# Northkill Creek Watershed Coldwater Conservation Plan

**Prepared by The Delaware Riverkeeper Network**

**January 2006**

**This Coldwater Conservation Plan was funded in part by grants from:**

**the Cold Water Heritage Partnership and**
**the Pennsylvania Department of Environmental Protection's**
**Growing Greener Stewardship Fund.**

***Cover photos:***

*Brook trout (PA Fish & Boat Commission, www.fish.state.pa.us)*

*The Northkill Creek, State Game Lands 110 (Delaware Riverkeeper Network)*

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## What is a Riverkeeper?

A Riverkeeper is a full-time, privately funded, non-governmental ombudsperson, whose special responsibility is to be the public advocate for a water body. A Keeper's clients are the river resource and the citizens who fight to protect it.

The Delaware Riverkeeper's job is to advocate for the Delaware River and all of the tributaries and habitats of the watershed. Supported by a committed staff and volunteers, Delaware Riverkeeper Maya van Rossum monitors compliance with environmental laws, responds to citizen complaints and need for support, identifies problems that affect the Delaware River Watershed, and responds accordingly. Serving as a living witness to the condition of the ecosystem, the Riverkeeper is an advocate for the people's right to protect and defend the environment.

**The Delaware Riverkeeper Network (DRN)** is dedicated to protecting and restoring the Delaware River, its tributaries and habitats. Since 1988, DRN, a nonprofit membership organization and affiliate of the American Littoral Society, has worked throughout the 13,539 square mile of the Delaware River Watershed empowering citizens to take more active roles in protecting the streams and creeks that flow through their neighborhoods. Activities include taking stances on regional and local issues that threaten aquatic ecosystems, organizing and supporting communities working to protect local streams, stream restoration projects, volunteer monitoring, pollution hotlines, an enforcement program, and student intern opportunities.

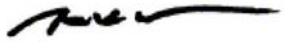
# Foreword

The Northkill Creek stands among Berks County's highest quality streams. From its source on Blue Mountain to the I-78 Bridge, the Northkill Creek is designated by the Pennsylvania Department of Environmental Protection as an Exceptional Value stream, status reserved for those waterways deserving the highest level of protection. Only 13 streams in the Schuylkill River watershed have been designated as Exceptional Value streams; 9 of those originate within Berks County's borders.

To receive this designation, the stream must first have long-term water quality that exceeds levels necessary to support propagation of aquatic life and recreation in and on the water. The stream must also pass biological and/or recreational criteria. For roughly its first three miles, the Northkill Creek exceeds these rigorous standards. Although the reach from the I-78 Bridge to the Tulpehocken (or the slackwater of the Blue Marsh Reservoir), is not currently designated Exceptional Value, (this stream segment is designated Cold Water Fishery), the promise of the protected headwaters suggests that the lower portions of the Northkill Creek watershed have the potential, given the necessary care and protection, for improved water quality.

The Northkill Creek's potential to achieve improved water quality is underscored by the Pennsylvania Fish and Boat Commission designation as a wild trout stream. This designation applies not only to the Northkill's headwaters, but also extends down to the Northkill Creek's confluence with the Little Northkill Creek. The wild trout stream designation includes all of the Northkill's tributaries, such as the Mollhead and Wolf Creeks, as these streams function as habitat for segments of wild trout populations, including nurseries and refuges, and in sustaining water quality necessary for wild trout.

This Coldwater Conservation Plan has been prepared to provide guidance to citizens, environmental groups, community organizations, and municipal officials seeking to implement watershed protection and restoration efforts that will help the Northkill Creek achieve improved water quality. This Plan 1) summarizes in, plain language, monitoring data that characterize the health of the Northkill Creek watershed, 2) increases community awareness of the factors that threaten the long-term health of this system, and 3) encourages community participation in efforts that will produce tangible improvements in the health of the Northkill Creek watershed.



Maya K. van Rossum,
the Delaware Riverkeeper

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# Recommendations

- *Formally organize a Northkill Creek Watershed Association.*

  Citizen groups have formed across Berks County to provide vehicles through which projects to protect and restore local streams can be implemented. An organized effort to protect the Northkill Creek watershed could help to ensure that this system continues to shine for future generations. Informally, a small group of individuals, led by the Delaware Riverkeeper Network and the Berks County Conservation District, began meeting in 2003 as the Northkill Creek Watershed Association, however the long-term viability of such an organization depends on the initiative of the citizens who live, work and recreate in the Northkill Creek watershed.

- *Establish a Northkill Creek water quality monitoring effort to track trends over a relatively long period of time, to investigate if the ecosystem and human uses of it are improving, staying the same, or getting worse.*

  Impacts such as acid rain, invasive species, changing land use, and stormwater runoff raise concerns for the long-term water quality in the Northkill Creek watershed. Water quality studies conducted to date continue to note a healthy aquatic community that should be protected. Water quality in the watershed receives acceptable ecological condition scores although organic enrichment with elevated nitrate levels continues to be noted with the Little Northkill sub-watershed delivering higher nutrient loadings. Further study to pinpoint sources of the nutrient enrichment on the watershed is recommended. Such a study could help lead to on-the-ground- restoration projects that would help reduce nutrient inputs. Other monitoring tasks that would benefit long-term protection of water quality include gathering baseline data to supplement and build on existing datasets, documenting sources of nutrient enrichment, identifying those dams that no longer serve a purpose and would be suited for removal, and documenting the extent of invasive species.

**Potential Northkill Creek Watershed Stakeholders**

Watershed residents
Landowners (public, private, and corporate)
Tulpehocken Area School District
Hamburg Area School District
Berks County Conservation District
Farmers and farm organizations
Berks County Conservancy
Consulting firms/Environmental professionals
Service organizations (e.g., Rotary, Lions Clubs)
Scouting, 4-H and other youth groups
Conservation and sporting groups (e.g., Tulpehocken Trout Unlimited, Berks Federated Sportsmen)
Hiking Clubs (e.g., the Appalachian Trail Club)
Audubon Pennsylvania's Kittatinny Ridge Project
The Nature Conservancy
Sewer and Water Authorities (e.g., the Bernville Sewage Treatment Plant and the Western Berks Water Authority)
Berks County Planning Commission
Albright College
Penn State Cooperative Extension
Pennsylvania Department of Conservation & Natural Resources (PA DCNR) Rivers Conservation Program
PA DCNR Bureau of Forestry
Pennsylvania Department of Environmental Protection, (PA DEP) Bureau of Watershed Conservation
Pennsylvania Department of Environmental Protection's Reading District Office
PA DEP Southcentral Regional Office
Pennsylvania Department of Transportation
Pennsylvania Fish and Boat Commission
Pennsylvania Game Commission
United States Army Corps of Engineers
United States Geological Survey

- *Increase opportunities for students in the Hamburg and Tulpehocken Area School Districts to participate in watershed education and hands-on riparian restoration.*

  The Northkill Creek watershed takes in portions of both the Hamburg and the Tulpehocken Area School Districts. Both offer environmental studies classes and/or clubs for high school students. These programs present opportunities to begin answering questions about impacts to water quality in the Northkill Creek watershed while providing students and potentially the larger community with hands-on experience in watershed monitoring, restoration and protection methods. Experiential watershed protection training would result in on-the-ground streamside improvements to protect the Northkill Creek watershed now and would also influence land management practices of the next generation of landowners.

- *Establish a continuous riparian corridor along the Northkill Creek and its tributaries with special attention focusing on the Wolf Creek drainage and the Little Northkill sub-watershed's Spring Creek drainage.*

  Water quality studies have found that nitrogen levels increase as you move lower in the watershed with increased residential development and highway runoff also contributing to degradation. A review of data collected in 2003 found that the entire Northkill Creek watershed exceeds nitrate thresholds for aquatic life impairment and that the Little Northkill sub-watershed also exceeds the phosphate threshold. Streamside buffers absorb nutrients and pollutants, slow rainwater runoff and filter out sediments. The establishment of streamside buffers would also help to prevent soil erosion, diffuse the energy of floodwaters thereby reducing flood damages, and, through shading, cool water temperatures which would improve fish habitat. To date, efforts to establish riparian buffers in the Tulpehocken Creek watershed have met with limited interest. Greater public education about buffer benefits, along with an incentive-based approach for buffer establishment, are needed.

- *Provide the Northkill Creek watershed's associated forests and floodplains, from the headwaters to the creek's confluence with the Little Northkill, with additional protection and consideration in the environmental impact review process.*

  The Pennsylvania Fish and Boat Commission's designation of the Northkill Creek, from its headwaters to the creek's confluence with the Little Northkill, as a wild trout stream is not a regulatory or management designation. However, this biological designation can be linked to more substantial protections under powers available to municipalities. Streamside buffers and forested areas are critical not only to ensuring water quality, but also to protecting the health of fish populations. Trees and shrubs help to prevent soil erosion, diffuse the energy of flood flows, and shade and cool streams. The loss of streamside buffers and forested areas, through excessive destruction and clear cutting, results in increased air-borne dust, greater erosion, decreased groundwater recharge, reduced cooling and degraded water quality. Existing floodplain regulations still allow substantial disturbance. Northkill Creek watershed municipalities should be encouraged to enact subdivision and land development ordinances that preserve the maximum number of trees on a site; enact riparian buffer ordinances that protect existing buffers; encourage site work that protects the health of trees on a site; and strengthen flood plain ordinances.

- *Establish Environmental Advisory Councils in Northkill Creek watershed municipalities or a multi-municipal Environmental Advisory Council for the Northkill Creek watershed.*

  An Environmental Advisory Council (EAC) is appointed by elected township or borough officials and is comprised of 3-7 community residents. The EAC, the establishment of which is authorized through Act 177 of 1996 (originally Act 148 of 1973) is charged with advising the local planning commission, park and recreation board and elected township or borough officials on the protection, conservation, management, promotion and use of natural resources. In May 2004, Berks County established a countywide EAC to "provide leadership in objectively reviewing environmental issues and to provide guidance to the County regarding environmental matters within Berks County and the region (Berks County EAC, 2005)." In addition Upper Bern Township in the Northkill Creek's headwaters, recently voted to establish an Environmental and Agricultural Advisory Council (EAAC) to provide guidance to township supervisors regarding agricultural as well as environmental concerns. The establishment of this EAAC in the Northkill Creek watershed can serve as a model to other watershed communities as to how individual EACs or a multi-municipal EAC could help ensure long-term protection of the Northkill Creek watershed.

- *Encourage joint planning among Northkill Creek watershed municipalities (which will require the development of a joint comprehensive plan and adoption of a joint zoning ordinance) in order to discourage sprawl.*

  Northkill Creek watershed municipalities are experiencing high population growth rates as open space and agriculture lands are converted to housing developments. Joint municipal planning provides a mechanism for achieving a coherent approach to growth management by encouraging development in areas with existing population concentrations such as the Boroughs of Bernville and Strausstown or other areas suitable for increased development while discouraging the sprawling use of land. The Berks County Planning Commission established a Joint Planning Program in 1992 to encourage regional cooperative planning efforts. Other goals for the program include improving the quality of local comprehensive plans, creating greater dialogue between County and municipal officials during planning, and encouraging consistency with the County Comprehensive Plan. Northkill Creek watershed communities have already embraced the joint planning process. Jefferson Township and Bernville Borough have collaborated; Upper Tulpehocken and Upper Bern Townships and Strausstown Borough have collaborated with Tilden and Windsor Townships and Hamburg Borough. However, there has not been an effort to date to collaborate on watershed-related planning or planning on a full watershed basis. Undertaking a Northkill Creek watershed water budget study on the extent of available water resources, existing and projected demand for water, and management recommendations, would provide valuable guidance for joint planning that could discourage sprawl and safeguard water resources.

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## 7The Lay of the Land

The Northkill Creek rises along the Blue Mountain near Shartlesville and flows nearly 11 miles south to its confluence with the Tulpehocken Creek at Bernville. The creek's drainage area, or watershed, covers roughly 42 square miles (*see map, p. 7*). Northkill Creek tributaries include Mollhead and Wolf Creeks, and the Little Northkill Creek with its tributaries, Birch, Jackson and Spring Creeks. The Little Northkill, with a drainage area of 22 square miles, is the Northkill's largest tributary.

Jefferson, Penn, Tulpehocken, Upper Bern and Upper Tulpehocken Townships in Berks County and small portions of South Manheim and Wayne Townships in Schuylkill County comprise the Northkill Creek watershed. Bernville and Strausstown Boroughs are also located within the Northkill Creek watershed.

How we use land is directly linked to stream health. In the Northkill Creek watershed, nearly 37% of land is classified as being in forested use. Land use in the lower watershed is dominated by general agriculture and, overall, 61% of the watershed is in agriculture. But change is rapidly coming to the region and future land use may look very different. The Conservation Fund's 2002 *Report on the State of the Schuylkill Watershed* puts the loss of farmland to non-agricultural uses in Berks County at a rate of about 2,000 acres annually.

Residents of the Northkill Creek watershed have begun to note development pressures as forests and farmlands are consumed by sprawling development. In 1999, during public meetings organized to seek input for the development of the Schuylkill River Watershed Conservation Plan, residents of the "Tulpehocken Watershed Group" (the Northkill is a tributary of the Tulpehocken) identified inconsistent and ineffective land use planning and zoning as the most important issue in the region. In a comprehensive community wide needs assessment*, Berks 2000 Update A Look at Today . . . A Plan for Tomorrow* (2000), the United Way of Berks County identified critical community issues based upon the results of three surveys. Despite its inclusion on only one of the surveys, the use of farmland for development was overwhelmingly identified as the primary neighborhood issue of concern among suburban and rural Berks County residents.

The sprawling development that is associated with inconsistent and ineffective land use planning is accompanied by an increase in the amount of impervious surfaces -- roads, parking lots, driveways, and rooftops. As impervious surfaces increase, the amount of precipitation that is allowed to filter into the soil is decreased and the amount of runoff is increased. Stormwater runoff enters streams in greater volume and with greater velocity, scouring stream banks and beds and damaging stream ecosystems.

Stormwater runoff can begin to cause degradation when the total area of impervious surfaces reaches 10% of the total watershed area. For the Northkill Creek watershed, that means that degradation of stream health begins at only 4.2 square miles of impervious surface area. A stormwater management plan has been prepared for the Tulpehocken Creek watershed, which includes the Northkill Creek and its tributaries. The plan does not address post development volumes; by focusing only on preventing increases in peak runoff rates, this plan leaves streams at risk from post development volumes.

Although the Pennsylvania Department of Environmental Protection anticipated slow population growth for the Tulpehocken Creek watershed, (*Watershed Restoration Action Strategy (WRAS) State Water Plan Subbasin 03C, 2004)*, rapid growth is more likely to be the reality:

- From 1970 to 1980, while population grew 5.4% across Berks County, Jefferson Township experienced 53.4% population growth. Tulpehocken and Upper Tulpehocken Townships each experienced growth of over 40% during this same period.
- From 1980 to 1990, Berks County's population grew at a rate of 7.68%, but in most Northkill Creek watershed townships, population growth was greater, ranging from 10.67% in Tulpehocken Township to 46.01% in Penn Township. In Jefferson Township, which had a high growth rate in the ten years prior, population grew at 7.63%, comparable to the County's growth rate.

- From 1990 to 2000, Berks County experienced 11% population growth, outpacing neighboring counties. Growth in Upper Bern and Penn Townships ran below this average (1.44% and 8.85% respectively), but the average growth in Jefferson and Upper Tulpehocken Townships, while lower than in the previous decade, was still above 15%.

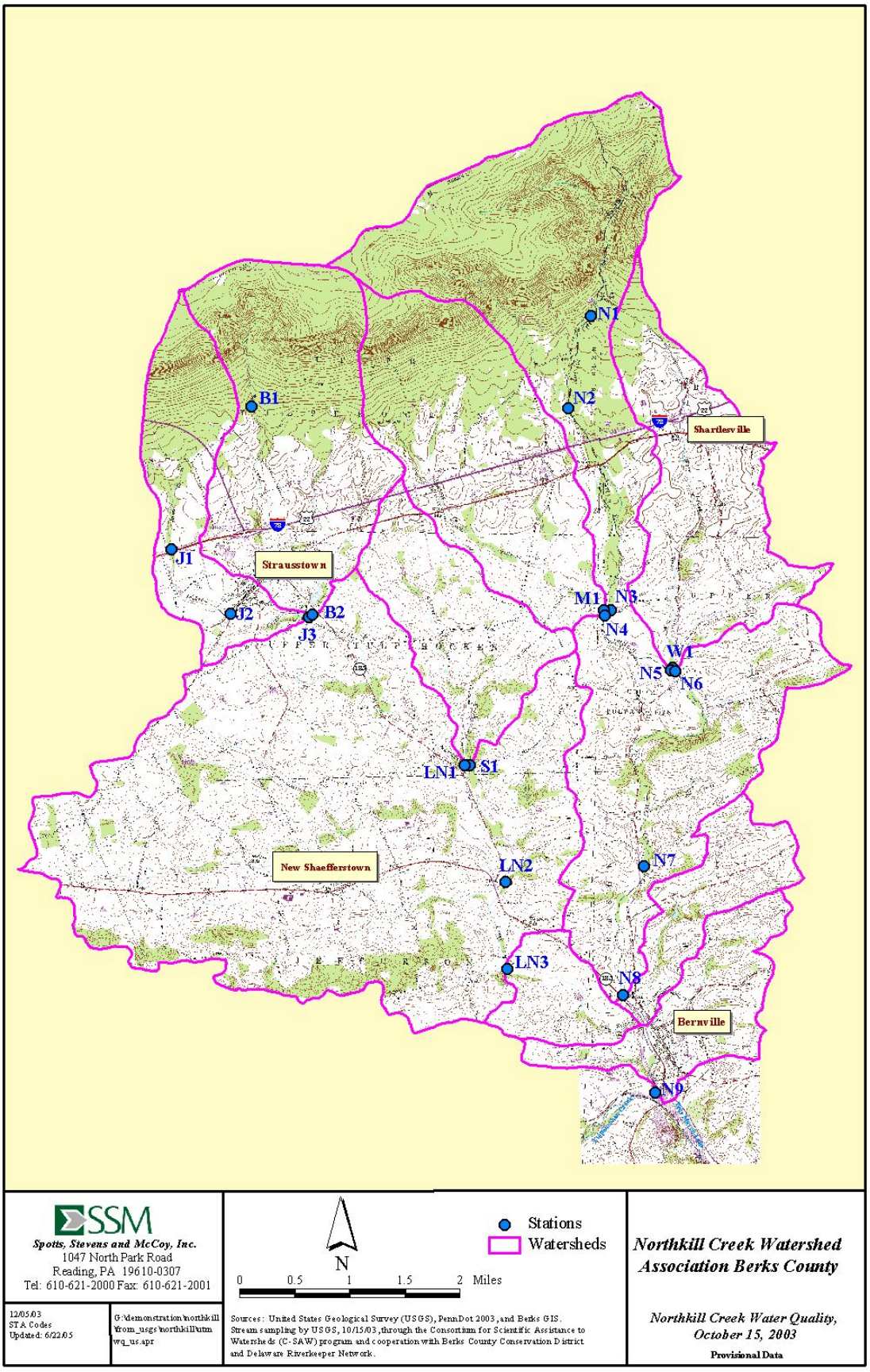
Population growth brings with it an increase in the demand for water and increased pressure on local water supplies. With decreased groundwater recharge capabilities resulting from the increased impervious surfaces associated with sprawling development, land use planning must consider how much water is available and what limits there may be to meet future demands.

*Berks Vision 2020*, the County's comprehensive plan, supports Smart Growth, the American Planning Association concept that encourages a more efficient and environmentally sensitive use of land. *Berks Vision 2020* places designated and future growth areas in the Northkill Creek watershed adjacent to existing development and suggest that those "areas that are not proposed for connection to public water systems should use zoning that will promote the reliable supply of water." A water budget study for the Northkill Creek watershed would provide local municipal officials with information on the extent of available water resources, identify those areas where the demand for water may exceed available supplies, and present management recommendations to safeguard water resources.

## *The Northkill Creek Watershed*

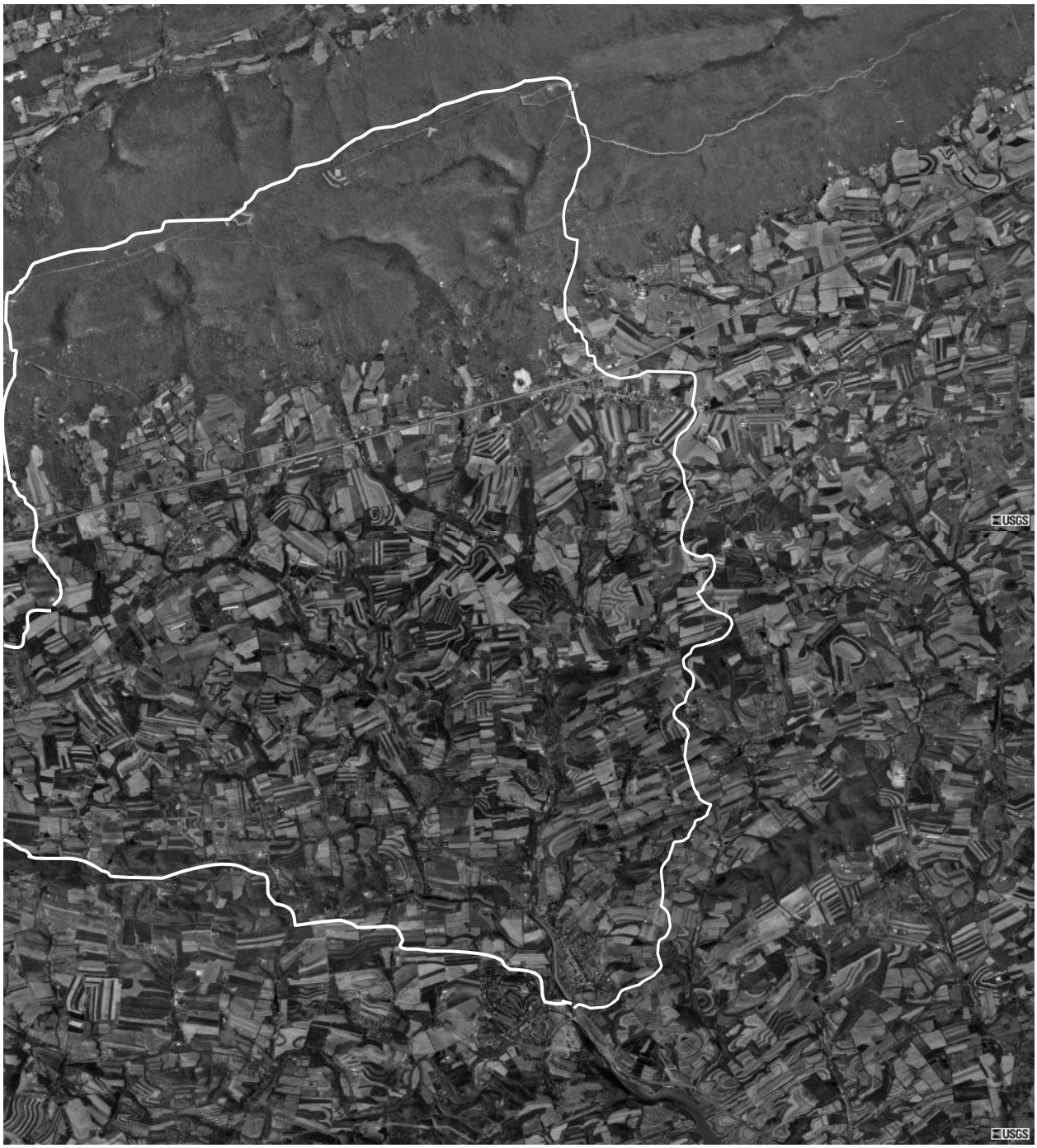
| **2003 Monitoring Locations, USGS (*see map, p. 7*).** | | | | |
|---|---|---|---|---|
| **Map ID** | **Little Northkill sub-watershed** | | **Map ID** | **Northkill sub-watershed** |
| *J1* | Jackson Cr at Schubert/Mountain Rds | | *N1* | Upstream Northkill Cr |
| *J2* | Jackson Cr at Strausstown Rte 22 | | *N2* | Above I-78 Northkill Cr |
| *J3* | Jackson Cr at Anthony's Mill dam outflow | | *N3* | Northkill Cr above Mollhead Cr |
| *B1* | Birch Cr above Bloody Spring Rd | | *M1* | Mollhead Cr at Northkill Cr |
| *B2* | Birch Cr at Anthony's Mill below Rte 183 | | *N4* | Northkill Cr below Mollhead Cr |
| *S1* | Spring Cr at L. Northkill Cr, behind Way-Har | | *N5* | Northkill Cr above Wolf Cr |
| *LN1* | Little Northkill Cr behind Way-Har | | *W1* | Wolf Cr at Northkill Cr |
| *LN2* | L. Northkill Cr at Rte 183/Schaefferstown Rd | | *N6* | Northkill Cr below Wolf Cr |
| *LN3* | Little Northkill Cr near Bernville, PA | | *N7* | Northkill Cr |
| | | | *N8* | Northkill Cr near Bernville, PA |
| | | | *N9* | Northkill Cr at dam, at Bernville, PA |

## *The Northkill Creek Watershed*



***The Northkill Creek Watershed Digital Ortho Quadrangle***

*Image compiled from Terraserver-USA, courtesy of USGS.*




This Digital Ortho Quadrangle (DOQ) aerial image, with the Northkill Creek watershed roughly outlined in white, illustrates the predominant land use of agriculture. Just as the forested headwaters can be clearly discerned, only small areas of streamside vegetation are present to buffer water quality throughout the lower parts of the watershed. The establishment of a continuous riparian buffer along the Tulpehocken and its major tributaries, which includes the Northkill Creek, was identified as a goal of the *Tulpehocken Creek Watershed Conservation Plan* (2001).

## *Watershed Characteristics*

***Geology:*** The bedrock of the Northkill Creek watershed, formed approximately 400 million years ago, is comprised primarily of sandstones interbedded with shale and siltstone, shales, slates, quartzite, chert, and limestone fragments. Quartz-rich rock underlies the major ridges.

A stream's buffering capacity indicates its ability to neutralize acidic pollution and depends largely on the underlying bedrock. The better the buffering capacity of the bedrock, the greater the likelihood that negative impacts to the stream from acidic precipitation and associated runoff can be neutralized and effects on aquatic life reduced.

None of the watershed's underlying rock types, with the exception of the limestone fragments, affords significant buffering capacity to the Northkill Creek or its tributaries. With limited buffering capacity, these streams have limited ability to neutralize acidic pollution. As a result, air pollution and careless actions on the land can have serious implications for the long-term health of the watershed.

The type of bedrock in a watershed also affects water quantity. The water-bearing properties of the Northkill Creek watershed's bedrock are somewhat limited. Areas underlain by shale typically produce only small amounts of water. This limitation must be considered when planning for land use and density of residential development. If these groundwater limitations are not considered, domestic water supplies will be diminished or exhausted, especially during a drought. With stream baseflow inextricably linked to groundwater, diminished groundwater levels can have serious implications for aquatic life.

***Topography:*** The Northkill Creek watershed is characterized by steep to moderate slopes that are carved by a branching pattern of streams. Blue Mountain, which forms the Northkill Creek's headwaters region, stands out sharply above the more gently rolling valleys of the lower watershed. Blue Mountain is underlain primarily by sandstone, a material resistant to weathering, resulting in steeper slopes on the higher elevations. More moderate slopes tend to be underlain with shales, which also resist weathering. Valley floors are often composed of material that weathers more rapidly with correspondingly thicker soils. Material weathered from upslope areas may also be deposited on valley floors.

***Soils:*** Weathering of shale and siltstone form the basis of the soils of the Northkill Creek watershed. These soils can be grouped into two associations: the Hazleton-Dekalb-Buchanan Association and the Berks-Weikert-Bedington Association.

- *Hazleton-Dekalb-Buchanan Association* consists of deep and moderately deep soils formed in material weathered from acid sandstone, quartzite, and conglomerate. These soils, found along the upper slopes and crest of the Blue Mountain, can be marked by instability and stoniness. They have low natural fertility and are poorly suited to crops. Buchanan soils tend to have a seasonally high water table and standing surface water can present management problems.
- *Berks-Weikert-Bedington Association* consists of shallow to deep, well-drained soils formed in material weathered from slightly acid shale and siltstone. These soils have a tendency to be droughty and erosion can be a problem. With slopes of 8% or more, runoff is medium to rapid and the hazard for erosion is moderate to high. Berks and Weikert soils have moderate to low natural fertility. With Weikert soils, which tend to be steeper and shallower than the other soils in the association, depth to bedrock (1 1/2 to 3 feet) can limit use.

***Weather:*** The climate of Berks County is fairly mild, with warm humid summers and mild winters. Average monthly temperatures range from 30° F in January to 77° F in July. Local variations result primarily from differences in elevation.

Near Blue Mountain, average winter temperatures are lower than in the southern part of the county and snow accumulation can be greater. Total precipitation near Blue Mountain averages 44 inches annually, however rainfall can be slightly less over lower parts of the watershed.

In addition to being located downwind of the Ohio Valley's coal-fired power plants, which discharge acid deposition-causing air emissions, Pennsylvania itself ranks third among the fifty states as a producer of these gases. As a result, Pennsylvania receives more acid deposition than any state in the country. Streams with limited buffering capacity, such as the Northkill and its tributaries, tend to be more vulnerable to the effects of acid deposition. The Pennsylvania Fish and Boat Commission has therefore listed the Northkill Creek among stocked streams vulnerable to further acidification and monitors these streams annually.

### *Stream Health/Stream Studies*

From 1972 to present, chemical and biological sampling have been performed at various locations in the Northkill Creek watershed. The Pennsylvania Department of Environmental Resources conducted Aquatic Biology Investigations in 1972, 1974, and 1982, an Acid Rain Study from 1982-1984, and Exceptional Value Status Study in 1985 and a Nutrient Survey in 1987. Its successor, Pennsylvania Department of Environmental Protection (PA DEP), conducted Aquatic Biology Investigation in 1996, and Rapid Bioassessments in 1996, 1998 and 1999. The Pennsylvania Fish and Boat Commission (PFBC) has conducted fish population studies. The Stroud Water Research Center (Stroud Center) included the Northkill Creek watershed among 19 Schuylkill River watershed sites that it sampled from 1996 to 2000. The Stroud Center study sampled stream bottom-dwelling macroinvertebrates (e.g. mayflies and other insects, worms and crayfish). In 2003, the United States Geological Survey (USGS) under the Consortium for Scientific Assistance to Watersheds (C-SAW), with support from the Pennsylvania Department of Environmental Protection's Growing Greener Stewardship Fund, conducted comprehensive monitoring of chemical and biological factors at twenty-five locations throughout the Northkill Creek watershed including all major tributaries.

In addition, the USDA-Natural Resources Conservation Service in collaboration with the Berks County Conservation District undertook a visual assessment of the Northkill's Wolf Creek tributary (Fies, personal communication). Also prepared in 1996 by the USDA-Forest Service was a Forest Resources Report for the Tulpehocken Creek Watershed that identified riparian buffer needs of all the streams in the watershed.

***Water Chemistry:*** Water chemistry is complex with many relationships and factors affecting the concentrations of substances in our streams. Concentrations vary naturally in streams and depend on geology, soils, vegetation, and climate of the watershed. There are also fluctuations in concentrations dependant on the time of the day and the season. The chemical water quality of a stream is healthy if naturally occurring substances are present in concentrations appropriate for the stream ecosystem and aquatic life. Problems occur when human activities change these natural concentrations or introduce foreign substances that may be toxic.

This analysis of water chemistry focuses on the most recent data available, that was collected by USGS in 2003 (Durlin and Schaffstall, 2004). In addition, for the purposes of this discussion, the greater Northkill Creek Watershed has been broken down into two sub-watersheds: the Northkill sub-watershed, comprised of Mollhead and Wolf Creeks and the Northkill main stem; and the Little Northkill sub-watershed, comprised of Jackson, Birch, and Spring Creeks and the Little Northkill itself. The "Northkill Creek watershed" is distinctly different from the "Northkill sub-watershed." The "Northkill Creek Watershed" includes *both* the Little Northkill and Northkill sub-watersheds.

The dates of the USGS water quality survey were October 15-16, 2003. Rain fell on October 14, 2003[1]; on the morning of October 15, stream levels were falling. Data from the USGS streamflow gage on the Tulpehocken Creek at Bernville (see Appendix A*: Tulpehocken Creek near Bernville, October 11-17, 2003*) suggests that the Northkill Creek may have been carrying much higher streamflows -- over 200 cubic feet per second, or cfs -- than the normal monthly mean for October, 80.3 cfs.

[1] Based on Reading rainfall data.

Therefore, it was assumed that during the USGS survey, that the streams sampled were carrying some amount of residual storm-related runoff and associated non-point source pollutants. The available weather data also indicates that the watershed was experiencing typical late October temperatures and other conditions. Leaf-off had begun, but had yet to be completed.

As land uses and practices vary over a watershed, sub-watersheds may deliver varying amounts of the same pollutant to the stream. As the USGS survey measured stream flow at each monitoring site, sub-watershed pollution delivery rates can be calculated and compared.

The Little Northkill sub-watershed drains 52.5% of the Northkill Creek watershed land area while the Northkill sub-watershed drains 42.2%(Table A). Flow data reveals that on the day and times of sampling, the Little Northkill sub-watershed was delivering 61% of the Northkill Creek's flow while the Northkill sub-watershed was delivering only 37%[2]. Each square mile of the Little Northkill sub-watershed was delivering an average of 2.5 cfs while the Northkill Creek sub-watershed was delivering only 1.9 cfs/mi$^2$. Although the difference in flow delivery between the two sub-watersheds is of some importance, to attribute a cause to this factor was beyond the scope of this analysis.

**Table A: Areal Breakdown, Northkill Creek Watershed**

| Sub-watersheds | Area (in square miles)* | Percent of watershed |
|---|---|---|
| **Northkill** | | |
| Mollhead | 4.0 | 9.6 |
| Wolf | 4.3 | 10.2 |
| Northkill | 9.4 | 22.4 |
| ***Subtotal*** | *17.7* | *42.2* |
| **Little Northkill** | | |
| Jackson | 1.9 | 4.6 |
| Birch | 4.0 | 9.6 |
| Spring | 2.2 | 5.3 |
| Little Northkill | 13.9 | 33 |
| ***Subtotal*** | *22* | *52.5* |
| **UNT 2** | 1.1 | 2.7 |
| **Total** | **41.9** | **100** |

***** *Land area was calculated using the grid method.*

Pollutant loadings were calculated for the Little Northkill and Northkill sub-watersheds using the water chemistry and flow data collected October 15-16, 2003. Pollutant loads, usually expressed as pounds per day (e.g., a pound of nitrate delivered over a day's time), were calculated by multiplying the pollution concentration by the stream flow and then dividing by watershed area to generate "pounds per day per square miles." *Pounds of Pollutants Per Square Mile, Northkill Creek Watershed* (Appendix B) compares the pollutant, concentration and loadings for the Little Northkill and Northkill sub-watersheds. Similarities and differences appear when loadings are compared. However the Little Northkill sub-watershed was delivering not only higher cfs, but also higher loadings per square mile than the Northkill sub-watershed on the date of the sampling with exceptions for iron and zinc, which may reflect differences in geology and groundwater contributions.

Nitrate and phosphate concentrations (as N and P) for the Little Northkill, 2.77 and 0.07 mg/l, are particularly significant. The Northkill sub-watershed had concentrations of 1.67 and less than 0.02 mg/l. A recent study of nutrient impacts on Pennsylvania stream biology indicated that the thresholds for these two parameters are 2.01 and 0.07 mg/l respectively, above which stream biology is negatively impacted. The nitrate and phosphate concentrations for the Little Northkill are at or greater than the threshold while the nitrate concentrations for Northkill sub-watershed approaches the threshold. However, if the October 15-16, 2003, flow delivery rates were about 5 times greater than low flow delivery[3], nitrate concentrations in the Little Northkill sub-watershed might have been as high as 13.8 mg/l. For the Northkill sub-watershed, nitrate concentrations could have been 7.6 mg/l.

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[2] Calculated from 55.8/89.7 and 33.9/89.7 respectively. Does not include the two Bernville tributaries.

[3] A study done by the USGS (Fisher, *et al*., 2004) indicates that summer 1999 flows (low flow conditions) in this portion of the Valley and Ridge geologic province averaged about 0.5 cfs/mi$^2$. This suggests that the stream flows observed during the October 2003 sampling flows may have been as much as 4 to 5 times higher than low flow conditions.

*Water Quality in the Delaware River Basin, Pennsylvania, New Jersey, New York, and Delaware, 1998 – 2001* (2004) presented findings of a water quality assessment of the Delaware River Basin. Although the study found that the median nitrate for the Delaware River Basin was 0.87 mg/l (May to June base flow, 1999 - 2001), the mean concentration of nitrate nitrogen at the Tulpehocken Creek at Bernville exceeded 95 percent of the sites nationwide and had the highest observed nitrate concentration, 10.5 mg/l, for the Delaware River Basin. USGS data for the period for October 1998 to September 1999 found 81% of nitrate values for the Tulpehocken Creek at Bernville to be greater than 7 mg/l and 35% to be higher than 8 mg/l (dissolved nitrate + nitrite).

That both the Little Northkill and Northkill sub-watersheds exceed the nitrate-N thresholds for aquatic life impairment is a reasonable conclusion. Also, that the Little Northkill exceeds the phosphate-P threshold as well. This determination is supported by the results of a source water assessment undertaken by the Philadelphia Water Department (PWD) in 2002 for the Western Berks Water Authority (WBWA) whose intake is on the Tulpehocken Creek downstream of the Blue Marsh Reservoir. Nitrate and pesticide contamination from agricultural runoff, bacterial and chemical contamination from discharges of sewage treatment plants and industrial sources, and contamination from roadway accidents and urban runoff were identified as top water quality concerns. Further, the Northkill Creek was listed among the agriculture runoff priority areas for WBWA.

One manifestation of a biological impact from excessive nutrients is increased primary productivity, a measure of aquatic plant activity and growth for both algae and rooted aquatic plants. This is easily observed in streams because plant photosynthesis and respiration affect dissolved oxygen and pH values. In simple terms, during the daytime, sunlight stimulates photosynthesis which adds dissolved oxygen to the stream while removing carbon dioxide (The removal of carbon dioxide increases pH).

The amount of oxygen that can theoretically be dissolved in a stream's water is dependent on the water temperature, with colder water holding higher amounts of oxygen than warm water. The amount of oxygen dissolved in a water sample compared to the theoretical maximum amount that could be present at that temperature is referred to as "percent saturation." Factors that influence dissolved oxygen concentrations include: volume and velocity; climate and season; the type and number of organisms present in the stream; altitude; dissolved or suspended solids; amount of nutrients in the water; organic wastes; riparian buffers; and groundwater inflow. In natural waters, the oxygen saturation is usually around 95%; natural decay of organic materials removes a small amount of oxygen, keeping the water from reaching 100% saturation. If aquatic plants are very productive, super-saturated conditions can occur resulting in saturation above 100%.

**Table B: Comparison of pH and Percent Dissolved Oxygen**

| Little Northkill sub-watershed | Map ID | pH | % D.O. |
|---|---|---|---|
| Jackson Cr at Schubert/Mountain Rds | J1 | 7.75 | 101.5 |
| Jackson Cr at Strausstown Rte 22 | J2 | 7 | 94.3 |
| Jackson Cr at Anthony's Mill dam outflow | J3 | 7.8 | 102.7 |
| Birch Cr above Bloody Spring Rd | B1 | 5.48 | 101.2 |
| Birch Cr at Anthony's Mill below Rte 183 | B2 | 7.88 | **107.1** |
| Spring Cr at L. Northkill Cr, behind Way-Har | S1 | 7.71 | **107.0** |
| Little Northkill Cr behind Way-Har | LN1 | 7.78 | **108.2** |
| L. Northkill Cr at Rte 183/Schaefferstown Rd | LN2 | 7.78 | **108.0** |
| Little Northkill Cr near Bernville, PA | LN3 | 8 | 96.5 |

| Northkill sub-watershed | Map ID | pH | % D.O. |
|---|---|---|---|
| Upstream Northkill Cr | N1 | 5.96 | 99.9 |
| Above I-78 Northkill Cr | N2 | 7.31 | 97.9 |
| Northkill Cr above Mollhead Cr | N3 | 7.21 | 95.8 |
| Mollhead Cr at Northkill Cr | M1 | 7.22 | 96.4 |
| Northkill Cr below Mollhead Cr | N4 | 7.26 | 96.8 |
| Northkill Cr above Wolf Cr | N5 | 7.34 | 96.7 |
| Wolf Cr at Northkill Cr | W1 | 7.29 | 95.7 |
| Northkill Cr below Wolf Cr | N6 | 7.21 | 99.2 |
| Northkill Cr | N7 | 7.43 | 100.2 |
| Northkill Cr near Bernville, PA | N8 | 7.39 | 97.0 |
| Northkill Cr at dam, at Bernville, PA | N9 | 7.3 | **91.8** |

When saturation values rise above 100% and corresponding pH increases are seen, it can be assumed that primary productivity is occurring. High primary productivity can impair aquatic life. At night, after the sun goes down, photosynthesis shuts down, but plant respiration continues. During the night, dissolved oxygen levels in highly productive streams often tumble to levels harmful to aquatic organisms; pH levels respond in like fashion. Similarly, when algae use up all available nutrients, the plant dies and the natural decay process can rob oxygen from the water, resulting in fish kills.

An examination of percent dissolved oxygen and pH at various locations in the Little Northkill and Northkill sub-watersheds indicates that the Little Northkill is experiencing excessive primary productivity (Table B). In this dataset, the maximum temperatures are only in the 50's (°F) so values above 100% saturation are significant. Of particular concern here are observed values at or above 107% which still exceed 100% saturation when adjusted for local elevation. This condition is likely the result of nutrients entering watershed streams from various human (and livestock) activities occurring on the landscape.

The low percent saturation value for the Northkill Creek at the dam at Bernville (the lowest value for this dataset) reflects the influence of the impoundment. The dam slows the water, giving it more time to warm up and lose oxygen. Other factors contributing to lower oxygen levels could include dissolved or suspended solids, the amount of nutrients in the water, organic wastes and in adequate riparian buffers.

Fish, aquatic insects, and other aquatic organisms require, in general, pH in the 6.5 to 9.0 range. On the sampling date, pH values in the headwaters of Northkill Creek, Northkill Creek sub-watershed (N1), and Birch Creek, Little Northkill sub-watershed (B1), were 5.96 and 5.48 respectively. Although the upstream location in Jackson Creek (J1), Little Northkill sub-watershed, and the other upstream location on Northkill Creek (N2), Northkill Creek sub-watershed, had suitable pH values, the data for these sites show low alkalinity and calcium levels, a sign of very limited acid buffering capacity (Table C).

**Table C: Locations and Values of Concern for pH**

| PH and Buffering Capacity Considerations | | pH | % D.O. Sat. | Alkalinity | Calcium |
|---|---|---|---|---|---|
| **Northkill sub-watershed** | | | | | |
| Upstream Northkill Cr | (N1) | √ 5.96 | 99.9 | √ 6 | √ 0.8 |
| Above I-78 Northkill Cr | (N2) | 7.31 | 97.9 | √ 7 | √ 2.3 |
| **Little Northkill sub-watershed** | | | | | |
| Jackson Cr at Schubert/Mountain Rds | (J1) | 7.75 | 101.5 | √ 7.8 | √ 10.6 |
| Birch Cr above Bloody Spring Rd | (B1) | √ 5.48 | 101.2 | √ 2.2 | √ 1.1 |

√ *denotes values of some concern*

The low buffering capacity suggests that these locations are very susceptible to acidification and likely have low pH conditions at other times. The data collected on October 15-16, 2003, clearly indicate that all of the Northkill Creek watershed north of I-78 is impacted by acidification. The magnitude of the problem is seen by comparing the upstream locations on Northkill Creek and Birch Creek with the rest of the locations (Table D).

**Table D: Comparison of pH, Alkalinity and Calcium on a Sub-Watershed Basis**

| | pH range | pH log average | Alkalinity range | Alkalinity average | Calcium range | Calcium average |
|---|---|---|---|---|---|---|
| **Northkill sub-watershed** | | | | | | |
| All locations | 5.96 - 7.72 | 7.2 | 6 - 37 | 22.3 | 0.8 - 18.5 | 9.9 |
| Excluding Upstream Northkill Cr | 7.21 - 7.61 | 7.3 | 7 - 37 | 23.8 | 2.3 - 18.5 | 10.7 |
| Upstream Northkill Cr (Station 15) | N/A | 5.96 | N/A | 2.2 | N/A | 1.1 |
| **Little Northkill sub-watershed** | | | | | | |
| All locations | 5.48 - 8 | 7.5 | 2.2 - 47 | 31.5 | 1.1 - 19.6 | 14.6 |
| Excluding Birch Cr above Bloody Spring Rd | 7 - 8 | 7.7 | 7.8 - 47 | 34.5 | 10.6 - 19.6 | 15.9 |
| Birch Cr above Bloody Spring Rd (B1) | N/A | 5.48 | N/A | 6 | N/A | 0.8 |

The available water quality data suggest locations and even sources of pollution. Townships in the Little Northkill sub-watershed have been experiencing higher growth and development rates than the townships in the Northkill Creek sub-watershed. This is one possible explanation of the higher loadings, but not the only one.

Additional information can also be derived by looking at how the concentration of pollutants increase or decrease as a stream travels downstream through its drainage area and what happens when various tributaries enter the stream. Longitudinal profiles were developed for nitrate, sulfate, sodium, turbidity, alkalinity, and specific conductivity (*Longitudinal Profile, Nitrate, Little Northkill and Northkill Sub-watersheds* is presented in Appendix C). These parameters measure different aspects of water quality, but, for both the Little Northkill and Northkill sub-watersheds, the concentration of each parameter was low above I-78. Below I-78, concentrations increased and were sustained by large concentrations entering from tributary streams. Based on the concentrations emanating from these tributaries and their resultant impact on downstream water quality, the Spring Creek drainage area in the Little Northkill sub-watershed and Wolf Creek in the Northkill sub-watershed present opportunities for pollutant reduction. The exact source of concentrations and the need, if any, to reduce them, however, require additional monitoring and studies. Visual assessments may be sufficient to determine areas suitable for streambank buffer planting that could reduce pollution impacts.

The data from the USGS study echo studies conducted by the PA DEP in the 1980's and 1990's: the headwaters were described as being in better condition than the lower parts of the system where increased residential development and highway runoff are contributing to degradation in water quality. Nitrogen levels increased as you moved lower in the watershed, into more densely populated areas, and toward the confluence with the Tulpehocken Creek at Bernville. Chloride and sodium, which can be derived from road salts, animal wastes, and sewage, show the same trends.

***Biology:*** Chemical testing provides a picture of stream health at the time the sampling was undertaken. However, aquatic organisms can provide better insight into long-term stream health and continuing effects. The degradation of water quality can result in the elimination of those more sensitive aquatic organisms that are least able to cope with adverse conditions. Fish populations may become less diverse if subjected to repeated episodes of low dissolved oxygen or heavy sediment loads, but fish do have the ability to swim away and can move significant distances in response to stream impacts. For this reason, the bottom dwelling invertebrates that can be seen with the naked eye, or macroinvertebrates, that spend all or part of their lives in the stream can best serve as canaries of the stream, their presence or absence telling us a great deal about the health of the aquatic community. Macroinverterbrates include aquatic insects, or the aquatic stages of insects, as well as clams, worms, and crayfish.

In October 2003, ecological surveys of the Northkill Creek watershed were conducted by the USGS. Fish species were collected and identified at five locations (Species identified during these surveys are indicated in Appendix D).

PFBC studies of the Northkill Creek watershed have found the headwaters of the Northkill Creek support a coldwater fishery dominated by brook trout in all stations in all years, however downstream reaches show an increase in warm water species with corresponding decline in cold water species. Studies have found a general increase in family representation from upstream to downstream. USGS biological sampling found similar results (Table E).

**Table E: Fish Species Richness (Number of Families)**

| Map ID or PFBC Station | Year | | | | | |
|---|---|---|---|---|---|---|
| | ***1977*** | ***1982*** | ***1983*** | ***1984*** | ***1985*** | ***2003*** |
| **Little Northkill sub-watershed** | | | | | | |
| B1 | | | | | | 1 |
| B2 | | | | | | 7 |
| **Northkill sub-watershed** | | | | | | |
| PFBC 0101 | | 1 | 2 | 1 | 1 | |
| N1, also PFBC 0102 | 5 | 2 | 2 | 4 | 2 | 2 |
| N2, also PFBC 0103 | 8 | 9 | 8 | 8 | 8 | 7 |
| N7, also PFBC 0302 | | | | | | 13 |

In a study of spatial and historic change in fish communities in the Schuylkill River watershed (Fairchild, *et al.*, 1997), stream size and position within the watershed were found to influence fish species composition more strongly than water chemistry. This is borne out by the results of the 2003 USGS sampling which shows the number of Cyprinids, or minnows, that were collected increased as you moved downstream in the watershed (Appendix E compares the presence or absence of minnows in the 2003 USGS study with that found in Exceptional Value Status Study in 1985). Fairchild, *et al.*, (1997) found that *Rhinichthys atratulus*, Blacknose dace, was most frequently sampled and often occurred in slightly lower order streams than its congener, *R. cataractae*, Longnose dace. Blacknose dace has been found frequently in Northkill Creek fish sampling and is found more frequently than Longnose dace. *Semotilus atromaculatus*, Creek chub, was found to be particularly widespread overall in the Schuylkill River watershed study often occurring in streams with low pH and small headwater streams.

*Anguilla Rostrata*, American eel, was identified during the 2003 USGS sampling. Eels are catadromous. They spawn in the ocean, but spend most of their lives in freshwater. As eels migrate far upstream, their presence in the Northkill Creek is not surprising. Although dams block the migration of anadromous fish, such as *Alosa sapidissima*, American shad, which spawn in freshwater and spend much of their lives in the ocean, eels have been seen to wriggle over such obstructions as long as the surface remains wet. However, with concerns being raised recently that eel populations are in serious decline, opportunities should be investigated for removing barriers and improving eel passage on the main stem Schuylkill River and in the Northkill Creek watershed.

The Northkill Creek watershed, with its long history of agricultural land use, is dotted with farm ponds, millponds and other impoundments. Dams interfere with natural stream processes such as the movement of sediment. Rivers move both water and sediment. The erosion, transportation and deposition of sediment are the mechanisms by which streams change shape. The continuity of sediment transport is interrupted by dams. Instead, sediment accumulates in impoundments eventually filling them. As a result, the river downstream of the dam may be "hungry" for these materials.

A hungry river will scour its bed, downcut its channel and erode its banks. Trout habitat can be harmed as smaller gravels are transported away without replacement from upstream area. Dams flood productive riffle habitats and they were often built on prime spawning areas. Dams affect water quality, negatively changing water temperature, dissolved oxygen content, and turbidity. The impoundments that dams create often act as heat sinks, increasing downstream temperatures to unnaturally high levels that can stress aquatic life. In 2003, Delaware Riverkeeper Network staff undertook a study of two Ridley Creek headwater streams to observe the impact that small dams may have on water temperature (F. Zerbe, personal communication, April 19, 2005). One tributary is free-flowing with no dams present; the other's flow is impounded by four small manmade dams. Both headwater streams are about the same length and drain similar land use types with forested, residential, and agricultural influences. Over a four-day period during August and September, a total of 21 readings were taken. The free flowing tributary had an average temperature of 61.1°F; the impounded tributary averaged 70.4°F, nearly ten degrees higher. Free-flowing stream temperatures ranged from 58.8°F to 63.7°F while the impounded tributary's temperatures ranged from 67.5°F to 74.3°F. The free-flowing stream exhibited the optimal temperatures for trout and other coldwater fish that you expect to find in a forested headwater stream. On the tributary influenced by impoundments, all but three readings exceeded 68.0°F, unnaturally warm temperatures for a spring-fed headwater stream.

Opportunities to restore impounded streams to free flowing conditions should be investigated to benefit resident as well as migratory species. The highest profile dam in the Northkill Creek watershed is Anthony's Feed Mill Dam. The National Inventory of Dams lists this structure, completed in 1927, as being 15 feet in height and 110 feet in length. This privately owned dam impounds Jackson Creek. The removal of this structure or the construction of fish passage at this dam would present the opportunity to increase awareness of the negative impacts dams have on aquatic ecosystems as well as to open upstream areas to migratory fish and improve water quality.

The PFBC designates the Northkill as Approved Trout Waters, meeting the criteria to be stocked with trout. In 2005, 1,900 trout, including both brown and rainbow, were stocked in the Northkill Creek from T-659 (Feick Dr.) Bridge to the creek mouth at Blue Marsh Reservoir, a distance of more than three miles. The creek, open to trout harvest during the extended season, is described by PFBC as "[a] quality trout stream . . . [with] good access and trout that hold well into summer . . . Pressure on this stream seems to drop dramatically within a few weeks after opener, while plenty of trout usually remain in the stream . . ."(PFBC, 2004)

*Anthony's Feed Mill Dam on Jackson Creek*

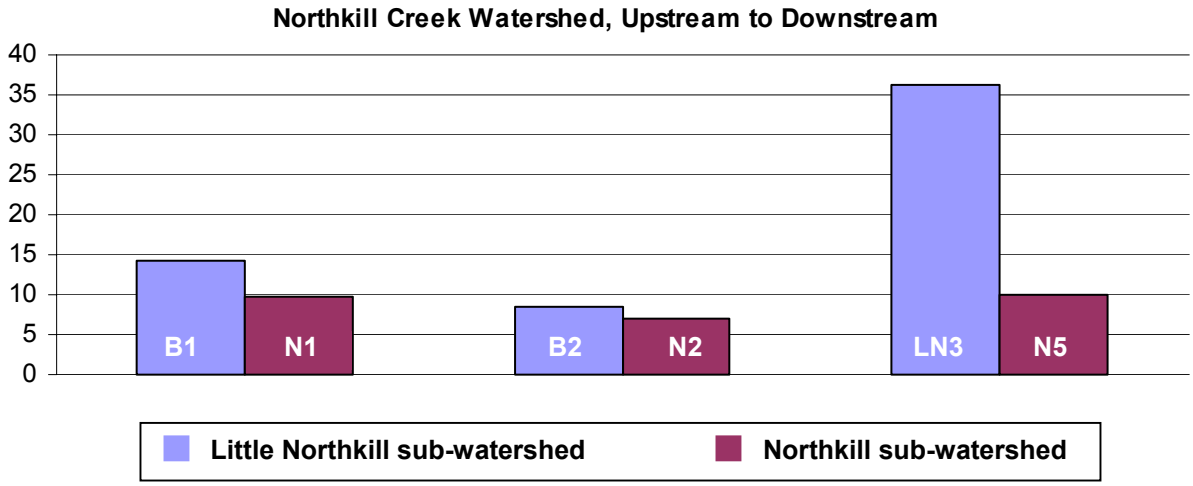
During April 2005, PFBC expanded wild trout stream designation for the Northkill extending it now from the Creek's headwaters to its the confluence with the Little Northkill Creek at Bernville, a reach over 15 miles in length (PFBC, 2005). This is a biological designation. To be classified as a wild trout stream, requires that the trout found there have resulted from natural reproduction and that the habitat supports wild trout. To make this determination, PFBC investigators examine location and habitat and look for direct evidence of natural reproduction of trout. They should find young of the year trout less than 150 mm occurring at some time in the stream section, or two or more ages of wild trout occurring at some time within the stream section. All tributaries to wild trout streams are also classified as wild trout streams for their function as habitat for segments of wild trout populations, including nurseries and refuges, and in sustaining water quality necessary for wild trout. Although "wild trout stream" is not a regulatory designation, it can be linked to more substantial protections under powers available to the municipalities and PA DEP (Austen, 2005).

The Northkill Creek watershed was included in a five-year study of biological health of the Schuylkill River watershed undertaken by the Stroud Center (The Conservation Fund, 2002). From the results of the study, which sampled macroinvertebrates between 1996 and 2000 at 19 locations including most major Schuylkill River tributaries, the Stroud Center drew general conclusions about water quality. The stream sites that scored highest for water quality, which included the Northkill Creek, were predominantly forested and rural. By contrast, the Tulpehocken Creek, which the Northkill feeds, was among the lowest scoring streams.

During the 2003 USGS study, macroinvertebrates were also collected at six locations and preserved. Subsequently, 100-organism sub-samples were randomly selected from each of these six samples using a standardized grid. Sub-samples were identified to order or family level by volunteers who had received instruction in identification techniques. Volunteers were supervised by Delaware Riverkeeper Network and Stroud Center staff. Both sub-samples and original samples were stored at the Berks County Conservation District. These data were analyzed for the purposes of this report using the Virginia Save Our Streams (VA SOS) multi-metric index which examines a number of individual metrics (mayflies+stoneflies+caddisflies, common net-spinners, lunged snails, beetles, percent tolerant, and percent non-insects) then calculates a water quality score using a multi-metric index. The VA SOS multi-metric index identifies a numerical threshold that distinguishes between acceptable (*7-12*) and unacceptable ecological condition (*0-6*). All six locations sampled received acceptable ecological condition scores (Appendix F).

The 2003 macroinvertebrate data do suggests that follow-up monitoring should be pursued to determine if the watershed conditions are changing and, if so, to determine the cause of any impairment. The VA SOS multi-metric index gives higher scores to those sites comprised of less than 46.7% tolerant individuals. Although all Northkill Creek watershed sites were comprised of less than 46.7% tolerant individuals, the Little Northkill Creek near Bernville, Map ID LN3, showed a sharp increase in the percent of tolerant organisms collected (Chart A).

**Chart A: Percent Tolerant Individuals**




Another metric that raises questions about the water quality of the Little Northkill Creek is the Percent EPT, or Mayflies+Stoneflies+Caddisflies. When looking at Percent Mayflies+Stoneflies+Caddisflies, values of 50% or greater are good, values between 50% and 25% are moderate, and values below 25% are poor. For the Little Northkill sub-watershed, values drop from a healthy 58% in the headwaters on Birch Creek to a moderate 45% a few miles downstream on Birch Creek at Anthony's Mill below Rte 183 to a 39% on the Little Northkill near Bernville. Although the Northkill Creek at Bernville receives a 37%, the Northkill sub-watershed's headwaters sites score 52% and 61%.

***Summary:*** The Northkill Creek watershed is a jewel in the Berks County landscape deserving of greater protection and a coordinated restoration approach. Water quality in the ecologically fragile headwaters remains in good condition, but lower areas of the watershed are experiencing nutrient enrichment. How land in the Northkill Creek watershed is managed will ultimately determine the fate of this jewel. A coordinated effort that seeks to educate the public about the environmental and economic benefit of streamside buffers, an incentive-based approach to establish buffers in the Wolf Creek and Spring Creek drainages, along with the coordinated passage of subdivision and land development ordinances that preserve buffers and encourage their expansion are key steps to ensuring the long-term health of the Northkill Creek watershed.

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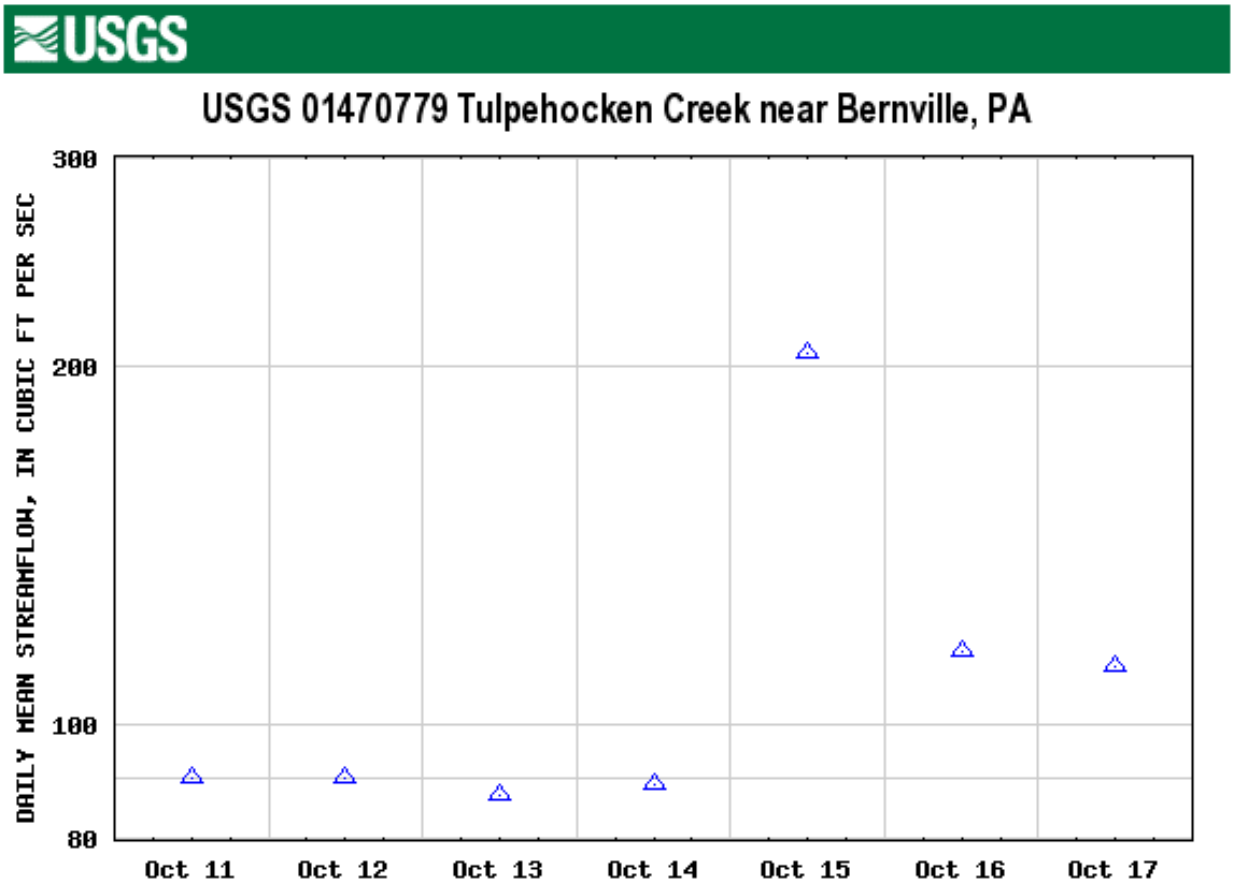
## Appendix A

*Tulpehocken Creek near Bernville, October 11-17, 2003*



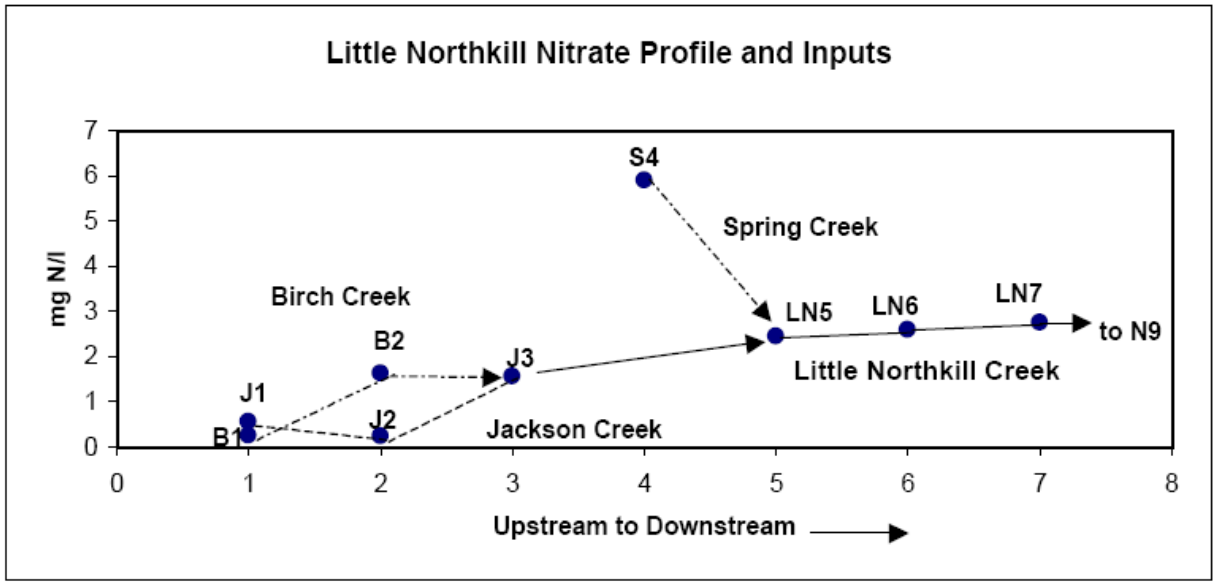
## Appendix B

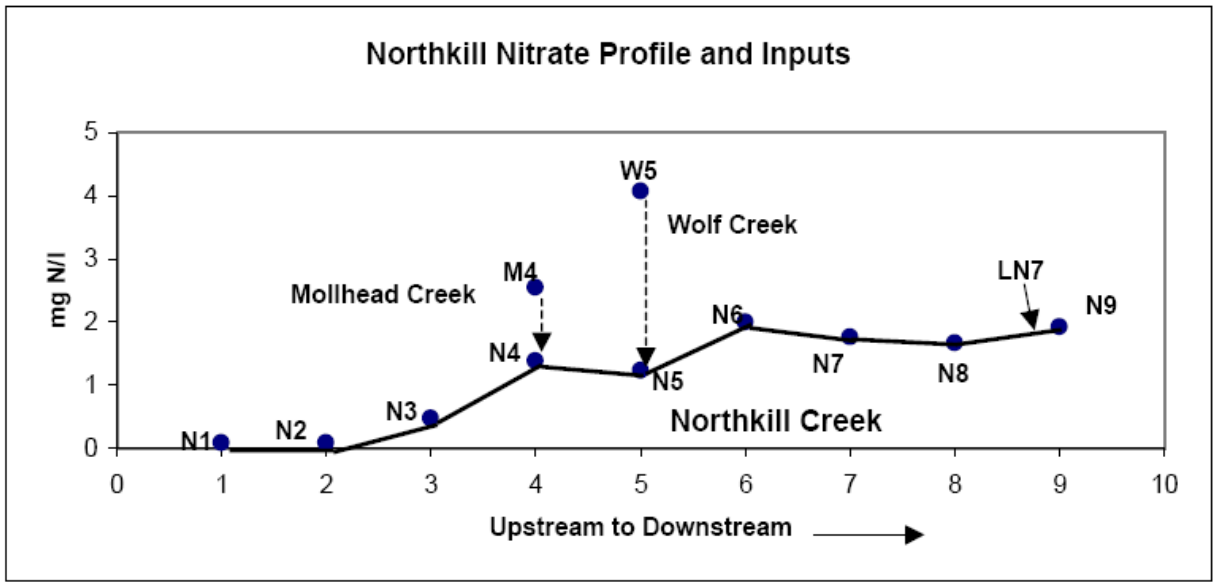
*Pounds of Pollutants Per Square Mile, Northkill Creek Watershed*

| Parameters | | Little Northkill sub-watershed | Northkill sub-watershed |
|---|---|---|---|
| **Nitrate-nitrogen** | mg/l | 2.77 | 1.67 |
| | lbs/day | 833 | 453 |
| | Lbs/day/mi$^2$ | 37.9 | 35.6 |
| **Alkalinity** | mg/l | 47 | 29 |
| | lbs/day | 14136 | 7875 |
| | lbs/day/mi$^2$ | 642 | 445 |
| **Phosphate P** | mg/l | **0.07** | **< 0.02** |
| | lbs/day | 21 | |
| | lbs/day/mi$^2$ | 0.96 | |
| **Sulfate** | mg/l | 13.2 | 10.6 |
| | lbs/day | 3969.3 | 2878.24 |
| | lbs/day/mi$^2$ | 180.42 | 162.61 |
| **Sodium** | mg/l | 6.3 | 4.8 |
| | lbs/day | 1894.46 | 1303.35 |
| | lbs/day/mi$^2$ | 86.1 | 73.63 |
| **Chloride** | mg/l | 23.1 | 10.3 |
| | lbs/day | 6946.36 | 2796.78 |
| | lbs/day/mi$^2$ | 315.7 | 158 |
| **Calcium** | mg/l | 15.7 | 12.1 |
| | lbs/day | 4721.11 | 3285.54 |
| | lbs/day/mi$^2$ | 214.6 | 185.6 |
| **Iron** | mg/l | 0.19 | 0.2 |
| | lbs/day | 57.1 | 54.31 |
| | lbs/day/mi$^2$ | 2.6 | 3.1 |
| **Magnesium** | mg/l | 5.3 | 3.8 |
| | lbs/day | 1594 | 1031.8 |
| | lbs/day/mi$^2$ | 72.4 | 58.3 |
| **Zinc** | mg/l | 9 | 15 |
| | lbs/day | 2706 | 4073 |
| | lbs/day/mi$^2$ | 123 | 230 |

## Appendix C

*Longitudinal Profile, Nitrate, Little Northkill and Northkill Sub-watersheds*



*Prepared by Charles A Cravotta III, Ph.D., P.G.*
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215 Limekiln Rd.
New Cumberland, PA 17070

## Appendix D

*Fish species identified during ecological surveys of Northkill Cr., Berks Co., Pa., Oct. 2003*[4]

| Taxa | | Minimum pH in PA[5] | Pollution Tolerance[6] | Birch Creek | Birch Creek | Northkill Creek | Northkill Creek | Northkill Creek |
|---|---|---|---|---|---|---|---|---|
| ORDER<br>Family<br>*Genus species* | Common Name | | | B1 | B2 | N1 | N2 | N7 |
| CYPRINIFORMES | | | | | | | | |
| Cyprinidae | | | | | | | | |
| *Cyprinella analostana* | Spotfin shiner | 6.4 | M | 0 | 0 | 0 | 0 | 5 |
| *Exoglossum maxillingua* | Cutlips minnow | 6.1 | I | 0 | 9 | 0 | 0 | 57 |
| *Luxilus cornutus* | Common shiner | 6.0 | M | 0 | 0 | 0 | 0 | 22 |
| *Notropis hudsonius* | Spottail shiner | 6.4 | M | 0 | 0 | 0 | 0 | 1 |
| *Pimephales notatus* | Bluntnose minnow | 5.6 | T | 0 | 0 | 0 | 0 | 8 |
| *Rhinichthys atratulus* | Blacknose dace | 5.6 | T | 0 | 164 | 4 | 20 | 44 |
| *Rhinichthys cataractae* | Longnose dace | 5.9 | I | 0 | 0 | 0 | 0 | 6 |
| *Semotilus atromaculatus* | Creek chub | 5.2 | T | 0 | 15 | 0 | 4 | 5 |
| Catostomidae | | | | | | | 0 | |
| *Catostomus commersoni* | White sucker | 4.6 | T | 0 | 1 | 0 | 1 | 65 |
| SILURIFORMES | | | | | | | | |
| Ictaluridae | | | | | | | | |
| *Noturus insignis* | Margined madtom | 5.9 | M | 0 | 0 | 0 | 0 | 3 |
| ANGUILLIDAE | | | | | | | | |
| Anguillidae | | | | | | | | |
| *Anguilla rostrata* | American eel | 6.4 | M | 0 | 0 | 0 | 1 | 0 |
| CYPRINODONTIDAE | | | | | | | | |
| Fundulidae | | | | | | | | |
| *Fundulus diaphanus* | Banded killifish | 6.5 | T | 0 | 1 | 0 | 0 | 0 |
| SALMONIFORMES | | | | | | | | |
| Salmonidae | | | | | | | | |
| *Salmo trutta* | Brown trout | 5.9 | M | 0 | 0 | 0 | 24 | 1 |
| *Salvelinus fontinalis* | Brook trout | 5.0 | M | 24 | 0 | 28 | 14 | 0 |
| PERCIFORMES | | | | | | | | |
| Centrarchidae | | | | | | | | |
| *Ambloplites rupestris* | Rock bass | 6.0 | M | 0 | 0 | 0 | 0 | 2 |
| *Lepomis cyanellus* | Green sunfish | 6.4 | T | 0 | 0 | 0 | 1 | 0 |
| *Micropterus salmoides* | Largemouth bass | 4.7 | M | 0 | 1 | 0 | 0 | 0 |
| Percidae | | | | | | | | |
| *Etheostoma olmstedi* | Tessellated darter | 5.9 | M | 0 | 10 | 0 | 0 | 13 |
| **Total number of individuals collected:** | | | | **24** | **201** | **32** | **65** | **232** |
| Total number of species identified: | | | | **1** | **7** | **2** | **7** | **13** |

4Fish collected and identified by M. D. Bilger and R. A. Brightbill, USGS
5Minimum pH of occurrence in freshwater in Pennsylvania as reported by Butler, *et al* (1973).
6Pollution tolerance: I (intolerant), M (moderate), T (tolerant), adapted from Barbour, *et al* (1999).

## Appendix E

*Comparison of Presence/Absence of Fish Species in 2003 USGS Study with 1985 Exceptional Value Status Study*

| | | | | | Little Northkill sub-watershed | | Northkill sub-watershed | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | B1 | B3 | PFBC 0101 | | | | N1, also PFBC 0102 | | | | | | N2 also PFBC 0103 | | | | | | N7 also PFBC 0302 |
| | | Minimum pH in PA7 | Pollution Tolerance8 | Stream Order Mean ± SD[9] | *2003* | *2003* | *1982* | *1983* | *1984* | *1985* | *1977* | *1982* | *1983* | *1984* | *1985* | *2003* | *1977* | *1982* | *1983* | *1984* | *1985* | *2003* | *2003* |
| CYPRINIFORMES Cyprinidae | | | | | | | | | | | | | | | | | | | | | | | |
| *Cyprinella analostana* | Spotfin shiner | 6.4 | M | 3.7±1.1 | | | | | | | | | | | | | | | | | | | X |
| *Exoglossum maxillingua* | Cutlips minnow | 6.1 | I | 3.5±1.3 | | X | | | | | | | | | | | X | X | X | X | X | | X |
| *Luxilus cornutus* | Common shiner | 6.0 | M | 3.2±1.0 | | | | | | | | | | | | | | | | | | | X |
| *Notropis hudsonius* | Spottail shiner | 6.4 | M | 3.6±1.0 | | | | | | | | | | | | | | | | | | | X |
| *Pimephales notatus* | Bluntnose minnow | 5.6 | T | 3.5±1.1 | | | | | | | | | | | | | | | | | | | X |
| *Notemigonus crysoleucas* | Golden Shiner | | | 3.7±1.2 | | | | | | | | X | | | | | | | | | | | X |
| *Rhinichthys atratulus* | Blacknose dace | 5.6 | T | 2.7±1.1 | | X | | | | | X | | X | X | | X | X | X | X | X | X | X | X |
| *Rhinichthys cataractae* | Longnose dace | 5.9 | I | 3.2±1.0 | | | | | | | X | | | | | | X | X | X | X | X | | X |
| *Semotilus atromaculatus* | Creek chub | 5.2 | T | 2.5±1.1 | | X | | | | | X | | | | | | X | X | X | X | X | X | X |

7 Reported by Butler, *et al* (1973)

8 Adapted from Barbour, *et al* (1999).

[9] Reported in Fairchild, *et al* (1997).

## Appendix F

*Macroinvertebrate Analysis with VA SOS Multimetric Index, Northkill Creek Watershed*

| | Northkill sub-watershed | | | Little Northkill sub-watershed | | |
|---|---|---|---|---|---|---|
| **Map ID** | *N1* | *N2* | *N5* | *B1* | *B2* | *LN3* |
| **Location Description** | *Upstream Northkill Cr* | *Above I-78 Northkill Cr* | *Northkill Cr above Wolf Cr* | *Birch Cr above Bloody Spring Rd* | *Birch Cr at Anthony's Mill below Rte 183* | *Little Northkill Cr near Bernville, PA* |
| **Total # of Organisms** | 103 | 115 | 99 | 106 | 106 | 102 |
| **Total # of Taxa** | 12 | 10 | 11 | 10 | 12 | 14 |
| **% EPT Taxa** | 52% | 61% | 37% | 58% | 45% | 39% |
| **# of EPT Individuals** | 54 | 70 | 37 | 61 | 47 | 40 |
| **% Common Netspinners** | 17% | 20% | 31% | 15% | 17% | 3% |
| **% Lunged Snails** | 0% | 1% | 1% | 0% | 0% | 0% |
| **% Beetles** | 1% | 4% | 18% | 2% | 18% | 8% |
| **% Tolerant** | 10% | 7% | 10% | 14% | 9% | 36% |
| **# of Tolerant Individuals** | 10 | 8 | 10 | 15 | 9 | 37 |
| **% Non-Insects** | 3% | 0% | 6% | 8% | 4% | 27% |
| ***Multimetric Index Score**** | ***9*** | ***10*** | ***9*** | ***9*** | ***12*** | ***10*** |

* (0-6 Unacceptable ecological condition; 7-12 Acceptable ecological condition)

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