program (see Land Resources chapter), which provide reimbursement for up to 75 percent or more of incurred costs. Recent efforts have also focused on no-till or reduced-till practices, which greatly reduce erosion and fuel costs associated with plowing (Swope, personal communication, 2006). Increased funding for any of these programs is always needed. The local Natural Resources Conservation Service (NRCS), located in Butler, can be contacted for more information.

Forestry Practices

The amount of water running off a forest during a rainstorm depends in large part on the forest age and proportion affected by timber harvesting. Following a cut, there is an increase in the amount of water running off a forest patch because fewer trees exist to intercept rainfall or to transpire water. Most of the water infiltrates into soil or carries sediment and nutrients to streams. High-grade cuts (which remove the best-quality trees and leave little for regeneration) and other practices leaving few standing trees can increase the amount of runoff to streams. The filtering function of forests can be maintained through a number of practices, such as dispersing harvesting operations so that only a small percentage of any watershed is affected at any one place and time, utilizing forestry methods that leave an appropriate amount of trees to prevent sediment and erosion, leaving enough streamside forest to filter sediment from surface runoff, utilizing thinning practices to maximize filtering capacity and forest health, and implementing additional sediment and erosion control BMPs (Klapproth & Johnson, 2000). These are discussed further in the Land Resources chapter.

Development Practices

Land ordinances can be tailored to protect water resources. One of the biggest impacts is development on floodplains, which are natural features of a stream that dissipate water during flood events. Even smaller-scale development along floodplains reduces their effectiveness. Removing riparian vegetation can also increase the amount of streambank erosion, causing stream widening and a buildup of sediment on the stream bottom. Effective land ordinances restrict building in these and other sensitive areas, or allow building if certain requirements are met (Klapproth & Johnson, 2000).

Calgon ledge

Stormwater runoff is also an issue that should be adequately addressed in ordinances. During storm events, large amounts of water runs off paved surfaces and other impervious areas, rapidly increasing the amount of pollution and water entering streams. Some of these issues can be avoided by preventing certain types of building in sensitive areas, and encouraging building options to allow rainwater to percolate into soils instead of into roadways and drains.

The elimination and draining of wetlands for development can exacerbate flooding occurrences and severity, reduce a watershed's filtering capacity, and lead to increased sediments entering streams. Stream channelization, another root cause of increased erosion, sedimentation, and flooding, often occurs during construction practices and in heavily developed areas.

Sewage Waste

Contamination from both public sewage treatment and private on-lot systems is a potential concern. Public services are available in a small geographic area but are concentrated in boroughs, which are more populated than townships. All of these systems have a DEP point discharge permit to discharge treated sewage waste, which may contain some amount of nutrients and bacteria. These discharges have the potential to impact stream health and public water supplies, particularly if they are malfunctioning. This could cause drinking water contamination and increased drinking water treatment costs, because improperly treated effluent can enter surface water and groundwater.

Rural, on-lot systems typically contribute an even greater amount of sewage waste into streams when they are not maintained properly. Conventional systems consist of a large tank designed to hold about two days of wastewater and allow solids to settle out, and a drain field that distributes wastewater so that it can be slowly absorbed into the underlying soil. These systems remove much of the bacteria but are not very effective at removing nitrogen. They often "fail" when the drain field becomes clogged, causing raw sewage to back up out of the tank or through the ground, and end up in streams and groundwater. The systems must be pumped out every few years to prevent buildup and clogs (BF Environmental Consultants, 2004).

More advanced on-lot systems are designed to remove nitrogen by moving effluent through a series of chambers containing different kinds of microbes, which uptake the nitrogen. These systems have pumps, moving parts, and other components that need to be inspected every few years. These more advanced systems can remove twice the amount of nitrogen as conventional systems, but are more expensive and can have higher environmental impacts if not pumped out (BF Environmental Consultants, 2004).

Nutrients and organic matter from sewage effluent can cause an increase in alkalinity and conductivity of water. It is believed that these inputs may actually mitigate the impacts of AMD by raising the pH in streams that would otherwise be acidic.

Monitoring Bacteria in the Streams of the Connoquenessing Watershed

This study was initiated by Connoquenessing Watershed Alliance in 2004 to determine the suitability of the Coliscan® Easygel® system for volunteer monitoring of Escherichia coli (E. coli) bacteria as an indicator of health risk to humans in recreational waters. In addition, the study established a set of protocols for watershed organizations utilizing volunteers to monitor bacteria.

Brush Creek

Findings from the initial study show the bacteria levels at selected sites along Connoquenessing Creek, Thorn Creek, Little Connoquenessing Creek, Glade Run, Breakneck Creek, Brush Creek, Muddy Creek, and Slippery Rock Creek. Sampling occurred initially at 10 sites and at a total of 18 sites after the first sampling revealed elevated E. coli levels in some areas. The study occurred between August 31, 2004 and December 29, 2004.

Though late summer hurricanes affected weather and precipitation after the initial sampling date, causing a flushing effect, which temporarily decreased the levels of E. coli recorded, levels rose again once time passed. Preliminary findings of the study indicated elevated levels of bacteria in Brush and Breakneck creeks, and to a lesser degree in Slippery Rock Creek and Glade Run. This led to the addition of eight sites along those stretches, in an attempt to identify the source of bacteria pollution.

In general, suspected causes of bacteria level spikes included malfunctioning septic systems at recreational camps, hurricane damaged sewer lines, periodic release of chlorinated sewage treatment plant effluent, and sewage overflow. Streams that showed inconsistent findings or elevated levels of impairment were recommended for further study.

Pennsylvania's State Water Plan

Act 220, passed in December of 2002, requires that DEP update Pennsylvania's State Water Plan within five years to determine the quantity of water in Pennsylvania, the amount of water used, and how much will be available in the future (DEP[3]).

The State Water Plan has not been updated in more than 25 years and, as a result, we do not know which areas have critical water needs until water supplies are dry. Pennsylvania has experienced serious water droughts in the last ten years and water use has increased dramatically.

Starting in March 2004, DEP required any commercial, industrial, agricultural, or individual withdrawing 10,000 or more gallons of water per day, averaged over a 30-day period, to register and report their water use to DEP. Those using less than 10,000 gallons may choose to register voluntarily help DEP get a more complete picture of water use (DEP[2]).

To carry out the planning provisions of the law, a Statewide Water Resources Committee was formed to help guide the plan. Six regional water resource committees were also created to facilitate the development of regional components of the plan. Among their responsibilities is carrying out a public participation process to ensure that people with an interest in water resource issues have adequate opportunities to provide input. A series of meetings was held in 2005 at each of the six regional planning areas to better define local water resource problems and opportunities (DEP[2]).

Glade Run

During the development of the plan, areas were identified where demand exceeded available supplies. These Water Planning Areas will serve as planning boundaries for the creation of detailed water budgets to be used in Critical Area Resource Plans. These will be submitted for review and comment to the official planning agency and governing body of each municipality in the identified area prior to recommendations (DEP[2]).

The act also establishes a formal program to promote voluntary water conservation and water use for all water users. A Water Resources Technical Center will be created to promote the use and development of water conservation and efficiency education and programs (DEP[2]).

The Connoquenessing Creek Watershed is located in the Ohio River Basin. Five regional priorities have been developed by the Ohio Regional Water Resources Committee. These include:

- Maintaining water supply (loss prevention), considering the impacts of mining, loss of residential water, groundwater/stormwater recharge/old infrastructure and malfunctioning sewage systems, and contingency plans
- Implementing appropriate, applied technologies, including remediation and conservation technologies
- Identifying and planning for economic development opportunities, including how to replace water used, developing positive incentives for economic growth, and defining intended water uses
- Conducting public education and outreach on water resources, including obtaining feedback and providing information
- Balancing multi-purpose uses, including protecting existing uses, water budgeting, and developing a balance between different uses under both regular and emergency conditions

Water Quality Trading

Water quality trading is when facilities with higher pollution control costs, called "buyers" purchase the right to pollute from "sellers", or other companies that have reduced their pollution output below their required limits. This can enable polluters to reduce pollution at a lower cost than it would be to make reductions at their facilities. For instance, it may be cheaper for a polluter that discharges nitrates to buy credits from a polluter that can reduce its nitrate discharges more easily. Or, it may be cheaper for a polluter to pay for the installation of BMPs on a farm than to develop technologies to reduce pollution from nitrates. If the same pollution reduction goal can be achieved through trading, then it is a benefit to both the company and the farmer.

Connoquenessing Creek drains into the Beaver River just beyond the railroad bridge

Generally, certain criteria must be met for a Water Quality Trading program to work. There must be a "driver," or reason why pollution reductions are being sought. This is usually a TMDL, which requires point-source polluters to reduce their level of pollution by a certain amount in order for water quality standards to be met. The water quality trading will be most effective if the sources within the watershed have different costs to control their pollution, making it more economically profitable to trade. Also, the levels of pollution must be such that not all sources in the watershed must reduce their inputs. This provides a reason to bargain. Finally, watershed stakeholders and state regulatory agencies must be willing to try an innovative approach and to engage in trading design and implementation issues. Water Quality Trading should be conducted within a legal, regulatory framework, such as the NPDES Program, which requires point source polluters to obtain permits to discharge pollutions in waterways of the United States.

Proponents of trading think that it can help achieve improvements at the lowest cost to society. It provides incentives for companies to lower their amount of pollution. Ideally, a regulatory agency or appointed committee controls the transfer of pollution credits between polluters. If a company lowers its amount of pollution below its "target" limit, it will be paid for these credits by the regulatory agency. Other companies that go over this limit can purchase these credits from the regulatory agency. If non-point pollution is present in the watershed, there is the potential for a company to pay for the implementation of BMPs in exchange for polluting over its target amount. The type of program used depends on the pollution issues in the watershed.

All water trading activities must comply with the requirements of the Clean Water Act as well as state and local requirements, including public notification of transfers of trading credits. One potential problem with water quality trading is localized impacts. For example, all of the credits purchased may discharge into the same small stream. Because of these possible complications, it is important that the trading program be designed so that localized impacts do not occur. For instance, the amount of credits that can be purchased by certain polluters can be set by the regulatory agency. Water quality trading is usually most successful in developed areas, and it is unclear whether such mechanisms would be effective in the project area.