Lower Kishacoquillas Creek Watershed Assessment

Financed by a Pennsylvania Department of Environmental Protection (PA DEP) Growing Greener Grant.

Prepared by:

Mifflin County Conservation District
20 Windmill Hill #4
Burnham, PA 17009

Lewistown Area High School
2 Manor Dr.
Lewistown, PA 17044

For:
Penns' Creek Chapter of Trout Unlimited

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November 2005

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The following students worked hard to make this assessment a meaningful document, and in the meantime, they learned a lot!

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Cadie Pruss, Mifflin County Conservation District, Project Coordinator

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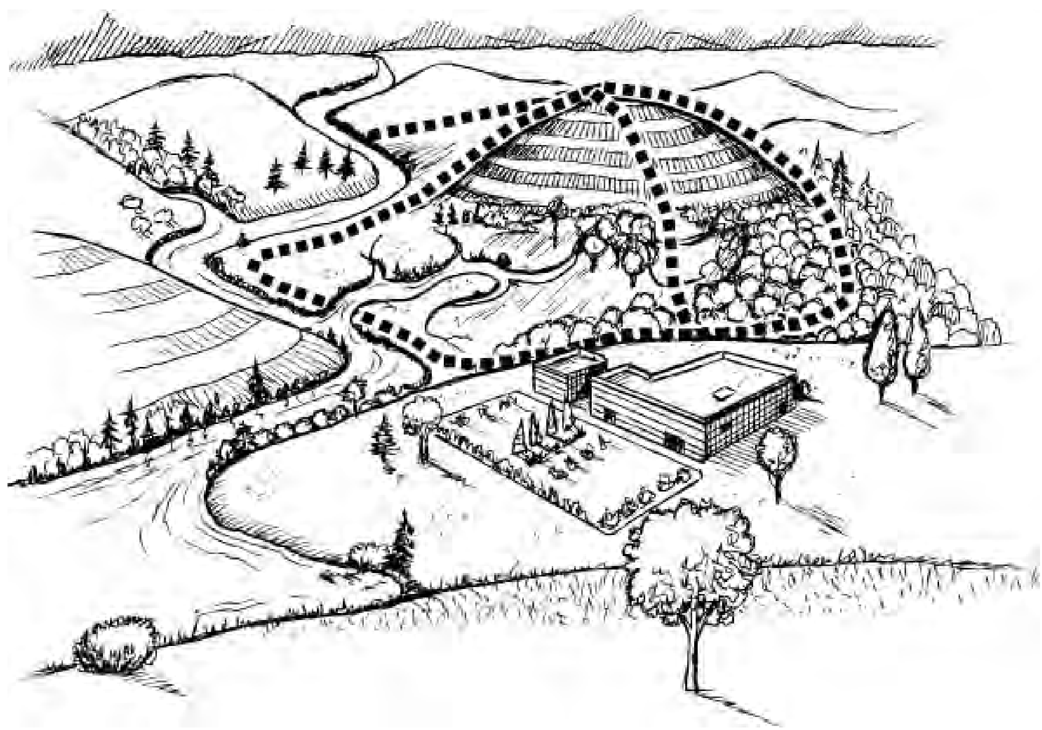
I. What Is A Watershed?

The geography of a watershed is much like a bathtub. Imagine pouring a cup of water into a bathtub: the water flows from the lip of the tub, down the side, across the sloping bottom, and eventually into the drain. All water on the earth flows from areas of higher elevation to areas of lower elevation and eventually into a body of water. This describes a watershed—the land area impacting a body of water. The route that water follows as it flows across the landscape allows for the delineation of watersheds, which are regions of land that drain from the highest topographic point to the lowest topographic point, usually a stream, river, or lake. The size of a watershed varies depending on the surrounding topography. As small streams (tributaries) join larger streams and rivers, the land area impacting the water body grows. Small watersheds join to form large watersheds and eventually drain to the oceans (Oregon State University Sea Grant).



http://www.ctic.purdue.edu/KYW/glossary/whatisaws.html

The Water Cycle

The water cycle, also known as the hydrologic cycle, is the process through which water is recycled (Figure 1.1). Water is stored in the atmosphere in the form of clouds and water vapor. The surrounding air temperature determines the state that the water will assume when it falls to the earth as precipitation in the form of rain, snow or ice. Precipitation may be taken up by the roots of plants and released through their leaves through the process of transpiration. Precipitation that is not absorbed by plants may infiltrate the soil to become part of the underground water supply, which is referred to as groundwater. Groundwater eventually connects with surface water bodies, such as streams, lakes, rivers, and oceans. In the event of heavy precipitation, soil can become saturated, preventing further absorption of water into the ground. Excess water runs over the surface of the ground and into a body of water. This excess, unabsorbed water, is often referred to as "runoff".

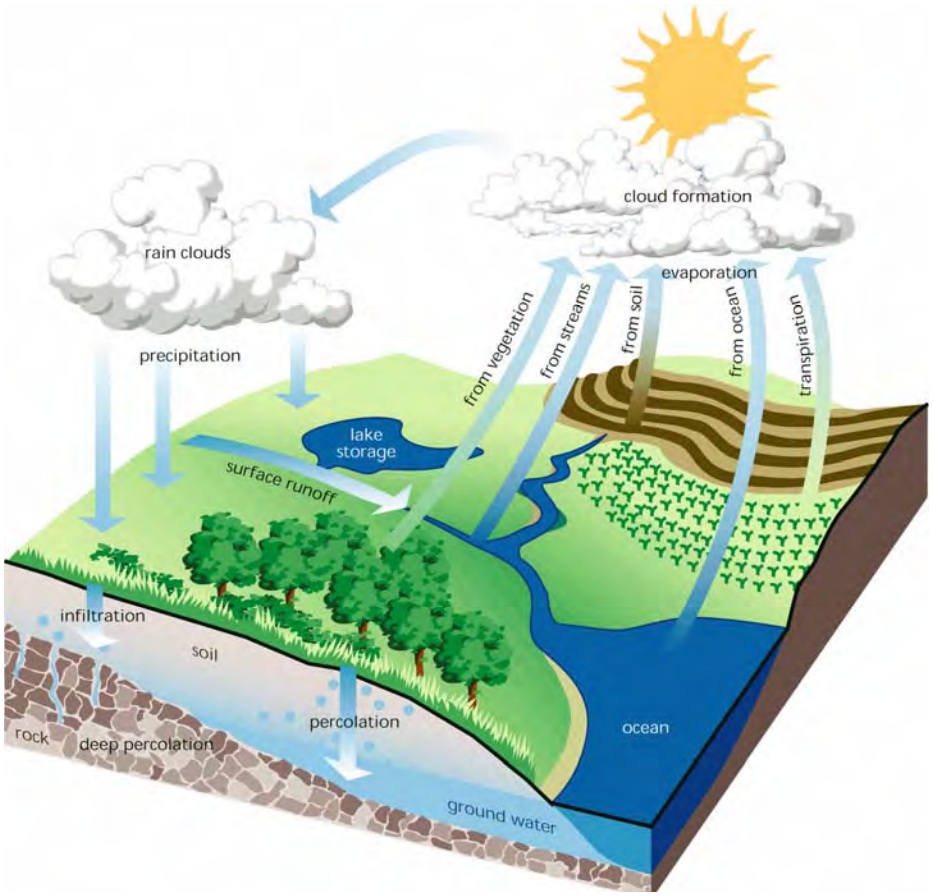


Figure 1.1. The hydrologic cycle. The transfer of water from precipitation to surface water and groundwater, to storage and runoff, and eventually back to the atmosphere is an ongoing cycle (*http://www.cet.nau.edu/Projects/SWRA/research.html*).

Runoff has become a common problem in modern societies because of the increased incidence of impervious surfaces, which are surfaces that do not allow water to infiltrate the soil. Some common impervious surfaces found in urban environments include rooftops, concrete or asphalt roads, and hard-packed dirt. Runoff picks up pollutants as it flows over the ground and carries them into bodies of water. The water stored in surface water eventually returns to the atmosphere through evaporation, thus completing the water cycle.

II. Why Is It Important To Study Watersheds?

Water is essential to all life. By studying the many aspects of watersheds, researchers can improve the health and quality of life for both human and animal communities alike. Good water quality is vital to the health of all watersheds, regardless of size, from the smallest stream to the largest raging river because ultimately they are all interconnected. Surface water and groundwater are physically connected; therefore human activities that affect one source of water also affect the other.

Watershed studies can lead to the identification of pollution sources. Once identified, work can be done to eliminate them, which can improve not only the practical value of water resources, but their recreational value as well.

Clean drinking water benefits all members of a community. Contaminants such as heavy metals are unhealthy. Lead contamination has been linked to premature births, seizures, behavioral disorders, and brain damage in humans and animals (Fracasso et al. 2002). Many other illnesses have been linked to waterborne diseases from contaminated drinking water.

Recreation is also important. Forested or open areas to hike, hunt, snowmobile or cross crounty ski not only provide valuable places for recreation, but also protect the soil from erosion, allow infiltration, and allows the water cycle to complete the process so that we can have healthy groundwater for drinking and healthy streams for recreating. A healthy stream supports various fish species, such as trout, that are highly valued by fishermen. Many families enjoy swimming in and tubing on local streams and rivers. Recreational activities bring in revenue for the community from the sale of hunting and fishing equipment and other recreational products like snowmobiles, skis, inner tubes and boats. Without healthy watersheds, these opportunities for fun times with family and friends would not be available.

How Can You Tell if a Stream is Healthy?

Healthy streams are a function of a balanced relationship between chemical, physical (habitat), and biological processes. Water chemistry has to be favorable for sustaining life, drinking, or recreation. Chemical events that negatively affect the water chemistry can be chronic or acute. A chronic problem is one that is sustained over a long period of time, such as a direct pollutant discharge or continual livestock access to a stream. An acute problem is one which is observed over a short time period, such as contamination from a chemical spill or pollutants washed into a stream during a a storm event. Either type of event can be lethal to aquatic organisms.   Using the analogy of a house, a chronic problem might be a house with lead paint and lead pipes causing long-term health problems for the people who live there, whereas a house fire would be considered an acute problem. Either way, the people living in the house might not survive.

The habitat, both in the stream and adjacent to the stream, has to be able to provide the necessary requirements for survival of aquatic organisms, including resting areas, spawning areas, and feeding areas. Using the analogy of the house again, if a family's house burned down while they were away, they would have survived the fire, but afterward they would have to build a new house or move away because they require shelter to survive. After all of the fire debris has been removed, the family's lot may look fine to a person driving by, but no one could live there—at least not until they built a new house! If the outside structure of the new house was constructed first it might appear that someone could be living there, and indeed the shelter component of survival would be satisfied, but until the builders added plumbing (water), a refrigerator (food), electricity, sewer, etc., no one could live there even though the house appeared habitable.

Finally, looking at the aquatic organisms that actually inhabit the stream will indicate if the water chemistry and habitat are suitable. If a stream fails to provide the necessary living requirements for a particular organism, it will not be found in that area. Water chemistry, appropriate habitat and the presence of desirable life all provide portions of the answer to the question "is the steam healthy?" Each of these three components is equally important and can not be evaluated without also evaluating the others.

Threats to Water Quality

Human activities within a watershed, such as the construction of impervious surfaces, use of household or agricultural chemicals, implementation of certain agricultural practices, and improper disposal of waste affect the quality of ground and surface waters as they are recycled during the water cycle.

Impervious surfaces

Because impervious surfaces are prevalent in urban regions, storm water runoff is a huge problem threatening water quality of streams and rivers flowing through highly populated areas. As runoff flows over roadways and rooftops, it becomes contaminated with salts, oils, vehicle exhaust byproducts, and heavy metals such as aluminum, iron, lead, manganese, and zinc (Karouna-Renier and Sparling 2001).

Chemicals and nutrients

Chemicals used in urban, industrial and agricultural practices, commonly find their way into groundwater, streams, rivers, lakes, and oceans through infiltration, storm water runoff or direct disposal into a body of water. People use chemicals all of the time, but rarely think about what happens to those chemicals afterwards. Household cleaners are perhaps the most widely used chemicals, although chemicals are used in most business as well. Many sewage treatment plants do not do an adequate job of removing these chemicals (Gagnon and Saulnier 2003). Houses that have on-lot septic systems have no measure of treating the water other than infiltration. Chemicals such as lawn and agricultural fertilizers that are applied directly to the ground infiltrate into the groundwater.

Excess plant nutrients from lawn and agricultural fertilizers are common aquatic contaminants. When fertilizers become incorporated into aquatic systems, they foster the growth of algae, leading to an excess of plant biomass. An overgrown population of algae depletes oxygen from the water as it dies and decomposes, resulting in the deaths of fish and aquatic insects (Faulkner et al. 2000). In rural area, agricultural fertilizers have a bigger impact than lawn fertilizers and their introduction into streams is exacerbated by farming practices that increase erosion and nutrient loss (Plaster 2003).

Some conventional tillage and crop management practices add to soil loss from wind and water erosion. Conventional tillage involves breaking the soil surface up into fine particles to create a soft, easily penetrable substrate in which to plant new crops. While conventional tillage allows farmers to plant seeds and establish new crops quickly, the fine soil particles it produces are easily washed away during rain storms, increasing sediment loads in nearby streams. In addition, conventional tillage requires inverting the top layers of the soil, effectively burying organic material and nutrients left over from the previous year's crops. Therefore, crops planted in soils prepared using conventional tillage must be treated with fertilizer and pesticides to ensure that the nutrients required for plant growth will be available to the new crops. When rain falls on newly established fields cultivated using conventional tillage methods, the nutrients from applied fertilizers are washed into water bodies along with the top layers of soil (Plaster 2003).

Crop production is not the only agricultural activity affecting the integrity of streams in rural watersheds. Livestock grazing can also lead to unfavorable water and habitat conditions. Some effects of livestock grazing in streams include changes in channel morphology, substrate composition, turbidity, stream temperature, and plant and animal production (Fleischer 1994). Animals allowed unrestricted access to the stream itself often defecate and urinate while standing in the water, adding additional nutrients to the system. Livestock pastured adjacent to streams may eat all of the vegetation. Water traveling over bare dirt in an over-grazed pasture ends up directly in the stream, carrying with it any manure, fertilizers, and chemicals.

Improper Disposal of Waste

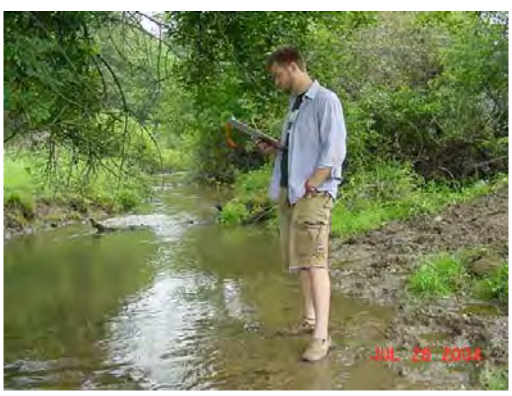
Other urban practices that result in the deposition of harmful chemicals into water bodies include illegal dumping of household and industrial waste, authorized municipal and industrial dumping, and improper sewage treatment and disposal. Illegal dumping allows harmful chemicals to infiltrate into the ground, thus contaminating the groundwater. Illegal dumping is a serious threat to water quality and it is made worse when the dumping occurs in sinkholes, which are a direct conduit to groundwater.

Watershed Protection and Management

Land use planning can help a community grow in ways that protect landscape diversity in the form of streams, wooded areas, and wetlands while providing an attractive and safe place for people to live. The protection of forests and wetlands is an important aspect of watershed management. Numerous species of animals are found only in forested or wetland environments. Activities such as logging, road building, and clear-cutting of forests decrease water quality by increasing the amount of suspended solids in the water column due to soil erosion (Ehrhart et al. 2002). Tree roots hold soil together, and when this support system is removed soil is carried by storm water into streams and rivers. Wetlands often provide a buffer between completely dry land and a body of water. Plant species found in wetland areas trap sediment and filter out excess nutrients present in runoff before they can be incorporated into aquatic systems. The destruction of these habitats is not only harmful to aquatic creatures, but to terrestrial species as well. All activities that prevent soil erosion, aid in infiltration, and reduce runoff are important in protecting water quality.

Local Interest in Watershed Protection

In 2003, Mr. Douglas Reddy, advisor for the Lewistown Area High School Conservation Club (Conservation Club) in Mifflin County, Pennsylvania, applied for a Growing Greener Grant from the Pennsylvania Department of Environmental Protection (PADEP). This grant application was sponsored by the Penns Creek Chapter of Trout Unlimited. The Conservation Club was successful in attaining the grant and in 2004 Lewistown High School students, in conjunction with the Mifflin County Conservation District (MCCD), began work on the Lower Kishacoquillas Creek Watershed Assessment.



Portions of Kishacoquillas Creek, locally known as Kish Creek, were recognized as an impaired waterway, first in the Susquehanna River Basin Commission's water quality assessment reports in 1997 and 1998 (McGarrell 1997; Edwards 1998), and then in 2001 by PADEP during an assessment. The primary causes of impairment included industrial municipal discharge and agricultural pollution (McGarrell 1997). However, little research has been conducted in recent years on the portion of Kish Creek from Mann's Narrows in Reedsville to the stream's mouth at the Juniata River.

In 2000 the Mifflin County Conservation District was awarded a PADEP Growing Greener Grant to conduct an assessment of 175 square miles of the Kish watershed within the townships of Menno, Union, Brown and Armagh. This assessment did not include any portion of the watershed south of Jacks Mountain. The findings of this assessment, published in 2003, identified impaired areas and led to recommendations for improving stream conditions throughout the watershed. As a result, several restoration projects have been completed and more are underway. The condition of Kish Creek in this region has shown improvement due to efforts such as these. By completing a similar assessment of the lower portion of the watershed, Conservation Club students hoped to identify problems and make recommendations regarding the implementation of future restoration projects.

The assessment of the Lower Kishacoquillas Creek watershed included monthly chemical and storm water sampling, multiple macroinvertebrate surveys, fish and bird studies, and the evaluation of in-stream and riparian habitat at five sample sites. The students also performed visual assessments of the entire 8-mile stretch Kish Creek included in the study. Over the course of two years, Conservation Club members, the Conservation District's watershed specialist, and one Pennsylvania State University student (collectively referred to as "we") conducted research in the field and in the office to complete this important project.

III. Description of the Lower Kishacoquillas Creek Watershed

The entire Kishacoquillas Creek watershed drains an area of 191 square miles (122,240 acres) including agricultural, urban, and industrial lands (Pruss 2003). The focus of this assessment was the Lower Kishacoquillas Creek watershed, located in central Mifflin County, Pennsylvania. This small portion of the larger Kish Creek watershed encompasses 27 square miles (17,528 acres) and includes three streams: the main stem of Kish Creek and two tributaries, Buck Run and Hungry Run (Figure 3.1). The 8-mile stretch of Kish Creek evaluated in this study begins at Mann's Narrows, a naturally formed gap in Jacks Mountain created by the creek (Pruss 2003), and ends at the confluence of Kish Creek and the Juniata River in Lewistown. This section of Kish Creek flows primarily through the urban landscapes of Lewistown, Burnham, and Yeagertown (Figures 3.2 and 3.3). Hungry Run and Buck Run both join the main stem of Kish Creek in Burnham, with Hungry run flowing in from the northeast and Buck Run from the southwest. The landscape drained by these tributaries is dominated by agricultural fields and livestock operations until the streams approach Burnham, where land use types shift to an urban focus (Figures 3.4 and 3.5).

Confluence of Kishacoquillas Creek and the Juniata River, Lewistown, Pennsylvania

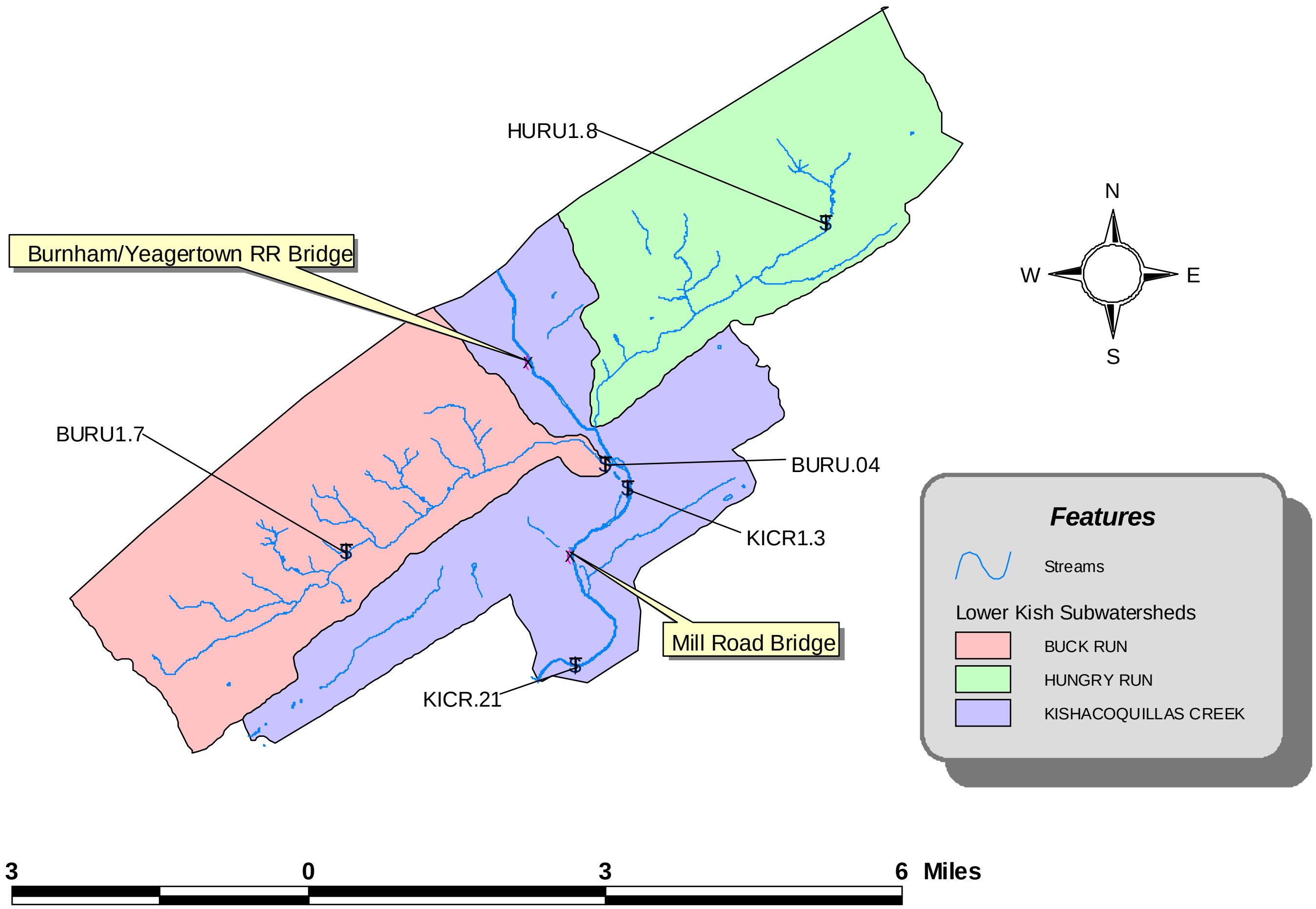


Figure 3.1. The Lower Kishacoquillas Creek watershed separated by subwatershed. Study sites are indicated by blue triangles and the boundaries of the HQ-CWF section is indicated by and pink circles.

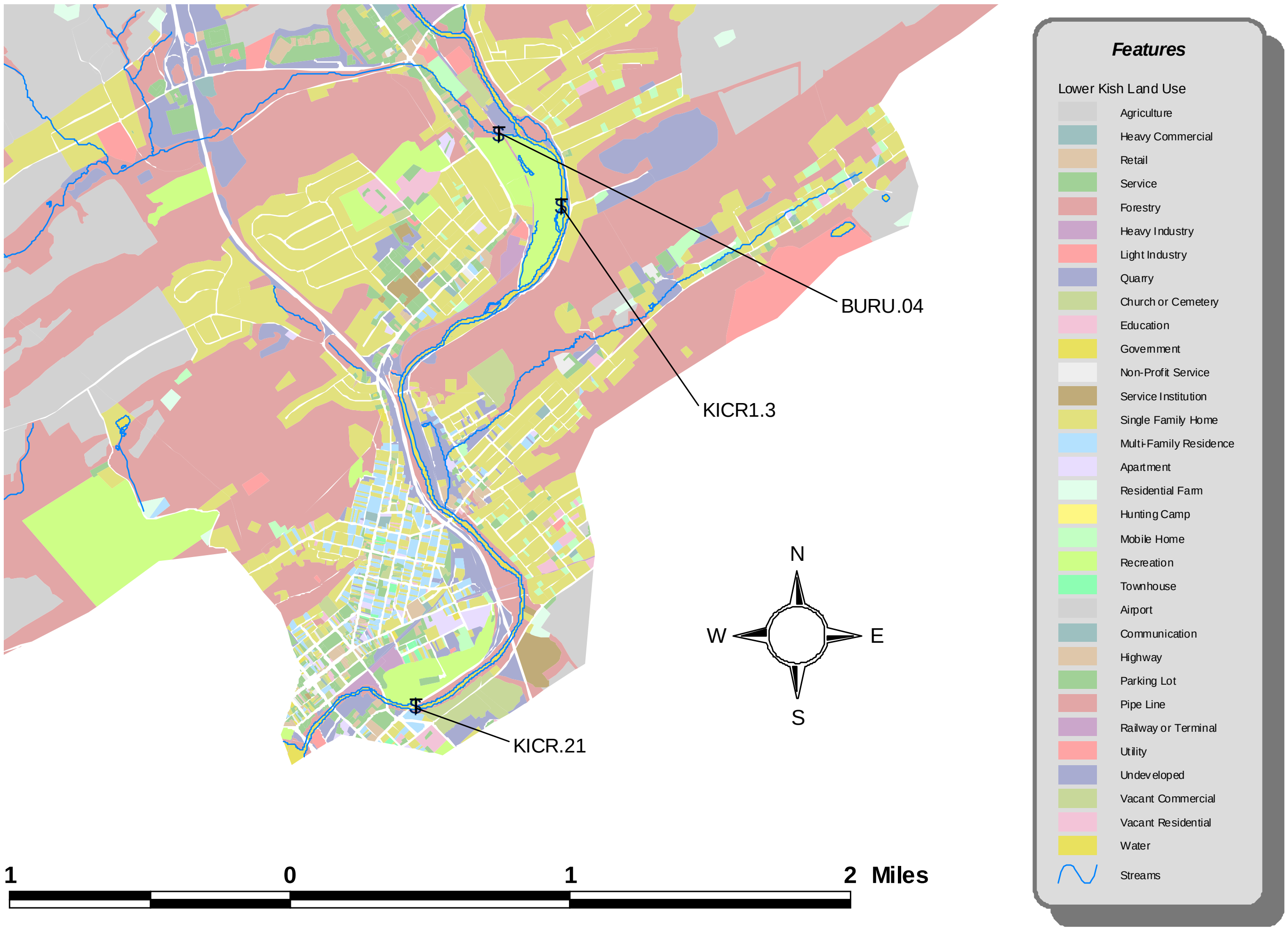


Figure 3.2. Land use patterns in the Lewistown area of the Lower Kishacoquillas Creek watershed.

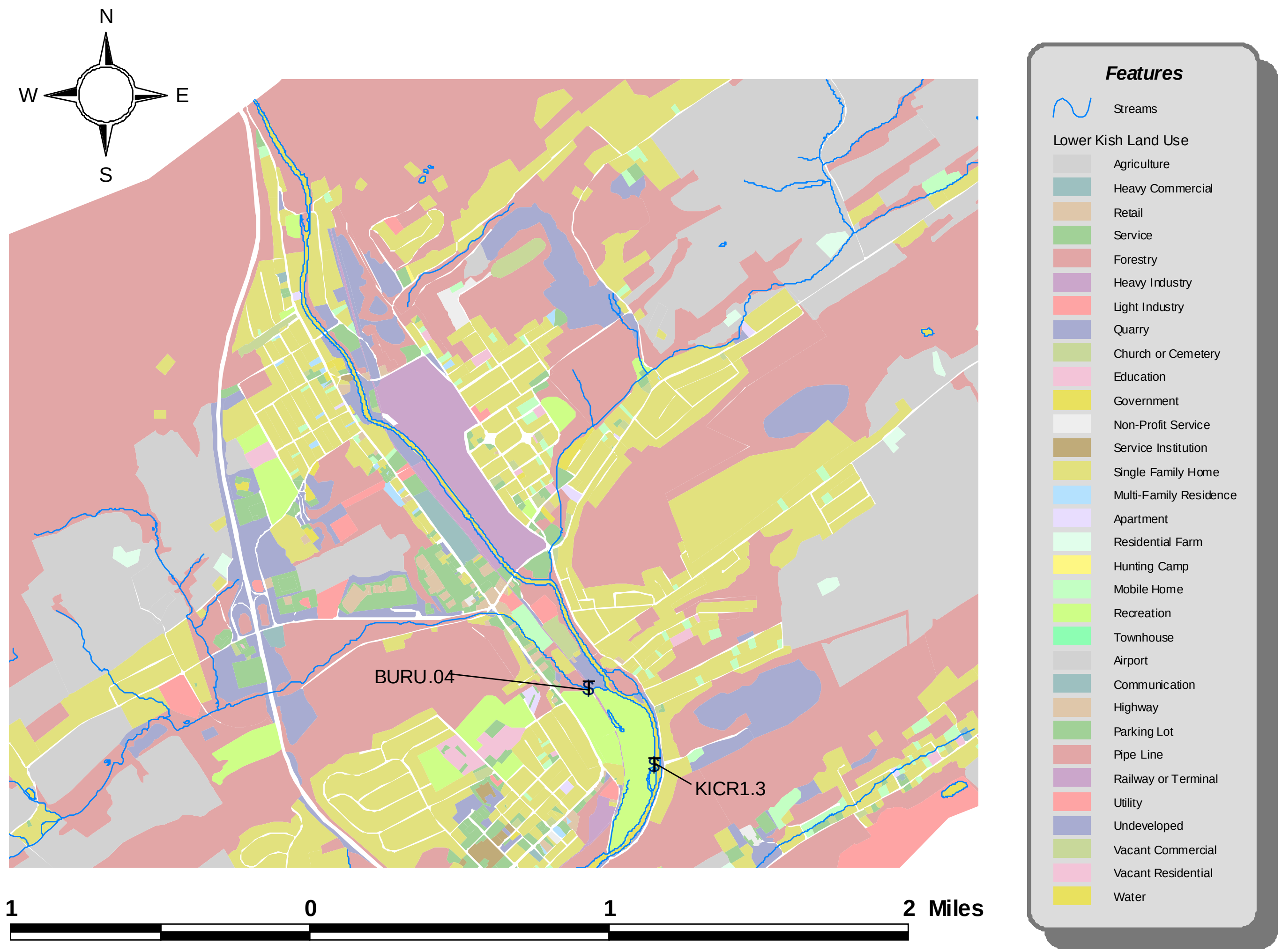


Figure 3.3. Land use patterns in the Burnham/Yeagertown area of the Kishacoquillas Creek watershed.

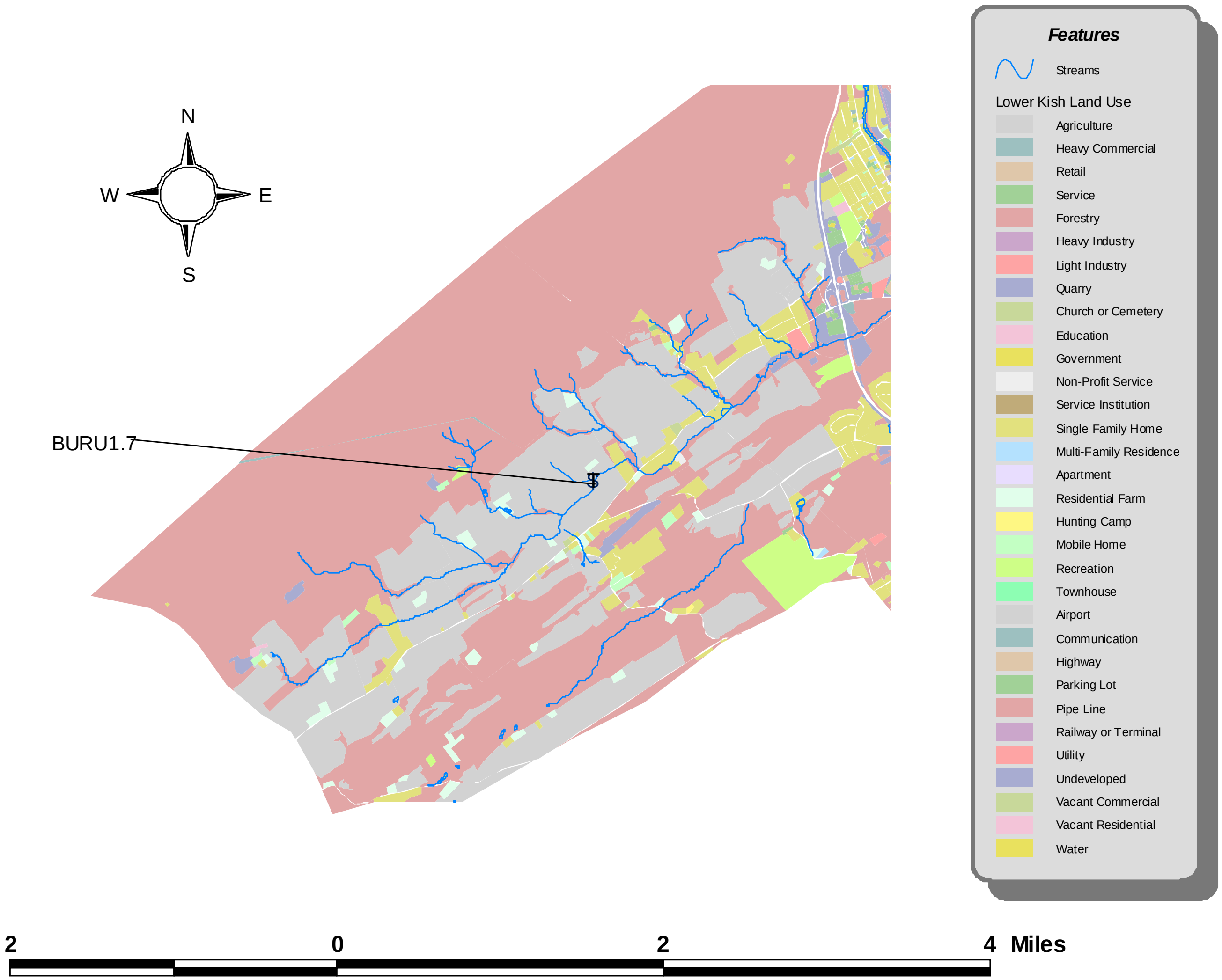


Figure 3.4. Land use patterns in the southwest portion of the Lower Kishacoquillas Creek watershed.

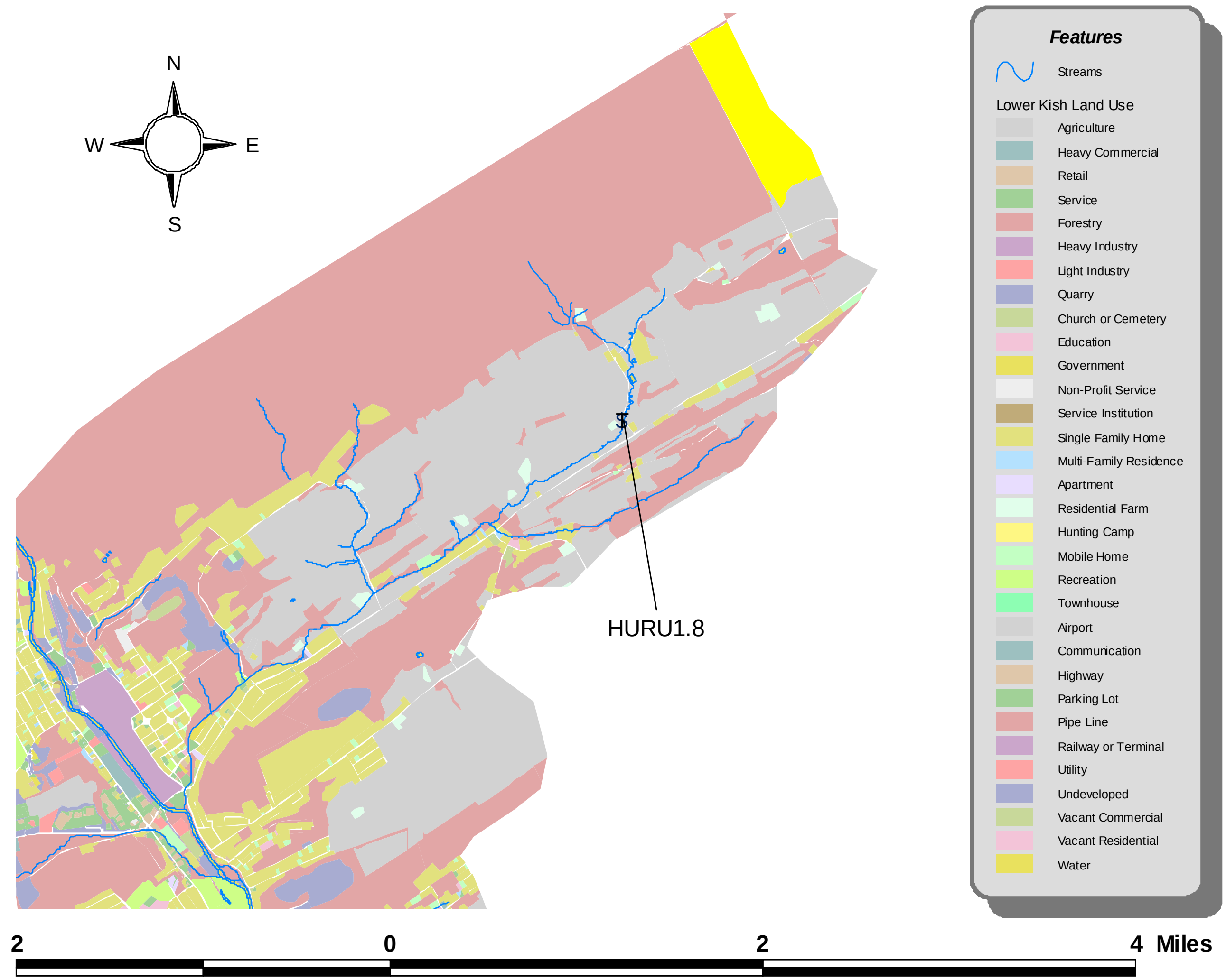


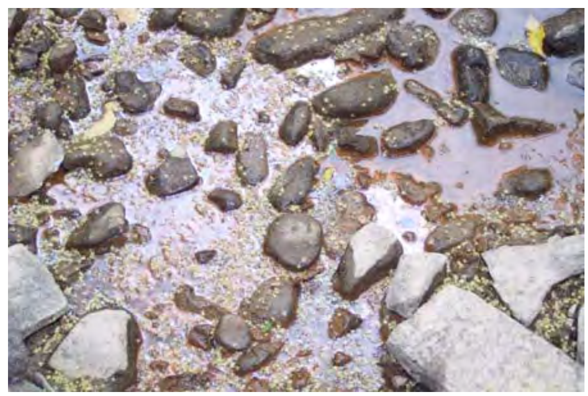
Figure 3.5. Land use patterns in the northeast portion of the Lower Kishacoquillas Creek watershed.

Geology

Carbonate rocks, such as limestone and dolomite, are the primary components of Mifflin County bedrock (Farley and Lipscomb 1981). Because it is a highly basic substance, carbonate dissolves rapidly in the presence of certain types of acid, such as carbonic acid, which is a weak acid found in Pennsylvania's rainwater. Carbon dioxide gas in the atmosphere reacts with water in the clouds to form carbonic acid. During a storm, acidic rainwater infiltrates the soil where it may further react with CO_2 gas in the ground, creating more carbonic acid. Carbonic acid is the main acid responsible for dissolving carbonate rock (Kochanov 1999).

Geologic areas comprised mainly of carbonate rocks are predisposed to forming underground caves, caverns, sinkholes and other depressions as layers of rock dissolve. Groundwater flows through these subterranean fissures and then surfaces as a spring. Many smaller tributaries in the Kishacoquillas watershed are spring-fed and disappear beneath the ground for miles before resurfacing in a new location. Streams that exhibit this type of flow pattern are often referred to as disappearing streams (Kochanov 1999). This feature of Kish Creek's tributaries poses an interesting question for researchers studying the stream. It is very difficult to determine where these underground streams flow and what kinds of pollutants they may pick up before rejoining the main channel.

Another feature of carbonate bedrock is its predisposition toward forming sinkholes. A sinkhole opens up when surface material moves downward as layers of underlying rock are dissolved due to the reaction between carbonate rock and acid rain (Kochanov 1999). For decades, it was a common practice on many farms to dispose of waste materials and derelict machinery in sinkholes, allowing pollutants to seep through to the water table and contaminate groundwater supplies. If an organic chemical that is less dense than water, such as engine oil or gasoline, leaks into groundwater, it may float along on top of the water's surface for miles. This can lead to widespread contamination.



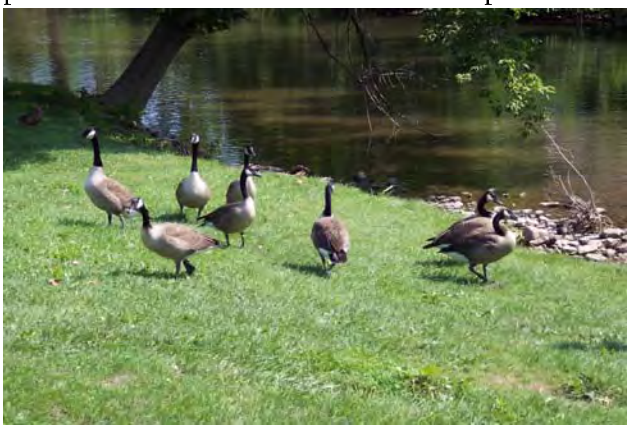
Water that has been polluted in this fashion may eventually join with an underground spring and surface somewhere far away. Many people believe it is safe to drink water bubbling out of a spring, but it is nearly impossible to tell where this "pure" water actually came from.

Habitat and Wildlife

Prior to European settlement, the primary habitat type in Mifflin County was oak-pine forest. Many acres of these forests dominated by eastern white pine and eastern hemlock were clear-cut prior to 1900 for industrial purposes or to create agricultural fields. These practices wiped out large portions of the region's old growth forests, which were eventually replaced by today's mixed-oak forests (Abrams and Nowacki 1992). Mixed-oak forests are considered transitional habitat and are composed mainly of red and white oaks, maples, beeches, spruces and other conifers (Wernert 1982). The Lower Kish Creek watershed is located within Pennsylvania's Ridge and Valley ecoregion, and is characterized by steep ridge slopes and flat, fertile valleys (Bradley et al. 2002).

Many diverse mammal and bird species are native to Mifflin County's mixed-oak forests. Commonly observed mammals include gray and red squirrels, eastern chipmunks, raccoons, red foxes, little brown bats, Virginia opossums, black bears and white-tailed deer. More elusive inhabitants, such as the gray fox and the bobcat, are occasionally seen in deeper woodland areas (Wernert 1982). Recently, the infamous coyote has repopulated Pennsylvania and is now seen and heard regularly within the boundaries of the Lower Kish Creek watershed. Recently, the Pennsylvania Game Commission reintroduced a small population of river otters to the Juniata River area where they had been previously extirpated. Sightings of river otters along Kish Creek have been reported by some Burnham residents and it is possible that a few otters have migrated into Kish Creek from the Juniata River.

The mixed-oak forests and open meadows of the Lower Kish Creek watershed also provide habitat for a number of bird species from songbirds to raptors. Warblers, sparrows, red-eyed vireos, scarlet tanagers, eastern bluebirds, and black-capped chickadees are often seen by birdwatchers in the watershed. Familiar backyard visitors such as the American robin and the blue jay are also common. Many watershed residents enjoy viewing and feeding the creek's abundant waterfowl in local parks. The Lower Kish Creek watershed is home to several birds of prey, including red-tailed hawks, sharp-shinned hawks, broad-winged hawks, red-shouldered hawks, turkey vultures, great horned owls, eastern screech owls, and even the occasional bald or golden eagle (Wernert 1982).



Climate

The Lower Kish Creek watershed experienced a wide range of weather conditions during the 14-month period covered by this assessment. The summer of 2004 was characterized by above average precipitation and below average temperatures. Several hurricanes affected the area in late August through the month of September, bringing extensive flooding and high winds (Figures 3.6-3.10). Precipitation was 1.5 times higher than average in August 2004 and 3 times higher than average in September 2004.

Figure 3.6. Behind the baseball field near Mann's Narrows during the September 2004 flood (left) and during the dry summer of 2005 (right).

Figure 3.7. Baseball field near Mann's Narrows during the September 2004 flood (left) during the dry summer of 2005 (right).

Figure 3.8. The pond in Derry Community Park in Burnham during the flood in September 2004 (left) and during the dry summer of 2005 (right).

Figure 3.9. The railroad bridge in Derry Community Park in Burnham after the flood in September 2004 (left) and during the dry summer of 2005 (right).

Figure 3.10. Pavilions at Derry Community Park in Burnham during the flood in September 2004 (left) and during the dry summer of 2005 (right).

Unlike the summer of 2004, the summer of 2005 was very hot and dry (Tables 3.1-3.2). Precipitation in May 2005 was 1.5 times lower than average, while June 2005 precipitation was 2 times lower than average. Maximum daily temperatures exceeded 32°C (90°F) on eight days in June and seven days in July.

Table 3.1. Average high and low temperatures (°C) and average precipitation (cm) for Lewistown, Pennsylvania from 1880 to 2004

Month	Average Max. Temp.	Average Min. Temp.	Average Precip.
January	2	-7	6.93
February	4	-7	6.15
March	10	-2	8.56
April	17	3	8.2
May	23	8	10.54
June	27	13	11.63
July	29	16	10.62
August	28	15	8.08
September	24	11	9.09
October	18	4	7.7
November	11	0	8.81
December	4	-4	7.44

Source: Borough of Lewistown Wastewater Treatment Plant

Table 3.2. Average high and low temperatures (°C) and average precipitation (cm) for Lewistown, Pennsylvania from June 2004 to July 2005.

Month	Average Max.Temp.	Average Min. Temp.	Total Precip.
Jun-04	25.3	13.9	117.1
Jul-04	27.5	16.5	112
Aug-04	27.5	16	126.2
Sep-04	24.9	13.7	273.3
Oct-04	16.7	5.8	75.2
Nov-04	13.3	2.7	81.8
Dec-04	5.3	-4.3	81.5
Jan-05	2.9	-5.9	107.2
Feb-05	5.7	-3.9	60.5
Mar-05	6.6	-2.4	94
Apr-05	18.2	3.6	61
May-05	20.1	6.3	65
Jun-05	29	16.1	53.3
Jul-05	30.3	18.2	136.1

Source: Borough of Lewistown Wastewater Treatment Plant

People

The 2000 Census estimated the population of Mifflin County to be 46,486 people with 25,021 of those people living in the Lower Kish Watershed. There are three boroughs located within the Lower Kish Creek watershed: Lewistown (population 21,898), Burnham (population 1,995), and Yeagertown (population 1,128).

The manufacturing industry employs 29.4% of Lewistown residents (Figure 3.11), a figure undoubtedly influenced by two of Mifflin County's major employers, Case-New Holland agricultural equipment in Belleville and Standard Steel in Burnham (Pruss 2003). Social services and the retail trade industry are also major sources of employment for Lewistown residents (Figure 3.11). Lewistown lacks a well-developed public transportation system with no mass-transit bus routes. As a result, most citizens (80.2%) commute to work by car alone, while another 12.0% carpool (Figure 3.12) (U.S. Census Bureau 2000).

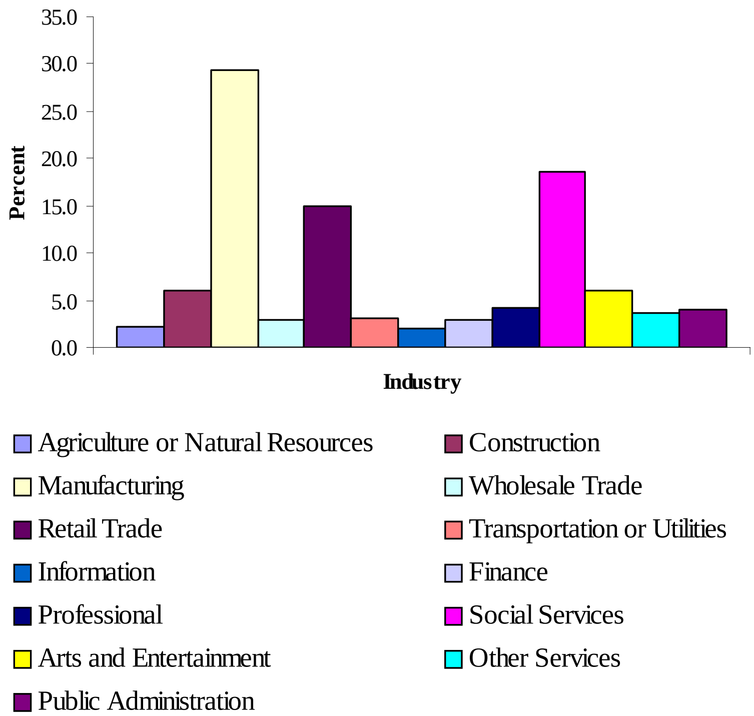


Figure 3.11. Breakdown of % employment by industry for Lewistown, Pennsylvania. *Source: U. S. Census Bureau (http://factfinder.census.gov).*

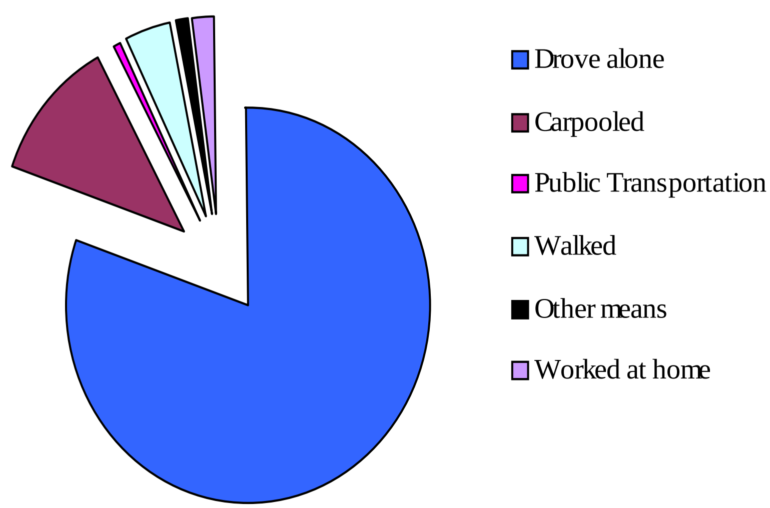


Figure 3.12. Daily transportation means of Lewistown residents in the year 2000. *Source: U. S. Census Bureau (http://factfinder.census.gov).*

The area's manufacturing industries coupled with relatively high traffic volumes created by many single-passenger commuters provide major potential sources of pollution. Industrial waste, vehicle exhaust and associated "road grime" contain heavy metals, petroleum hydrocarbons, and nutrients that are detrimental to the health of aquatic ecosystems (Hall and Anderson 1988). Whether or not these substances are affecting the streams of the Lower Kish Creek watershed, and if so, to what extent their effects are felt, was one of the major focuses of this assessment.

Water Use and Wastewater Disposal

The public sewer system in the Lower Kish watershed is limited to urban areas in Lewistown, Burnham, and Yeagertown (Figure 3.13). There are two sewage treatment plants in the watershed, one in Granville Township serving the residents of Yeagertown and Lewistown, and one in Burnham Township which serves the residents of Burnham Township and several properties in Derry Township, including the Greater Lewistown Plaza shopping center and the Clarion Inn, among others (Mifflin County Planning Commission 2000). The Burnham Wastewater Treatment Plant is located along the main stretch of Kish Creek and serves all of Burnham Township (Mifflin County Planning Commission), which according to the U.S. Census Bureau consists of 983 households. The Lewistown Wastewater Treatment plant, located along the Juniata River, serves 4,375 households in Lewistown Borough and an additional 2,904 households in Derry Township (Mifflin County Planning Commission 2000). The remainder of households in the Lower Kish Creek watershed have private on-site septic systems for sewage retention and disposal.

Wastewater treatment plants often receive waste from both domestic and industrial sites. The waste is treated and then emptied directly into streams. Although wastewater treatment plants generally do a satisfactory job removing certain materials—such as suspended solids, oxygen-demanding biological and chemical substances, nutrients like nitrogen and phosphorus, and pathogenic bacteria—they do not always rid wastewater of metals, oils, greases, and chemicals (Gagnon and Saulnier 2003). Heavy metals tend to be high in municipal wastewater due mostly to industrial inputs, but also from human domestic practices like cooking and cleaning, which contribute a significant amount of zinc and manganese to treatment plant effluent (US EPA 1986). The presence of metals in wastewater effluent can cause increases in conductivity and decreases in pH that may be observed as far as 10km downstream of the discharge site (Gagnon and Saulnier 2003).

In 2001, the Chesapeake Bay Foundation (CBF) published the results of a study investigating the environmental impact of sewage treatment plants in the Chesapeake Bay watershed. The Lower Kish Creek watershed is part of this larger watershed, so the Lewistown and Burnham Wastewater Treatment Plants were included in this study. The CBF determined overall scores for each treatment plant in the study based upon the amount of nitrogen pollution in milligrams nitrogen per liter of water (mg N/L) discharged from the plant daily. Overall scores ranged from unacceptable to excellent based upon the following criteria: unacceptable (8.1 mg N/L or higher), needs improvement (5.1-8.0 mg N/L), good (3.1-5.0 mg N/L), and excellent (less than 3.1 mg N/L). The Burnham Borough Wastewater Treatment Plant, with a daily nitrogen output of 2.7 mg N/L, received a score of excellent, while the Lewistown Borough Wastewater Treatment Plant received an overall score of unacceptable for its daily discharge of 14.0 mg N/L (Chesapeake Bay Foundation 2001).

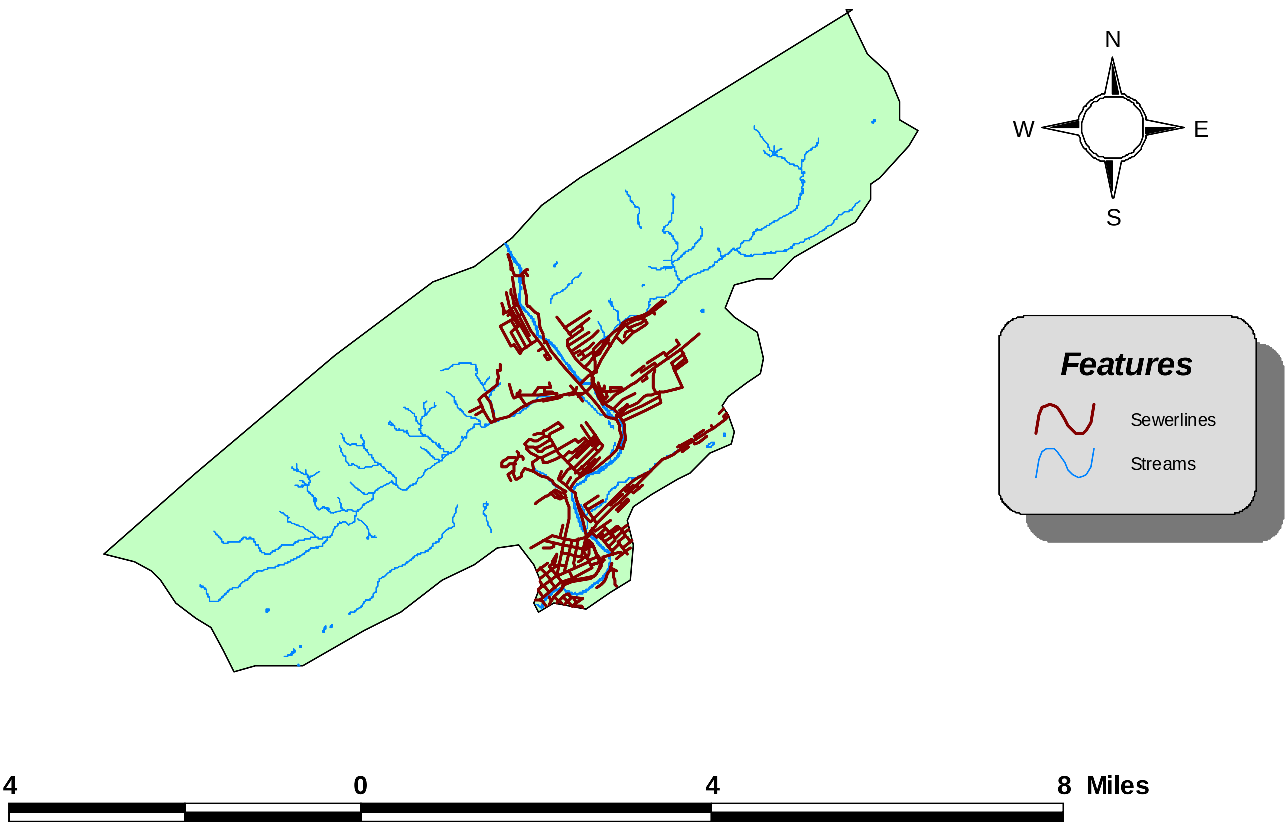


Figure 3.13. Sewer lines in the Lower Kish Creek watershed.

IV. Project Overview

Description of the Five Study Sites

Two sites along the main stem portion of Kish Creek and three sites along its two main tributaries were chosen as sampling locations for this study (Figure 4.1). Sites along the tributaries, Buck Run and Hungry Run, were selected to illustrate the difference in physical and chemical characteristics between urban and agricultural streams. The main stem of Kish Creek flows through urban and industrial areas in Lewistown, while Buck Run and Hungry Run flow through farmland (Table 4.1).

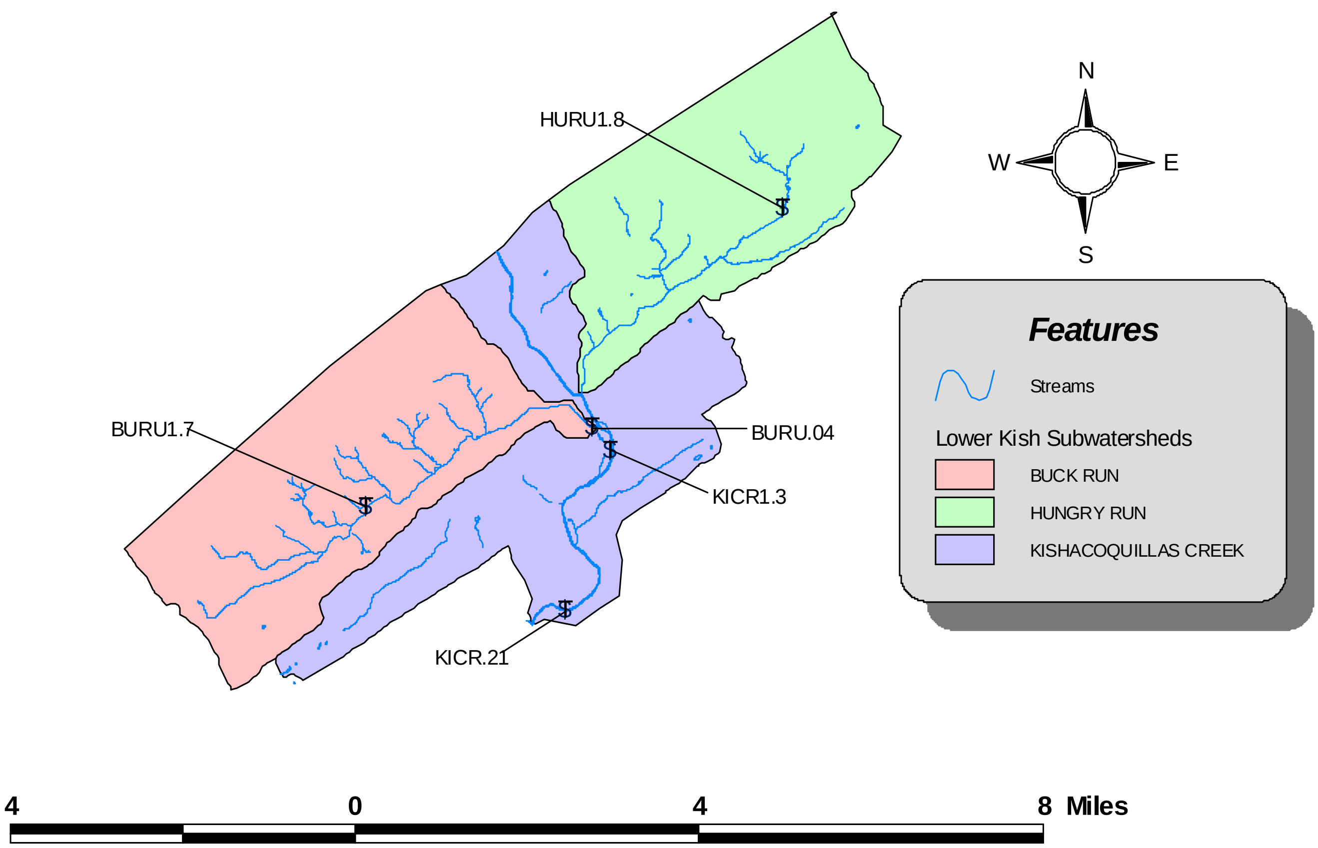


Figure 4.1 Study sites in the Lower Kish Watershed shown by subwatershed.

Agricultural versus urban land uses in the Lower Kish Creek watershed. Cows in a pasture at HURU1.8; downtown Lewistown near KICR.21.

Protected Water Uses in Pennsylvania

PADEP publishes a list of statewide water quality standards, water uses, and protected water uses in the Commonwealth's Pennsylvania Code, Title 25, Environmental Protection, Chapter 93, Water Quality Standards. All states are required by the Clean Water Act of 1972 to report on water quality (Pruss 2003). The Clean Water Act is a federal law focusing on the maintenance of minimum standards for all of America's waterways. Some waters within the Lower Kishacoquillas watershed are also classified for protected water uses pertaining to aquatic life, and must meet additional criteria outlined in PA Code Title 25, Chapter 93.

Aquatic Life Definitions

- *Cold Water Fishery (CWF)*: Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna that are indigenous to a cold water habitat.
- *High Quality Cold Water Fishery (HQ-CWF)*: A CWF that meets one or more of the conditions outlined in section 93.4b of PA Code Title 25.
- *Trout Stocked Fishery (TSF)*: Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna that are indigenous to a warm water habitat.
- *Class A Wild Trout Water*: A surface water classified by the Pennsylvania Fish and Boat Commission (PFBC), based on species-specific biomass standards, which supports a population of naturally produced trout of sufficient size and abundance to support a long-term and rewarding sport fishery.

Site HURU 1.8

Designation of Streams Within the Lower Kishacoquillas Creek Watershed

PADEP classifies Buck Run, Hungry Run, and the portion of Kish Creek south of Mill Road as Trout Stocked Fisheries (TSF). Four of the five study sites, including BURU.04, BURU1.7, KICR.21, and HURU1.8, are listed as TSF (Table 4.1). North of Mill Road, Kish Creek is classified as a High Quality Coldwater Fishery (HQ-CWF) and the Pennsylvania Fish and Boat Commission lists this portion of the creek as Class A Wild Trout Waters. One of our study sites, KICR1.3, lies within this section of the creek (Table 4.1).

Site KICR1.3

Table 4.1. Geographic location, ownership, PA DEP protected use designation, and description of setting for the five study sites.

Site Name	Latitude/ Longitude	Ownership	PA DEP Protected Use	Setting	Description of Location
BURU.04	40°37'32"/ 77°33'41"	Public	TSF	Urban	Derry Park, Burnham; near railroad bridge, upstream of Buck Run/Kish Creek confluence
BURU1.7	40°36'46"/ 77°36'42"	Private	TSF	Agricultural	Has a fenced, planted riparian Buffer
HURU1.8	40°40'11"/ 77°28'38"	Private	TSF	Agricultural	No fenced buffer; cows have direct access to the stream
KICR.21	40°35'46"/ 77°34'03"	Public	TSF	Urban	Recreation Park, Lewistown; under highway bridge
KICR1.3	40°37'06"/ 77°33'34"	Public	HQ-CWF; Class A Wild Trout	Urban	Derry Park, Burnham; near campground; large population of ducks

Site BURU.04

Site KICR .21

V. Assessment Components

In order to produce a complete picture of the current state of the Lower Kish Creek watershed, we gathered data concerning the three components of an aquatic system: water chemistry, habitat, and biology.

Water Chemistry

Chemical tests can be performed in the field or in a laboratory. Common field tests include measurements of pH, conductivity, alkalinity, and dissolved oxygen content. Laboratory tests, such as those measuring nitrate, sulfate, phosphorus, and ammonia-nitrogen levels, and fecal coliform are important for determining nutrient levels in the water. If a water body is a source of drinking water for humans, it must test negative for fecal coliform (PA DEP 2001). Water collected during a storm event is also generally analyzed for hardness and heavy metals.

Total suspended solids, the total amount of suspended solid material in the water column, can also be measured in the laboratory to determine the extent of erosion in the watershed. When total suspended solids are high, there is a large amount of sediment in the stream which can be harmful to fish populations because of its detrimental effects on the respiratory surfaces of the gills. Sediment also settles over the eggs of substrate-nesting fishes such as trout and prevents oxygen from getting to the developing embryos (Bradley et al. 2002). High mortality of eggs due to sediment abundance results in low reproductive output in affected streams. Abnormally high results from any of these pollutants could indicate inputs of agricultural fertilizers or industrial discharge.

The results of field and laboratory water chemistry tests indicate the suitability of the water for sustaining aquatic habitats and supporting aquatic life. The presence of chemicals or excess nutrients can lead to habitat problems such as overgrowth of aquatic plants and proliferation of waterborne diseases. In addition, physical contaminants measured in water chemistry analyses, such as sediment, can alter in-stream habitat to the extent that the stream can no longer support aquatic insects, fish, or other animals.

Habitat

The Environmental Protection Agency established a protocol for the assessment of stream habitats. This protocol outlines a procedure for evaluating habitat quality based upon twelve physical parameters important to the survival and reproduction of fish in lotic (flowing-water) environments. EPA clearly defines the twelve parameters and descriptions of what features would earn a particular location a rating of poor, marginal, suboptimal, or optimal for a particular parameter.

Definitions for the Twelve Habitat Parameters (from Barbour et al. 1999)**:**

1. *Instream Cover (fish)*: A measure of the relative quantity and variety of natural structures in the stream, such as cobble (riffles), fallen trees, logs, and undercut banks, available as refugia for feeding, spawning, and nursery functions. A wide variety of structures

provides aquatic organisms a large number of niches and increases habitat diversity. A lack of structural diversity reduces the potential for recovery following disturbance.

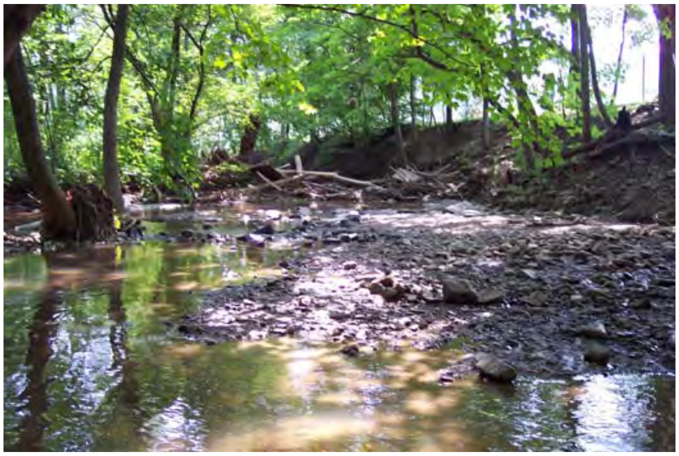
2. *Epifaunal Substrate*: Epifaunal substrate is essentially the amount of niche space or hard substrates (rocks, snags) available for insects, snails, fish, and other aquatic species. Numerous types of insect larvae attach themselves to rocks, logs, branches, or other submerged substrates. The greater the variety and number of available niches or attachment sites, the greater the variety of insects in the stream. Rocky-bottom areas are critical for maintaining a healthy variety of insects. Snags and submerged logs provide additional areas for macroinvertebrate colonization, increase diversity, and provide important areas for fish.

3. *Embeddedness*: Embeddedness refers to the extent that rocks (gravel, cobble, and boulders) are surrounded by, covered, or sunken into the silt, sand, or mud of the stream bottom. As rocks become embedded, fewer living spaces are available to macroinvertebrates and fish for shelter, spawning, and egg incubation. To estimate the percent of embeddedness, observe the amount of silt or finer sediments overlying and surrounding the rocks. If kicking does not dislodge the rocks or cobble, they may be greatly embedded. It may be useful to lift a few rocks and observe the extent of the dark area on their underside.

4. *Velocity/Depth Regimes*: Fast water increases the amount of dissolved oxygen in the water, keeps pools from being filled with sediment, and helps food items like leaves, twigs, and algae move more quickly through the aquatic system. Slow water provides spawning areas for fish and shelters macroinvertebrates that might be washed downstream in high stream velocities. Similarly, shallow water tends to be more easily aerated, but deeper water stays cooler longer. The best stream habitat includes all four habitat categories of slow, deep; slow, shallow; fast, deep; and fast, shallow.

5. *Channel Alteration*: A measure of large-scale changes in the shape of the stream channel. Channel alteration includes concrete channels, artificial embankments, straightening of the natural channel, riprap, or other structures, as well as recent sediment bar development.

6. *Sediment Deposition*: This parameter measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result. Sediment bars typically form on the inside of bends, below channel constrictions, and where stream gradient decreases.

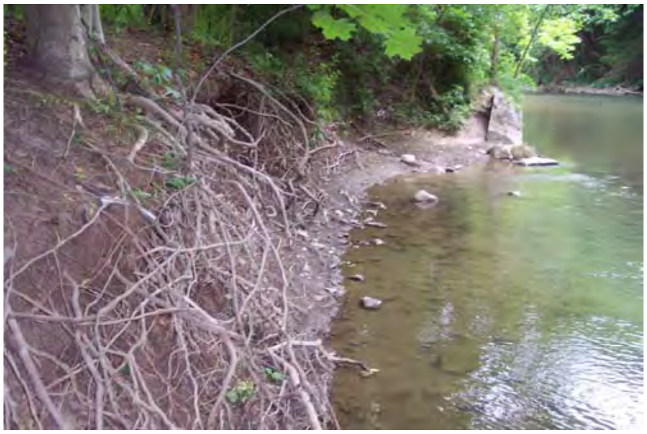


Bars tend to increase in depth and length with continued watershed disturbance. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms.

7. *Frequency of Riffles*: Riffles are a source of high-quality habitat and diverse fauna. An increased frequency of riffle occurrence greatly enhances the abundance and diversity of the stream community. Riffles are important because they serve as spawning and feeding areas for fish, increase the amount of dissolved oxygen, and the essential habitat required for many macroinvertebrates.

8. *Channel Flow Status*: The degree to which the channel is filled with water. The flow status will change as the channel enlarges, or as flow decreases as a result of drought or diversions for irrigation. When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited.

9. *Condition of Banks*: A measurement of whether the stream banks are eroded or have the potential for erosion. Steep banks are more likely to suffer from erosion than are gently sloping banks and are therefore considered unstable. Eroded banks indicate a problem of sediment movement and deposition. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil. Assessments of both the upper and lower banks should be done concurrently. The upper bank is the land area from the break in the general slope of the surrounding land to the top of the bankfull channel. The lower bank is the intermittently submerged portion of the stream cross section from the top of the bankfull channel to the existing waterline.



10. *Bank Vegetative Protection*: Measures the amount of vegetative protection afforded to the stream bank. The root systems of plants growing on stream banks help hold soil in place. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of instream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap.

11. *Grazing or Other Disruptive Pressure*: This is a measure of disruptive changes to the riparian zone because of grazing or human interference (e.g., mowing). In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded. Residential developments, urban centers, golf courses, and rangeland are the common causes of anthropogenic pressure on the riparian.

12. *Riparian Vegetative Zone Width*: Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. A vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input to the stream. A relatively undisturbed riparian zone supports a robust stream system.

Biological

Macroinvertebrates

While chemical analyses provide a mere snapshot of water quality conditions at a given moment in time, biological indicators offer a more in-depth look at pollution levels over time (Navis and Gillies 2001). Unlike animals living on land, biological organisms existing in a water body cannot easily escape their environment when conditions are less than ideal. Because aquatic creatures are constantly confined to a particular body of water, whatever toxins are present in the water may accumulate in their body tissues over time (Cairns and Dickson 1971). Some organisms are more sensitive to poor water quality than others. One group of creatures commonly used as biological indicators are the aquatic macroinvertebrates, or water-dwelling insects large enough to be seen by the naked eye. The absence of certain pollution-sensitive macroinvertebrate species reveals that pollutants may have been present in the water at some point even if they do not show up in the results of chemical tests taken on a particular day (Wallace et al. 1996).

Scientific Classification of Benthic Macroinvertebrates

People living in different regions may have different names for the same organism. For example, the terms “crayfish,” “crawfish,” and “crawdad” all refer to the same organism. These regional expressions are called common names. A common name generally does not provide specific information about the organism or its relationship to other organisms. Regional dialects can become confusing when researchers from different backgrounds are trying to communicate ideas about an organism. To avoid this confusion, scientists refer to animals using scientific or Latin names.

Every known living creature is assigned a unique scientific name. This name consists of two parts: genus and species. Although the species name may be repeated among organisms, the genus name is never repeated, ensuring that no two creatures will have the same scientific name. The naming of organisms is so complex that it required the creation of the science of taxonomy. Taxonomy defines a classification system consisting of seven levels: kingdom, phylum, class, order, family, genus, and species. For the purposes of our assessment, we classified macroinvertebrates to the family level. An example of classification for the eastern crayfish *Cambarus bartonii* is:

Kingdom – Animalia
Phylum – Arthropoda
Class – Malacostraca
Order – Decapoda
Family – Cambaridae
Genus – Cambarus
Species – bartonii

Biotic Indexes

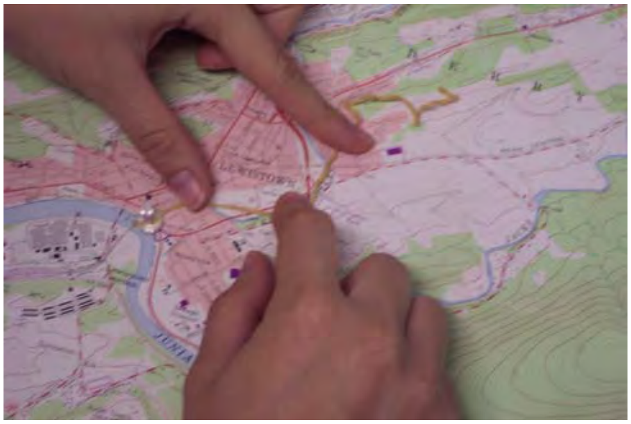
A biotic index is a tool used to classify a stream's degree of impairment based upon the presence or absence of certain species of aquatic macroinvertebrates. Most biotic indexes assign arbitrary numbers to each type of organism according to its ability to tolerate pollution. If a sample contains a large number of pollution-sensitive organisms, the stream probably has good water quality. Conversely, samples dominated by pollution-tolerant creatures indicate poor water quality. It is difficult to discuss biotic indexes generally because there are many indexes available and each one has its own scoring system and yields slightly different information. For this assessment, we used the following five indexes commonly used in fisheries and watershed research:

- *Taxa Richness*: The total number of families found in the sample. This index measures overall diversity of organisms and the number increases with stream health.
- *Modified EPT Index*: The number of families from the orders Ephemeroptera or mayflies (excluding the families Baetidae, Caenidae, and Siphlonuridae), Plecoptera or stoneflies, and Trichoptera or caddisflies (excluding the families Hydropsychidae and Polycentropodidae). These three orders are considered pollution-sensitive; a high number of EPT families in a sample indicate good stream health.
- *% Modified EPT*: The percent of the total families from the orders Ephemeroptera (excluding the families Baetidae, Caenidae, and Siphlonuridae), Plecoptera, and Trichoptera (excluding the families Hydropsychidae and Polycentropodidae). High numbers indicate good water quality.
- *% Modified Mayflies*: The percent of the total families from the order Ephemeroptera (excluding the families Baetidae, Caenidae, and Siphlonuridae). Increases with stream health.

VI. Methods

Naming the Sample Sites

We used an ordered process to develop names for our sample sites. This system produces a unified data set that is reproducible and easily understood. Sample sites may be quickly identified either on a topographical map or in the field. Because of the simplicity of the naming process, additional sites can be easily added if needed for future studies. The sites were given names in the following manner:



1. Each stream was given a new four-letter designation. Combine the first two letters of each word in the proper name to obtain this designation. For example, **Bu**ck **Ru**n becomes **BURU**.
2. To differentiate between sites on the same stream, use a map to measure the distance from the mouth of the stream to the site itself. Tape a piece of string to a topographic map so that the end of the string lies even with the mouth of the stream. Run the free end of the string from the mouth of the stream to the site location, following any bends in the stream as closely as possible.
3. Mark the string at the location of the sample site.

4. Using a ruler, measure the length of the string in inches from the attached end to the mark that identifies the location of the sample site.
5. Divide this measurement (in inches) by the miles per inch scale on the map. For example, if the map scale is 5.3 miles/inch and the measurement was 8.9 inches, the result of this calculation would be 1.679 miles.
6. Round the numbers calculated in Step 5 to two digits. These numbers are then placed at the end of the abbreviation obtained in Step 1. The completed name for this example would be **BURU1.7.**

Site BURU 1.7

Water Chemistry

We completed water chemistry analyses at each of the five study sites on an almost monthly basis. The following six tests were completed in the field using a Hach water quality test kit: air and stream temperatures, pH, conductivity, alkalinity and dissolved oxygen. Water samples were also collected and sent to Analytical Laboratory Services, Inc. to be analyzed for nitrate, total phosphorus, sulfate, ammonia-nitrogen, fecal coliform, and total suspended solids.

Additionally, we conducted water chemistry analyses during five storm events. During these storm events we measured air and stream temperatures and pH in the field, and also collected water samples, preferably from the first flush of the storm, to send to the lab for analysis. Storm water samples were tested for hardness and total metals, including aluminum, iron, lead, manganese, and zinc.

Chemical Parameters Measured in the Field:

<u>Temperature</u>

We measured the air temperature in degrees Celsius (°C) by hanging a thermometer from a tree branch, preferably in a shaded area. Stream temperature was measured in (°C) using a waterproof thermometer. We placed the thermometer in the middle of the channel on the stream bottom in order to measure the temperature of the water flowing in the middle of the water column. The same thermometers were used every month to increase the precision of measurements. We also designated one thermometer for use in the stream and one for use on land. Using the same thermometer to measure temperature in both water and air is not advisable because of the possibility of temperature variations caused by evaporation.

<u>Dissolved Oxygen</u>

We measured dissolved oxygen using the Hach Company's titration test kit 0.2-4 and 1-20 mg/L range. While standing in the center of the stream channel and facing upstream, we collected water from the middle of the water column to use for this test, which was then completed on the bank.

<u>pH</u>

Using a Pocket Pal electronic handheld meter, we took pH measurements from each of our five sites. We calibrated the pH meter before each use following the instructions outlined in the Hach kit manual.

<u>Conductivity</u>

We measured conductivity using a Pocket Pal electronic handheld meter calibrated following the instructions in the Hach kit manual.

Alkalinity

The Hach Company titration test kit 20-400 mg/L was used to measure alkalinity. While facing upstream, we collected water from the center of the stream channel in the middle of the water column, and then returned to the bank to complete the test.

Chemical Parameters measured in the Lab:

Water samples were collected at each sample location for analysis at Analytical Laboratory Services, Inc. Bottles containing the appropriate reagents were obtained from the lab prior to sampling. Water was collected while standing in the center of the stream channel and facing upstream. We collected water from the middle of the water column using a clean bottle without reagents. This method was used so as not to wash any reagents into the stream. The water was then poured into the bottle containing reagents.

The labels on all bottles were filled out prior to leaving the site and on most occasions, were filled out before the bottle was filled with water because it is easier to write on a dry label then one that has gotten wet. The water samples were kept on ice in a cooler and were dropped off at a location to be delivered to the lab the following morning. All water samples were dropped off on the day of collection.

The following seven tests were completed by Analytical Laboratory Services: nitrate, sulfate, total phosphorus, ammonia-nitrogen, fecal coliform, total suspended solids, and hardness. .

Chemical Parameters Measured during Storm Events:

During storm water sampling we measured air and stream temperature and pH in the field for comparison with regular monthly samples. Every effort was made to collect storm water samples during the "first flush" of a storm, or first one inch of rain from a storm. We attempted to collect the water samples to send to the lab while standing in the center of the stream channel and facing upstream. However, if the water was too high to reach the middle of the stream, the sampler waded in as far as safety permitted. The same procedure was used for storm water sampling as for non-storm event sampling. Water samples for heavy metal analysis did not need to be kept on ice. The following six tests were completed by Analytical Laboratory Services: Hardness, Aluminum, Iron, Lead, Manganese and Zinc.

Habitat

Using the EPA's Rapid Bioassessment Protocol, which scores habitat quality based upon twelve instream and riparian parameters (See Definitions for the Twelve Habitat Parameters, pg. 26), we evaluated each of the five sampling sites. We also wanted to evaluate the entire mainstem of Kish Creek beginning at the stream's mouth and ending at Mann's Narrows, however, due to time constraints we divided the stream into

100-meter sections and completely evaluated every odd-numbered section. We first measured 100 meter sections on a map using the string method and then we field checked the measurements by measuring 100 meter sections while walking in the stream, or along the banks. Fifty (50) 100 meter sections were evaluated on Kish Creek.

Biological

Macroinvertebrate Surveys

Volunteers from Trout Unlimited helped identify macroinvertebrates during the June and July 2004 samples. Personnel from the Pennsylvania Fish Commission identified the macroinvertebrates during the August 2004 sampling, and Penn State senior, Brianna Hutchison, identified the macroinvertebrates during the June 2005 sample. All of the samples were identified at least to family level.

We collected benthic macroinvertebrates from riffle areas at each of the five sample sites using a 1-meter x 1-meter kick seine. One person held the seine against the stream bottom while another individual disturbed the substrate in a 1-m^2 area directly upstream. Any large rocks in the 1-m^2 area were rubbed by hand to dislodge clinging organisms. We then removed the seine from the water and spread it out on the bank where we identified the macroinvertebrates collected. Using forceps, we gently transferred the organisms from the seine into an ice cube tray, separating them according to family. This procedure was preformed at one or two different locations along the stream at each study site. We surveyed macroinvertebrates four times during the summers of 2004 and 2005. We recorded our results on PADEP's "Unassessed Waters Field Form: Wadeable Streams" and classified each family based upon its relative abundance. The relative abundance categories included rare (less than 3 individuals), present (3-9), common (10-24), abundant (25-100), and very abundant (greater than 100). We used this data to calculate scores for four biotic indexes, including taxa richness, "modified" EPT index, % modified EPT, and % modified mayflies.

Other Surveys

In addition to the macroinvertebrate surveys described above, we surveyed birds and fish of the Lower Kish watershed. Volunteers from the Towpath Naturalist Society aided us in the identification of birds by sight and sound at each of the five study sites in July 2004. We recorded all birds that were seen or heard on a data sheet.

In July 2005, we sampled fish using rod and reel and a 1-meter x 1-meter kick seine. When sampling with rod and reel we used live bait (red worms, wax worms, mealworms), Power Bait, and artificial lures (rubber worms, spinners). We fished using rod and reel at six sites, three below Mill Road bridge and three above, for one hour at each site. Sites were chosen based upon our observations of fishes at these locations during the visual assessment. During the visual assessment, we noticed warmwater fishes such as smallmouth bass, bluegill, and crappie in the section of the stream classified as a high quality coldwater fishery by PADEP. We used a kick seine and hand nets in order to sample minnows and benthic fish species at the six sites sampled using rod and reel, as well as two additional sites. One person held the seine against the stream bottom while two others walked in front of the net, disturbing the substrate with their feet. The seine was then lifted bottom first from the water and any fish caught were deposited in a Styrofoam bucket filled with water. We also collected some fish using hand nets. All fish captured were identified and released. Data were recorded on a fish sampling data sheet.

VII. Results and Discussion

Water Chemistry

Chemical Parameters Measured in the Field:
<u>Temperature</u>

Temperature is important to aquatic life in a number of ways. Studies have shown that water temperature is the most influential factor affecting growth and survival of trout in stream ecosystems (Baltz et al. 1987; McRae and Diana 2005). The optimal temperature range for growth of juvenile brook trout is between 12-15°C, with a maximum tolerance of 18°C (McCormick et al. 1972). Stoneman and Jones (2000) demonstrated that elevated stream temperatures above 18°C greatly increase trout mortality during the summer months. Although other trout species, such as brown and rainbow trout, can tolerate slightly higher water temperatures than brook trout, after a point these species will also experience thermal stress and decreased functioning of internal processes (Railsback and Rose 1999). All aquatic organisms have a narrow range of optimal temperatures in which they can maintain bodily functions without becoming stressed. If temperatures become too extreme, the creature cannot sustain the processes of life and will die (Diana 2004).

Based on the maximum daily temperature limits for CWF and TSF outlined in PA Code Title 25, Chapter 93, the five study sites showed a higher-than-predicted trend for temperatures over the 12 months of sampling (Figure 7.1) One of our study sites, KICR1.3, is classified as a HQ-CWF. Stream temperatures measured at this site consistently exceeded the maximum temperature limit for CWF. The other four study sites are classified as TSF. Stream temperatures measured at these sites generally fell within the acceptable temperature range for TSF except in January, February, and March 2005 when all four exceeded TSF maximums. During these three months, the measured stream temperatures exceeded daily maximums for even WWF. The site with the warmest stream temperatures for nine out of 12 months, BURU1.7, also exceeded the upper temperature limit for TSF in June 2004, June 2005, and July 2005.

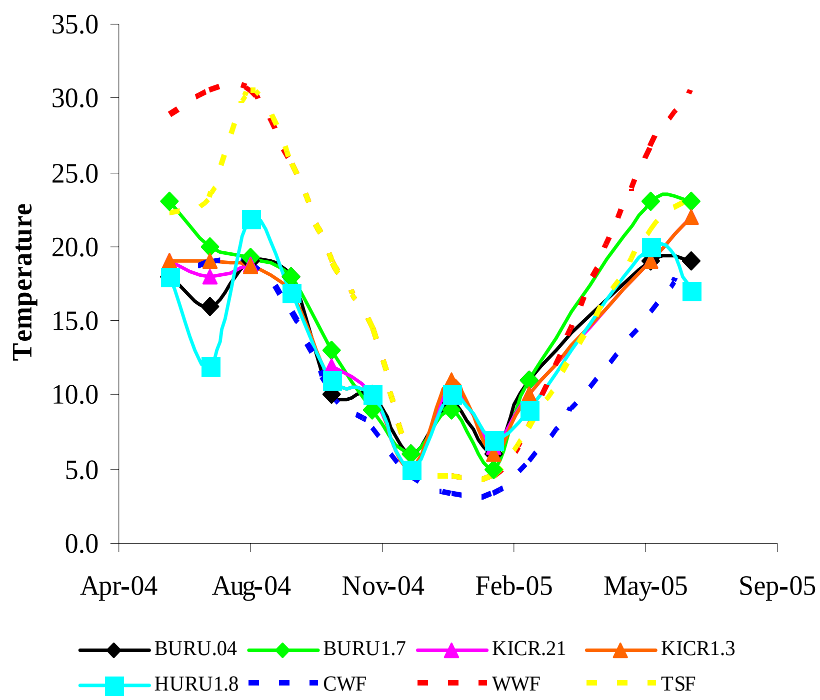


Figure 7.1. Temperature (°C) at each of the five study sites from June 2004 to July 2005, including PADEP maximum temperature standards for CWF, WWF, and TSF.

Dissolved Oxygen

Just like animals on land, aquatic organisms require oxygen for survival. Water becomes oxygenated as oxygen molecules from the atmosphere dissolve in water, or when aquatic plants undergo photosynthesis. Cold water tends to hold more oxygen than warm water (PA DEP 2000).

Water becomes depleted of oxygen as aquatic animals and plants respire or transpire. The decomposition of organic material by detritivorous bacteria can also reduce the amount of oxygen in a body of water (Brosnan and O'Shea 1996). Organic material in a stream is often the result of algal blooms, or as we have seen, when compost piles are put along the stream bank. Livestock grazing sometimes leads to decreases in dissolved oxygen due to increases in stream temperature as riparian vegetation is removed (Stone et al. 2005).

During this assessment the results for milligrams per liter (mg/L) of dissolved oxygen exceeded PADEP minimum standards for CWF and TSF at all of the sites.

In addition to mg/L of dissolved oxygen, percent saturation of dissolved oxygen in the water is also important. Percent saturation values greater than 125% are considered dangerous to fish (Hach Inc.) while values less than 60% are considered dangerously low. Percent saturation at BURU1.7 was greater than 140% in December 2004. Two other sites had percent saturation levels that were close to reaching the over-saturated level. In June 2004, HURU1.8 had 120% saturation of dissolved oxygen, and in June 2005, KICR1.3 had 122% saturation. There were also several occasions when percent saturation at some sites was close to being too low. BURU.04 had dissolved oxygen percent saturations of 65% in September 2004, and 67% of July 2005. Dissolved oxygen percent saturation was 65% at HURU1.8 in September 2004.

There is an expected relationship between air temperature, stream temperature, and dissolved oxygen content. Air temperature and stream temperature are directly related; as air temperature increases, stream temperature increases. Water retains heat for longer time periods than air; therefore stream temperatures are generally warmer than air temperatures heading into the winter months. In general, the five study sites illustrated the expected relationship between these three factors. BURU1.7 deviated from the expected trend most noticeably, holding nearly the same amount of dissolved oxygen in the water year-round, even during the winter months (Figure 7.2). Dissolved oxygen was very high (18 mg/L) at this site in December 2004 which does follow the expected trend.

Alkalinity

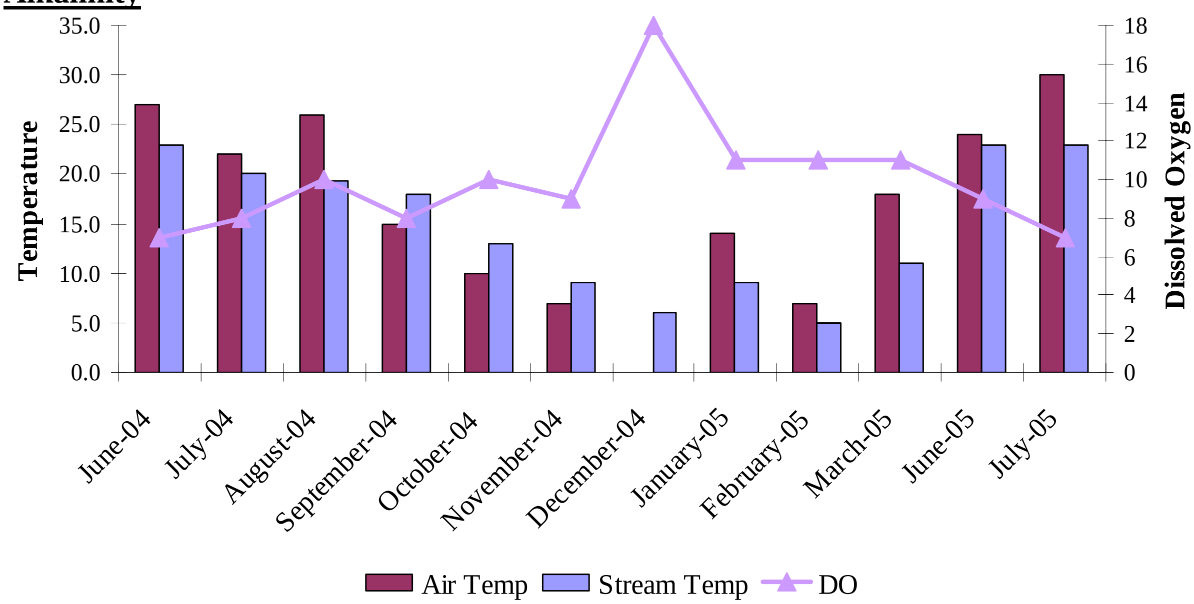


Figure 7.2. Air and stream temperatures versus dissolved oxygen content at BURU1.7 from June 2004 to July 2005.

Alkalinity is the measure of water's ability to neutralize acid and maintain a constant pH, which is important for the health of aquatic organisms. Generally, streams with high alkalinities are less vulnerable to acid input from mine drainage, acid rain, and other sources. Certain compounds, such as the carbonate found in limestone, increase the alkalinity of a stream (PA DEP 2000). PADEP indicates that all streams should have a minimum alkalinity of 20 mg/L $CaCO_3$ (PA DEP 2001), although true limestone streams consistently have limestone measures of at least 140 mg/L $CaCO_3$ (Pruss 2003).

Alkalinity at the five sites ranged from 100 to 420 mg/L $CaCO_3$ with an average of 183 mg/L $CaCO_3$. All of the study sites exceeded PADEP standards for minimum acceptable alkalinity.

pH

pH refers to the amount of free hydrogen ions (H+) compared to the free hydroxide ions (OH-) in the water. A liquid having a high number of free hydrogen ions is acidic, while a liquid with more free hydroxide ions is said to be alkaline. pH is recorded as a number between 0 and 14, with a pH reading of 7 considered neutral, meaning that the numbers of H+ and OH- ions in the water are approximately equal. Low pH values correspond with acidic conditions, and high pH values indicate alkaline conditions (PA DEP 2000). Most aquatic organisms require the pH range to be between 6 and 9 for optimal survival.

Pennsylvania's rainwater tends to be more acidic than normal rain, with an average pH of 4.3 (Kochanov 1999). The limestone geology of the Kish watershed helps neutralize the acidic rain water. The pH among all sites ranged from 6.9-8.5 with a mean value of 7.6. During fall and winter months, pH was lower than during summer months.

pH is also important because it plays a role in many chemical reactions, including those involving common water contaminants such as aluminum, and ammonia (PA DEP 2000).

Conductivity

Conductivity refers to water's ability to conduct electricity. Materials such as minerals, salts, metals, and acids increase conductivity. These materials are found naturally in the streambed itself or in the soil, and they are also common in fertilizers. Certain metals may be harmful to livestock when consumed in drinking water, and many salts cause soil degradation, rendering water unfit for irrigation purposes.

Conductivity ranged from 174-580 mS with an average of 300 mS. Site BURU.04 consistently had the highest conductivity readings, and BURU1.7 had the lowest readings every month except June and August 2004.

Chemical Parameters Measured in the Lab:

Total Phosphorus

Phosphorus is essential to plant growth. The most common source of excess phosphorus is fertilizer (Eghball and Gilley 1999). Phosphorus accumulates in soil, so when soil is washed into a stream it carries phosphorus with it (Eghball et al. 2002). Streams with high phosphorus content suffer from algal blooms and their associated problems (See Dissolved Oxygen). To control algae growth, the EPA water quality criteria state that phosphates should not exceed .1 mg/l in streams or flowing waters.

Total phosphorus readings ranged from undetected to 0.17 mg/L with a mean of 0.14 mg/L. Phosphorus was only detected at KICR.21 and KICR1.3

Sulfate (SO_3)

Sulfate infiltrates streams as sulfur-containing rocks break down, when acid rain falls, from acid mine drainage, and as a byproduct of the bacterial breakdown of debris. Animals and plants need to take in trace amounts of sulfate for survival, but it is not an important nutrient. Sulfate can have a harmful laxative effect on living organisms when concentrations exceed 250 mg/L in water, and can even be fatal to fish if concentrations reach 1000 mg/L (PA DEP 2000).

None of the sites had sulfate concentrations exceeding PADEP's maximum standard. Sulfate concentrations were between 2.8 mg/L and 36.7 mg/L with an average of 22.0 mg/L.

Nitrate (NO_3)

Nitrogen, especially in the form of ammonia ions, nitrites, or nitrates, is essential to plant growth. The most common source of excess nitrogen is manure. High instream nitrogen levels can cause algal blooms (PA DEP 2000) or excessive plant growth in the stream. This is especially true of shallow, warm streams with high sediment loads. See Dissolved Oxygen for the reasons algal blooms are a problem.

The range of nitrate concentration readings was 0.61 mg/L to 4.0 mg/L with a mean of 2.25 mg/L. These values are all below PADEP's maximum allowable nitrate level.

Ammonia-Nitrogen (NH_3-N)

Ammonia-nitrogen, found in animal wastes, is another potentially toxic nutrient. Ammonia-nitrogen toxicity levels are dependent upon stream temperature and pH and were calculated for each site for each month using the formula found in PA Code, Title 25, Chapter 93.7, Table 3.

Table 7.1. PADEP criteria for continuous concentrations of ammonia-nitrogen (mg/L) for each of the five study sites.

Date	BURU.04	BURU1.7	HURU1.8	KICR.21	KICR1.3
June 2004	0.501	0.000	1.030	0.000	0.703
July 2004	0.642	1.449	0.124	0.380	0.251
August 2004	0.443	0.446	0.110	0.914	6.358
September 2004	0.197	0.111	0.056	0.419	0.314
October 2004	0.409	0.796	0.103	0.614	0.326
November 2004	0.179	0.164	0.057	0.210	0.210
December 2004	0.126	0.089	0.038	0.134	0.067
January 2005	0.121	0.256	0.064	0.248	0.210
February 2005	0.147	0.177	0.046	0.194	0.213
March 2005	0.127	0.153	0.056	0.126	0.116
June 2005	0.199	0.420	0.081	0.380	0.202
July 2005	0.237	0.742	0.175	0.703	0.110

Ammonia-nitrogen was detected on nine occasions (2%) of the 48 samples sent to the lab over the course of this study. On three of these occasions, contaminant levels exceeded PADEP criteria for maximum continuous concentrations. In October 2004, the site on Hungry Run HURU1.8, recorded an ammonia-nitrogen concentration of 0.12 mg/L (0.103 mg/L maximum- see Table 7.1). In February 2005 both sites on Buck Run exceeded PADEP criteria. BURU.04 ammonia-nitrogen concentration was 0.16 mg/L (0.147 mg/L maximum- see Table 5.1) and BURU1.7 ammonia-nitrogen concentration was 0.370 mg/L (0.177 mg/L maximum-see Table 5.1). It was interesting to note that the elevated ammonia-nitrogen levels on Buck Run did not correspond with the spike in the fecal coliform levels that occurred in July 2004 and July 2005.

Fecal Coliform

Fecal coliform counts measure the concentration of fecal bacterial colonies in a water body. Contamination of stream water with fecal matter leads to other problems such as the overabundance of certain bacteria. Elevated counts may be the result of improper sewage treatment, failed septic systems, or poor pasture or manure management practices. U. S. Environmental Protection Agency (US EPA) standards require that water used for drinking must have a fecal coliform count of zero. PADEP also sets a maximum allowable fecal coliform count for waterways used for recreational purposes such as swimming

Twenty-five samples from the five study sites taken between the months of May 2004 and August 2005 exceeded PADEP maximum fecal coliform levels for recreational water use (Figure 7.3). The highest fecal coliform reading was 7000 col/100mL at BURU1.7 in July 2004. BURU.04 also had a high fecal coliform count of 4700 col/100mL in July 2005. BURU.04, BURU1.7, and KICR.21 exceeded the maximum fecal coliform limit in October and November 2004 as well. The lowest fecal coliform count was 20 col/100mL at HURU1.8 in March 2005. The average fecal coliform count for the five sites was 1026 col/100mL.

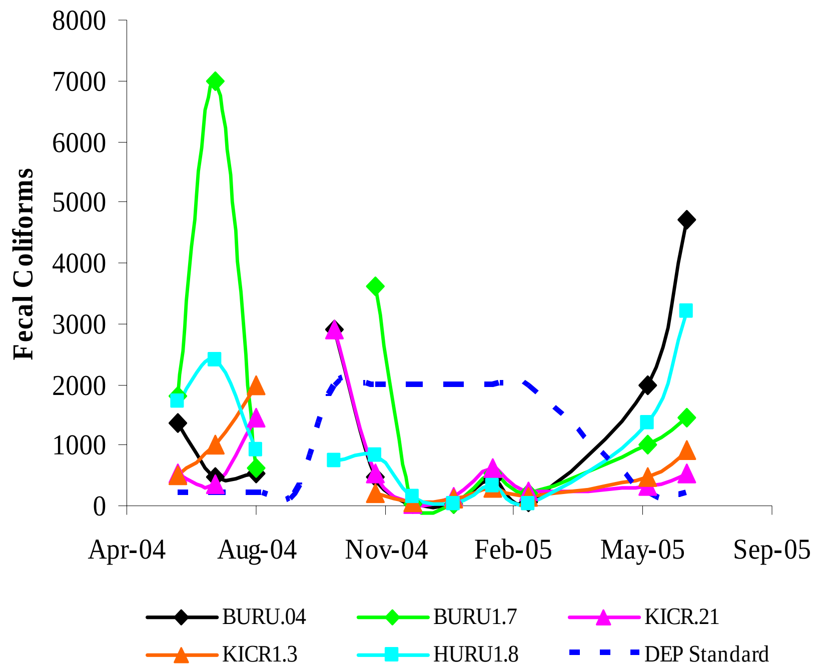


Figure 7.3. Fecal coliforms (# colonies/100mL) count at each of the five study sites from June 2004 to July 2005, including PADEP maximum fecal coliform count standard

Total Suspended Solids (TSS)

Total suspended solids are an indicator of erosion and/or runoff or high levels of bacteria (US EPA 2002). When TSS is high, turbidity increases, interfering with the ability of some aquatic organisms to find food or cover.

Total suspended solids levels ranged from undetectable to 82 mg/L with an average of 13 mg/L (Table 7.2). It is not surprising that the highest measurement was recorded near the mouth of Kish Creek (site KICR .21) in the wintertime. Streambanks are the most exposed during the winter months making them vulnerable to erosion and practices such as spreading manure on frozen ground cause those applied solids to run off the land surface into receiving streams. The site farthest downstream demonstrated the cumulative effect of these factors.

Table 7.2. Total suspended solids (mg/L) detected at the five study sites in samples from June 2004 to July 2005.

Date	BURU.04	BURU1.7	HURU1.8	KICR.21	KICR1.3
June 2004	5	6	17	x	6
July 2004	6	x	6	5	24
August 2004	8	6	5	8	x
September 2004	*	*	*	*	*
October 2004	x	*	x	x	*
November 2004	5	x	x	18	x
December 2004	10	5	8	82	x
January 2005	6	6	6	14	5
February 2005	9	20	x	x	x
March 2005	19	20	13	42	45
June 2005	6	6	9	5	5
July 2005	6	8	x	x	10

* Indicates no data for that month.
x Indicates that TSS was not detected.

Hardness

Hardness is a measure of the amount of calcium and magnesium ions present in the water and is associated with water chemistry factors such as pH and alkalinity. Many studies investigating the relationship between stream water hardness and aquatic biota, especially macroinvertebrates, have been conducted (Sutcliffe and Carrick 1973; Krueger and Waters 1983; Stelzer and Burton 1993; Eggert and Burton 1994). These studies suggest that densities of macroinvertebrates and fish are higher in streams with high alkalinities or high calcium concentrations, both factors contributing to increased water hardness. There are no EPA health standards for hardness, but water hardness is classified by the U.S. Department of Interior and the Water Quality Association as follows, soft: 0-17.1 mg/l, slightly hard: 17.1-60 mg/l, moderately hard: 60-120 mg/l, hard: 120-180mg/l and very hard 180 mg/l and over. Samples from BURU1.7 scored in the “moderately hard” range, BURU.04, KICR.21 and KICR1.3 all scored in the “Hard” range, and HURU1.8 scored from “Hard” to “Very Hard”.

Chemical Parameters Measured during Storm Events: Heavy Metals

Heavy metals are common components of urban and agricultural runoff and may be toxic to living organisms at certain concentrations. The U.S. Environmental Protection Agency established two levels of toxicity, chronic and acute. The continuous toxicity level indicates the concentration at which that metal becomes toxic to organisms exposed to it continuously over long periods of time. The acute toxicity level for a particular metal indicates the concentration at which that metal becomes toxic to organisms exposed to it for even brief periods of time, such as during a storm event (PA Code Chap. 93).

Lead and zinc are both listed in the EPA's Federal Clean Water Act section 307(a) as priority pollutants because they are commonly used, persistent, and toxic, and because they are commonly found in wastewater discharge. Laboratory analysis of the storm water samples collected at the five study sites revealed that concentrations of several heavy metals, including lead and zinc, exceeded national water quality standards. Table 5.3 shows the heavy metal concentrations at each site for all of the storm samples. The presence of aluminum, iron, lead, manganese, and zinc at toxic levels in stormwater runoff is therefore a major concern for the health of this watershed (see Areas of Concern in the Watershed).

The July 5, 2005 storm soaked the area after nearly a month of no significant rainfall, which may have accounted for the particularly high levels of aluminum and other metals found in runoff from this storm. A prolonged dry spell allows time for contaminants to build up on impervious surfaces and in the soil, and when a soaking rain finally falls these substances are washed into water bodies. While an overall dry 2005 may have accounted for the high concentrations of heavy metals in July 2005. We observed that July 2004 also experienced higher concentrations of heavy metals than other months, indicating that it may be more than just precipitation patterns.

Table 7.3. Total metals (mg/L) measured in storm water samples collected from the five study sites in 2004 and 2005.

Date	Site	Aluminum (Al)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Zinc (Zn)
July 2004						
	BURU.04	18.3	13.30	0.009	0.629	0.07
	BURU1.7	0.8	0.66	x	0.050	x
	HURU1.8	4.5	3.61	x	0.190	0.03
	KICR.21	7.4	6.15	0.016	0.209	0.07
	KICR1.3	10.4	7.58	0.010	0.370	0.09
August 2004						
	BURU.04	0.3	0.23	x	0.027	x
	BURU1.7	0.2	0.32	x	1.780	x
	HURU1.8	0.2	0.19	x	0.023	x
	KICR.21	0.2	0.16	x	0.011	x
	KICR1.3	0.3	0.18	x	0.012	x
September 2004						
	BURU.04	0.5	0.56	x	0.085	x
	BURU1.7	0.4	0.61	x	0.170	x
	HURU1.8	0.8	0.55	x	0.018	x
	KICR.21	0.3	0.62	x	0.050	0.02
	KICR1.3	0.3	0.47	x	0.059	x
November 2004						
	BURU.04	x	x	x	0.013	x
	BURU1.7	*	*	*	*	*
	HURU1.8	x	0.13	x	0.017	x
	KICR.21	1.4	0.95	x	0.020	0.02
	KICR1.3	0.1	0.10	x	0.007	x
February 2005						
	BURU.04	*	*	*	*	*
	BURU1.7	*	*	*	*	*
	HURU1.8	*	*	*	*	*
	KICR.21	0.2	0.15	x	0.008	x
	KICR1.3	0.2	0.17	x	0.009	x
July 5, 2005						
	BURU.04	14.9	11.00	0.011	0.248	0.28
	BURU1.7	46.5	39.00	0.025	0.992	0.13
	HURU1.8	3.7	2.91	x	0.113	x
	KICR.21	8.6	8.29	0.014	0.399	0.08
	KICR1.3	5.4	5.70	0.025	0.200	0.17
July 8, 2005						
	BURU.04	4.6	2.97	x	0.098	x
	BURU1.7	4.5	3.18	x	0.116	x
	HURU1.8	2.5	1.79	x	0.062	x
	KICR.21	7.2	6.31	0.017	0.058	0.21
	KICR1.3	2.0	1.48	x	0.069	x

* Indicates no data for that parameter for that month.
x Indicates that the metal was not detected.

Hardness

Storm water samples were evaluated for hardness in the laboratory to determine specific toxicity criteria for hardness-dependent metals like lead and zinc. Increased water hardness decreases the toxicity of hardness-dependent metals (Bob Schott, personal communication). Additionally, increased water hardness reduces the toxicity of some metals, rendering them lethal only at higher concentrations.

Based upon the storm water data collected and the corresponding monthly samples, hardness did not appear to be affected by runoff. Only the July 2005 storm water samples had lower hardness values than the regular monthly samples at all five sites.

Aluminum (Al)

Aluminum is a nutritional trace element. The U.S. Environmental Protection Agency reports the following toxicity levels for aluminum:

- Continuous concentration = 0.087 mg/L
- Acute concentration = 0.750 mg/L

Concentrations of aluminum exceeded continuous concentration levels in 94% of the samples, often by several orders of magnitude, and 55% of the samples exceeded the level established for acute concentrations, also often by several orders of magnitude. Both sampling dates in July 2005 experienced aluminum levels greater than 2.0mg/L at all sample sites. Aluminum concentrations were particularly high at all five sites during the July 5, 2005 storm event. On that date the aluminum concentration at BURU1.7 (46.5mg/L), was 62 times higher than the acute toxicity level outlined by PADEP. During the July 2004 all sample sites exceeded the level established for acute concentrations and except for BURU1.7 (0.8mg/L) all the sites were greater than 4.0mg/L. November 2004 was the only month that aluminum did not exceed standards at every site when no aluminum was detected at BURU.04 and HURU1.8.

Fish are particularly sensitive to high concentrations of aluminum. Prolonged exposure can cause respiratory distress in adult fish and abnormal development of juveniles (US EPA 2005a)

There are several possible sources for the aluminum found in the Lower Kish Creek watershed storm water samples. A study by Chang et al. (2004) reports that concentrations of aluminum found in roof runoff in urban developments exceeded the national water quality standards at least 12% of the time. This study also found that aluminum shingles were not the only roofing type to have elevated aluminum concentrations in runoff. Wood shingles, composition shingles, and galvanized iron shingles also leached aluminum during storm events. In addition to rooftops, impervious surfaces (such as packed dirt, roadways, and other paved surfaces), and construction sites are other potential sources of Al found in runoff (Gagnon and Saulnier 2003). The Lower Kish watershed, especially in the Kish subwatershed encompassing Lewistown, Burnham, and Yeagertown, has a significant amount of impervious surfaces (Figure 7.4). Also, a new bridge connecting Yeagertown and Reedsville is under construction directly over Kish Creek near Mann's Narrows. These potential sources of aluminum may also be contributing to the high concentrations of other heavy metals found in runoff at our study sites.

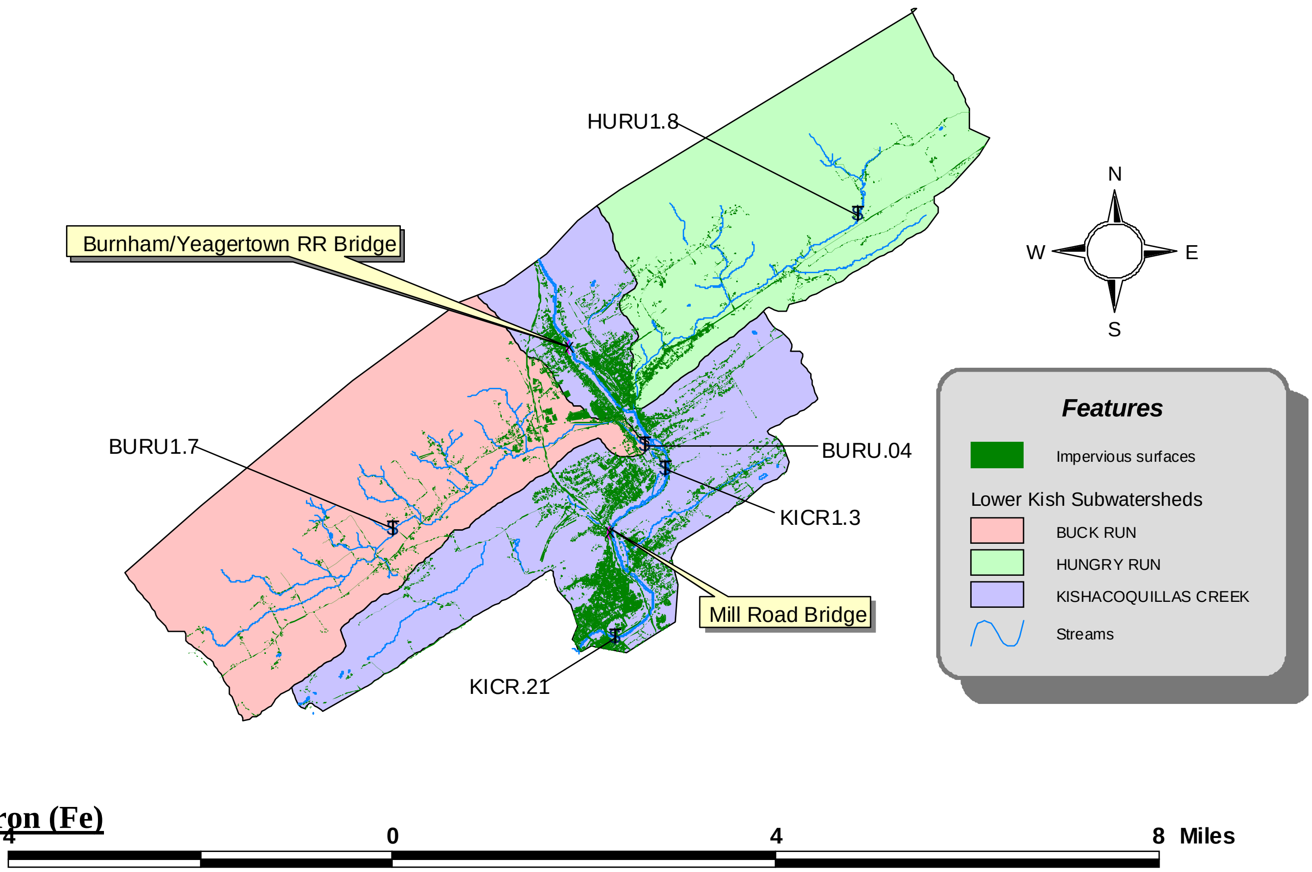


Figure 7.4. Distribution of impervious surfaces in the Lower Kishacoquillas Creek watershed.

Iron (Fe)

Iron is an important trace element in the diets of fish and other animals. This mineral plays an active part in many physiological and metabolic reactions within an organism's body, including blood transport and oxygen transfer (Watanabe et al. 1997). Fish take up iron through their gills and from the food they consume by absorbing it through their intestinal lining (Segner and Storch 1985). Although iron is not considered a toxicant of primary concern on EPA's Federal Clean Water Act section 307(a) list, like any metal, iron can be toxic at high concentrations. EPA does list the following toxicity level for dissolved iron:

- Continuous concentration = 1 mg/L

Almost half (45%) of the samples collected for iron exceeded the continuous concentration outlined by PADEP, often by several orders of magnitude. In addition to exceeding the continuous concentration toxicity level, the iron concentrations at all of the study sites also pose a human health concern by exceeding EPA's consumption standards in 71% of the samples (See Table 5.3). EPA lists the following maximum acceptable dissolved iron level for human water sources:

- Human health criteria = 0.300 mg/L

Excess iron in water used by humans for drinking or washing is considered undesirable due to the chemical reaction between iron and oxygen in water, the end product of which is iron oxide or rust (PA DEP 2000). Human health concerns regarding iron are mainly aesthetic, meaning that this metal's presence in water used for drinking tends to leave a bad aftertaste that can be detected by human consumers.

Iron is a very common soluble mineral found in various rocks and soil types. Runoff picks up dissolved iron from rocks and soil as it flows over the landscape, carrying it into receiving water bodies such as streams and lakes. During our visual assessment of habitat in the Lower Kish Creek watershed, we saw evidence of iron in the environment as a rust-colored substance in the sediment and coating the exposed root hairs of trees (Figure 7.5).

Figure 7.5. Red root hairs (*left*) and rusty sediment (*right*), main stem of Kish Creek in Lewistown, PA.

Lead (Pb)

Because lead has toxic effects on organisms even at very low concentrations, it is essential to monitor lead presence in streams, even if it does not appear to be a primary component of runoff. Lead is considered one of US EPA's ten priority pollutants (Johnson 1998).

The toxicity level of dissolved lead in a water body is dependent upon water hardness. Thus, toxicity levels were different for every site each month depending on hardness values. To determine the maximum continuous and acute concentrations of total recoverable lead for each month (Tables 7.4 and 7.5), we used our measured hardness values and the following formulas given by PA Code, Title 25, Chapter 16, Appendix A, Table 1:

- Continuous concentration = $\{1.46203-[\ln(\text{hardness})*0.145712]\}*e^{[1.273*\ln(\text{hardness})-4.705]}$
- Acute concentration = $\{1.46203-[\ln(\text{hardness})*0.145712]\}*e^{[1.273*\ln(\text{hardness})-1.460]}$.

Table 7.4. PADEP criteria for continuous concentrations of total recoverable Pb (mg/L) for each of the five study sites.

Date	BURU.04	BURU1.7	HURU1.8	KICR.21	KICR1.3
August 2004	0.0051	0.0076	0.0054	0.0044	0.0042
September 2004	0.0027	0.0028	0.0074	0.0039	0.0034
November 2004	0.0052	*	0.0059	0.0048	0.0044
February 2005	*	*	*	0.0044	0.0042
July 5, 2005	0.0023	0.0051	0.0064	0.0056	0.0038
July 8, 2005	0.0037	0.0025	0.0049	0.0021	0.0042

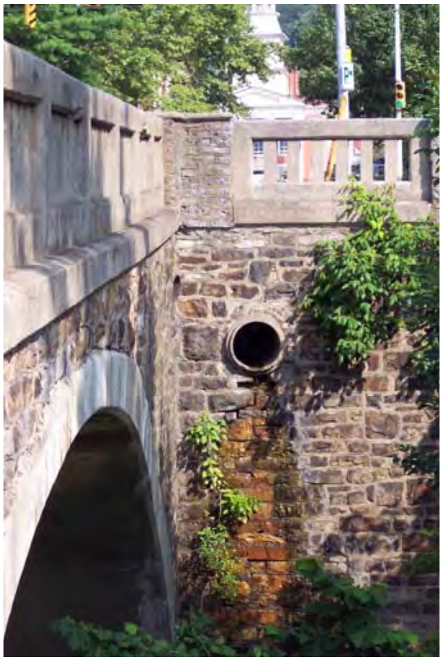
* Indicates no data for that site for that month.

Table 7.5. PADEP criteria for acute concentrations of total recoverable Pb (mg/L) for each of the five study sites.

Date	BURU.04	BURU1.7	HURU1.8	KICR.21	KICR1.3
August 2004	0.1318	0.1948	0.1383	0.1123	0.1073
September 2004	0.0688	0.0716	0.1883	0.1001	0.0858
November 2004	0.1340	*	0.1506	0.1224	0.1138
February 2005	*	*	*	0.1138	0.1087
July 5, 2005	0.0058	0.1296	0.1629	0.1427	0.0965
July 8, 2005	0.0937	0.0653	0.1253	0.0534	0.1080

* Indicates no data for that site for that month.

Most of the samples (74%) did not detect any metal at all, although it was detected above acute levels at BURU.04 and BURU1.7 and above continuous concentration levels at KICR.21 and KICR1.3 during the July 5, 2005 storm event. During the July 8, 2005 storm event lead was not detected at four of the five sites, but at KICR.21, the sample site at the mouth of Kish Creek, lead levels exceeded the continuous concentration levels.



Lead concentrations ranged from undetectable to 0.025 mg/L, with the highest concentrations found at BURU1.7 and KICR1.3. All sites except HURU1.8 had at least one value exceeding the continuous concentration of lead outlined by PADEP.

This extremely toxic metal has been found to have several deleterious effects on biological organisms. Lead sometimes mimics essential elements such as calcium, magnesium, iron, and zinc in the bodies of animals, disrupting production and function of enzymes involved in physiological and metabolic reactions (Jeannette 1981). Lead can also cause insertion of erroneous nucleotides in DNA codes, leading to genetic mutations (Johnson 1998), and has been proven to be carcinogenic in the human body (Fracasso et al. 2002). Some organisms, including caddisflies and freshwater algae, have the ability to take up and store lead in their bodies without succumbing to the metal's toxic effects (Biddinger and Gloss 1984). Higher organisms, such as fish, that consume insects and plants harboring high lead concentrations can develop symptoms of lead poisoning that may result in death (Jeanette 1981).

Inorganic lead is found in many types of urban, industrial, and agricultural waste and often becomes incorporated into stream ecosystems via runoff from storm events (Godwin 2001). Lead was a common component of many substances used by humans for over a thousand years before its toxic properties were discovered in the late 1800s (Ferraro et al. 2004). Even in modern times there are many sources of lead in the environment and it can be difficult to determine precisely where dissolved lead detected in storm water runoff originated. Although there are a few natural sources of lead in the environment, the lead entering streams, rivers, lakes, and oceans is derived primarily from human caused sources. Lead is a common constituent of batteries, ammunition, cable coverings, caulking, pipes, solder, and gasoline additives. Lead also occurs in many organic and inorganic compounds, such as lead acetate, lead nitrate, and lead oxide, that have various industrial and domestic uses (Johnson 1998).

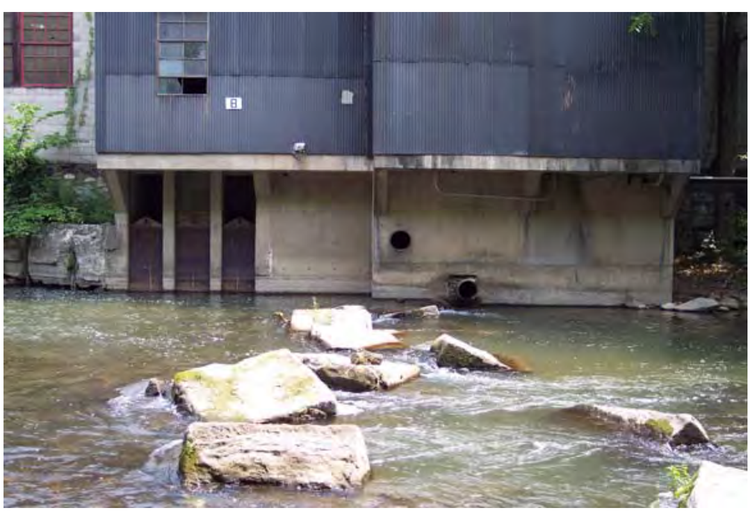
Manganese (Mn)

Manganese is another important trace mineral involved in the proper physiological and metabolic functioning of fish and other animals. Manganese is similar to iron in that it leaves a metallic aftertaste in the mouth of consumers when it is present in drinking water. EPA does not list aquatic toxicity levels for manganese, although EPA does provide dietary guidelines for the safe human consumption of aquatic organisms living in waters with dissolved manganese:

- Human health criteria (water + organism) =0.050 mg/L
- Human health criteria (organism only) = 0.100 mg/L

Manganese concentrations exceeded human consumption limits (water +organism) in 55% of the samples and was at the human health criteria (water + organism) for one of the samples, making it a significant component of runoff in this watershed. All sites had at least three samples at, or exceeding consumption guidelines recommended by PADEP.

. This metal has toxic effects on birds and mammals, although it has not been shown to affect fish (US EPA). Birds that consume high quantities of manganese experience anemia and decreased growth, while mammals suffer from alterations in brain chemistry, stomach irritation, low reproductive output, behavioral changes, and muscular weakness (US EPA 2005a). In fish,



manganese is an important nutrient that plays a role in brain function and the metabolism of lipids (fats) and carbohydrates (Watanabe et al. 1997). An inadequate supply of dietary manganese can result in retardation of growth (Ishac and Dollar 1968). Exactly how fish absorb manganese is unclear, although absorption likely occurs both through the gills from dissolved Mn in the water column and through the intestinal wall from food consumed (Watanabe et al. 1997).

Manganese is found naturally in many types of rock and soil. Human caused sources of manganese include iron and steel production plants, power plants, and coke ovens. Manganese is used in steel production to improve the strength of the material, and is commonly found in other products, including dry-cell batteries, matches, and fireworks (US EPA 2005a). The industrial plants of the Lower Kish Creek watershed, such as Standard Steel in Burnham, provide a likely source of manganese found in storm runoff at our study sites.

Zinc (Zn)

Zinc, a mineral required by fish and other animals in trace amounts, is involved in numerous metabolic pathways in the body. Zinc acts both as a catalyst for metabolic reactions and as a structural component of cellular DNA (Watanabe et al. 1997). Additionally, zinc may play a part in regulating the growth patterns of fish (Chesters 1991). Fish derive zinc both from the water column through their gills and from dietary sources through intestinal absorption. The presence of certain compounds, especially those containing calcium, can inhibit absorption of waterborne zinc. Despite inhibition by calcium-containing compounds, even relatively low levels of dissolved zinc can be toxic to fish (Watanabe et al. 1997).

Zinc toxicity levels are dependent upon water hardness. Thus, toxicity levels were different for every site each month depending on hardness values. To determine the maximum continuous and acute concentrations of total recoverable zinc for each month (Tables 7.6-7.7), we used our measured hardness values and the following formulas given by PA Code, Title 25, Chapter 16, Appendix A, Table 1:

- Continuous concentration = $0.986*e^{[0.8473*\ln(\text{hardness})+0.884]}$
- Acute concentration = $0.978*e^{[0.8473*\ln(\text{hardness})+0.884]}$.

Table 7.6. PADEP maximum continuous concentration of total recoverable Zn (mg/L) for the five study sites.

Date	BURU.04	BURU1.7	HURU1.8	KICR.21	KICR1.3
August 2004	0.21	0.28	0.22	0.18	0.18
September 2004	0.12	0.13	0.28	0.17	0.15
November 2004	0.21	*	0.23	0.20	0.18
February 2005	*	*	*	0.18	0.18
July 5, 2005	0.11	0.20	0.25	0.22	0.16
July 8, 2005	0.16	0.12	0.20	0.10	0.18

* Indicates no data for that site for that month.

Table 7.7. PADEP maximum acute concentration of total recoverable Zn (mg/L) for the five study sites.

Date	BURU.04	BURU1.7	HURU1.8	KICR.21	KICR1.3
August 2004	0.21	0.28	0.21	0.18	0.17
September 2004	0.12	0.13	0.27	0.17	0.15
November 2004	0.21		0.23	0.19	0.18
February 2005				0.18	0.18
July 5, 2005	0.11	0.20	0.24	0.22	0.16
July 8, 2005	0.16	0.12	0.20	0.10	0.18

* Indicates no data for that site for that month.

Zinc does not appear to be a major component of storm water runoff in the Lower Kish Creek watershed. It was detected at toxic levels at some of the sites only in samples collected in July 2005 during heavy rainstorms that followed a long dry period. Thus, any zinc in the runoff likely accumulated on surfaces and in soils over an extended time period.

Zinc becomes toxic to fish, wild birds, and mammals even at relatively low concentrations (Watanabe et al. 1997). Aquatic organisms, including plants, exhibit impaired growth, survival, and reproduction when exposed to elevated levels of zinc. Zinc accumulates in stream sediment and is also found in a dissolved state as hydrated zinc ions and organic and inorganic complexes. Birds experience pancreatic breakdown, poor growth, and weight loss when they consume high levels of zinc in their diet. Elevated zinc causes a variety of problems in mammals including: decreased function of the cardiovascular and immunological systems; developmental retardation; liver, pancreas, and kidney problems; neurological dysfunction; and reduced reproductive success (Eisler 1993).

As with aluminum, roof runoff is a highly significant source of zinc in streams. Chang et al. (2004) discovered that zinc concentrations in rainwater exceeded national water quality standards 100% of the time. There are many possible sources of zinc in roofing materials, included galvanized gutters and downspouts, nails, solder, fungi-resistant materials, coating, atmospheric deposition of aerosols, and the decomposition of organic matter. Zinc is highly soluble in water and readily leaches out of zinc-containing compounds such as those mentioned above (Chang et al. 2004). Compounds containing zinc are also often used in pesticides, herbicides and rodenticides (US EPA 2005b), all of which are commonly used chemicals in urban and agricultural environments.

Habitat

Our evaluation of habitat along the main stem of Kishacoquillas Creek revealed several problem areas. The majority of the five study sites scored marginal or poor on the following parameters:

embeddedness (60%), sediment deposition (60%), condition of banks (60%), grazing or other disruptive pressure (60%), and riparian vegetative zone width (80%). All of the study sites scored optimal or suboptimal for instream cover, channel alteration, and channel flow status. Habitat scores by parameter for each of the five study sites are summarized in Table 7.8.

Table 7.8. Habitat scores by parameter for each of the five study sites.

Habitat Parameter	BURU.04	BURU1.7	HURU1.8	KICR.21	KICR1.3
Instream Cover (fish)	14	16	15	14	17
Epifaunal Substrate	10	15	15	14	12
Embeddedness	11	9	6	15	7
Velocity/Depth Regimes	13	17	11	11	10
Channel Alteration	11	15	16	13	12
Sediment Deposition	9	12	9	12	9
Frequency of Riffles	11	18	18	17	8
Channel Flow Status	15	13	14	15	13
Condition of Banks	11	16	6	8	8
Bank Vegetative Protection	14	19	12	7	8
Grazing or Other Disruptive Pressure	13	16	9	8	7
Riparian Vegetative Zone Width	10	15	5	6	7
Total Score	*142*	*181*	*136*	*140*	*118*

Overall, our five study sites scored slightly higher on the RBP than the main stem of Kish Creek. Four of the five sites scored suboptimal overall, and one site (KICR1.3) scored marginal. None of the 50 additional sites on Kish Creek scored optimal. Forty percent (40%) of the sites scored suboptimal, 56% scored marginal, and 4% scored poor overall. The majority of the sites scored marginal or poor for the following five parameters: sediment deposition (66%), condition of banks (90%), bank vegetative protection (80%), grazing or other disruptive pressure (74%), and riparian vegetative zone width (90%). The majority of the sites scored optimal or suboptimal for the following six parameters: instream cover (88%), epifaunal substrate (52%), embeddedness (54%), velocity depth regimes (64%), channel alteration (58%), and channel flow status (100%). There was one parameter, frequency of riffles, for which exactly half of the sites scored optimal or suboptimal and the other half scored marginal or poor. Based on our observations the three areas of greatest concern were condition of banks, bank vegetative protection, and riparian vegetative zone width. A summary of the results of our visual assessment of the main stem of Kish Creek can be found in Table 7.9.

Table 7.9. Summary of the number of sample locations in each scoring range by parameter for the 50 locations surveyed.

Habitat Parameter	Optimal	Suboptimal	Marginal	Poor
Instream Cover (fish)	19	23	5	2
Epifaunal Substrate	10	16	10	14
Embeddedness	3	24	15	8
Velocity/Depth Regimes	20	12	13	5
Channel Alteration	1	28	14	7
Sediment Deposition	2	15	26	7
Frequency of Riffles	16	9	6	19
Channel Flow Status	13	37	0	0
Condition of Banks	0	5	36	9
Bank Vegetative Protection	0	10	28	12
Grazing or Other Disruptive Pressure	0	13	19	18
Riparian Vegetative Zone Width	1	4	25	20
Overall Score	*0*	*20*	*28*	*2*

In addition to evaluating odd-numbered sites along the main stem of Kish Creek for the 12 RBP habitat parameters, we also recorded our general observations about each even-numbered site.

Biological

Macroinvertebrates

Table 7.10 Macroinvertebrates found in the Lower Kish Watershed

Common Name	**Scientific Order(s)**	**Common Families (Hilsenhoff pollution tolerance score)**
Mayflies	Ephemeroptera	Baetidae (6), Caenidae (7), Ephemerellidae (2), Heptageniidae (3), Isonychiidae (3), Leptophlebiidae (4)
Stoneflies	Plecoptera	Leuctridae (0), Peltoperlidae (2), Perlidae (3), Perlodidae (2), Taeniopterygidae (2)
Caddisflies	Trichoptera	Brachycentridae (1), Hydropsychidae (5), Hydroptilidae (4), Limnephilidae (4), Rhyacophilidae (1)
Dragonflies	Odonata	Gomphidae (4)
Dobsonflies/Alderflies	Megaloptera	Corydalidae (3), Nigronia (2), Sialidae (6)
True Flies	Diptera	Chironomidae (6), Simuliidae (6), Tipulidae (4),
Beetles	Coleoptera	Elmidae (5), Psephenidae (4)
Snails	Gastropoda	Lymnaeidae (7), Physidae (8)
Crustaceans	Decapoda, Isopoda, Amphipoda	Cambaridae (6), Asellidae (8), Gammaridae (4)
Miscellaneous worms	Oligochaeta (10), Annelida (9), Hirudinea (8), Oligocheata (10), Turbellaria (9), Other worms (9)	Tubificidae (10)

Table 7.10 shows the 17 different orders and the families in those orders that were collected during the sampling and their Hilsenhoff Biotic Index score. The Hilsenhoff Biotic Index, which uses pollution tolerance values ranging from 1-10, increasing as water quality decreases, was not calculated for this assessment, however the DEP data form we used to record the data denotes each pollution tolerance value Hilsenhoff assigned to each family and we listed above. Based on this information, student could instantly see if a macroinvertebrate was pollution tolerant (value >5) or pollution intolerant (value <5).

All five study sites had mayflies, stoneflies, and caddisflies (orders Ephemeroptera, Plecoptera, and Trichoptera) present in at least one of the four macroinvertebrate samples taken during the summers of 2004 and 2005. Collectively these three orders are used to determine a biotic health index called the EPT index. A "modified" EPT index excludes the following families because they are more pollutant tolerant than the rest; (mayflies) Baetidea , Caendiae, Siphlonuridea, (caddisfly) Hydropsychidae, Polyentropodidae. The "modified" mayfly index excludes the families Baetidea , Caendiae, Siphlonuridea for the same reason (Table 7.11).

Table 7.11. Macroinvertebrate biotic index scores by date and study site.

	Taxa Richness	Modified EPT Index	% Modified EPT	% Modified Mayflies
June-04				
BURU1.7	13	5	38%	23%
BURU.04	8	1	13%	0%
HURU1.8	9	3	33%	22%
KICR1.3	13	6	46%	15%
KICR.21	11	2	18%	9%
July-04				
BURU1.7	11	1	9%	0%
BURU.04	13	4	31%	15%
HURU1.8	11	2	18%	9%
KICR1.3	13	5	38%	8%
KICR.21	11	3	27%	9%
August-05				
BURU1.7	6	1	17%	0%
BURU.04	9	3	33%	11%
HURU1.8	10	3	30%	10%
KICR1.3	9	1	11%	11%
KICR.21	13	4	31%	8%
June-05				
BURU1.7	17	4	24%	18%
BURU.04	21	7	33%	14%
HURU1.8	17	6	35%	12%
KICR1.3	18	6	33%	17%
KICR.21	15	5	33%	20%

The percentages given in the above table represent the number of families collected from the Orders mayflies, stoneflies and caddisflies. They do not represent the percent of individuals collected in the samples form those orders. For example the June 2005 sample for BURU.04 had 21 different families collected. Seven (7) of those families were mayflies, stoneflies or caddisflies (33% of the families collected), yet the dominant species collected in that sample was the scud (Gammaridae) which made up 30% or more of the individuals in the sample while collectively the families used in the "Modified EPT index" only made up about 8% of the total individuals collected in the sample. The potential is there to increase the number of individuals in the families used to make up the "Modified EPT index", but first we need to improve the habitat and water quality.

BURU 1.7

By number of individuals collected, the common netspinner caddisfly (Hydropsychidae) was the dominant family at this site. Other prominent families included the riffle beetle (Elmidae), scuds (Gammaridae), and the small minnow mayfly (Baetidae). Stoneflies were found in all samples collected from BURU1.7 and surprisingly common. The large brown stonefly (Perlidae) was “abundant” (25-100 individuals) at this sample location in the June 2005 sample and “common” (10-24 individuals) in the July 2004 sample.

Contrary to BURU.04’s June 2004 results, this site had a high percent (23%) of mayfly families in the June 2004 sample. Mayflies, stoneflies and caddisflies families made up 38% of the sample in June 2004 (but not necessary 38% of the individuals in the sample) (Figure 7.6). Despite the good results in June 2004, this site had the lowest Modified EPT Index score three out of four times (75%), as well as the lowest % Modified EPT and % Modified Maylifes scores two out of four times (50%). BURU1.7 scored lowest on the taxa richness index two out of four times (50%).

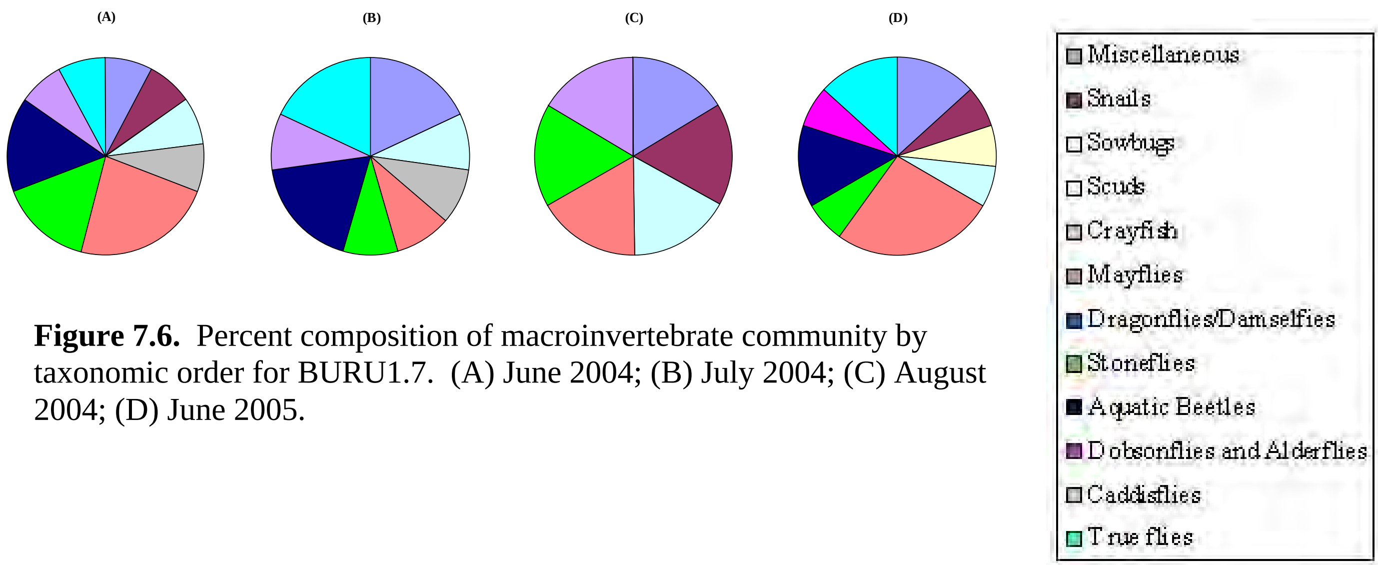


Figure 7.6. Percent composition of macroinvertebrate community by taxonomic order for BURU1.7. (A) June 2004; (B) July 2004; (C) August 2004; (D) June 2005.

BURU.04

By number of individuals collected, scuds (Gammaridae) dominated this sample site. Other prominent families included the small minnow mayfly (Baetidae) and the water penny (Psephenidae). All of the samples had mayflies and although the small minnow mayfly was the most abundant mayfly, the spiny crawler mayfly (Ephemerellidae) was also relatively common. We found stoneflies in all of the BURU.04 samples. Mayflies, stoneflies and caddisflies made up more than 30% of the families represented in the samples three of the four times (but not necessary 30% of the individuals in the sample) (Figure 7.7). BURU.04 exhibited diversity in the species composition during the June 2005 sample, where it showed the highest diversity (21 families) over all, compared to the June 2004 sample where it showed a significantly lower species diversity of only 8 different families and only 13% of those families were mayflies, stoneflies or caddisflies (Table 7.10). Dobsonflies were found in the July 2004 sample (Nigronia) and the June 2005 sample (Corydalidae), but in both cases they were rare (<3 individuals).

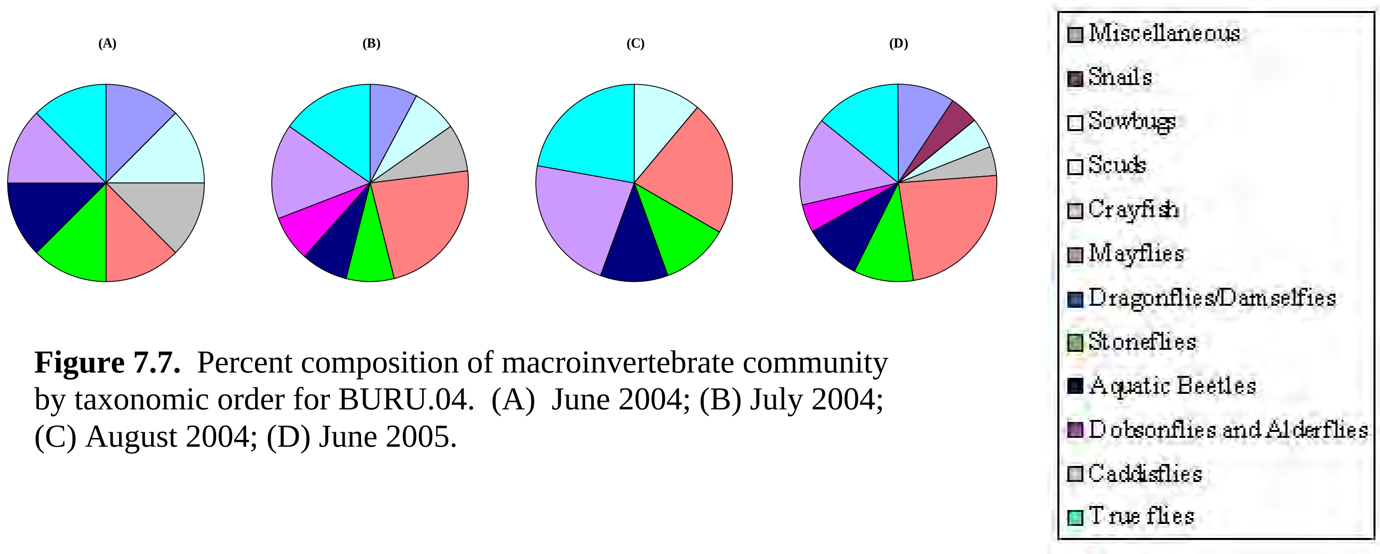


Figure 7.7. Percent composition of macroinvertebrate community by taxonomic order for BURU.04. (A) June 2004; (B) July 2004; (C) August 2004; (D) June 2005.

HURU 1.8

By number of individuals collected, the common netspinner caddisfly (Hydropsychidae) was the dominant family at this site. Other families that were found in abundance at this site included scuds (Gammaridae), the spiny crawler mayfly (Ephemerellidae), riffle beetles (Elmidae) and black fly larvae (Simuliidae). We only found stoneflies in August 2004 and June 2005 at this site (Figure 7.8). This was the only site to have any of the dragonfly families collected in the sample. We collected dragonflies (Gomphidae) during the August 2004 sample, but it was rare (<3 individuals).

The June 2005 sample was the best for this location. Taxa richness, Modified EPT index, and % Modified EPT were all higher in June 2005 than in previous samples. Only % Modified mayflies was lower than it had been in other samples (Table 7.10).

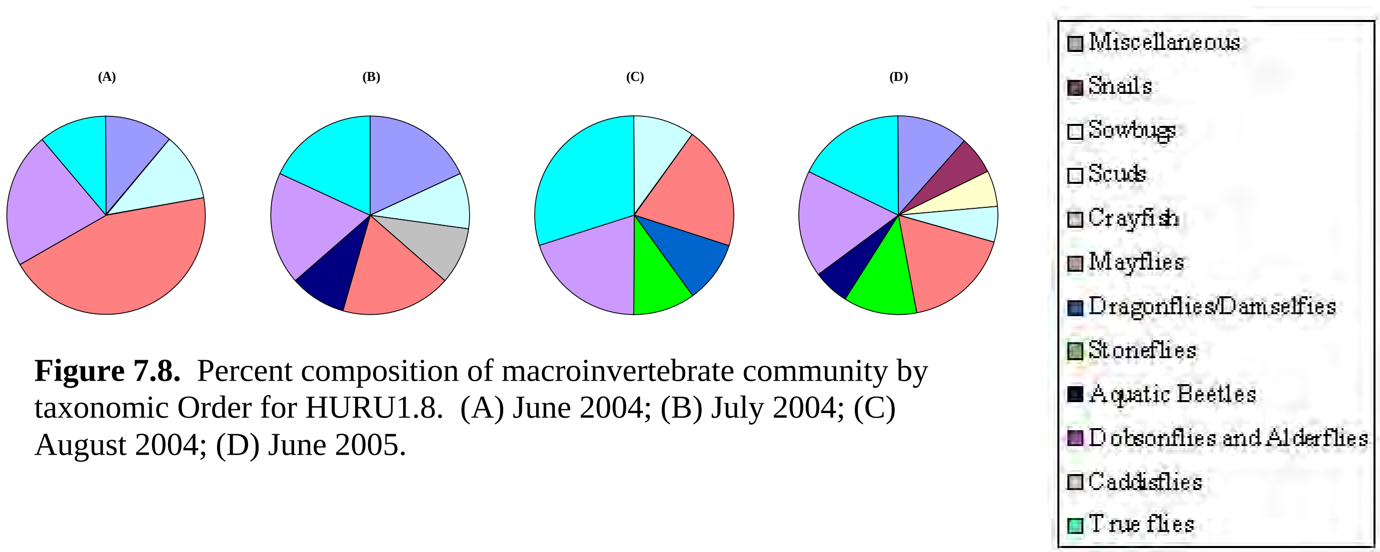


Figure 7.8. Percent composition of macroinvertebrate community by taxonomic Order for HURU1.8. (A) June 2004; (B) July 2004; (C) August 2004; (D) June 2005.

KICR 1.3

Scuds (Gammaridae) dominated this sample site. Other prominent families included the small minnow mayfly (Baetidae) and Annelid worm (Tubificidae) which has a pollution tolerance index of 10. We found stoneflies in samples collected in June 2004, July 2004, and June 2005, but not in samples collected in August 2004 (Figure 7.9). Overall, KICR1.3 scored highest or tied with another site for the highest value six times. KICR1.3 was the most diverse site overall, having the highest or tying with another site for the highest taxa richness score for three out of four samples. This site also had the highest Modified EPT Index and % Modified Mayflies scores for two samples out of four.

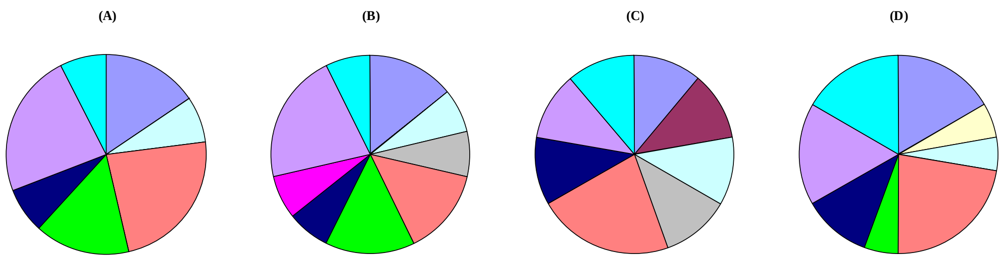


Figure 7.9. Percent composition of macroinvertebrate community by taxonomic order for KICR1.3. (A) June 2004; (B) July 004; (C) August 2004; (D) June 2005.

KICR .21

At KICR.21, aquatic worms (Miscellaneous orders and families including Oligocheata, Tubificidae, and Turbellaria) were Very Abundant (>100 individuals) and dominated the macroinvertebrate samples by number of individuals collected. Aquatic worms are tolerant of pollutants (the above scoring 10,10 and 9 respectively in the Hilsenhoff pollution tolerance value) and are a concern in such large numbers. The common netspinner caddisfly (Hydropsychidae) and scuds (Gammaridae) were also abundant at this location. In the June 2005 sample, the small minnow mayfly (Baetidae) was the dominant mayfly. Both the common netspinner caddisfly and the small minnow mayfliy are considered pollution tolerant and not included in the "modified ETP index". Only one sample from KICR.21, collected in July 2004, contained stoneflies (Figure 7.10).

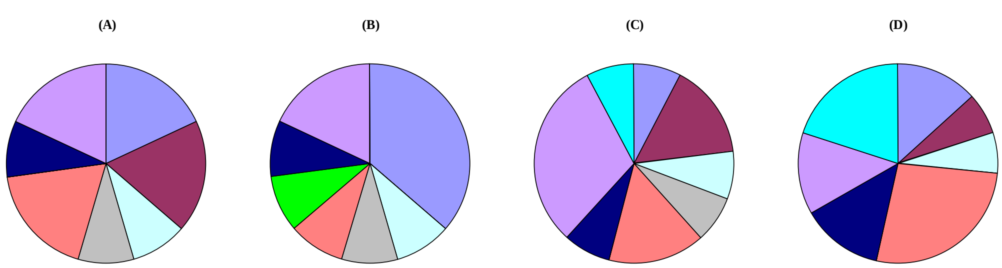


Figure 7.10. Percent composition of macroinvertebrate community by taxonomic Order for KICR.21. (A) June 2004; (B) July 2004; (C) August 2004; (D) June 2005.

Other Surveys

Birds

We identified a total of 31 bird species at the five study sites (Table 7.12). Of these 31 species, only one, the American Robin, was present at all five sites. We observed three other species at three of the five sites, nine other species at two of the five sites, and 18 other species at one site only. Twenty-seven of the 31 bird species we identified are native to the area for at least part of the year. Sixteen of the native bird species observed are year-round residents, while 11 species spend only their breeding season in Pennsylvania. We identified four non-native bird species at some of our study sites, including the European starling, the rock dove, the English sparrow, and the domestic duck. For a complete breakdown of species observed at each site, see Appendix F.

Table 7.12. Summary of bird species and the number of sites where they were identified.

Species	# of sites	% of sites	Species	# of sites	% of sites
Robin	5	100%	Hawk	1	20%
Gray Catbird	3	60%	Duck	1	20%
Morning Dove	3	60%	Black-capped Chickadee	1	20%
Mallard	3	60%	Woodpecker	1	20%
Starling	2	40%	English Sparrow	1	20%
Song Sparrow	2	40%	Carolina Wren	1	20%
Northern Cardinal	2	40%	Tree Swallow	1	20%
Barn Swallow	2	40%	Eastern Bluebird	1	20%
American Goldfinch	2	40%	Northern Mockingbird	1	20%
Grackles	2	40%	Kingfisher	1	20%
Red-winged blackbird	2	40%	Field Sparrow	1	20%
American Crow	2	40%	Common Yellowthroat	1	20%
Eastern Phoebe	2	40%	Killdeer	1	20%
Cliff Swallow	1	20%	Eastern Meadowlark	1	20%
Pigeon	1	20%	Cowbird	1	20%
Northern Flicker	1	20%			

Fish

We sampled fish using both rod and reel and seine or hand nets. When using rod and reel, artificial lures seem to be more effective than live bait. For every one fish caught using live bait, two were caught on artificial lures. We caught six fish of three different species using rod and reel, all downstream of Mill Road bridge below the area designated HQ-CWF. A summary of fish species caught using rod and reel can be found in Table 7.13.

Table 7.13. Summary of the fish species collected by rod and reel, including air and stream temperatures, and pH of the sample location.

Species	Bait Type	Air Temperature	Stream Temperature	pH	Location
Smallmouth Bass	Spinner	20.0	21.0	7.8	Mouth of Kish
White Sucker	Red Worm	20.0	21.0	7.8	Mouth of Kish
White Sucker	Red Worm	23.0	21.0	7.8	Upstream of mouth, near railroad bridge
Creek Chub	Rubber Worm	24.5	20.0	7.6	Blue garage/apartment building
Creek Chub	Rubber Worm	24.5	20.0	7.6	Blue garage/apartment building
Smallmouth Bass	Rooster Tail	24.5	20.0	7.6	Blue garage/apartment building

Our fishing efforts using nets were more successful. We netted 70 fish of nine different species, plus four unidentifiable fish larvae between the eight locations sampled. At the railroad bridge near the mouth of Kish Creek, we netted a young-of-year (YOY) smallmouth bass. When sampling with nets at Derry Park in Burnham, we collected a banded darter. Banded darters are not native to the Juniata River or Susquehanna River Drainage, but they have been introduced in this area. We found the same minnow and darter species throughout the Lower Kish; however, we did not capture any sculpins in areas not designated HQ-CWF. A summary of fish species caught using nets can be found in Table 5.14.

Table 7.14. Summary of fish species collected by net, including air and stream temperatures, and pH of the sample location.

Species	Number	Air Temperature	Stream Temperature	pH	Location
Creek Chub	2	29.0	23.0	7.8	Above mouth near RR bridge
Fall fish	10	29.0	23.0	7.8	Above mouth near RR bridge
Smallmouth Bass	1	29.0	23.0	7.8	Above mouth near RR bridge
Tessellated Darter	3	29.0	23.0	7.8	Above mouth near RR bridge
Fish Larvae	4	27.0	30.0	8.0	Drainage pond
Blacknose Dace	1	29.0	25.0	8.1	Rec. Park lower end
Fall fish	4	29.0	25.0	8.1	Rec. Park lower end
Tessellated Darter	8	29.0	25.0	8.1	Rec. Park lower end
White Sucker	1	22.0	16.0	7.9	Unnamed tributary near Olde Mill
Banded Darter	1	30.0	27.0	7.9	Derry Park
Creek Chub	9	30.0	27.0	7.9	Derry Park
Fall fish	4	30.0	27.0	7.9	Derry Park
Creek Chub	1	24.0	21.0	8.1	Below dam at Standard Steel
Slimy Sculpin	4	24.0	21.0	8.1	Below dam at Standard Steel
Tessellated Darter	3	24.0	21.0	8.1	Below dam at Standard Steel
Blacknose Dace	4	20.0	18.0	7.8	Under 322 bridge
Fallfish	4	20.0	18.0	7.8	Under 322 bridge
Mottled Sculpin	2	20.0	18.0	7.8	Under 322 bridge
Slimy Sculpin	4	20.0	18.0	7.8	Under 322 bridge
Tessellated Darter	3	20.0	18.0	7.8	Under 322 bridge
White Sucker	1	20.0	18.0	7.8	Under 322 bridge

VIII. Areas of Concern in the Watershed

The results of our assessment of the Lower Kishacoquillas Creek Watershed bring to light several areas of concern regarding the chemical, physical, and biological integrity of the system. This assessment was not large enough to identify possible causes for and sources of impairment. Now that some issues have been identified, members of Trout Unlimited, students, or other concerned citizens can further study the causes of these impairments and methods that can be used to improve water quality, habitat, and biological communities in the Lower Kish Creek watershed.

Of the area we studied, only Hungry Run is listed on the Clean Water Act Section 303 (d) list of impaired waters. Based on our findings, we feel that Buck Run should also be added to this list and the section of Kish Creek designated HQ-CWF, Class A Wild Trout should lose this special designation and be classified as a Trout Stocked Fishery.

Water Chemistry

<u>Temperature</u>

It is hard to emphasize temperature enough. All of the sample locations exceeded the maximum temperature limits on multiple occasions. Three months in a row all of the sample locations exceeded temperature standards for Warm Water Fisheries. One site on Buck Run (BURU 1.7) exceeded the limits nine out of 12 months. Trout (even stocked trout) can not be expected to survive in these warm conditions.

We observed several dead regulation-size brown trout during our visual assessment of habitat along the main stem of Kish Creek. One of these many trout was located within the boundaries of the HQ-CWF area. It is possible that other factors such as hooking stress, or percent saturated oxygen, contributed to the mortality of these large trout, but high stream temperatures recorded during the summer of 2005 may have had a big impact.

Fish aren't the only ones affected by warm temperatures. Consistent high water temperatures only 2-6°C warmer than expected have the potential to alter the reproductive cycle of aquatic macroinvertebrates. Macroinvertebrates play an important role in aquatic systems as a source of food for omnivorous and predaceous fish species such as trout (Alliance for the Chesapeake Bay). Factors negatively affecting the macroinvertebrates at the bottom of the food chain have repercussions that are felt all the way up to the top predators.

Possible causes for these high stream temperatures include a high percentage of impervious surfaces surrounding the stream, a lack of vegetated buffer along the streams, or warm discharges to the stream. Summer water temperatures in a stream lacking a forested buffer may be as much as 6-11ºC warmer than those in a stream located within a wooded area.

Dissolved Oxygen

Although milligrams per liter of dissolved oxygen was not an issue at any of the sites, percent saturation was an issue on multiple occasions, both dangerously high and dangerously low. If the percent of saturated oxygen is too high, it can cause fish to suffer from a condition in which bubbles of oxygen (a gas) block the flow of blood through blood vessels, causing death. If the percent of saturated oxygen is too low, fish can't breathe and can die. Abrupt changes in dissolved oxygen induce stress and subsequently make fish more susceptible to disease.

Many species of macroinvertebrates, especially mayfly, stonefly, and caddisfly species, require high dissolved oxygen content and do not survive well in an oxygen-depleted environment (PA DEP).

Fecal Coliform

All of the sample locations had periods of very high fecal coliform levels. The highest level was sampled at BURU 1.7. This site also had extremely high fecal coliform counts on several occasions, further indicating that agricultural pollution may be a problem in this subwatershed. High fecal coliform counts, such as those experienced at BURU1.7, can have deleterious effects on aquatic fauna due to the reduction in dissolved oxygen that occurs when bacteria counts are high (Brosnan and O'Shea 1996).

Heavy Metals

All five of the heavy metals we tested for exceeded EPA guidelines at least once in our study. Further investigation should be conducted to determine the extent of heavy metal contamination. This would include testing well water, or other ground water sources, stream flow (not during storm events) and stormwater runoff. Based on our results, aluminum, iron, and manganese all appear to be candidates for exceeding the concentration levels on a continuous basis. Each of these three heavy metals exceeded EPA's continuous concentration levels about 50% of the times sampled. All of these heavy metals, particularly aluminum and manganese have associated health risks for prolonged exposure and further study should be conducted to determine if they are truly exceeding the continuous concentration levels as our results suggest. If they are, they could be a real heath concern to people who use groundwater in this watershed as their drinking water. Regardless, the acute concentration levels were exceeded on multiple occasions (in the case of aluminum, more than half of the time we sampled) raising red flags and furthering the argument that sources of these metal should be investigated.

Pollutants of primary concern in this area include the heavy metals mentioned above. It is important to note that the heavy metal data for this assessment is a measure of dissolved metals, not metal content of sediments. Studies by Sasaki et al. (2005), DeNicola and Stapleton (2002), and McKnight and Feder (1984) indicate that accumulation of toxic metals in stream sediments has a greater effect on benthic macroinvertebrates than dissolved metals in the water column. At sites where pollution-tolerant taxa dominate, it would be beneficial to test sediments for toxic metals in addition to evaluating aqueous metals.

Habitat

The riparian habitat in the Lower Kish Creek watershed appears compromised in many areas along the length of the stream. Riparian vegetative zone width along Kish Creek is generally poor in this densely populated watershed, resulting in several of the impairments noted during our visual assessment of habitat. Parameters such as erosion, condition of banks, bank vegetative protection, grazing and other disruptive pressure, and sediment deposition are all directly related to the primary problem of a narrow riparian vegetative zone.

The root systems of trees growing along a stream function to hold the soil together and prevent it from getting washed away with the flow of the moving water. Vegetation along a stream also stops overland flow of eroding soils thus preventing the soil from entering the stream. Sediment carries with it excess nutrients and any detrimental chemicals present in the soil, which then become incorporated into the aquatic ecosystem (Alliance for the Chesapeake Bay 2000). The presence of sediment in a stream also increases turbidity and changes the morphology of the stream bed, often to the detriment of aquatic organisms that rely on a specific type of substrate for survival and reproduction (US EPA 2002).

Erosion is a significant problem along this portion of Kish Creek. Many banks are steeply cut and lack supporting vegetation extending to the stream's edge. In areas where streamside vegetation is present up to the stream's edge, most of the trees and shrubs have exposed roots because erosion is so extensive. Where the stream flows adjacent to community parks, businesses, homes, and roadways, riparian vegetation is often closely cropped or nearly absent. Short mowed grass, although better than bare dirt, lacks the benefits provided by trees, shrubs and native grasses or even unmowed lawn grasses. While short, lawn grasses use nitrogen and phosphorus, they do not grow deep roots that hold the soils during heavy rains and they do not have the stem density to stop overland flow of soil.

Stretches of bare, hard-packed dirt are also common along Kish Creek, especially adjacent to the area's numerous bridges. Such barren stretches are particularly vulnerable to erosion because they lack the protection of plant root systems. Hard-packed dirt creates an impervious surface comparable to concrete or asphalt surfaces, so runoff becomes a problem in these areas as well. In addition to holding soil together against the eroding force of stream flows, plants also reduce runoff by absorbing nutrients and chemicals before they reach the water (Albert 2001). Functional riparian buffers are therefore essential to maintaining the integrity of a stream system.

Sediment deposition in the main stem of Kish Creek as a result of erosion is evident in many areas. Long stretches of slow-moving, heavily silted water is common. Some sections of the stream are so heavily affected by excess sediment that the stream bed completely lacks structure in the form of the cobble and gravel substrates that are imperative to trout survival and reproduction. In these areas, the stream more closely resembles a pond because of the condition of the stream bed and the stagnant water flow. It was in these areas of high sedimentation that we observed fish species such as bluegill and crappie that are generally considered lentic (still water) species (Diana 2004). In addition to destroying necessary habitat for important fish and macroinvertebrate species, fine sediments tend to accumulate toxic chemicals and heavy metals (Campbell 1994). Studies indicate that sediment is a significant source of metals in the diets of aquatic macroinvertebrates, especially filter feeders (Karouna-Renier and Sparling 2001). Birdsall et al. (1986) found that more than 90% of total lead in urban stormwater runoff is harbored in fine sediment particles.

It is possible that the extensive erosion and resulting sedimentation along Kish Creek was due to the extremely high, fast flows that accompanied the hurricane weather systems that moved through the area in the fall of 2004. However, the deforested state of the stream's banks surely contributed to the degree of erosion and its associated problems.

Invasive Plant Species

While conducting the visual assessment of Kish Creek habitat we noted the presence of several invasive plant species in the watershed. Invasive plants are plants which grow quickly and aggressively, spreading and displacing other plants, dominating the landscape and decreasing the plant diversity in the invaded area. Some of the traits of invasive plants include: aggressive growth; prolific reproduction; a high degree of adaptability; hardiness; and resistance to many control and elimination methods (Alliance for the Chesapeake Bay 2003). Because many native fauna do not recognize invasive plants as sources of food or shelter, plant invaders act to decrease diversity of insect and animal species in an area as well. We observed the following invasive plant species in the Lower Kish Creek Watershed:

- Purple loosestrife *Lythrum salicaria* (Figure 8.1)
- Multiflora rose *Rosa multiflora* (Figure 8.2)
- Duckweed *Lemna obscura* (Figure 8.3)
- Garlic mustard *Alliaria petiolata*
- Reed canary grass *Phalaris arundinacea*
- Canada and bull thistle *Cirsium arvense* and *C. vulgare*
- Norway maple *Acer platanoides*
- Tree-of-Heaven *Ailanthus altissima*

Figure 8.1. Purple loosestrife growing on the bank of Kish Creek at Derry Community Park in Burnham, PA.

Figure 8.2. Multiflora rose (*right*) growing along the bank of Hungry Run at the study site HURU1.8.

Figure 8.3. Duckweed growing in Kish Creek near Mann's Narrows.

Invasive plants alter the natural processes of native ecosystems to which the inhabitants of that system are adapted. For example, purple loosestrife grows so densely in wetland areas that it begins to soak up all of the moisture in the area, destroying the quality of the wetland. Garlic mustard releases a chemical through its root system that changes the chemistry of the surrounding soil, resulting in a loss of habitat for soil-dwelling creatures such as earthworms and salamanders. Because of their negative effects on plant and animal communities, controlling invasive plant species is an important part of watershed management (Alliance for the Chesapeake Bay 2003).

Biological

Macroinvertebrates

Our macroinvertebrate surveys also indicate impairment in the watershed. High numbers of pollutant tolerant species were found at many of the sites. Sample locations along Kish Creek (KICR 1.3 and KICR .21) had high numbers of pollutant tolerant species. KICR .21 was dominated by miscellaneous aquatic worms, 2/3 of which had the highest pollution tolerance score (10) given in the Hilsenhoff rating and the other 1/3 scored 9. Although some pollution sensitive

macroinvertebrate species were found at each of the sites, conditions were not good enough for them to dominate the samples even if they dominated the number of families in the samples.

Despite having the lowest index scores and highest fecal coliform count, BURU1.7 still supports a fairly diverse macroinvertebrate community, including many species of mayflies and stoneflies, which are considered two of the most sensitive macroinvertebrate orders.

Invasive Species

During our visual assessment of the main stem of Kish Creek, we observed the presence of invasive and hybrid species. One of the invasive species, which we captured on a number of occasions, is the rusty crayfish. The rusty crayfish (Figure 8.4), native to the Ohio River drainage in Western Pennsylvania, are larger and more aggressive than species native to the Lower Kish Creek watershed and the Susquehanna River drainage and often out compete native species for the best living spaces and food sources (PA Sea Grant 2004). A single gravid female has the potential to produce thousands of offspring and populate an entire area. Native crayfish populations can suffer to the point of localized extirpation in areas where rusty crayfish become abundant (PA Sea Grant 2004). Because of their aggressive, yet elusive nature, rusty crayfish do not constitute a good source of food for smallmouth bass and large trout. This increases predation pressure on native crayfish. A local extirpation of native crayfish in Kish Creek would mean reduced availability of food for popular game fish species and would be harmful to the integrity of the fishery. The combination of competitive pressure for living spaces and food source and an increase in predation pressure makes it all the more difficult for native crayfish to exist in the watershed.

Figure 8.4. A male rusty crayfish captured in Kish Creek. Note the characteristic red blotch on the sides and the red tail. These crayfish also have smooth, blue-tinted claws. The claws of crayfish native to the Susquehanna River drainage are marked with rows of small bumps and lack a bluish tint (PA Sea Grant 2004)

Another non-native animal observed in the Lower Kish watershed is the domestic duck, a species originally brought over from Europe hundreds of years ago. The most harmful effect of domestic ducks on the native fauna of a region is their ability to hybridize with native species like the mallard (Figure 8.5). We observed dozens of mallard-domestic hybrids along Kish Creek, concentrated primarily in Derry Community Park in Burnham, where they are a favorite of campers and other park visitors. The large population of ducks in the park is having a detrimental effect on both riparian and in-stream habitat. Ducks eat young shoots of vegetation growing along the bank, thus preventing them from growing. The banks of the stream in Derry Park are particularly eroded due not only to the lack of riparian vegetation, but also the constant traffic of ducks going in and out of the water (Figure 8.6). In-stream habitat is also affected by the presence of a large number of ducks. Ducks defecate and urinate while swimming, increasing the fecal coliform counts, nitrogen and ammonia concentrations within the stream.

Figure 8.5. Hybrid ducks crossing the bicycle path parallel to Kish Creek in Derry Community Park. Note the iridescent green heads of the males (characteristic of mallards) and the white breast feathers (characteristic of domestic ducks).

Figure 8.6. Footprints of ducks in the mud along the barren and eroded banks of Kish Creek in Derry Park.

There are several other non-native species of birds commonly associated with urban areas in the Lower Kish Creek watershed. European starlings, English sparrows, and pigeons are all common in the Lewistown area. These birds, like the domestic duck, were brought to America by European settlers and became very abundant due to their abilities to readily adapt to human populated environments. Starlings and English sparrows thrive in urban centers while many native songbirds dependent on un-fragmented forests or grasslands. The valleys that have continuous farms and wooded ridges are home to more native species of birds, although non-native birds were observed there too.

High-Quality, Coldwater Fishery/ Class A Wild Trout Waters: an area of "special" concern

Kish Creek includes a section classified as HQ-CWF/Class A Wild Trout Waters between the Yeagertown Railroad bridge and Mill Road bridge in Burnham. One of our study sites, KICR1.3, is located within the boundaries of this special stretch of Kish Creek. HQ-CWF/Class A Wild Trout Waters must meet even more stringent water quality standards than CWF. Maximum daily temperatures should be lower and dissolved oxygen concentrations should be higher than in CWF. A section of stream classified as Class A Wild Trout Waters should also have sufficient habitat to support a naturally reproducing population of trout. Based upon the results of our assessment, we identified several areas of concern specific to the HQ-CWF and its population of wild trout.

Water Chemistry

<u>Temperature</u>

The most obvious trend in the KICR1.3 water chemistry data was its deviation from the stream temperature standards outlined for its designated Protected Use. Stream temperatures consistently exceeded PADEP's maximum temperature standard for HQ-CWF over the 14-month observation period. This site was often the warmest or second-warmest site of the five overall. High stream temperatures can be detrimental to fish species adapted to cold waters because the physiological and metabolic processes of these species do not function optimally above a certain temperature (Diana 2004). As we stated above, we did observed several dead brown trout. Water temperatures at KICR1.3 exceeded the maximum tolerable temperature for brook trout in June, July, and August 2004, and in June and July 2005.

The above-average air temperatures experienced by the Lewistown region in 2005 may explain the high stream temperatures observed at KICR1.3 and the other four study sites during this time period. Stream temperatures at KICR1.3 did not exceed the temperature standards for HQ-CWF as much in 2004 when air temperatures were close to or below the historical average. With only one year's worth of data, it is not possible to confidently determine if the high stream temperatures were the sole result of unusually high air temperatures or if some other factor (i.e., industrial, municipal, or agricultural effluent, etc.) caused water temperatures to rise.

<u>Heavy Metals</u>

The concentrations of lead, iron, aluminum, and zinc found in storm water samples collected at KICR1.3 frequently violated national water quality standards for both chronic and acute levels.

Concentrations of the highly toxic metal lead exceeded the maximum continuous concentration toxicity level in July 2004 and 2005. One possible source of lead found in KICR1.3 storm runoff samples is the wastewater treatment plant located upstream of the site in Burnham. Fitzpatrick et al. (1995) estimated that more than 700,000 pounds of lead are released from urban wastewater treatment plants every year. Outfall from this plant emptying into Kish Creek should be tested for lead during overflow events to determine if this facility is a significant source of lead.

Concentrations of dissolved iron also exceeded national water quality standards for continuous concentration in July 2004 and 2005. Iron does not have toxic effects on aquatic organisms until concentrations exceed 1.0 mg/L; KICR1.3 experienced concentrations of 7.58 mg/L in July 2004, and 5.70 mg/L and 1.48 mg/L during two separate storm events in July 2005.

Aluminum concentrations exceeded DEP's continuous toxicity level during storm events in August, September, and November 2004, as well as in February 2005. During a June 2004 storm event, the total dissolved Al concentration in the water sample we collected from KICR1.3 reached 10.4 mg/L, which is far above DEP's acute toxicity level of 0.750 mg/L (PA Code Chap. 93). Aluminum concentrations at KICR1.3 exceeded the acute toxicity level on two other occasions, reaching 5.4 mg/L during storm events on July 5, 2005 and 2.0 mg/L on July 8, 2005.

Another toxic metal found to exceed DEP's acute toxicity level in storm water samples collected at KICR1.3 is zinc. During the July 5, 2005 storm event, total dissolved Zn at this site was 0.17 mg/L. The acute toxicity level calculated for this hardness-dependent toxic metal based upon KICR1.3's July 5, 2005 hardness value is 0.16 mg/L. Although Zn levels in our water samples from this site did not exceed water quality standards during any other storm events, it is still important to test for Zn on a regular basis in the future to determine if a problem exists.

Habitat

Another possible explanation for the high stream temperatures recorded at KICR1.3 involves the condition of the site's riparian zone. Only one of the four other sites scored lower for the EPA Rapid Bioassessment habitat parameter "Bank Vegetative Protection." Tall vegetation, especially trees and large shrubs, growing along a stream provides protection from temperature changes for fish and other aquatic organisms (Gregory et al. 1991). Abundance of brook and rainbow trout has been positively correlated with extensive forest canopy cover (Smith and Kraft 2005). The stretch of Kish Creek encompassing KICR1.3 is located adjacent to the manicured grass lawns of Derry Community Park, with very few large trees to shade the stream (Figure 8.7). Consequently, the stream is directly exposed to the sun at all times of the day.

(A)

(B)

(C)

Figure 8.7. KICR1.3 flowing alongside Derry Community Park in Burnham, PA. Note the houses and the road visible through the trees along the right bank in all three photos. *(A)* Long stretches of the stream are exposed to direct sunlight during daylight hours; *(B) In* addition to lacking tall shade trees, the KICR1.3 riparian zone is reinforced with rip-rap stones in some areas; *(C)* The grass is mowed right up to the stream's edge along the left bank of the stream, which contributes to problems of erosion and bank instability

Biological

Macroinvertebrates

KICR1.3 consistently yielded top scores for biotic indexes, including the highest taxa richness, Modified EPT Index, and % Modified EPT scores for two of the four samples. We sampled macroinvertebrates four different times at KICR1.3 and found three different pollutant intolerant stonefly families. Only one family was collected in three different samples (June 2004, July 2004, June 2005) and the other two families were only collected one time each, both during summer months of 2004. All of the stonefly families we collected were rare (<3 individuals) and no stoneflies at all were collected in the August 2004 sample. Three different pollution intolerant caddisfly families were collected and they were more numerous that the stoneflies. Despite these facts, we found large numbers of Tubificidae, a worm with a pollution tolerant score of 10. The significant presence of this worm is a concern and our study was not able to indicate why this site was favorable to the worm. The other macroinvertebrate families that were abundant in our sampling at this location are also pollutant tolerant species. More study is necessary to determine why the pollution tolerant species dominate this area when clearly some pollution intolerant species are present.

IX. Conclusions

We feel that this assessment ended up asking many more questions than it answered. Further study is necessary to determine the sources and extent of the heavy metals and other water quality standards. A study such as this can only point out that there is a problem and hopefully get the community involved by first letting them know about the problems, and then learning more about how to correct these problems.

Our assessment indicates that DEP and the Fish Commission should reevaluate the status of Buck Run to a listing on the 303 (d) list of impaired streams, and the section of Kish Creek designated HQ-CWF, Class A Wild Trout should lose this special designation and be classified as a Trout Stocked Fishery.

We further conclude that the Boroughs and townships in this watershed should make an effort to eradicate the invasive species. This effort could be accomplished by civic organizations such as Trout Unlimited, The Lewistown Area High School Conservation Club, Towpath Naturalist Society, or other interested organizations. To insure that vegetative invasive species don’t return, native species should be planted in their place.

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