

FINAL REPORT

Lake Galena & North Branch Neshaminy Creek Watershed Implementation Plan



September 24, 2010

Prepared by:

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**Bucks County
Conservation District**

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Photograph of Lake Galena on a cool October morning in 2005. The Bucks County Conservation District and its consultant, Aqua Link, monitored the water quality of the lake from April through October in 2005. Photograph taken by Ed Molesky of Aqua Link.

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Acknowledgements

The Lake Galena and North Branch Neshaminy Creek Watershed Implementation Plan (WIP) Project would not be possible without the financial support of the Pennsylvania Department of Environmental Protection (PA DEP) and the U.S. Environmental Protection Agency (US EPA) through the federal Section 319 Nonpoint Source Grant Program.

Aqua Link would like to thank the County Commissioners and the District Board of Directors for their support of this project, thereby allowing the District to serve as the Project Sponsor and contributing author of the final report. Once again, Aqua Link commends their strong commitment for protecting and restoring the water resources of Bucks County.

Aqua Link would also like to thank Gilmore and Associates, Inc. for their assistance in assessing major stormwater management facilities for this project. Lastly, Aqua Link would like to especially thank Ms. Gretchen Schatschneider, Ms. Meghan Rogalus and Ms. Rachel Onuska of the Bucks County Conservation District for all of their hard work and time that they dedicated towards this project. Special thanks are also extended to Mr. Stephen Lathrop of PA DEP for all his assistance throughout the duration of this project.



Edward W. Molesky, CLM

President
Aqua Link, Inc.

Executive Summary

Lake Galena, a 365-acre county owned impoundment, is located approximately 3 miles northwest of downtown Doylestown and serves as the focal point of Peace Valley Park. The lake was created back in 1974 by constructing an earthen dam across the North Branch of the Neshaminy Creek. Lake Galena was built for flood control, water supply and recreation. Drinking water is drawn from the North Branch Neshaminy Creek (NBNC) approximately two miles downstream of the Lake Galena outfall. Raw surface water is treated at the Forest Park water facility and supplies water to about 150,000 people in Bucks and Montgomery Counties.

In order to further protect and improve the water quality of the North Branch Neshaminy Creek and Lake Galena, the Bucks County Conservation District and its consultant, Aqua Link, performed the Lake Galena & North Branch Neshaminy Creek Watershed Implementation Plan (WIP) Project. This project was performed from November 2007 through September 2009. The PA DEP and the U.S. EPA provided funding for this project through the federal Section 319 Nonpoint Source Program.

The primary goal of this WIP project was to update the watershed management plan that was developed as part of the 1995 Phase I Diagnostic-Feasibility Study for Lake Galena. Since the mid-1990's, the District and others have observed substantial population growth in Central Bucks County. This rapid growth has resulted in vast amounts of land development throughout the watershed. Based upon these changes in land use, many believe that the management plan in the Phase I Study is outdated and it needed to be updated.

The Phase I Study revealed that Lake Galena was highly hyper-eutrophic in 1992-1993. The lake contained very high nutrient (phosphorus and nitrogen) concentrations resulting in very poor water clarity (transparency) due to the occurrence of noxious blue-green algal blooms. The deeper lake waters were essentially devoid of dissolved oxygen during most of the summer recreation season. The study determined that most of the nutrients and sediments to the lake were of nonpoint source origin from agricultural lands uses. Based upon this study, Lake Galena was placed on the State's 303(d) List of Impaired Waters.

The major tasks of this Lake Galena & North Branch Neshaminy Creek Watershed Implementation Plan project were as follows:

- To reassess active farming operations and to determine where additional agricultural BMPs are required.

- To assess the North Branch Neshaminy Creek for severe streambank erosion and to determine where stream stabilization BMPs are needed.
- To evaluate the condition of riparian buffers and to determine where riparian corridor restoration is required.
- To identify all major stormwater management facilities and to determine if any of these facilities can be retrofitted for water quality.
- To assess historical and newly acquired lake water quality data in order to more accurately determine whether the water quality of the lake has improved, degraded or remained unchanged.
- To estimate the current nutrient and sediment loadings via major tributaries to the lake.
- To estimate nonpoint source loadings of phosphorus, nitrogen and suspended solids (sediment) to Lake Galena using the AVGWLF (ArcView Generalized Watershed Loading Function) model.
- To estimate potential phosphorus, nitrogen and sediment loading reductions by implementing best management practices throughout the Lake Galena watershed using the PRedICT model.

The assessment portion of this WIP project has identified an extensive list of best management practices (BMPs) for future implementation. This list includes 12 different farms requiring agricultural BMPs, 21 stormwater management (SWM) facilities that can be retrofitted to improve water quality in residential housing developments, and approximately 3.4 miles of streambanks and riparian areas requiring stabilization and rehabilitation along the North Branch Neshaminy Creek.

Watershed modeling efforts (AVGWLF and PRedICT models) estimated that the total cost to implement all of the BMPs listed in this report is nearly \$2,600,000. These models have determined that roughly 5, 19 and 71 percent of the total cost would be allocated for the implementation of agriculture, urban (stormwater) and streambank protection BMPs, respectively.

The overall success of this watershed implementation plan will require a strong partnership and additional funding. First, this project will only succeed if existing partnerships are strengthened. The partners must remain committed over the long haul in protecting and further improving the water quality of the North Branch Neshaminy Creek and Lake Galena. At a minimum, the partnership should include the District, the North Branch Watershed Association, NRCS, the Bucks County Department of Parks and Recreation, the North Penn and North Wales Water Authorities, the PA

Fish and Boat Commission, PA DEP, PECO, local municipalities, local homeowners associations, local farmers and local sportsman groups.

With respect to future project needs, PA DEP, the District and its partners should continue monitoring the water quality of Lake Galena and its tributaries. The District and NRCS should continue working closely with farmers to identify additional agricultural lands requiring BMPs. In addition, stream and riparian assessments should be performed on the Hardiacken Creek and other tributaries to Lake Galena and lastly, the entire shoreline of Lake Galena should be assessed. All severely eroding lake banks should be stabilized using natural bioengineered techniques.

1. Introduction

Lake Galena (40.3173° N, 75.2034° N), a 365-acre county owned impoundment, is located approximately 3 miles northwest of downtown Doylestown and serves as the focal point of Peace Valley Park (Figure 1.1). The park is owned and maintained by the Bucks County Department of Parks and Recreation. The lake (PA 617) was created in 1974 by constructing an earthen dam across the North Branch of the Neshaminy Creek. Lake Galena was built under Public Law 566 and funded through the Soil Conservation Service (now known as the Natural Resources and Conservation Service, NRCS) for flood control, water supply and recreation. Drinking water is drawn from the North Branch Neshaminy Creek (NBNC) approximately two miles downstream of the Lake Galena outfall. Raw surface water is treated at the Forest Park water facility, which is jointly owned by North Penn and North Wales Water Authorities. This facility supplies water to about 52,000 households or about 150,000 people in Bucks and Montgomery Counties.

The lake and its surrounding parkland are open year round and provide park visitors with a wide variety of recreational opportunities including fishing, boating and picnicking. Walking, jogging and cycling are popular pastime activities since the park contains an improved pathway around the entire lake. The Peace Valley Nature Center is located within the park at the most northern end of the lake (Figure 1.1). This facility offers a wide variety of environmental education opportunities for children and adults alike. In addition, the PA Fish and Boat Commission manage the lake as a warmwater/coolwater fishery. The commission routinely stocks the lake with walleye, channel catfish and striped bass fingerlings.

In 1995, the North Penn and North Wales Water Authorities jointly completed a comprehensive Phase I Diagnostic-Feasibility Study for Lake Galena and its surrounding watershed (F.X. Browne, Inc. 1995). PA DEP and the U.S. EPA funded this Phase I Study through the federal Clean Lakes Program (Section 314 of the Clean Water Act of 1972). The water quality data that were reported in this study revealed that Lake Galena was highly hyper-eutrophic in 1992-1993. The lake contained very high nutrient (phosphorus and nitrogen) concentrations resulting in very poor water clarity (transparency) due to the occurrence of noxious blue-green algal blooms. The deeper lake waters were essentially devoid of dissolved oxygen during most of the summer recreation season. The study determined that most of the nutrients and sediments to the lake were of nonpoint source origin from agricultural lands uses. Based upon this study, Lake Galena was placed on the State's 303(d) List of Impaired Waters (F.X. Browne, Inc., 2005).

Since the Phase I Study, the Bucks County Conservation District and NRCS installed agricultural best management practices (BMPs) on eleven different farms in the Lake Galena watershed during the mid 1990's. The Nonpoint Source Program (Section 319 of the Clean Water Act of 1972) provided \$126,113 for installing these BMPs and local farmers provided an additional \$88,279 as a cost share match to this federal grant.

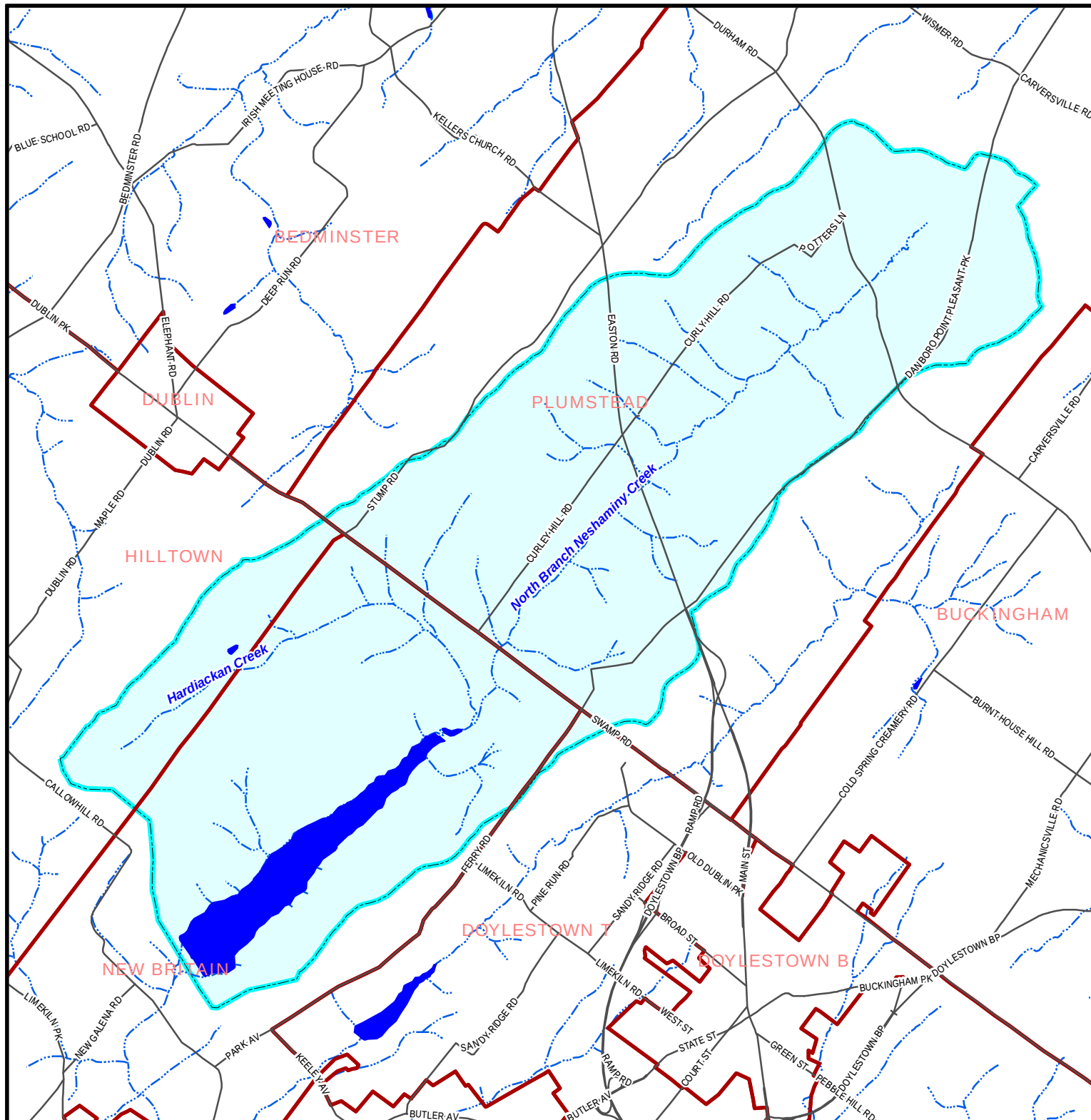


FIGURE 1.1
Political Boundaries of the
Lake Galena Watershed

Lake Galena
Watershed Assessment

January 13, 2010

Aqua Link, Inc.
Water Resources & Watershed Management



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- Lake Galena Watershed Boundary
- Municipal Boundary
- State Road
- Stream



0 1 2
Miles

In 2002, a TMDL (Total Maximum Daily Loading) assessment was completed for the entire Neshaminy Creek watershed, which includes the North Branch and Lake Galena. As noted in this assessment, the Lake Galena watershed has experienced a significant increase in residential development over the last 5-10 years, which has been identified as an important source of sediment to the lake during this time period. According to Pennsylvania's 303(d) list, the lake is being impaired by nutrients and suspended solids from various sources, including on-site wastewater, agriculture, urban runoff/storm sewers, and others (PA DEP 2003).

Since Pennsylvania does not currently have numeric water quality standards for nutrients or suspended solids, the overall goal of this TMDL is to improve the trophic status of Lake Galena from hyper-eutrophic to mesotrophic. Based on this goal, the water quality target to address the stated impairments has been set at 10 ug/l of chlorophyll-a. A combined watershed/lake water modeling approach was used to estimate current nutrient and sediment loads to the lake as well as to estimate phosphorus reductions needed to achieve the chlorophyll-a target of 10 ug/l (PA DEP 2003). Based on the modeling, it was estimated that the current annual phosphorus load of 3,909 kg/yr (1,776.8 lbs/yr) would have to be reduced to 1,127 kg/yr (512.3 lbs/yr) in order to achieve the chlorophyll-a target of 10 µg/l. With an additional 10% margin of safety (MOS) factor, this target phosphorus load is further reduced to 1,014.3 kg/yr (461.0 lbs/yr).

In agreement with the TMDL assessment, the District and others have observed substantial population growth in Central Bucks County since the 1995 Phase I Study. This rapid growth has resulted in a vast amount of land development throughout the Lake Galena and North Branch Neshaminy Creek watershed. Some active farms are now classified as inactive, while others have been converted to residential housing developments and commercial business centers. Based upon these land use changes, many have suspected that the management plan in the Phase I Study for the North Branch and Lake Galena watershed (F.X. Browne, Inc., 1995) is outdated and needs to be updated. For example, it was unclear if agriculture is still the major source of nonpoint pollution to the lake and its tributaries. In addition, it is suspected that stormwater runoff, streambank erosion and the lack of adequate riparian buffers may be significant nonpoint sources of nutrients and sediments. These three potential sources of nonpoint pollution were not specifically evaluated during the 1995 Phase I Study.

In order to update the watershed management plan, the Bucks County Conservation District applied for and received federal funding to perform the Lake Galena & North Branch Neshaminy Creek Watershed Implementation Plan (WIP) Project. The PA DEP and the U.S. EPA provided funding for this project through the federal Section 319 Nonpoint Source Program. The District and its consultant, Aqua Link of Doylestown, PA, performed this WIP project from November 2007 through September 2009. The primary tasks of this project were:

- To reassess all active farming operations and to determine where additional agricultural BMPs are required.

- To assess the North Branch Neshaminy Creek for severe streambank erosion and to determine where stream stabilization BMPs are needed.
- To evaluate the condition of riparian buffers and to determine where riparian corridor restoration is required.
- To identify all major stormwater management facilities and to determine if any of these facilities can be retrofitted for water quality.
- To assess historical and newly acquired lake water quality data in order to more accurately determine whether the water quality of the lake has improved, degraded or remained unchanged.
- To estimate the current nutrient and sediment loadings via major tributaries to the lake.
- To estimate nonpoint source loadings of phosphorus, nitrogen and suspended solids (sediment) to Lake Galena using the AVGWLF (ArcView Generalized Watershed Loading Function) model developed by the Pennsylvania State University (Penn State).
- To estimate potential phosphorus, nitrogen and sediment loading reductions achieved from implementing selected best management practices throughout the Lake Galena watershed using the PRedICT model developed by Penn State.

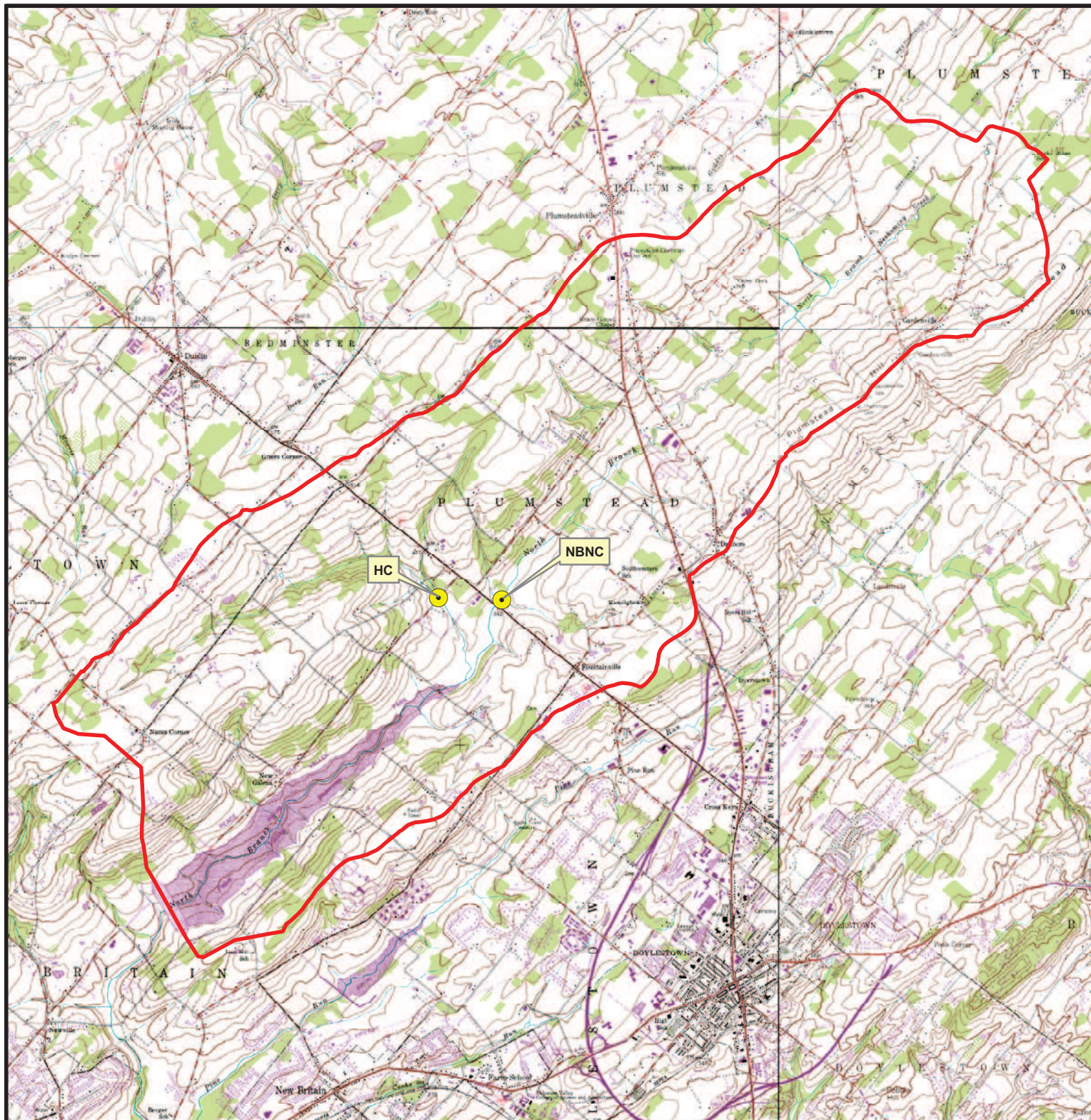


FIGURE 2.1
Topographic Base Map of
the Lake Galena Watershed

Lake Galena
Watershed Assessment

January 13, 2010

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- Watershed Boundary
- Stream Sampling Station



0 1 2
Miles

2. Lake and Watershed Characteristics

This section primarily discusses the physical characteristics of Lake Galena and its surrounding watershed. The information provided below is frequently cited throughout the remainder of this report.

2.1. Lake Characteristics

The morphological characteristics of Lake Galena are summarized in Table 2.1. Overall, Lake Galena is considered a slender, triangularly shaped impoundment along the North Branch Neshaminy Creek (Figures 2.1 and 2.2). The reservoir is moderately deep, which allows it to thermally stratify during the growing season (May through September). The deepest waters are located in the vicinity of the dam, which is located at the southern end of this reservoir. Conversely, the upper section of the reservoir is much shallower and narrower. The Peace Valley Nature Center is located along the northern shoreline of the lake.

According to PA DEP's *Chapter 93: Water Quality Standards* (www.pacode.com/secure/data/025/chapter93 on September 1, 2009), Lake Galena is classified as WWF (Warmwater Fishes) and MF (Migratory Fishes). The lake contains a variety of warmwater and some coolwater fish species including largemouth bass, striped bass, walleye, crappie (black and white), channel catfish, bullheads (brown and yellow) and an over abundance of white perch. The lake contains little structure (e.g. rock piles, timber, tree stumps) and few if any aquatic plants, which is often typical for flood control impoundments. The lack of aquatic vegetation may be attributed to annual lake water level drawdowns during the winter months and the occurrence of large algal blooms during the growing season. In general, winter water level drawdowns are performed to provide additional storage capacity for attenuating spring runoff.

Table 2.1 Morphologic Characteristics of Lake Galena

<i>Parameter</i>	<i>Lake Galena</i>
Lake Surface Area (A_0) – normal	365 ac (148 ha)*
Lake Surface Area (A_0) – high water	365 ac (148 ha)*
Lake Volume	55,128 ac-feet ($2.4 \times 10^9 \text{ ft}^3$, $6.8 \times 10^7 \text{ m}^3$, or 1,822 MG)*
Mean Water Depth (Z_{mean})	15 ft (4.6 m)*
Maximum Water Depth (Z_{max})	42 ft (12.8 m)*
Watershed to Lake Ratio	27 to 1 (27:1)**

* Diagnostic Feasibility Study of Lake Galena (F.X. Browne, Inc., 1995)

** Determined by Aqua Link, Inc. as part of this project



FIGURE 2.2
Orthophoto Map of the
Lake Galena Watershed

Lake Galena
 Watershed Assessment

January 13, 2010

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0 1 2
 Miles

2.2. Watershed Characteristics

Specific data (hydrology, topography, roadways, soils and land use) for the Lake Galena watershed were obtained from a variety of sources. These data were then analyzed using ArcView GIS (geographical information system) software with the Spatial Analyst module.

The Lake Galena watershed, which is 9,922 acres (15.5 square miles) in size, lies primarily within New Britain and Plumstead Townships (Figures 1.1, 2.1 and 2.2). The lake completely falls within New Britain Township, while most of the North Branch Neshaminy Creek and its headwaters are located in Plumstead Township (Figure 1.1). Small portions of the watershed also fall within Hilltown and Doylestown Townships (Figure 1.1).

2.2.1. Hydrology

The main tributary to Lake Galena is the North Branch Neshaminy Creek. This stream flows in a southwesterly direction into the northern section of Lake Galena (Figures 2.1 and 2.2). The headwaters of the North Branch are located in Plumstead Township near the intersection of Point Pleasant Pike and Moyer Road.

The North Branch also receives supplemental surface water from the Delaware River via the Point Pleasant Pump Station. The pump station, which is owned and operated by North Penn and North Wales Water Authorities, is used to augment flows during low flow conditions. This surface water withdrawal is permitted and regulated by the Delaware River Basin Commission (PA DEP 2003).

In addition, Lake Galena receives flow from several other smaller tributaries. The largest of these tributaries is the Hardiacken Creek. The Hardiacken Creek drains the southwestern portion of the watershed and discharges directly into the lake in close proximity to the North Branch. The headwaters of this stream are located in Hilltown Township along Upper Stump Road. From the dam of Lake Galena, the North Branch continues to flow southerly for about 2.5 miles and discharges into the Neshaminy Creek just south of Chalfont. Thereafter, the Neshaminy Creek meanders southeasterly across Bucks County and eventually discharges into the Delaware River near Bensalem.

Forest Park Water (Forest Park Water Treatment Plant) provides water to the North Penn and North Wales Water Authorities, which serve customers in Bucks and Montgomery Counties. The North Penn Water Authority (NPWA) serves about 27,000 customers in 13 municipalities. The North Wales Water Authority (NWWA) serves about 25,000 customers in 7 municipalities in two counties. Overall, Forest Park Water supplies an average of 13.5 million gallons per day (MGD) to an approximate combined population of 150,000 served by both authorities. The intake of Forest Park Water in the North Branch is located about 1.9 miles downstream of the Lake Galena dam in Chalfont Borough (PA DEP 2003).

According to PA DEP's *Chapter 93: Water Quality Standards* (www.pacode.com/secure/data/025/chapter93 on September 1, 2009), the Neshaminy Creek (source water to Lake Galena) and Lake Galena are classified as WWF (Warmwater Fishes) and MF (Migratory Fishes).

2.2.2. Topography

In general, the topography of the Lake Galena watershed consists of rolling low hills and valleys. The elevation of Lake Galena is 321 feet above MSL (mean sea level) as shown in Figure 2.2. The highest elevations are found along the western watershed boundary divide. The highest elevation, which is 642 feet, is located near the intersection Swamp Road (Route 313) and Upper Stump Road in Plumstead Township (Figures 1.1 and 2.1).

2.2.3. Geology and Soils

The Lake Galena watershed entirely lies within the Gettysburg-Newark Lowland Section of the Piedmont Province. This section consists mainly of rolling low hills and valleys developed on red sedimentary rock. There also are isolated higher hills developed on diabase, baked sedimentary rock (hornfels) and conglomerates. Almost all of the underlying sedimentary rock dips to the north or northwest and many of the smaller drainage ways are oriented normal to the direction of dip so that some of the topography has a northeast-southwest linearity. However, the basic drainage pattern is dendritic.

Soils are usually red and often have a visually striking contrast to the green of vegetation. Relief is generally in the area of 100 to 200 feet, but locally is up to 600 feet on some of the isolated hills. Elevation in the Section ranges from 20 to 1,355 feet. The Section is made up of sedimentary rocks that were deposited in a long, narrow, inland basin that formed when the continents of North America and Africa separated more than 200 million years ago (PA DCNR 2005).

With respect to soils, a total of fifty-two soil types representing twenty-nine different soil series are located throughout the Lake Galena watershed as shown in Figure 2.3. Of this total, six of the twenty-nine soil series, when combined, represent 76 percent of all soils within the watershed. The six most frequently occurring soil series in the Lake Galena watershed are listed in Table 2.2.

Information about the most abundant soils in the watershed is presented below. Soil descriptions were obtained at the USDA NRCS National Soil Survey Center website (www.ortho.ftw.nrcs.usda.gov). For more information about the soils in the watershed, refer to Appendix A of this report.

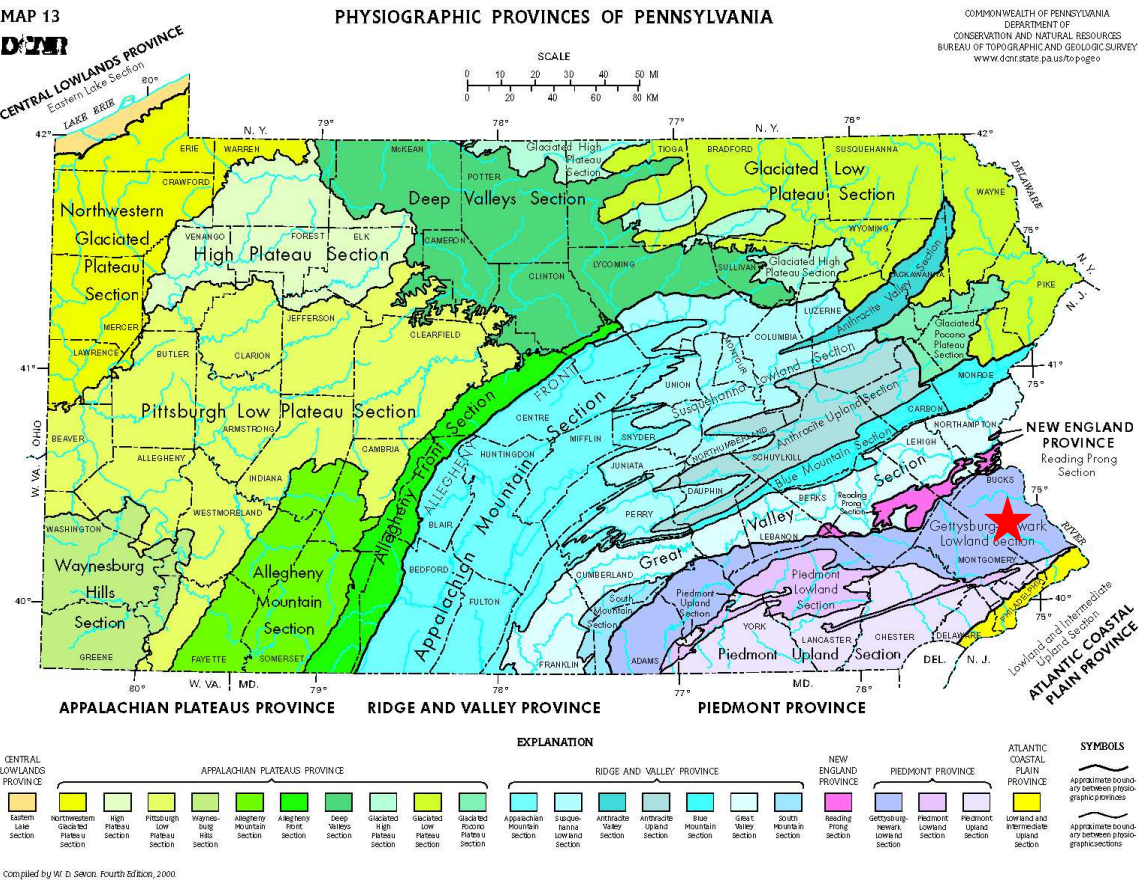


Table 2.2 Major Soil Series in the Lake Galena Watershed

Soil Series	Percent
Abbottstown silt loam	31.4
Croton silt loam	14.7
Readington silt loam	11.1
Amwell silt loam	7.9
Doylestown silt loam	5.8
Reaville channery silt loam	5.1
Total	76.0

Abbottstown Series

Soils are classified as deep, somewhat poorly drained soils. These soils are on nearly level to sloping concave upland flats, depressions and drainageways. Slopes range from 0 to 15 percent. These soils formed in residuum weathered from noncalcareous red shale, siltstone, and fine-grain sandstone. Soils associated with these soils are Bucks, Chalfont, Croton, Doylestown, Klinesville, Lawrenceville, Penn, Readington and Reaville soils. Drainage and permeability is somewhat poorly drained. Permeability is moderate above the fragipan and slow in and below the fragipan. Runoff class is medium on nearly level slopes, high on gentle slopes and very high on strongly sloping or moderately steep areas. Approximately 85 percent of the Abbottstown soils are used for cropland and pasture. Wooded areas consist of mostly hardwoods, mainly hickory and oak.

Croton Series

The Croton series consists of deep, poorly drained soils on nearly level and sloping upland flats. These soils formed in medium textured materials mainly over sandstone, siltstone, or shale. Slopes are 0 to 8 percent. These are the better drained than Abbottstown, Readington and Chalfont soils which are on the more sloping areas adjacent to the Croton soils on level areas or depressions. Overall, Croton soils are poor in drainage. Runoff is slow and permeability is slow in the fragipan. Excess water is perched above the fragipan in late winter and early spring but this has been used or has evaporated by summer. These soils are often associated with pin oak, white oak, ash, beech and red maple. Cleared areas are used mostly as pasture, hayland or are idle. A small part is used for growing corn.

Readington Series

The Readington series consists of deep and very deep, moderately well drained soils occurring on concave, nearly level to sloping lower hillsides, upland flats, drainage ways, and stream heads. The soils formed in medium textured residuum largely from reddish noncalcareous shale, siltstone, and fine-grained sandstone. Slopes range from 0 to 15 slopes. Permeability is moderately slow. Readington soils are in the same landscape as the Abbottstown, Athol, Bucks, Chalfont, Croton, Doylestown, Klinesville, Lansdale, Lawrenceville, Lewisberry, Penn, and Reaville soils. Approximately 85 percent of these soils are used as cropland. Woodland areas are oak-hickory mixed hardwoods.

Amwell Series

The Amwell series consists of deep and very deep, somewhat poorly and moderately well drained soils on uplands. They formed mainly in colluvial material derived from basic igneous rocks. Slopes range from 0 to 15 percent. Soils commonly associated with Amwell soils are Mount Lucas, Neshaminy, Norton, Parsippany, Penn, Towhee, Watchung, and Whippany soils. Dominant use for

these soils is woodland. Common trees are pin oak, red maple, elm, ash, and red oak. Few areas have been cleared and used for pasture or cultivated crops.

Doylestown Series

Soils are classified as deep and poorly drained. The permeability of these soils is moderate in the upper part of the solum and slow to moderately slow in the lower part. These soils are located along foot slopes and toe slopes of nearly level to gently undulating drainageways and broad basins. The parent materials of these soils are silty materials, presumably loess, over soil materials weathered from a variety of parent materials, but principally red shale. Slopes range from 0 to 8 percent and these soils are often associated with Chalfont, Lawrenceville, Bowmansville, and Buckingham, Fountainville, Duncannon, Nockamixon and Amwell soils. Approximately 50 percent of the Doylestown soils are in cropland and the remainder in woodland, pasture or nonfarm uses. Wooded areas consist of water tolerant mixed hardwoods.

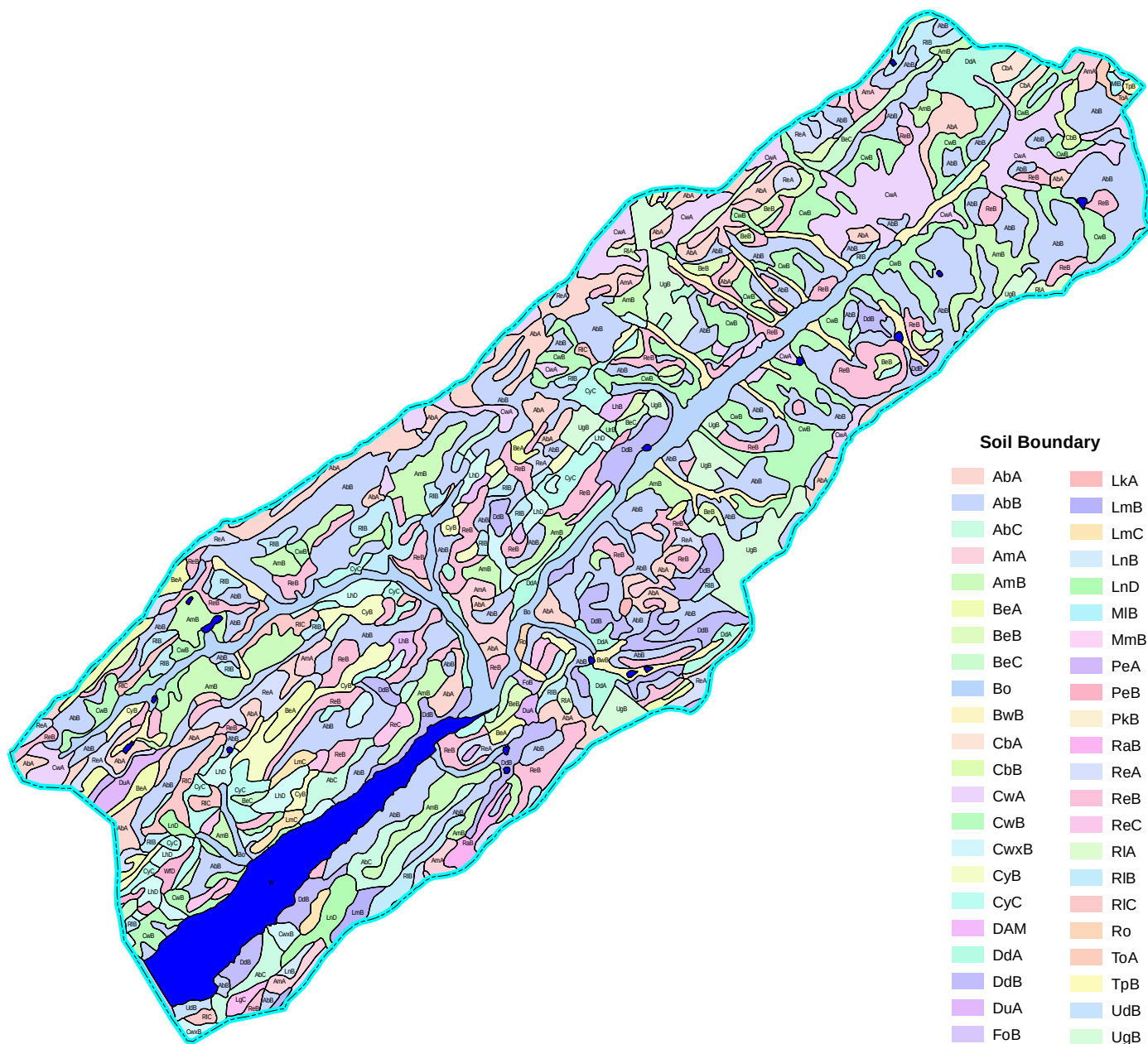
Reaville Series

The Reaville series consists of moderately deep, moderately well, and somewhat poorly drained soils formed in residuum weathered from red Triassic, interbedded shale, siltstone, and fine-grained sandstone. Slopes range from 0 to 15 percent. Permeability is slow. Surface runoff is medium to slow. Soils associated with Reaville soils include Abbottstown, Croton, Klinesville, Lansdale, Penn, Readington and Teas series. Moderately well and somewhat poorly drained. Most of the Reaville soils are cleared and cultivated. Hay, small grain, and corn are the principal crops, and some areas are in pasture. General farming and dairy farming are the main enterprises. The native vegetation was mixed hardwoods, predominantly oaks.

2.2.4. Land Use

The Lake Galena watershed is best described as a rural, agricultural watershed intermixed with woodlots (forest) and residential housing developments (Tables 2.3 and Figure 2.4). In 2000, the most dominant land uses were forest and agriculture. Forest (deciduous, coniferous and mixed) and agricultural (row crops, hay and pasture) land uses accounted for 38 and 36 percent of all land uses, respectively. In addition, urban and commercial lands represented about 16 percent of the lands in 2000. Most of the urban lands in the watershed consist of residential housing developments consisting of single family dwellings.

Changes in land use from 1992 to 2000 are presented and graphically shown in Table 2.4 and Figure 2.6, respectively. Table 2.4 and Figure 2.6 show that urban land uses dramatically increased from about 2 to 16 percent in only 8 years. Urbanization primarily occurred at the expense of both



Soil Boundary

AbA	LkA
AbB	LmB
AbC	LmC
AmA	LnB
AmB	LnD
BeA	MIB
BeB	MmB
BeC	PeA
Bo	PeB
BwB	PkB
CbA	RaB
CbB	ReA
CwA	ReB
CwB	ReC
CwxB	RIA
CyB	RIB
CyC	RIC
DAM	Ro
DdA	ToA
DdB	TpB
DuA	UdB
FoB	UgB
KIB	UrB
LgB	UyB
LgC	UzcB
LhB	W
LhD	WfD

FIGURE 2.3
Soils in the
Lake Galena Watershed

Lake Galena
Watershed Assessment

January 13, 2010

Aqua Link, Inc.
Water Resources & Watershed Management



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Watershed Boundary



0 1 2
Miles

forest and agriculture lands. The increase in wetlands and open waters are likely due to the construction of stormwater treatment basins at these housing developments. For more information, refer to Appendix A of this report.

Table 2.3 Land Uses in the Lake Galena Watershed in 2000

<i>Land Use</i>	<i>Area (acres)</i>	<i>Percent</i>
Deciduous Forest	2,859.2	28.8%
Hay/Pasture	2,149.3	21.7%
Row Crops	1,466.5	14.8%
Low Density Mixed (Urban)	1,381.5	13.9%
Mixed Forest	859.6	8.7%
Water	414.8	4.2%
Transitional	411.5	4.1%
Mined Land (Commercial)	121.5	1.2%
Coniferous Forest	107.6	1.1%
Woody Wetland	70.2	0.7%
High Density Mixed (Urban)	54.2	0.5%
Emergent Wetland	25.7	0.3%
Total	9,921.6	100.0%

Table 2.4 Land Uses in the Lake Galena Watershed in 1992 & 2000

<i>Land Use</i>	<i>Percent 1992</i>	<i>Percent 2000</i>
Urban/Commercial	2.2	15.7
Forest	44.9	38.6
Agriculture	49.0	36.4
Wetlands	0.3	1.0
Transitional	0.0	4.1
Open Water	3.8	4.2
Total	100.0%	100.0%

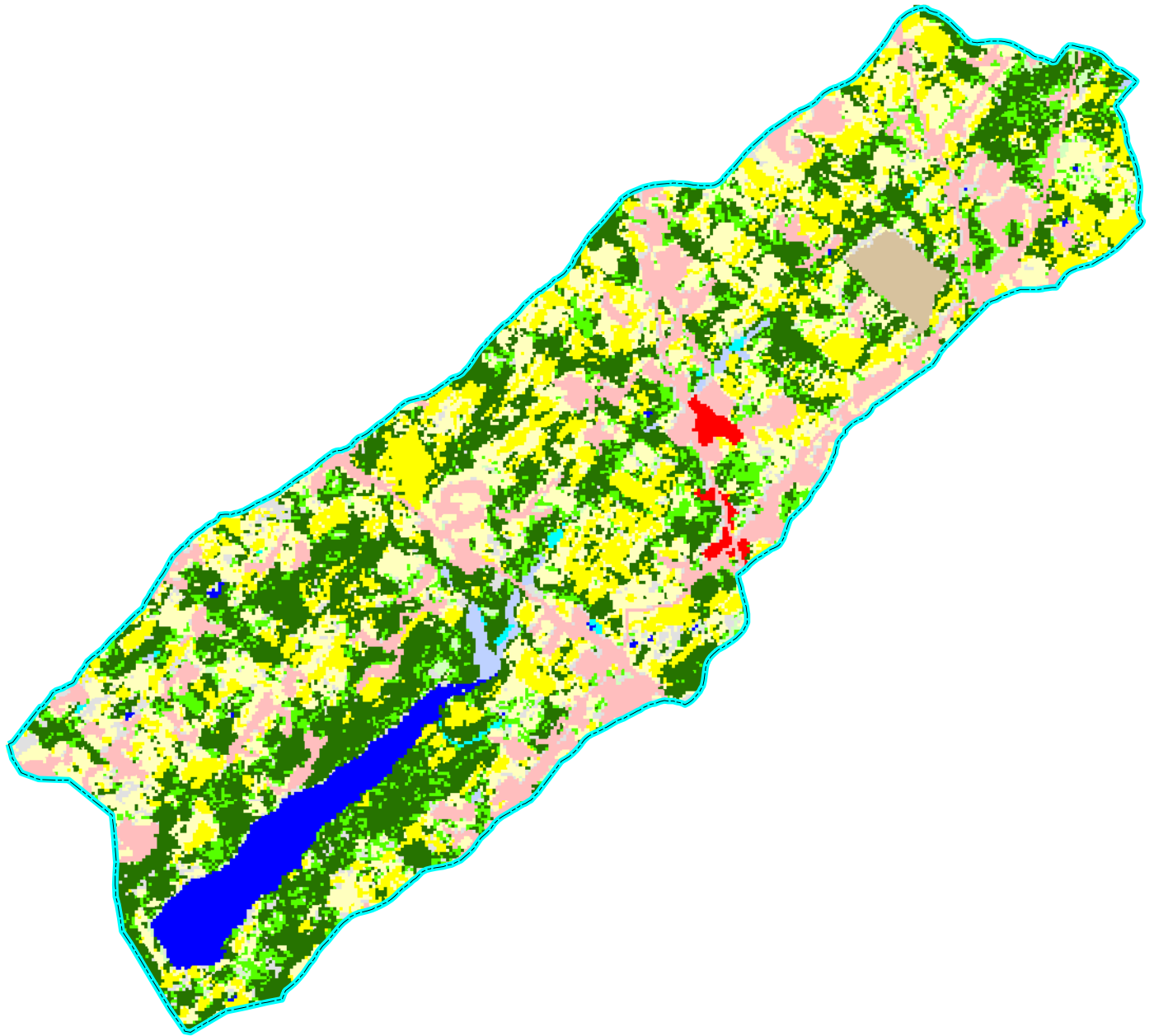


FIGURE 2.4
Land Use/Land Cover in the
Lake Galena Watershed

Lake Galena
 Watershed Assessment

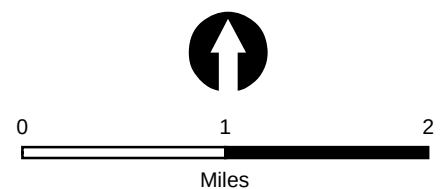
January 13, 2010

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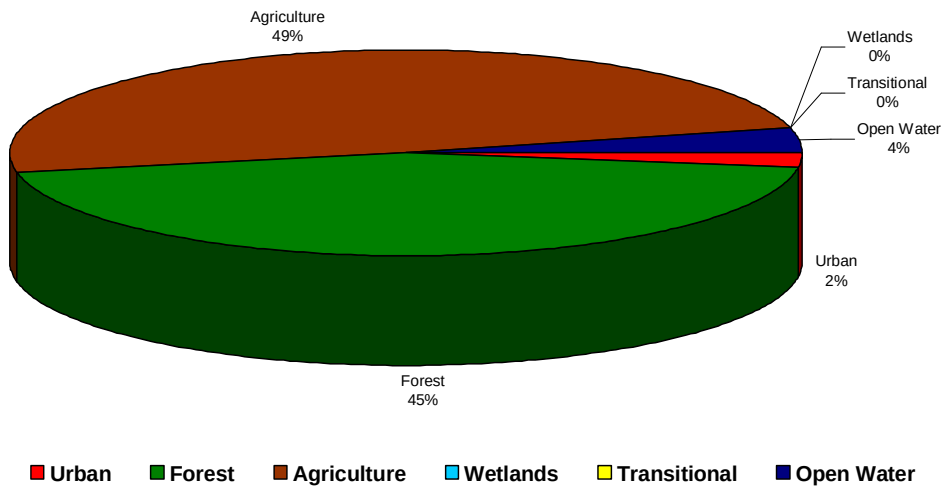


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- Watershed Boundary
- Land Use (Penn State Univ. 2000)**
- Water
- Low Density Mixed
- High Density Mixed
- Hay/Pasture
- Row Crops
- Coniferous Forest
- Mixed Forest
- Deciduous Wetland
- Woody Wetland
- Emergent Wetland
- Mined Land
- Transitional



Land Uses in 1992



Land Uses in 2000

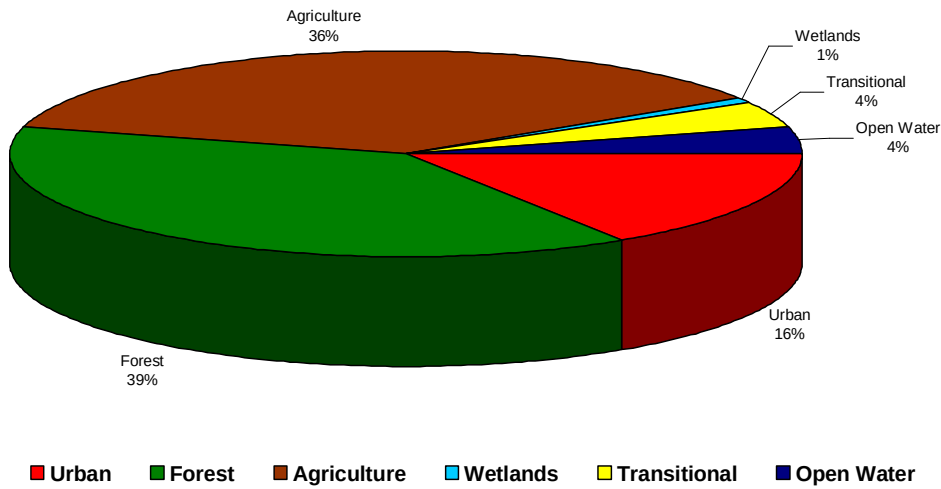


Figure 2.5 Comparison of Land Uses in the Lake Galena Watershed in 1992 & 2000

3. Lake Water Quality Trends

In 2005, the Bucks County Conservation District retained Aqua Link to monitor the water quality in Lake Galena. Two lake stations (Stations LG1 and LG2) were monitored once a month in April, June, July, August and October. Station LG1 is located in the deepest section of the lake near its dam (Figure 3.1), while Station LG2 is located up lake near the inlet of the North Branch Neshaminy Creek. All 2005 lake monitoring data were collected using standard PA DEP protocols. In addition, all collected lake water samples were transported to the regional PA DEP office, which were delivered to and analyzed by the PA DEP laboratory in Harrisburg, PA. Lake water quality data are presented in Appendix B. Appendix C includes a primer on lake ecology and watershed dynamics plus some useful lake and watershed management terms.

On each study date, in-situ water quality data (dissolved oxygen, temperature, pH, conductivity, specific conductance and transparency) were measured at 0.5 to 1.0 meter intervals throughout the water column at both stations. In-situ data were recorded using a YSI (Yellow Springs Instruments) 600XL Sonde with a 610D data logger. Transparency was measured in the field using a 20 cm (8 inch diameter) freshwater Secchi disk, which was quartered black and white. The YSI unit was calibrated immediately prior to the collection of any field data for the above water quality parameters.



Figure 3.1 Location of Lake Water Quality Monitoring Station LG1

In addition, surface and bottom water samples were collected at both stations on each study date. The depths for the collection of surface and bottom samples were defined as one meter below the lake surface and one meter above the lake sediments, respectively. All lake water samples were collected using a Kemmerer vertical water sampler unit. Immediately after collection, water samples were transferred into bottles supplied by the PA DEP laboratory and preserved accordingly in the field. The contract laboratory analyzed all collected lake water samples for total phosphorus, total nitrogen, total suspended solids and chlorophyll-a (surface water only).

The 2005 water temperature and dissolved oxygen profile data for Lake Galena at Station LG1 are graphically presented in Figures 3.2 and 3.3, respectively. Overall, the lake was strongly, thermally stratified during the months of June through August. In addition, the dissolved oxygen concentrations were strongly stratified when the lake was thermally stratified during the 2005 study period. In July and August, the dissolved oxygen levels fell below 1.0 mg/L for water depths exceeding 5 meters (16.4 feet).

The summer mean total phosphorus and chlorophyll-a concentrations for surface waters in 2005 at Station LG1 were 0.031 mg/L as P and 42.3 ug/L, respectively (Appendix B). The summer mean Secchi depth transparency value at this station in 2005 was 1.10 meters (3.6 feet). As noted in Section 1, the TMDL water quality target as proposed by PA DEP is a chlorophyll-a concentration of 10 ug/L. This is because Pennsylvania does not currently have numeric water quality standards for nutrients or suspended solids.

Overall, the primary goal of this TMDL is to improve the trophic status of Lake Galena from hyper-eutrophic to mesotrophic. For the TMDL, a combined watershed/lake water modeling approach was used to estimate current nutrient and sediment loads to the lake as well as to estimate phosphorus reductions needed to achieve the chlorophyll-a target of 10 ug/l (PA DEP 2003). Based upon the above, the 2005 summer mean chlorophyll-a concentration was more than four times higher than proposed TMDL limit.

The Carlson's Trophic State Index (TSI) values for total phosphorus, chlorophyll-a and Secchi depth were determined for each of the summer study dates. Next, the TSI values for each parameter were then averaged together. Based upon the above, the 2005 summer mean TSI values for total phosphorus, chlorophyll-a and Secchi depth were 54, 67 and 59, respectively. These TSI values indicate that Lake Galena still remained highly eutrophic in 2005.

Lastly, Aqua Link developed a historical water quality database for the epilimnetic (surface) waters at Station LG1 from 1985 through 2005. Key parameters (phosphorus, nitrogen, chlorophyll-a and Secchi depth) of this data set were plotted graphically over time as shown in Figures 3.4 through 3.7. As part of these graphs, Aqua Link plotted linear regression trend lines to illustrate if lake water quality was improving or degrading over time. The 1985 through 2000 water quality data were obtained from two reports prepared by F.X. Browne, Inc. of Lansdale, PA (F.X. Browne, Inc. 1998 and 2000) and the 2005 data were reported by PA DEP as discussed previously in Section 5.

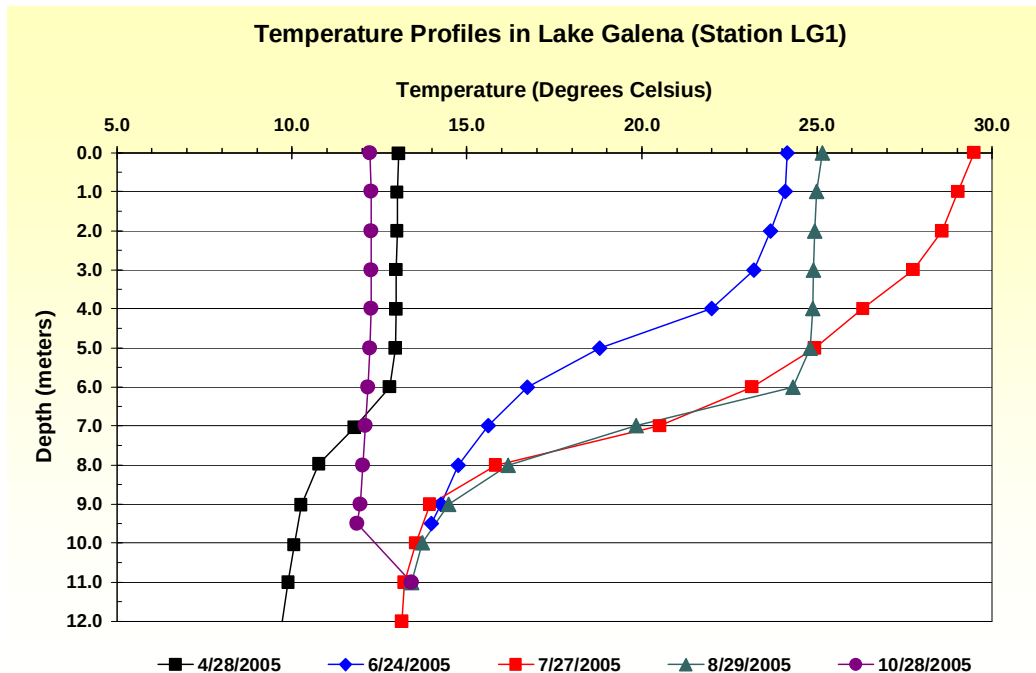


Figure 3.2 Temperature Profiles in Lake Galena (2005)

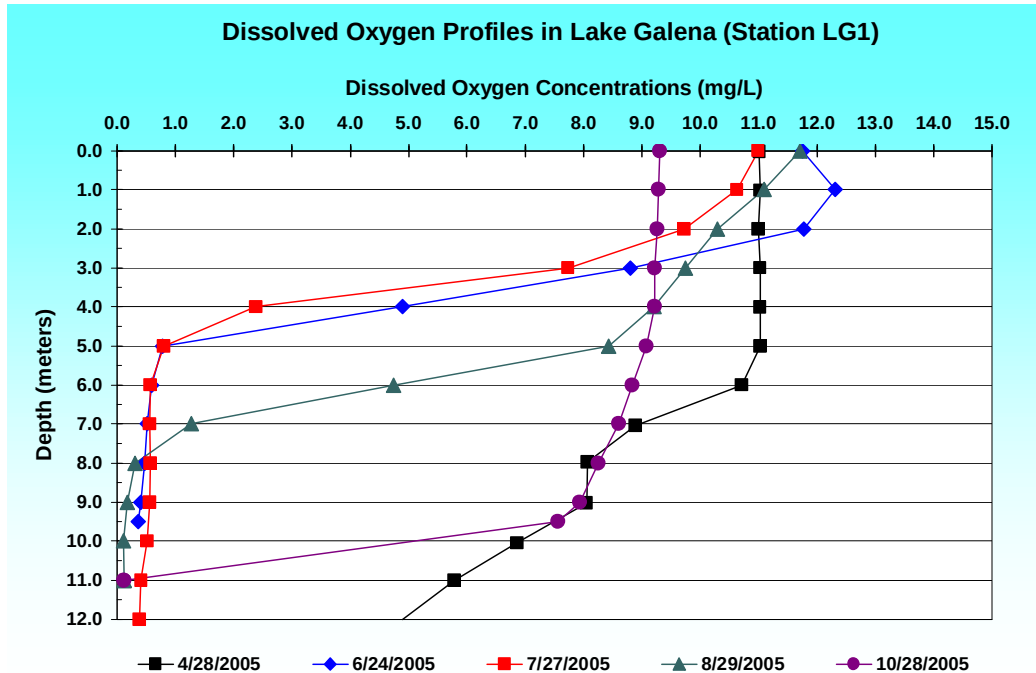


Figure 3.3 Dissolved Oxygen Profiles in Lake Galena (2005)

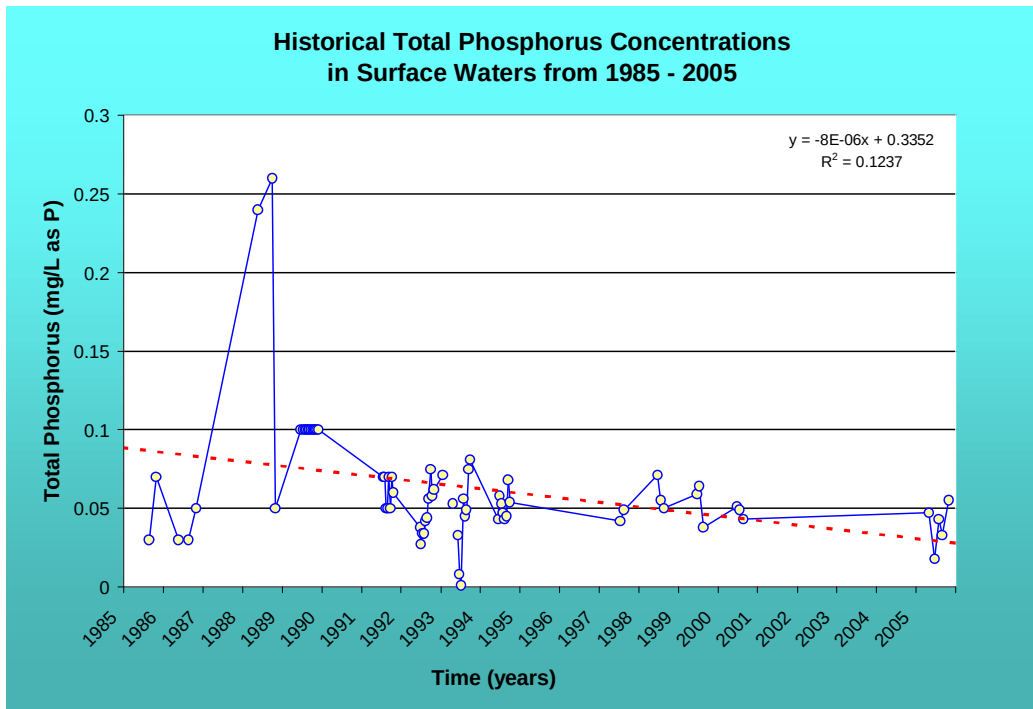


Figure 3.4 Total Phosphorus Concentrations in Lake Galena (1985-2005)

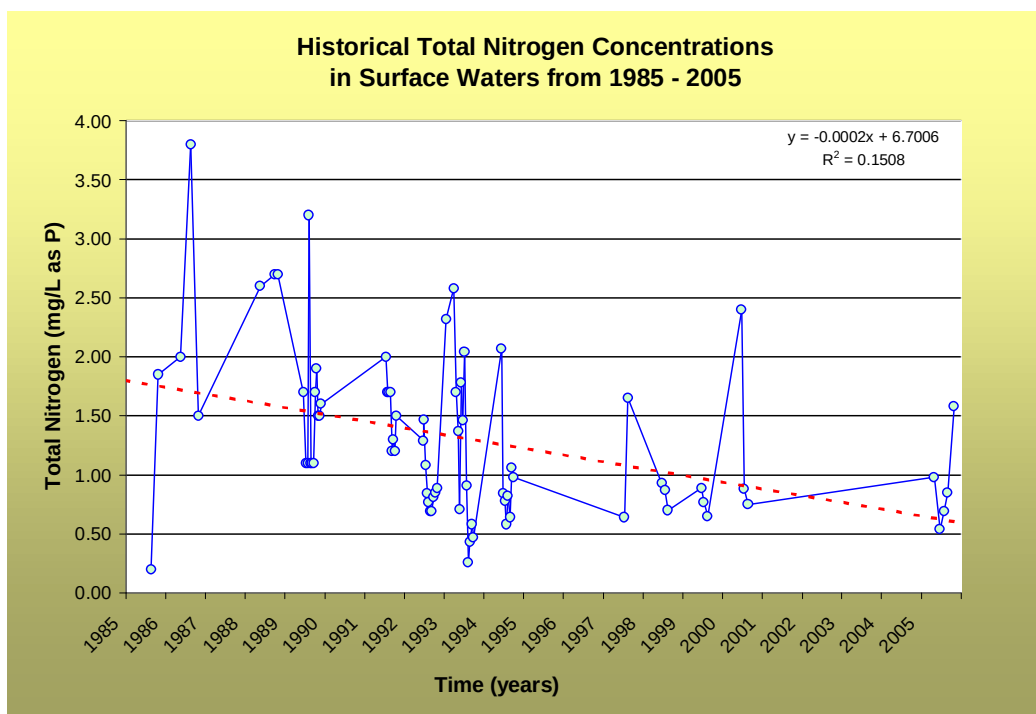


Figure 3.5 Total Nitrogen Concentrations in Lake Galena (1985-2005)

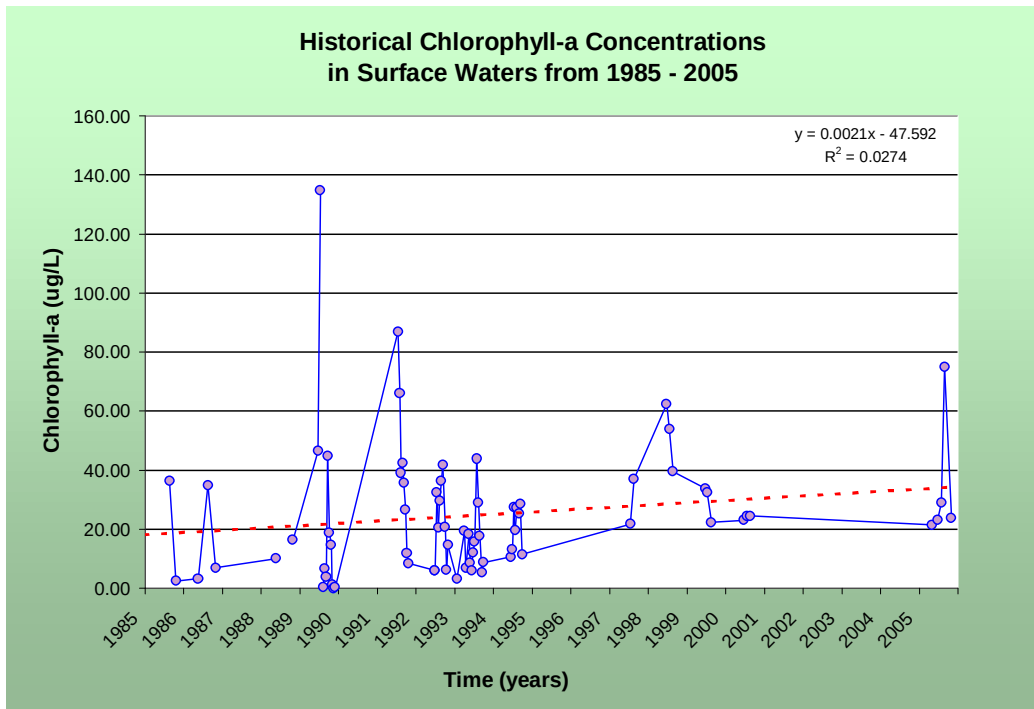


Figure 3.6 Chlorophyll-a Concentrations in Lake Galena (1985-2005)

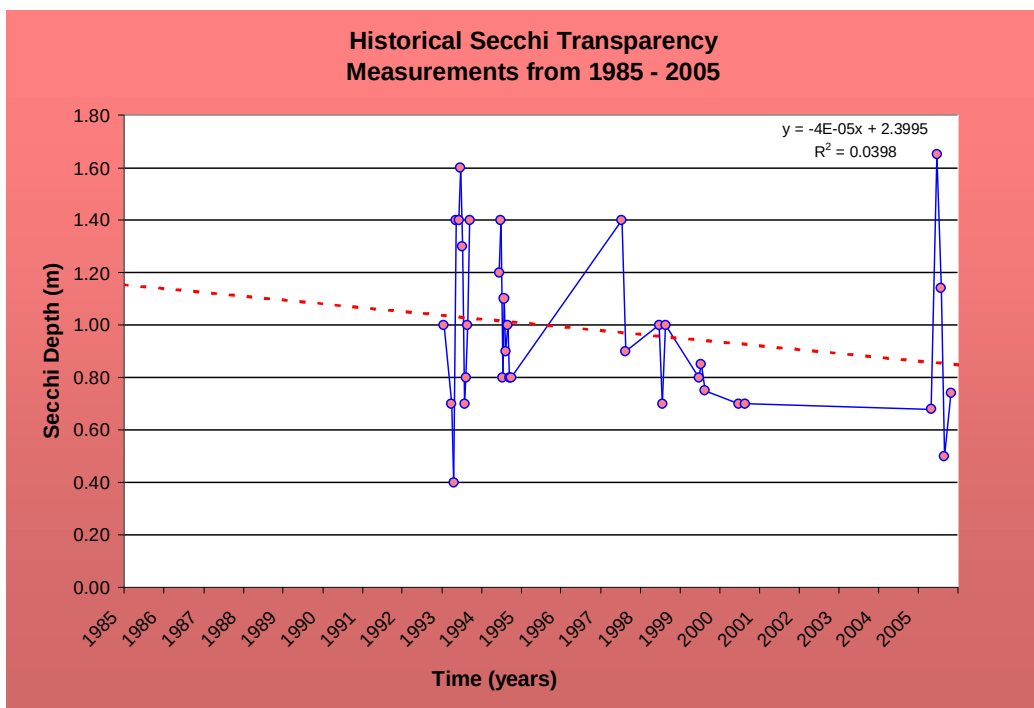


Figure 3.7 Secchi Disk Transparency Measurements in Lake Galena (1985-2005)

As expected, lake water quality data presented in Figures 3.4 through 3.7 fluctuated seasonally and annually. Overall, Figures 3.4 and 3.5 suggest that the nutrient concentrations (nitrogen and phosphorus) have slightly improved since 1985. Conversely, chlorophyll-a concentrations and Secchi depth values (water clarity) have increased and decreased, respectively. Based on these trends, it appears that Lake Galena still contains a sufficiently high amount of nutrients to promote large algal blooms (high chlorophyll-a concentrations), which impairs lake water quality.

4. Stream Monitoring

The stream monitoring program for this project extended from April through June 2009. The study design and how stream data were acquired are discussed in Section 4.1. In addition, stream data and results are presented in Section 4.2.

All stream data collected and analyzed for this project are located in Appendix D. It should be noted that the Bucks County Conservation District paid for all of the stream water quality data discussed in this report. PA DEP and EPA funded the remainder of the project through the awarded grant.

4.1. Study Design and Data Acquisition

In April 2009, Aqua Link with the assistance of the Bucks County Conservation District established stream stations along two largest tributaries to the lake – the North Branch Neshaminy Creek and the Hardiacken Creek. Written descriptions of these stations along with photographs are provided below in Table 4.1 and Figures 4.1 through 4.3, respectively. At these stations, staff gages were installed and cross sections were selected. These cross sections were used to collect and record incremental stream velocity and water depth data several times during this study at various flow regimes.

Table 4.1 Descriptions of Stream Monitoring Stations

<i>Station</i>	<i>Stream</i>	<i>Description</i>
NBNC	North Branch Neshaminy Creek	Upstream of Swamp Road (Route 313) bridge crossing
HC	Hardiacken Creek	Downstream of New Galena Road bridge crossing

Aqua Link monitored the stream stations once during baseflow (normal flow) and four times during stormflow (high flow) conditions in May and June 2009. During a sampling event, discrete water samples were collected and subsequently shipped to the contract laboratory for analysis. All collected stream samples were analyzed for total phosphorus, total Kjeldahl nitrogen (TKN), nitrate nitrogen, nitrite nitrogen and total suspended solids. At the time of sample collection, staff gage readings were recorded on designated field data sheets.

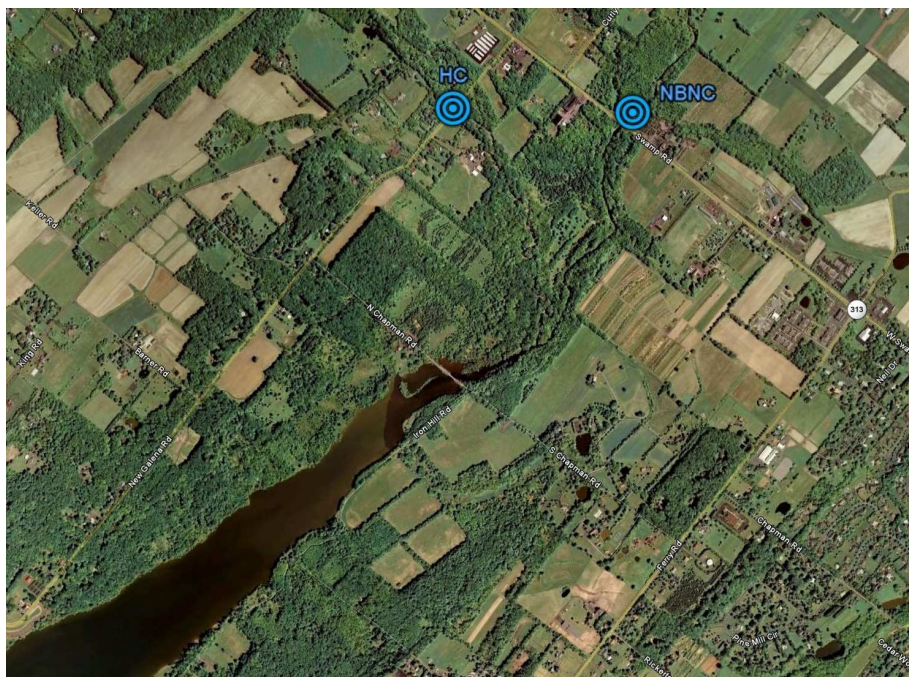


Figure 4.1 Location of Stream Monitoring Stations



Figure 4.2 Station NBNC (North Branch Neshaminy Creek)



Figure 4.3 Station HC (Hardiacken Creek)

Once all field data were acquired, Aqua Link determined the stream discharge (Q) when water samples were collected for laboratory analysis. First, Aqua Link calculated the instantaneous stream discharge values for all incremental stream water depth and velocity data that collected at both stream stations. Using statistical analysis, Aqua Link later developed linear regression equations for the stream stations in order to determine the stream discharge for all recorded staff gage readings (Appendix D).

4.2. Stream Water Quality Data and Results

The total phosphorus (TP), total nitrogen (TN, sum TKN, nitrate nitrogen and nitrite nitrogen) and total suspended solids concentrations for both stream stations during both baseflow and stormflow conditions are summarized in Table 4.2. For ease of comparison, a numerical ranking system was applied for each water quality parameter. For example, mean total phosphorus concentrations were ranked from 1 to 2 (best to worst in terms of water quality) during baseflow and stormflow conditions. The same ranking system was applied to total nitrogen and total suspended solids. The assigned points were tallied for the three stream stations. Therefore, the best and worst score a stream station could attain was 3 and 6 points, respectively.

Overall, the water quality at Stations NBNC and HC was quite similar during baseflow conditions (Table 4.2). The baseflow nutrient (phosphorus and nitrogen) and suspended solids (sediment) concentrations at these stations are considered moderately low. As expected, phosphorus and suspended solids concentrations increased dramatically during stormflow conditions. This suggests that phosphorus and sediment (suspended solids) concentration increases were attributed to nonpoint source loadings during storm events. Conversely, the nitrogen concentrations actually decreased at Station NBNC and slightly increased at Station HC. One plausible explanation for these nitrogen concentrations is a possible dilution effect during storms. This can occur if the primary sources of nitrogen to streams are point source discharges. Lastly, upon further examination, Table 4.2 shows that Station NBNC had the highest phosphorus and suspended solids concentrations during storm events. These concentrations were about 1.7 to 2 times higher than reported at Station HC.

Table 4.2 Stream Nutrient and Solids Concentrations

Station	Flow Regime	TP	TN	TSS	Ranking			
		(mg/L as P)	(mg/L as N)	(mg/L)	TP	TN	TSS	Total Pts
NBNC	Base	0.010	1.74	3.0	1.5	1	1.5	4.0
HC	Base	0.010	2.01	3.0	1.5	2	1.5	5.0
NBNC	Storm	0.205	1.08	91.5	2	1	2	5.0
HC	Storm	0.120	2.40	42.8	1	2	1	4.0

Note: Stormflow values are mean values, while baseflow values are only represented by a single value

Next, Aqua Link determined the instantaneous loadings of total phosphorus, total nitrogen and total suspended solids for the stream stations (Table 4.3). These loadings were determined by utilizing both water quality data reported by the contract laboratory and the discharge data estimated via the linear regression equations. The instantaneous loadings for total phosphorus, total nitrogen and total suspended solids were calculated for the individual study dates and then averaged together in order to obtain mean loading values as presented in Table 4.3. The loading values reported in this table are expressed on a mass per day basis (kilograms per day, kg/d).

Table 4.3 clearly shows that highest loadings to Lake Galena are from the North Branch Neshaminy Creek (Station NBNC). This is especially true for phosphorus and total suspended solids (sediments) during both baseflow and stormflow conditions. As expected, the nutrient and suspended solids loadings increased dramatically during stormflow conditions (Table 4.3). These increased loadings over baseflow (normal flow) conditions are attributed to increased streamflow volumes and concentrations (namely, phosphorus and suspended solids) during storm events.

Therefore, based upon the above, the water quality of Lake Galena will only improve if high nutrient and sediment nonpoint source loadings of from the major tributaries during storm events are significantly reduced. These stream data also strongly suggest that any watershed restoration in the North Branch Neshaminy Creek subwatershed should be given priority.

Table 4.3 Stream Nutrient and Solids Loadings

<i>Station</i>	<i>Flow Regime</i>	<i>Mean Q (cfs)</i>	<i>TP (Kg/d as P)</i>	<i>TN (Kg/d as N)</i>	<i>TSS (Kg/d)</i>	<i>Ranking</i>			<i>Total Pts</i>
						<i>TP</i>	<i>TN</i>	<i>TSS</i>	
NBNC	Base	8.9	3.58	69.5	611	2	2	2	6
HC	Base	4.4	1.13	62.7	195	1	1	1	3
NBNC	Storm	59.7	49.95	172.7	27,961	2	2	2	6
HC	Storm	27.4	12.11	166.2	5,848	1	1	1	3

Note: Stormflow values are mean values, while baseflow values are only represented by a single value

5. Comprehensive Watershed Investigation

A comprehensive watershed investigation was performed in order to determine significant nonpoint sources (NPS) of pollution to Lake Galena. Our investigation primarily focused on those NPS pollutants that are commonly responsible for accelerating the rate of lake eutrophication, namely nutrients (phosphorus and nitrogen) and sediments. As noted in Section 1, a TMDL (Total Maximum Daily Loading) assessment was completed for the entire Neshaminy Creek watershed in 2002. This assessment included the North Branch Neshaminy Creek, which is the main tributary to the lake, and Lake Galena (PA DEP 2003).

The primary goal of the TMDL is to improve the trophic status of Lake Galena from hyper-eutrophic to mesotrophic. Since there are no current water quality standards for phosphorus and sediments, PA DEP selected a water quality target of 10 ug/l for chlorophyll-a concentration for the lake (PA DEP 2003). The recommended target value for chlorophyll-a indirectly controls the amount of phosphorus and sediment loadings to the lake. This is because phosphorus is often the limiting nutrient in lakes and thereby controls primary production or the growth of phytoplankton (algae). In turn, phosphorus in streams is often transported as “sediment bound phosphorus” during storm events.

Our watershed investigation for this WIP project consisted of the following tasks: conducting a watershed tour; evaluating the condition of active agricultural lands; evaluating the condition of existing stormwater management facilities; and assessing the condition of the North Branch Neshaminy Creek and its riparian corridor. These major tasks are discussed in detail in Sections 5.1 through 5.4.

5.1. Watershed Tour

Aqua Link toured the Lake Galena watershed via truck using GPS receiver (Garmin Model GPS 76S) linked to a portable notebook computer. This equipment provided our field personnel with real-time location and topographic data throughout the watershed tour. The purpose of this watershed tour was to quickly gain a good understanding of the Lake Galena watershed and the tributaries to the lake. In addition, the watershed tour was extremely useful in performing the remaining tasks of the watershed investigation, selecting stream monitoring stations as discussed in Section 4, and analyzing and evaluating the GIS data for the Lake Galena watershed in Section 2.

5.2. Evaluation of Active Agricultural Lands

The Conservation District worked in collaboration with the United State Department of Agriculture Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA); local municipalities (New Britain Township, Plumstead Township and Hilltown township); the Penn State

Cooperative Extension to identify active agricultural operations and horse farms within the watershed. Roughly 110 farms were identified in the Lake Galena watershed. Of this total, approximately 78 farms have conservation plans developed for their operations.

Shortly after receiving the grant, the North Branch Watershed Association and Heritage Conservancy held several meetings with its watershed partners to promote public awareness about the WIP project. Next, the Conservation District sent a Survey and Funding Application to all known active farmers within the Lake Galena watershed (Appendix E). The purpose of this survey was to obtain updated information about active farms, any known nonpoint source problems, and whether any farmers were interested in applying for funding for the implementation of best management practices (BMPs). Overall, the response to these surveys was about 10 percent.

In addition to the survey and funding applications, the Conservation District reviewed conservation plans, performed ground surveys, and conducted personal interviews with farmers. The Conservation District was extremely diligent in identifying as many significant nonpoint source (NPS) problems occurring on agriculture lands in the watershed. The final product of this task is a detailed list of agricultural BMPs that are needed in the watershed as presented in Table 3.1. The locations of the farms (referred to as Participants) are listed in Table 5.1 and shown in Figure 5.1. Table 5.1 provides a list of proposed BMPs along with estimated costs for installation, planning, design and supervision. The total cost to implement all recommended BMPs, as estimated by the Conservation District in Table 5.1, is \$319,687.77.

5.3. Evaluation of Existing Stormwater Management Facilities

5.3.1. Methodology of SWM Facility Assessment

Initially, the Plumstead and New Britain townships provided a list of major stormwater management (SWM) facilities located within the Lake Galena watershed. Next, Gilmore and Associates (G&A) of New Britain, PA identified additional SWM facilities based upon their extensive experience in the watershed. For example, G&A serves as the Township Engineer for New Britain Township.

Once identified, G&A visited all of the identified major SWM facilities in the winter 2008-2009 and the winter 2009 and 2010. During these site visits, digital photographs were taken and the GPS coordinates were recorded for each of the facilities. In addition, field notes were prepared for all the inspected SWM facilities during the site visits. It should be noted that only a small portion of the watershed falls within Doylestown and Hilltown Townships. There are no major SWM facilities located within Doylestown Township portion of the watershed. The Hilltown Township portion of the watershed only contains several farm ponds and no major SWM facilities.

Table 5.1 List of Proposed Agricultural Best Management Practices

Participant	Ranking	Proposed BMP	Details	Total Installation Cost			Planning/Design/Construction Supervision				TOTAL Cost	
				Total Ac/Ft	Est. Cost/Unit	TOTAL	Hours			TOTAL		
							WS	ACT	NRCS			
40	1	Streambank Stabilization	bioeng for gully	200	ft	\$46.08	\$9,215.09	16.5	20.25	15	\$1,186.50	\$10,401.59
		Streambank Fencing	fence out stream	350	ft	\$8.57	\$3,000.00	5.5	6.75	5	\$395.50	\$3,395.50
		Streambank Stabilization	live stakes, riprap banks, riprap and rebar.	125	ft	\$48.00	\$6,000.00	18	10		\$504.00	\$6,504.00
50	3	Terraces/Diversions/Waterways	diversion	400	ft	\$10.46	\$4,185.19	2	39	14	\$1,228.00	\$5,413.19
25	2	Streambank Stabilization	6 rock barbs	200	ft	\$77.35	\$15,470.00	30	6	10	\$998.00	\$16,468.00
45	2	Terraces/Diversions/Waterways	100' grassed waterway, 400' grassed waterway	0.34	ac	\$9,000.00	\$3,099.17	1	10		\$198.00	\$3,297.17
		Terraces/Diversions/Waterways	diversion by road	200	ft	\$8.00	\$1,600.00	1	3		\$72.00	\$1,672.00
44	2	Terraces/Diversions/Waterways	diversion	2000	ft	\$8.00	\$16,000.00	1	8		\$162.00	\$16,162.00
		Ag Waste	manure stacking pad	1	no	\$28,325.93	\$28,325.93	1	8	1	\$197.00	\$28,522.93
		Terraces/Diversions/Waterways	grassed waterway	0.48	ac	\$9,000.00	\$4,338.84	1	8		\$162.00	\$4,500.84
		Nutrient Management	HUA	7500	ft2	\$2.50	\$18,750.00	1	4		\$90.00	\$18,840.00
		Nutrient Management	gutters	600	ft	\$13.00	\$7,800.00	1	3		\$72.00	\$7,872.00
46	2	Nutrient Management	Act 38 NMP	1	no	\$1,200.00	\$1,200.00	1	4		\$90.00	\$1,290.00
		Ag Waste	Manure stacking pad	1	no	\$28,325.93	\$28,325.93	1	8		\$162.00	\$28,487.93
5	1	Ag Waste	Manure stacking pad	1	no	\$28,325.93	\$28,325.93	1	8		\$162.00	\$28,487.93
		Nutrient Management	Act 38 NMP	1	no	\$1,200.00	\$1,200.00	1	4		\$90.00	\$1,290.00
		Nutrient Management	heavy use area	7500	ft2	\$2.50	\$18,750.00	1	3		\$72.00	\$18,822.00
		Terraces/Diversions/Waterways	diversin 1&2	300	ft	\$8.00	\$2,400.00	1	6		\$126.00	\$2,526.00
		Terraces/Diversions/Waterways	waterway 700'	0.48	ac	\$9,000.00	\$4,320.00	1	6		\$126.00	\$4,446.00
37	3	Cropland protection	cover crops	100	ac	\$25.00	\$2,500.00	1	2		\$54.00	\$2,554.00
		Conservation Tillage	no-till	100	ac	\$30.00	\$3,000.00	1	2		\$54.00	\$3,054.00
1	3	Cropland protection	cover crops	100	ac	\$25.00	\$2,500.00	1	2		\$54.00	\$2,554.00
2	1	Conservation Tillage	no-till	100	ac	\$30.00	\$3,000.00	1	2		\$54.00	\$3,054.00
		Terraces/Diversions/Waterways	sediment basin, 100' spillway, 200' diversion and 580' lined and 350' grassed waterway	1230	ft	\$36.11	\$44,413.40	1	42	32	\$2,054.00	\$46,467.40
		Streambank Fencing	fence out cattle from stream	1700	ft	\$5.00	\$8,500.00	8	8		\$288.00	\$8,788.00
		Streambank Stabilization	stream access for cattle	75	ft	\$26.67	\$2,000.00	8	6	3	\$357.00	\$2,357.00
		Stream Buffer	15' buffer, adjacent to cropland	570	ft	\$2.81	\$1,600.00	16			\$288.00	\$1,888.00
		Stream Buffer	half 15', half 35'	570	ft	\$2.81	\$1,600.00	16			\$288.00	\$1,888.00
		Stream Buffer	35' buffer	570	ft	\$2.81	\$1,600.00	16			\$288.00	\$1,888.00
		Terraces/Diversions/Waterways	225' start of stream, in cropland.	0.15	ac	\$9,000.00	\$1,394.63	1	6		\$126.00	\$1,520.63
15	2	Terraces/Diversions/Waterways	diversions	300	ft	\$8.00	\$2,400.00	1	6		\$126.00	\$2,526.00
		Cropland protection	field borders	0.64	ac	\$265.00	\$170.34	1	2		\$54.00	\$224.34
		Conservation Tillage	no-till soybeans and corn	15	ac	\$30.00	\$450.00	1	2		\$54.00	\$504.00
		Strip-Contour Farming	contour farming	15	ac	\$10.00	\$150.00	1	2		\$54.00	\$204.00
		Cropland protection	obstruction removal	0.52	ac	\$2,300.00	\$1,188.02	1	2		\$54.00	\$1,242.02
51	1	Ag Waste	stack pad	1	no	\$11,627.31	\$11,627.31	1	5		\$108.00	\$11,735.31
		Nutrient Management	HUA	7500	ft2	\$2.50	\$18,750.00	1	4		\$90.00	\$18,840.00
							\$309,149.77	163	258	80	\$10,538.00	\$319,687.77

Lastly, if available, SWM facility design information was obtained from the local municipalities. This information was used to evaluate the design of a stormwater management facility with respect to its actual construction. Both the design information, if available, and the existing conditions of each facility were considered in preparing this stormwater management assessment. In some cases, information regarding the proposed design/construction of such facilities was not available and the evaluation was performed only on field observations.

Major SWM Facilities – New Britain Township

Fox Pond, Lot 4 (No. 1)

The facility was designed as an infiltration basin. Some water was observed in the bottom of the basin as shown in Figure 5.3. As a result of this condition, naturalized vegetation has taken hold providing a wet meadow condition, which will enhance the basin and water quality.

Gilmore Tract (No. 2)

An attenuation basin was built to prevent localized increases in runoff, which would degrade conveyance facilities. This basin is located in a residential area and was designed to be shallow and maintained as lawn. This allows the basin area to be utilized for additional yard space during dry weather. Native plants were installed at the outlet structure to provide water quality and aesthetic improvements as shown in Figure 5.3.

Fountainville Center (a.k.a. NB Developers) (Nos. 3 & 4)

This commercial development was designed around a series of wetlands on the site. The stormwater management facilities consisted of two wet detention basins planted with naturalized vegetation. As shown in Figure 3.3, this vegetation has been allowed to develop on its own to the point where the detention basin, while remaining effective, is indistinguishable from the adjacent wetlands.

O'Toole Property (No. 5)

This facility was designed for subsurface detention and therefore, there are *no photographs* of this system since it is not visible. During our visit, the site was maintained as lawn and there were no apparent “wet” areas to indicate that the system was not performing as designed.

AA Self-Storage (No. 6)

This site is located at the intersection of Swamp Road (Route 313) and King Road. Runoff from the self-storage facility runs off of the paved areas into detention areas at the perimeter. The area east of the entrance drive, which is adjacent to Swamp Road, is maintained as lawn. There is some

evidence of erosion along a low flow channel that has developed over time. The area to the west of the drive is not mowed as often and is more of a meadow, which is more stable. Although the west facility is acceptable, the east basin should be modified to address the erosion issue and possibly establish a wet-meadow condition, which would improve water quality.

Residence at Chapman Road (No. 7)

It is unclear whether this pond is intended to be a stormwater management facility. Given the available storage above the normal water surface, however, it does appear to function as one. There are two potential issues with this pond. First, the edge of the pond has been maintained as a manicured lawn. This puts the pond at risk for erosion since most lawn grasses do not have sufficient root structure to resist these forces. The second issue is that the overflow standpipe has no trash rack or other controls, which would prevent clogging or the conveyance of debris.

Czestochowa Shrine Cemetery (Nos. 8 & 9)

These two basins are installed below the cemetery at the Shrine. Unfortunately, there was no design information available for these basins. Basin 1 appears to be installed as a sediment control structure, while basin 2 has been completed and stabilized as lawn. Both facilities are intended as dry detention facilities. During our site visit, Basin 1 has been allowed to support a naturalized meadow appearance, while Basin 2 has been maintained as manicured lawn. Unless the sediment control structure is still needed, it should be removed and replaced with appropriate “permanent” controls and trash racks. Additional vegetation should be considered for Basin 2 to enhance water quality.

Residence at Fretz Road (No.10)

No design information was available for this facility. It appears that it is a wet pond that is at an intermediate stage with erosion-sediment controls still in place. The pond contains some native grasses and vegetation, while the surrounding are maintained lawns. The erosion control structures should be removed once no longer needed. The vegetation, however, should remain to stabilize the facility and enhance water quality.

Driving Range – Swamp Road (No.11)

There was no information on the original design of this facility, however it appears to be a dry, extended detention facility with little or no water quality enhancement considered. The basin is well maintained for this purpose and the lawn is well established showing no evidence of erosion. The basin could be enhanced if it were allowed to become a more naturalized meadow or even a wetland.

Major SWM Facilities – Plumstead Township

North Branch Park (No.12)

The detention pond was installed as part of a 122-lot residential subdivision. The pond appears to be in good shape with little or no algae growth or soil erosion. The shoreline of the pond is maintained in a naturalized state. Consideration should be given to install trash/debris racks to prevent clogging and for general safety considerations.

Windtree Subdivision - Wet Detention Pond (No. 13)

The main detention facility was designed as a wet detention pond, which is located on dedicated open space on the opposite side of Curly Hill Road. Based upon our visit, it appears that this facility is functioning like a wetland basin. This type of facility provides similar benefits to a wet pond and appears to be well established. Therefore, ongoing maintenance should follow those guidelines for wetland basin systems.

Windtree Subdivision - Water Quality Basins 1 & 2 (Nos.14 & 15)

These stormwater management facilities were installed as part of a 116-lot residential subdivision. The water quality basins are smaller facilities located throughout the development. Basins 1 and 2 are in a central open space area in close proximity to the rear yards of most of the lots. Their profiles are characterized by minimal grading so that these areas become usable open space during dry periods. Therefore these facilities were intended to remain as lawn and have been maintained accordingly.

Windtree Subdivision - Water Quality Basin 3 (No. 16)

This basin, Basin 3, is also adjacent the rear yards of residential lots. Basin 3 is located along an existing drainage swale, which crosses under Curly Hill Road. This facility has been allowed to develop a naturalized wet-meadow appearance, which blends into the surrounding vegetation. Ongoing maintenance should monitor the influx of undesirable invasive species such as cattails or Phragmites. In addition, any woody vegetation in proximity to the outlet structure should be removed.

Bucks Country Gardens - Wetland Basin & Regional Wet Pond (Nos.17 & 18)

There are two stormwater facilities located on this commercial site. The first was originally intended as a dry detention facility, however the property owner (a nursery and landscaping contractor) has allowed the growth of native wetland plants in the basin. The second facility is a modified pond, which now serves as a regional detention facility containing a wet pond. Regular maintenance is performed on these basins including cutting back the vegetation 1-2 times per year as shown in Figure 3.3. In the past, these facilities occasionally have been inundated with invasive

species like cattails. In the future, it is recommended that these basins be routinely inspected and that all invasive species be removed.

Central Bucks Middle School – Tohickon School (Nos.19 & 20)

Per the SWM facilities report, these basins were designed as standard detention facilities. However, based upon a recent site visit, it appears that these basins are maintained as naturalized wet-meadow basins. Both basins have healthy growths of meadow grasses, which will improve the water quality of the basin discharges. Future maintenance for these facilities should be in accordance with the standards for wetland or wet-meadow basins including but not limited to cutting back the vegetation 1 to 2 times per year and the removal of exotic invasive species such as cattails, Phragmites, multi-flora rose and others.

Ridgeview Subdivision (No. 21)

This residential subdivision is located at the corner of Danboro-Point Pleasant Pike and Burnt House Hill Road. Although most of the development is in the Pine Run watershed, a small portion of the runoff is collected and treated in this basin at the above intersection and, therefore, is tributary to the Lake Galena watershed. Although there is no available design information, this basin appears to serve as a dry detention basin.

The basin is well maintained in most respects. The exception appears to be at the discharge endwalls into the basin and at the outlet structure. These areas have been allowed to grow naturally resulting in hydrophytic vegetation, trash accumulation, and the rooting of woody species.

Second Baptist Church (No. 22)

These facilities for this church were design as a “treatment train”, which included grass-lined swales, bioretention facilities, and a wet-meadow detention basin. Although installed according to their design plans, unfortunately these facilities were never planted with vegetation in either the bioretention areas or the basin, itself. Conversely, these facilities contain maintained lawn and water quality treatment would be significantly improved if invasive species were removed and revegetated according to the design plans.

George’s Tool Rental (No. 23)

The basin at this commercial site was designed as a dry detention facility. Although it remains functional for rate control, it does very little for water quality and is difficult to maintain when wet (Figure 3.3). This facility would be improved by reseeding it with a wet-meadow mix. By doing so, the facility would require less maintenance and maintenance would be performed during drier conditions. By controlling the growth of invasive species, this facility could be maintained with meadow grasses and wild flowers without loss of curb appeal.

Timberly Farms (No. 24)

This stormwater management facility was designed as a low-lying wetland basin, which blends into the surrounding area. It appears to have been maintained in accordance with the typical requirements for this type of facility. The vegetative growth is in good shape and of sufficient density to prevent erosion.

Central Bucks Athletic Association (No. 25)

Stormwater detention facilities were installed during a recent expansion of the athletic field facilities. Although originally designed as an infiltration basin, field condition indicated the presence of bedrock and dense soils in the basin location. The system was redesigned to utilize a filtration berm, which was constructed of compacted stone. This berm allows stored runoff to trickle out at a reduced rate over a wide area. Meadow grasses were seeded throughout the basin as low-growing, low-maintenance vegetation as originally planned.

Estates at Brookside (Nos. 26, 27, 28 & 29 or Basin 1a, Basin 1b, Basin 2 & Basin 3)

The detention facilities for the Estates at Brookside were designed and installed per standard stormwater management practices of the time. These facilities were built as extended detention dry basins with low flow channels. All of the facilities are located on private property and contained within stormwater management easements. The basins are kept in a lawn condition, which suits the on-lot locations and allows them to be used for additional yard areas during dry periods. Although the basins have been generally well maintained, the low flow channels have become areas for the deposition of sediments and debris from the runoff. These facilities could be improved by removing the concrete low-flow channels. Once removed, these channels should be replaced with a more naturalized stone channel that would allow the growth of native plant species and would improve the water quality during smaller storm events.

Country Greene Subdivision (Nos. 30 & 31)

Basin 1 was designed as a low-lying basin suited to the surrounding residential lots and open space. It is located adjacent to existing woods, which includes a small wetland area. Over the years, this basin received minimal maintenance and thereby allowing native vegetation to become established and resulting in a created wetland basin. Native vegetation may include some invasive species, which should be removed immediately.

Basin 2 was also designed as a low-lying, dry detention basin. It is larger and located more centrally within the development near roadways. This facility consists of well-maintained lawn, which can be used by residents during drier conditions. A concrete low-flow channel was installed along one edge of the basin floor, which has become a deposition area for sediment and debris. In order to

correct this problem while still maintaining a lawn-like appearance, it is recommended to replace the concrete with a more naturalized river-stone channel with native aquatic species. This would also allow for greater water quality improvement during the first flush of storm events.

Huntington Valley Bank (No. 32)

There was no design information available for this new facility, which was just completed during the last year. Ground cover is starting to become established within this basin and shrubs have been planted. Overall, it is assumed that the condition of the basin will continue to improve with normal maintenance practices.

Fountainville Executive Offices (No. 33)

This site is located just north of the intersection of Ferry Road and Swamp Road with the basin located to the rear of the developed areas. Although there is no design information available, the basin appears to be a dry-detention facility. The basin is well maintained as lawn with no signs of erosion. This basin could be enhanced by replacing the lawn areas with native meadow or wetland plants. Both of these modifications would improve water quality while reducing the amount of maintenance required. At a minimum, woody vegetation should be removed from the berm and the emergency spillway.

Central Bucks Elementary School – Route 611 (No. 34)

This site is located near the Bucks Country Gardens site and unfortunately there was no design information available for this facility. Based upon our site visit, the facility appears to be a wetland basin with well-established naturalized vegetation for water quality improvements. The facility was in good shape and will likely remain so if regular maintenance is performed.

Penn Engineering (Nos. 35 & 36)

This site was identified during field reconnaissance and unfortunately no design was available. These basins appear to be stable wetland basins containing naturalized vegetation. There are some exotic invasive species present in the basins, including Phragmites, which should be removed and replaced with native species.

Brookside East Subdivision (No. 37)

This residential development is adjacent to the Estates at Brookside and unfortunately, there was no design information available for this subdivision. It appears that this basin is a dry basin containing a naturalized meadow condition for water quality improvements. The facility was in good shape during the site visit and should remain so if regular, routine maintenance is performed.

5.3.2. Recommendations for Retrofitting Major SWM Facilities

Stormwater Management Projects – New Britain Township

Fox Pond, Lot 4 (No. 1)

Although intended for infiltration, this basin appears to have denser soils at the outlet/overflow structure. There was some minor ponding in this area, which has encouraged the growth of native hydrophytic plants. The recommendation for this facility is to allow the native plants to continue, but monitor the plant growth and routinely remove any invasive species. Invasive species, which should be removed include, but are not limited to, cattails, Phragmites, and multi-flora rose.

Residence at Chapman Road (No. 7)

A trash/debris rack should be added to the overflow standpipe to prevent blockage. The perimeter of the pond should be planted with native species to prevent erosion. In general, plants above 18-24 inches in height would have the added benefit of making this pond less attractive to geese. Although difficult to enforce, another recommendation is to reduce the nutrient loadings to the basin (i.e. lawn fertilizers), which contribute to algal growth.

AA Self-Storage Facility (No. 6)

The basin to the west of the entrance drive has been maintained in a meadow condition and appears stable. Conversely, the basin to the east of the entrance drive is kept in a mowed lawn condition and shows signs of erosion. The erosion is primarily located in what has become a low-flow channel through the basin. It is recommended that this channel be formalized with river stone and native plants, which would aid in stabilizing this channel. The remainder of the basin should be allowed to develop a meadow grass condition.

Driving Range – Swamp Road (No.11)

Although this facility is well maintained as dry basin with lawn, water quality could be improved by converting the vegetative cover to a meadow or even a wetland condition. The simplest solution would be to seed the basin with a meadow mix and allow it to develop naturally. This would also reduce the owner's maintenance responsibility to 1 to 2 mowings per year.

Czestochowa Shrine Cemetery (Nos. 8 & 9)

The sediment control structure on the one basin should be removed if all active earthmoving work has been completed. Native plants around this structure should be allowed to remain to improve water quality.



No. 1 - Photograph 1
Fox Pond, Lot 4



No. 2 - Photograph 1
Gilmore Tract



No. 3 - Photograph 1
Fountainville Center - Basin 1



No. 4 - Photograph 2
Fountainville Center - Basin 2



No. 6 - Photograph 1
AA Self-Storage – East of Entrance Drive



No. 6 - Photograph 2
AA Self-Storage – West of Entrance Drive

Figure 5.3 Major SWM Facilities in the Lake Galena Watershed



No. 7 - Photograph 1
Residence at Chapman Road



No. 8 - Photograph 1
Czestochowa Shrine Cemetery – Basin 1



No. 9 - Photograph 1
Czestochowa Shrine Cemetery – Basin 2



No. 10 - Photograph 1
Residence at Fretz Road



No. 11 - Photograph 1
Driving Range at Swamp Road



No. 12 - Photograph 1
North Branch Park

Figure 5.3 Major SWM Facilities in the Lake Galena Watershed



No.13 - Photograph 1
Windtree Subdivision – Wet Detention Basin



No.14 - Photograph 1
Windtree Subdivision – Water Quality Basin 1



No.15 - Photograph 1
Windtree Subdivision – Water Quality Basin 2



No.16 - Photograph 1
Windtree Subdivision – Water Quality Basin 3



No.17 - Photograph 1
Bucks Country Gardens – Wetland Basin



No.18 - Photograph 1
Bucks Country Gardens – Regional Wet Pond

Figure 5.3 Major SWM Facilities in the Lake Galena Watershed



No.19 - Photograph 1
Central Bucks Middle School



No.20 - Photograph 1
Central Bucks Middle School



No.21 - Photograph 1
Ridgeview Subdivision along Burnt House Road



No.22 - Photograph 1
Second Baptist Church



No.23 - Photograph 1
George's Tool Rental



No. 24 - Photograph 1
Timberly Farms

Figure 5.3 Major SWM Facilities in the Lake Galena Watershed



No.26 - Photograph 1
Estates at Brookside – Basin 1A



No.27 - Photograph 1
Estates at Brookside – Basin 1B



No.28 - Photograph 1
Estates at Brookside – Basin 2



No.29 - Photograph 1
Estates at Brookside – Basin 3



No.30 - Photograph 1
Country Greene Subdivision – Basin 1



No.31 - Photograph 1
Country Greene Subdivision – Basin 2

Figure 5.3 Major SWM Facilities in the Lake Galena Watershed



No.32 - Photograph 1
Huntington Valley Bank



No.33 - Photograph 1
Fountainville Executive Offices



No.34 - Photograph 1
Central Bucks Elementary School along Route 611



No.35 - Photograph 1
Penn Engineering – Basin 1



No.36 - Photograph 1
Penn Engineering – Basin 2



No.37 - Photograph 1
Brookside East Subdivision

Figure 5.3 Major SWM Facilities in the Lake Galena Watershed

Residence at Fretz Road (No.10)

Erosion and sediment (E&S) control measures should be removed if no longer needed.

All Other Facilities

Unless noted elsewhere, these other facilities are being maintained in good condition with appropriate water quality enhancements provided. Therefore, no recommendations are offered at this time.

Stormwater Management Projects – Plumstead Township

North Branch Park (No.12)

The pond is maintained in good condition with a naturalized perimeter. Consideration should be given to adding trash/debris racks at the outlet structure to prevent clogging.

Windtree Subdivision (Nos.14, 15 & 16)

Water Quality Basins 1 and 2 are being maintained as lawn. These basins may be retrofitted to improve water quality if lawn areas are converted to a meadow or other native vegetation. Although these low profile basins will become somewhat less useable for recreational purposes during dry weather, converting these areas to a meadow could reduce the maintenance costs incurred by the homeowners association.

Water Quality Basin 3 has been allowed to develop a naturalized appearance. This condition should be allowed to continue, however woody material at the outlet structure should be removed. Invasive species such as cattails and Phragmites should also be removed when present.

Second Baptist Church (No. 22)

It is recommended that the bioretention facilities upstream of the detention basin be planted in accordance with original design plan or a similar landscaping plan. This type of facility is designed in conjunction with the proposed vegetation to provide water quality improvement and uptake of runoff by the plants.

George's Tool Rental (No. 23)

The floor of the basin should be planted or seeded with a wet meadow mix of vegetation. This would provide increased water quality while reducing the owner's maintenance responsibilities without loss of curb appeal for the commercial property.

Estates at Brookside (Nos. 26, 27, 28 & 29)

The basins in this residential development are low profile facilities maintained in a lawn condition. Given the residential nature of the site, this allows the basin areas to be used for recreational purposes during dry weather and should remain as lawn. It is recommended, however, that the concrete low flow channels be removed and replaced with a naturalized stone channel with native vegetation. This would filter out sediments in the runoff and allow infiltration of smaller runoff events, thus improving overall water quality.

Fountainville Executive Offices (No. 33)

Although this facility is well maintained as dry basin with lawn, water quality could be improved by converting the vegetative cover to a meadow or even a wetland condition. The simplest solution would be to seed the basin with a meadow mix and allow it to develop naturally. This would also reduce the owner's maintenance responsibility to 1 to 2 mowings per year. At a minimum, woody vegetation should be removed from the berm and the emergency spillway.

Country Greene Subdivision (Nos. 30 & 31)

Basin 2 in this residential development is a low profile facility maintained in a lawn condition. Given the residential nature of the site, this allows the basin area to be used for recreational purposes during dry weather and should remain as lawn. It is recommended, however, that the concrete low flow channels be removed and replaced with a naturalized stone channel with native vegetation. This would filter out sediments in the runoff and allow infiltration of smaller runoff events, thus improving overall water quality.

Ridgeview Subdivision (No. 21)

The basin at Burnt House Hill Road and Danboro Pike is a low profile facility maintained in a lawn condition. Given the residential nature of the site, this allows the basin area to be used for recreational purposes during dry weather and should remain as lawn. It is recommended, however, that the woody vegetation growing at inflow and outflow points should be removed. Being in close proximity to these structures, woody plants will eventually impair the hydraulic regime of the basin and cause problems. On the other hand, the native herbaceous materials at the inflow and outflow points should be allowed to continue and even expand. The "wet" areas along the toe of the slope should be planted with native species to form a naturalized channel to the outlet structure. This would filter out sediments in the runoff and allow infiltration of smaller runoff events, thus improving overall water quality. It has the added benefit of providing a naturalized low flow area that would require less maintenance of this troublesome area.

All Other Facilities

Unless noted elsewhere, these other facilities are being maintained in good condition with appropriate water quality enhancements provided. Therefore, no recommendations are offered at this time.

5.4. Stream & Riparian Assessment

Aqua Link with the assistance of the District performed a comprehensive stream and riparian visual assessment of the North Branch Neshaminy Creek from its headwaters to Lake Galena. As part of this assessment, field staff walked the entire stream corridor and evaluated the stream channel, streambanks and adjacent riparian areas according to a *modified* version of the *Riparian Assessment Form* developed by Ms. Melissa Schnier of The Pennsylvania State University (Schnier 2003). A copy of our modified assessment form entitled *Stream and Riparian Visual Assessment Form* is provided in Appendix G.

Continuous stream and riparian areas of similar conditions are known as “stream segments”. In the field, an abrupt change in stream and/or riparian conditions represented the beginning of a new stream segment. Each stream segment was carefully evaluated according to the *Stream and Riparian Visual Assessment Form*. Using this form, the stream segments were assigned numerical scores ranging from 1 through 10 (poor to excellent) for each of the following ten attributes: riparian buffer width, riparian vegetation type, riparian vegetation density, bank vegetation type, bank vegetation density, bank stability, channel modification, in-stream cover, embeddedness and shading (canopy cover). The individual scores of all parameters were then tallied; and, based upon the total score, a stream segment was assigned an overall rating of poor, marginal, good or excellent.

Once a stream segment was evaluated, field staff carefully delineated the end points of a stream segment using a hand held Garmin GPS unit (Model GPSmap 76S). Digital photographs were taken of all stream segments. In addition, field staff identified and evaluated all significant stream and riparian problems according to the *Watershed Assessment – Problem Areas form* developed by Aqua Link (Appendix G). Once again, field staff photographed all significant stream and riparian problems using a digital camera and recorded their locations using the GPS unit.

The results of the stream and riparian visual assessment are presented in Tables 5.2 and 5.3 and Figures 5.4 through 5.6. Overall, five of the fifteen stream segments only obtained a “marginal” score (Table 5.2 and Figure 5.4). Based upon our field reconnaissance, Stream Segments A4-A5, A5-A6, B1-B2 and B3-B4 are greatly impacted by the PECO (Philadelphia Electric Company) electric power transmission line right-of-way. Unfortunately, this right-of-way encompasses about 1.75 stream miles along the North Branch in the upper, most northern portion of the Lake Galena watershed. Within this right-of-way, the streambanks are virtually devoid of woody vegetation, which are necessary to stabilize streambank soils (Table 5.2 and Figure 5.4). Consequently, severe streambank erosion was

observed throughout the right- of-way and thereby resulting in massive bank failures. In turn, eroded soils are adversely impacting downstream aquatic habitats and inevitably the water quality of the North Branch and Lake Galena.

Table 5.2 North Branch Stream and Riparian Assessment Data

Stream Segment	Stream & Riparian Score	Stream & Riparian Rating
A1-A2	83	Good
A2-A3	69	Good
A3-A4	67	Good
A4-A5	64	Marginal
A5-A6	55	Marginal
B1-B2	47	Marginal
B2-B3	72	Good
B3-B4	55	Marginal
B4-B5	81	Good
C1-C2	60	Marginal
C2-C3	85	Good
C3-C4	81	Good
D1-D2	73	Good
D2-D3	81	Good
D3-D4	91	Excellent

Table 5.3 Major Problems Observed along the North Branch

Problem ID	Stream Segment	Severely Eroding Banks (linear feet)
PA1	A1-A2	1,650
PA2	A2-A3	725
PA3	A3-A4	3,200
PA4	A4-A5	5,700
PB1	A5-A6	1,300
PB2	B1-B2	350
PB3	B2-B3	2,100
PC1	B3-B4	550
PC2	B4-B5	150
PC3	C1-C2	0
PC4	C2-C3	0
PD1	C3-C4	1,800
PD2	D1-D2	75
PD3	D2-D3	125
PD4	D3-D4	100
Total		17,825



Problem Area - PA1



Problem Area – PA2



Problem Area – PA3



Problem Area – PA4

Figure 5.6 Major Stream & Riparian Problems in the Lake Galena Watershed



Problem Area – PB1



Problem Area – PB2



Problem Area – PB3



Problem Area – PC1

Figure 5.6 Major Stream & Riparian Problems in the Lake Galena Watershed



Problem Area – PC2



Problem Area – PC3



Problem Area – PC3 (Source of Problem)



Problem Area – PC4

Figure 5.6 Major Stream & Riparian Problems in the Lake Galena Watershed



Problem Area – PD1



Problem Area – PD2



Problem Area – PD3



Problem Area – PD4

Figure 5.6 Major Stream & Riparian Problems in the Lake Galena Watershed

Based upon our assessment, the most significant factors degrading the ecological health of the North Branch Neshaminy Creek are streambank erosion due to the lack of adequate woody vegetation, the embeddedness of in-stream cover (rocks and cobble) by deposited sediments, and poor shading of the stream due the lack of trees along the streambanks and adjacent riparian areas.

Lastly, all of the major stream and riparian problems that were identified during the assessment portion of this project are presented in Table 3.3. The locations and photographs of these problems are shown in Figures 5.5 and 5.6, respectively. With the exception of PC3 and PC4, all of the problem areas are related to streambank erosion. The total estimated amount of severely eroding streambanks along the North Branch Neshaminy Creek is nearly 18,000 feet. This estimate includes both streambanks with stream segments if applicable. As discussed previously, most of the streambank erosion is located in the upper portion of the watershed along the PECO right-of-way.

For more information, refer to Appendix G of this report, which provides a list of recommendations to rehabilitate/restore all of the identified stream problems areas. Overall, many of the recommendations focus on maximizing the use of vegetative and bioengineering restoration measures, thereby creating a more natural appearance.

6. Watershed Modeling (AVGWLF & PRedICT Models)

6.1. ArcView Generalized Watershed Loading Function

For this project, the PA DEP Bureau of Watershed Management determined the existing nutrient and sediment loadings within the Lake Galena watershed using the ArcView Generalized Watershed Loading Function (AVGWLF) model. AVGWLF is a comprehensive watershed model based on a GIS interface that enables the prediction of nutrient and sediment loads across the watershed. AVGWLF uses a combination of regional data sets to derive estimates of model parameters with high spatial variability, and does not require the input of long-term stream monitoring data to calculate loading. For more information about the AVGWLF model, refer to Appendix H of this report.

For this project, additional user-created data sets for watershed-specific sources of nutrient and sediments were developed to improve the accuracy of the model's loading calculations. For the Lake Galena - North Branch Neshaminy Creek model, existing agricultural BMP, animal load, stormwater facilities, riparian buffer and streambank stabilization data collected as part of this project (Section 3) were summarized and submitted to PA DEP for incorporation into the AVGWLF model.

In contrast, the 2003 TMDL assessment for the entire Neshaminy Creek basin relied more heavily upon default loading values built within the AVGWLF model. Therefore, it is assumed that the AVGWLF modeling results for this project are more accurate than the 2003 TMDL assessment with respect to the Lake Galena watershed.

6.2. Pollution Reduction Impact Comparison Tool (PRedICT) model

The Pollution Reduction Impact Comparison Tool (PRedICT), which was developed by the Pennsylvania State University (Penn State), was used to estimate nutrient and sediment load reductions, which might be achieved by implementing various best management practices in the Lake Galena watershed. Penn State designed PRedICT as a companion software tool for the ArcView Generalized Loading Function (AVGWLF) model, thereby allowing professionals to evaluate pollution reduction strategies at the watershed level.

PRedICT also allows users to create various scenarios in which existing land uses and pollutant loads can be compared against proposed future conditions. These future conditions reflect the implementation of various pollution reduction strategies, including agricultural and urban BMPs, streambank stabilization, the conversion of septic systems to centralized wastewater treatment, and/or upgrading of municipal wastewater treatment plants. The first step in watershed modeling was to run the AVGWLF model for the study watershed, which allowed a scenario file to be generated. This scenario file served as the input file for PRedICT. This file contained specific watershed conditions and pollutant loads, thereby establishing existing conditions from which various future scenarios can be developed and compared. PRedICT then estimates pollutant load reductions for nitrogen,

phosphorus and sediment which can be achieved by implementing BMPs using reduction coefficients derived from a comprehensive literature review of BMP efficiencies. PRedICT also includes estimated cost information associated with the implementation of an assortment of practices. This allows users to evaluate the cost effectiveness of their recommendations in achieving their targeted load reductions.

6.3. PRedICT Model Inputs and Results

The Bucks County Conservation first uploaded the AVGWLF scenario file that was developed by PA DEP into PRedICT. Next, the District ran PRedICT by creating a future scenario file, which included all of the proposed BMPs discussed in Section 5 of this report. The results of the PRedICT model are included in Appendix H.

Overall, the PRedICT model estimated phosphorus, nitrogen and sediment load reductions of 47, 22 and 15 percent, respectively. These reductions assumed that best management practice (BMPs) were implemented according to the recommendations in Section 5. Section 5 discusses a variety of nonpoint problems throughout the watershed and recommends an extensive list of BMPs for future implementation. Based upon the PRedICT model, the total estimated cost for implementing all of the BMPs in Section 3 is \$2,593,043. This model also estimated that approximately 5, 19 and 71 percent of this total cost would be allocated for the implementation of agriculture, urban (stormwater) and streambank stabilization BMPs, respectively.

6.4. Model Limitations

There are two limitations of the model when attempting to capture the potential benefits of implementing best management practices throughout the Lake Galena watershed. These limitations are related to the fact that in some instances, site-specific watershed data could not be directly entered into the models.

First, the Lake Galena watershed that was not adequately captured in either model is the large amount of riparian property in the upper portion of the watershed within PECO Energy's right-of-way. In general, this public utility controls the growth of woody vegetation along its right-of-way. As noted in Section 3.4, this right-of-way encompasses about 1.75 stream miles along the North Branch in the northern portion of the Lake Galena watershed. Within this right-of-way, the streambanks are virtually devoid of any woody vegetation, which are necessary to stabilize streambank soils. For this project, the PECO right-of-way was identified as a significant nonpoint source problem that requires the implementation of streambank stabilization practices and establishing riparian buffers containing woody vegetation. Unfortunately, the PRedICT model limits the implementation of stream and riparian BMPs to only urban or agricultural land uses. To minimize our modeling error, the District included streambank stabilization and establishing riparian buffers within the PECO right-of-way under agricultural land use.

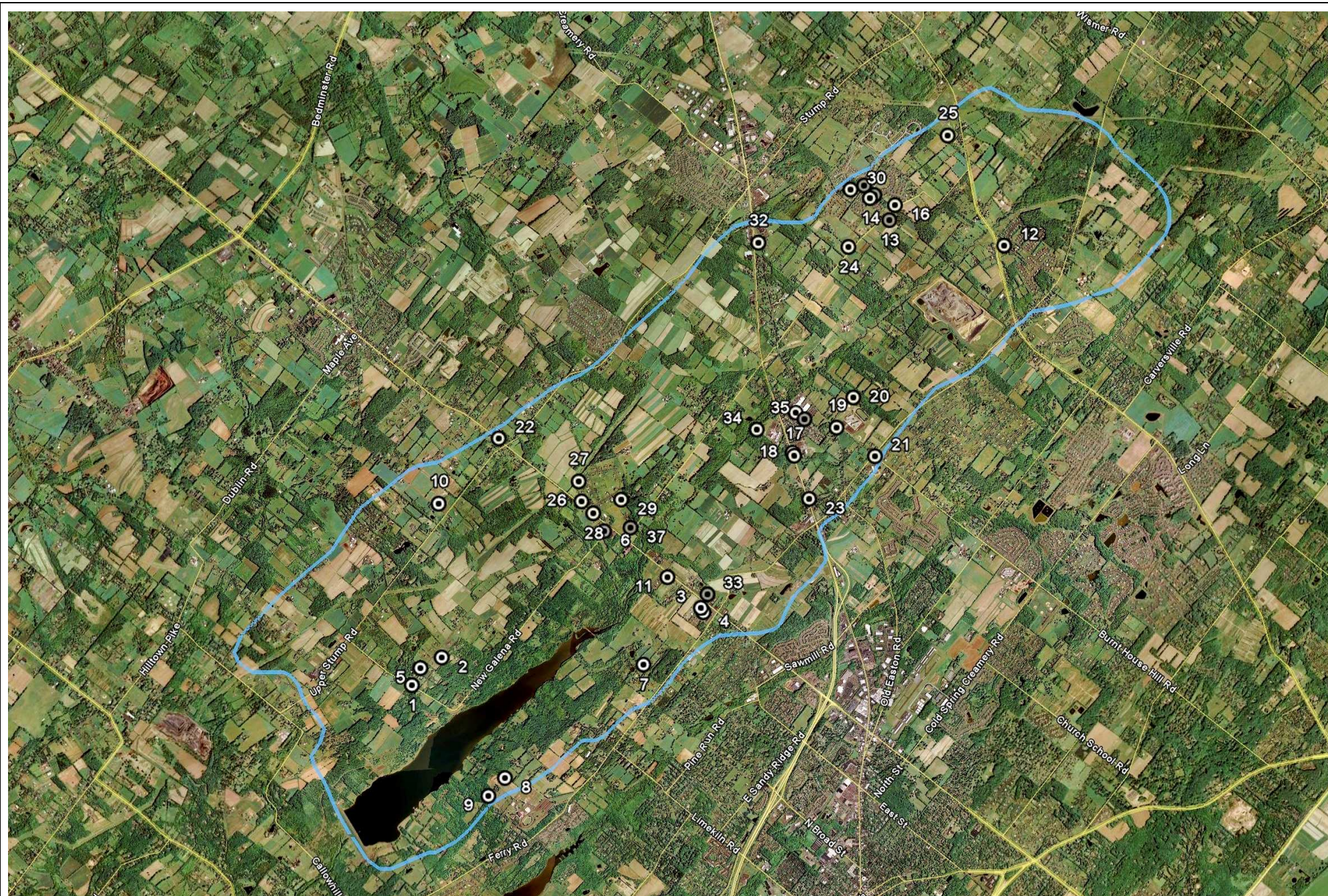
Secondly, the models cannot directly incorporate the potential benefits of restoring eroding shoreline areas along Lake Galena itself. The Bucks County Parks and Recreation Department is a long-standing partner of the Conservation District and one of the largest landowners in the Lake Galena watershed. Although the streambanks are largely well forested within the parkland, several areas of the lake shoreline itself are poorly vegetated and potential direct sources of sedimentation to the lake. Stabilization of portions of the shoreline of Lake Galena could be another key component to achieving the TMDL; however, the benefits of implementing shoreline restoration measures could not be directly accounted for using the models.



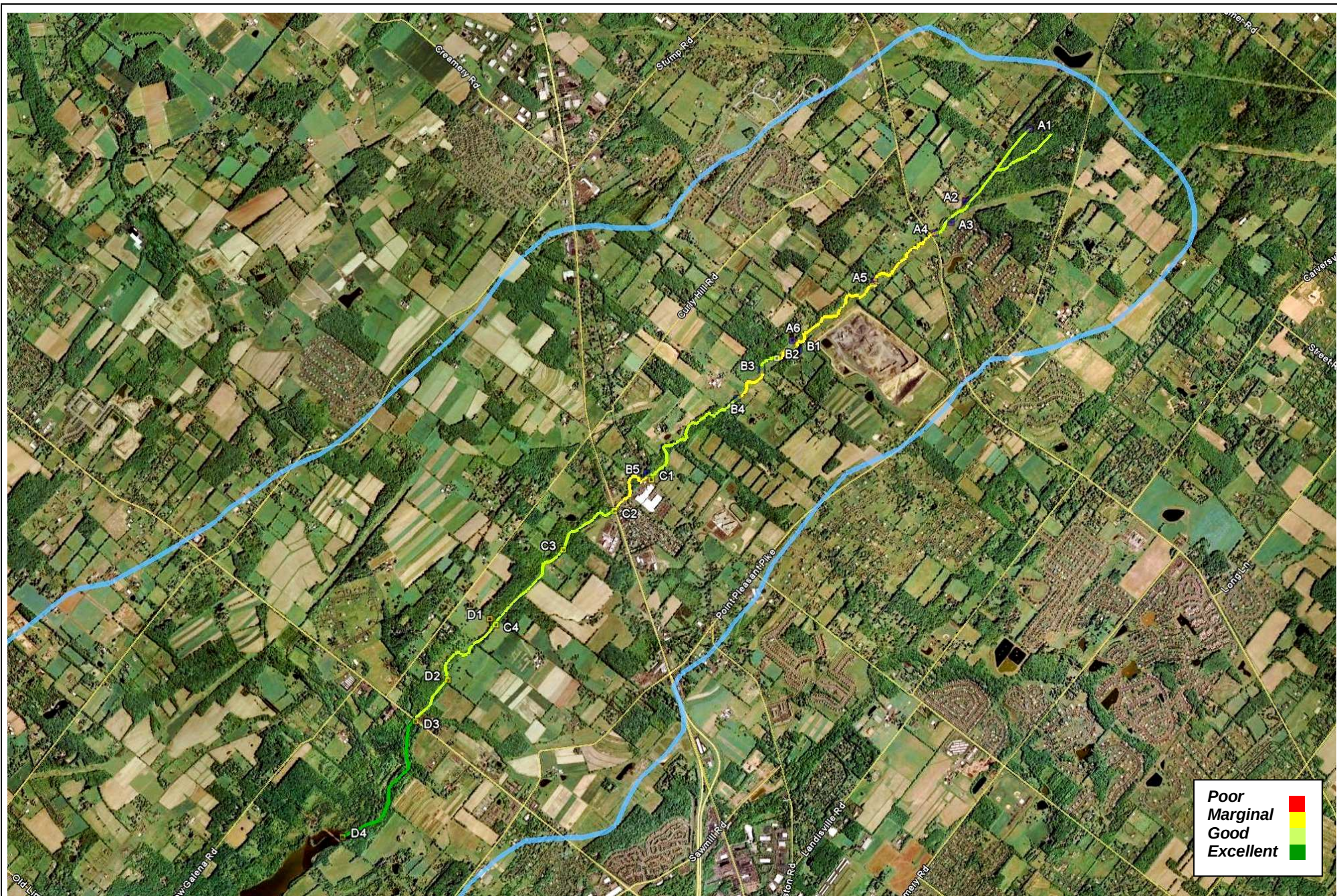
Figure 5.1 Locations of Proposed Agricultural BMP Projects
Lake Galena Watershed

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Water Resources & Watershed Management
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**Figure 5.2 Location of Major Stormwater Management Facilities
Lake Galena Watershed**



**Figure 5.4 Condition of Stream & Riparian Corridors
Lake Galena Watershed**

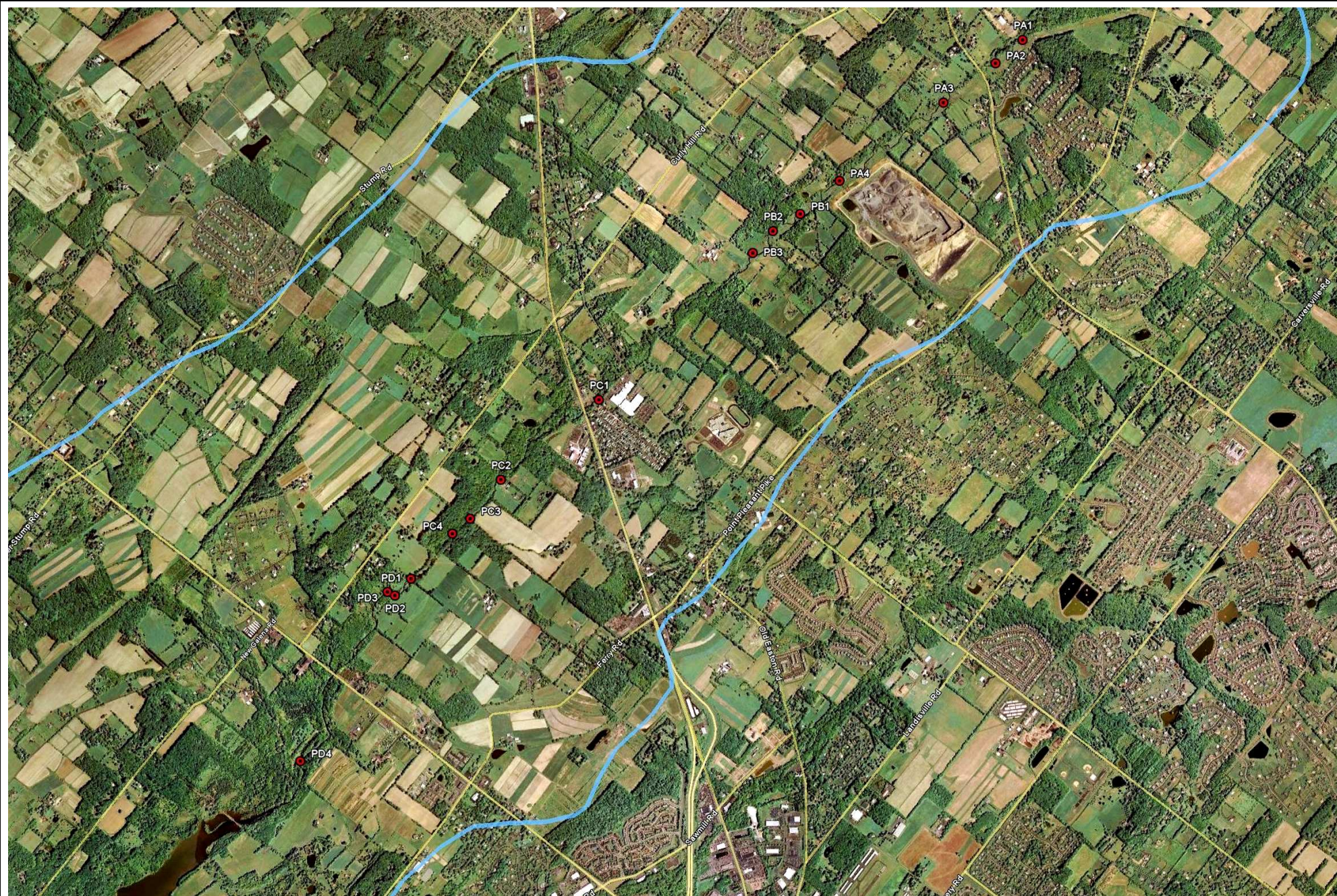


Figure 5.5 Location of Major Stream & Riparian Problems
Lake Galena Watershed

7. Recommendations & Future Project Needs

The Lake Galena and North Branch Neshaminy Creek (NBNC) watershed implementation plan project has identified an extensive list of best management practices (BMPs) for future implementation. All BMPs were discussed in detail in Section 3 of this report. These BMPs fall into one of three categories as noted below and presented in Table 7.1:

- Agricultural Best Management Practices
- Stormwater Best Management Practices
- Stream and Riparian Best Management Practices

Watershed modeling (AVGWLF and PRedICT models), which was performed as part of this project, has estimated that the total cost to implement all of the BMPs listed in this report to be nearly \$2,600,000. These models have determined that roughly 5, 19 and 71 percent of the total cost would be allocated for the implementation of agriculture, urban (stormwater) and streambank stabilization BMPs, respectively. Overall, the most significant nonpoint problems are generally associated with streambank erosion along the upper segments of the North Branch Neshaminy Creek. As noted in Section 3.4, the PECO (Philadelphia Electric Company) electric power transmission line right-of-way has created highly unstable streambanks due to clear cutting and right-of-way maintenance, and should be a top priority regarding BMP implementation.

An essential component of any watershed implementation plan requires a strong partnership and additional funding in order to succeed. First, this project will only be successful if existing partnerships are strengthened. The partners must remain committed to protecting and further improving the water quality of the North Branch Neshaminy Creek and Lake Galena. At a minimum, the partnership should include the Bucks County Conservation District, the North Branch Watershed Association, the USDA Natural Resources and Conservation Service (NRCS), the Bucks County Department of Parks and Recreation, the North Penn and North Wales Water Authorities, the PA Fish and Boat Commission, PA DEP, PECO, local municipalities, homeowners associations, farmers and sportsman's groups.

As discussed in Section 8, the North Branch Watershed Association with the assistance of the Bucks Conservation District should establish the Lake Galena and North Branch Neshaminy Creek Advisory Group. First, the advisory group should evaluate all of the proposed projects discussed in Section 3 and presented in Table 7.1. Next, the advisory group should contact all applicable landowners to determine their willingness to participate in the implementation project. Thereafter, the advisory group should priority rank all applicants and subsequently apply for funding for the implementation of watershed best management practices.

Table 7.1 Recommended Best Management Practices

BMP Category	Description	Priority Ranking	Site Location	Target Dates	Section(s)
Agriculture	12 different farms requiring agricultural BMPs	2	40, 5, 2, 51 25, 45, 44, 46, 15 50, 37, 1	2011 - 2013 2014 - 2016 2017 - 2019	Section 3.2 Table 3.1 & Figure 3.1
Stormwater	21 stormwater management (SWM) facilities to be retrofitted to improve water quality in residential housing developments	3	12, 14, 15, 16, 22, 23 26, 27, 28, 29, 33 30, 31, 21, 1, 7, 6 11, 8, 9, 10	2011 - 2013 2014 - 2016 2017 - 2019 2020 - 2022	Section 3.3, Figure 3.2 & Figure 3.3
Stream & Riparian	3.4 miles of streambanks and riparian areas requiring stabilization and rehabilitation along the North Branch Neshaminy Creek	1	PA1, PA2, PA3 PA4, PB1, PB2, PB3 PC1, PC2, PC3, PC4 PD1, PD2, PD3, PD4	2011 - 2013 2014 - 2016 2017 - 2019 2020 - 2022	Section 3.4, Table 3.2, Table 3.3, Figure 3.4 & Figure 3.5

Note(s): Recommendations are priority ranked from highest priority (1) to lowest priority (3).

All of the recommendations offered in the comprehensive management plan are eligible for state or federal funding. State funding may be obtained through the Pennsylvania Department of Environmental Protection's Growing Greener Grant Program. Federal funding for the implementation of the recommended BMPs may be obtained through U.S. Environmental Protection Agency's Section 319 (Nonpoint Source) Program, National Oceanic and Atmospheric Administration (NOAA) Coastal Zone Management Program, the Delaware Estuary Program, USDA Farm Service Agency's Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP), and USDA Natural Resources Conservation Service's (NRCS) Environmental Quality Incentives Program (EQIP). Nearly all of the recommendations of the management plan can be funded under the Nonpoint Source program, the Coastal Zone Management Program, the Delaware Estuary Program, while agricultural best management practices and riparian buffers are eligible for funding under the CRP, CREP and EQIP programs.

CREP is an offspring of the USDA Farm Service Agency's CRP Program. CREP is a voluntary program for agricultural landowners. Unique state and federal partnerships allow landowners to receive incentive payments for installing specific conservation practices. Through the CREP, farmers can receive annual rental payments and cost-share assistance to establish long-term, resource conservation covers on eligible land. EQIP is funded by the USDA Natural Resources Conservation Service (NRCS). EQIP offers financial and technical help to assist eligible farmers in order to install or implement structural and management practices on eligible agricultural land.

If funding is not available, the watershed stakeholders are strongly encouraged to implement some of the recommendations using their own financial resources. This type of watershed stakeholder commitment is viewed highly by the above agencies and can greatly improve the success of receiving state and federal funding in the future.

With respect to future project needs, PA DEP, the District and its partners should continue monitoring the water quality of Lake Galena and its tributaries. Newly acquired data should be entered into the existing water quality database and analyzed. Water quality trend analysis for the lake and streams will provide a useful tool in evaluating the overall success of any implemented in-lake and watershed restoration measures. All lake and stream samples should be collected and analyzed for the same parameters as described in this report. Secondly, the District and NRCS should continue working closely with farmers to identify additional agricultural lands requiring BMPs. In addition, stream and riparian assessments should be performed on the Hardiacken Creek and other tributaries to Lake Galena. Lastly, the entire shoreline of Lake Galena should be assessed and all severely eroding lake banks should be stabilized using natural bioengineered techniques.

8. Public Participation

The overall success of the Lake Galena and North Branch Neshaminy Creek Watershed Implementation Project (WIP) will largely depend upon the cooperation between various watershed stakeholders. As discussed in Section 7, it is recommended that the North Branch Watershed Association with the assistance of the Bucks Conservation District establish the Lake Galena and North Branch Neshaminy Creek Advisory Group. At a minimum, this advisory group will contain members from the North Branch Watershed Association, Bucks County Conservation District, PA DEP, Bucks County Department of Parks and Recreation, North Penn and North Wales Water Authorities, USDA Natural Resources and Conservation Service (NRCS), PA Fish and Boat Commission, Heritage Conservancy, Bucks County Planning Commission, local municipalities (New Britain, Plumstead, Doylestown and Hilltown Townships), farmers and sportsman's groups.

The newly formed advisory group will meet several times during the winter 2010 – 2011. The Conservation District will take the lead in coordinating these meetings. The purpose of these meetings is to discuss all recommendations offered in this report and to determine how various group members can assist one another in implementing the recommendations. In addition, this group will oversee the implementation of all best management practices. The advisory group will be responsible for informing citizens about lake and watershed issues and soliciting their involvement through press releases and public meetings. Thereafter, the advisory group will meet at least annually to discuss all work completed and those recommendations that will be addressed in the upcoming months.

Information about this project including upcoming watershed events and progress will be made available to the public. This will largely be accomplished by using the websites owned and maintained by the Conservation District and North Branch Watershed Association (NBWA). A copy of the final report and its appendices will be uploaded to both of these websites. Press releases and newsletters are and will continue to be used to inform the public about the project. The Conservation District, NBWA and the water authorities will be responsible for preparing press releases. The NBWA and the Conservation District have newsletters that will periodically share information about the project and the water quality of the lake.

Peace Valley Nature Center, the Conservation District and the NBWA primarily will be responsible for environmental education as it pertains to this project. The nature center, which is part of Bucks County Department of Parks and Recreation, along with the District and NBWA will integrate information from this project into its already highly successful environmental education curriculum.

9. Water Quality Milestones

The water quality of Lake Galena should be monitored on an annual basis. At a minimum, the lake should be tested for the same water quality parameters discussed in Section 3. In our opinion, continued lake water quality monitoring and water quality trend data analysis will provide an excellent way of gauging the overall success of any implemented lake and watershed best management practices. As noted in Section 1, PA DEP completed a TMDL (Total Maximum Daily Loading) assessment for the entire Neshaminy Creek watershed, which includes the North Branch and Lake Galena, back in 2002. According to Pennsylvania's 303(d) list, the lake is being impaired by nutrients and suspended solids from various sources, including on-site wastewater, agriculture, urban runoff/storm sewers, and others (PA DEP 2003).

Since Pennsylvania does not currently have numeric water quality standards for nutrients or suspended solids, the overall goal of the TMDL assessment is to improve the trophic status of Lake Galena from highly eutrophic to mesotrophic. Based on this goal, the water quality target to address the stated impairments has been set at 10 ug/l of chlorophyll-a. A combined watershed/lake water modeling approach was used to estimate current nutrient and sediment loads to the lake as well as to estimate phosphorus reductions needed to achieve the chlorophyll-a target of 10 ug/l (PA DEP 2003).

For this project, it is suggested that an annual summer mean chlorophyll-a of 20 ug/l be set as the target for the first five years. The project partners, as listed in Section 8, should strive to meet this target chlorophyll-a concentration by implementing the recommendations offered in this watershed implementation plan (WIP) report. Thereafter, the proposed annual summer mean chlorophyll-a concentrations are 15 and 10 ug/l should be the targeted values after ten and fifteen years, respectively.

If a target goal has not been met, the project partners will need to develop an adaptive management strategy. This may involve a number of action items including but not limited to securing more funding for best management practices implementation and encouraging more landowners to participate in the project. It cannot be over stress that the success of this WIP project will ultimately depend upon project partners to instill enthusiasm about the project and the willingness of landowners to participate in the project. In addition, under such conditions, the project partners will need to re-evaluate the proposed chlorophyll-a concentration targets and the suggested timetable to reach these targeted concentrations.

10. Literature Cited

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PA DEP. December 2003. *Total Maximum Daily Load (TMDL) Assessment for the Neshaminy Creek Watershed in Southeast Pennsylvania*.

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APPENDIX A

Land Use & Soils GIS Data

Lake Galena Watershed Soils Summary

Symbol	Description	Acres	Percent
AbA	Abbottstown silt loam, 0 to 3 percent slopes	629.4	6.6%
AbB	Abbottstown silt loam, 3 to 8 percent slopes	2,191.8	23.0%
AbC	Abbottstown silt loam, 8 to 15 percent slopes	164.2	1.7%
AmA	Amwell silt loam, 0 to 3 percent slopes	188.2	2.0%
AmB	Amwell silt loam, 3 to 8 percent slopes	565.5	5.9%
BeA	Bedington channery silt loam, 0 to 3 percent slopes	133.1	1.4%
BeB	Bedington channery silt loam, 3 to 8 percent slopes	117.6	1.2%
BeC	Bedington channery silt loam, 8 to 15 percent slopes	81.1	0.9%
Bo	Bowmansville-Knauers silt loams	449.8	4.7%
BwB	Buckingham silt loam, 3 to 8 percent slopes	220.9	2.3%
CbA	Chalfont silt loam, 0 to 3 percent slopes	30.7	0.3%
CbB	Chalfont silt loam, 3 to 8 percent slopes	18.8	0.2%
CwA	Croton silt loam, 0 to 3 percent slopes	545.0	5.7%
CwB	Croton silt loam, 3 to 8 percent slopes	763.5	8.0%
CwxB	Croton silt loam, 0 to 8 percent slopes, extremely stony	89.4	0.9%
CyB	Culleoka-Weikert channery silt loams, 3 to 8 percent slopes	160.8	1.7%
CyC	Culleoka-Weikert channery silt loams, 8 to 15 percent slopes	205.5	2.2%
DdA	Doylestown silt loam, 0 to 3 percent slopes	203.2	2.1%
DdB	Doylestown silt loam, 3 to 8 percent slopes	351.7	3.7%
DuA	Duncannon silt loam, 0 to 3 percent slopes	47.7	0.5%
FoB	Fountainville silt loam, 3 to 8 percent slopes	8.0	0.1%
KIB	Klinesville very channery silt loam, 3 to 8 percent slopes	0.3	0.0%
LgB	Lansdale loam, 3 to 8 percent slopes	5.2	0.1%
LgC	Lansdale loam, 8 to 15 percent slopes	13.7	0.1%
LhB	Lansdale loam, 0 to 8 percent slopes, extremely stony	40.4	0.4%
LhD	Lansdale loam, 8 to 25 percent slopes, extremely stony	145.4	1.5%
LkA	Lawrenceville silt loam, 0 to 3 percent slopes	4.9	0.1%
LmB	Lehigh channery silt loam, 3 to 8 percent slopes	26.4	0.3%
LmC	Lehigh channery silt loam, 8 to 15 percent slopes	41.2	0.4%
LnB	Lehigh channery silt loam, 0 to 8 percent slopes, extremely stony	9.0	0.1%
LnD	Lehigh channery silt loam, 8 to 25 percent slopes, extremely stony	56.3	0.6%
MIB	Mount Lucas silt loam, 3 to 8 percent slopes	5.7	0.1%
MmB	Mount Lucas silt loam, 0 to 8 percent slopes, extremely stony	13.0	0.1%
PeA	Penn channery silt loam, 0 to 3 percent slopes	6.4	0.1%
PeB	Penn channery silt loam, 3 to 8 percent slopes	0.0	0.0%
PkB	Penn-Klinesville channery silt loams, 3 to 8 percent slopes	3.1	0.0%
RaB	Raritan silt loam, 3 to 8 percent slopes	30.0	0.3%
ReA	Readington silt loam, 0 to 3 percent slopes	255.7	2.7%
ReB	Readington silt loam, 3 to 8 percent slopes	743.8	7.8%
ReC	Readington silt loam, 8 to 15 percent slopes	58.3	0.6%
RIA	Reaville channery silt loam, 0 to 3 percent slopes	77.6	0.8%
RIB	Reaville channery silt loam, 3 to 8 percent slopes	294.9	3.1%
RIC	Reaville channery silt loam, 8 to 15 percent slopes	109.1	1.1%
Ro	Rowland silt loam	6.7	0.1%
ToA	Towhee silt loam, 0 to 3 percent slopes	12.9	0.1%
TpB	Towhee-Glenville silt loams, 0 to 8 percent slopes, extremely stony	6.9	0.1%
UdB	Udorthents, shale and sandstone	11.3	0.1%
UgB	Urban land-Abbottstown complex, 0 to 8 percent slopes	338.4	3.6%
UrB	Urban land-Lansdale complex, 0 to 8 percent slopes	5.1	0.1%
UyB	Urban land-Reaville complex, 0 to 8 percent slopes	8.4	0.1%
UzcB	Urban land-Udorthents, shale and sandstone complex, 0 to 8 percent slopes	0.3	0.0%
WfD	Weikert-Culleoka complex, 15 to 25 percent slopes	24.7	0.3%
		9,520.6	100.0%

Lake Galena Watershed Soils Summary

Description	Acres	Percent	> 5%
Abbottstown silt loam	2,985.4	31.4	
Croton silt loam	1,397.9	14.7	
Readington silt loam	1,057.8	11.1	
Amwell silt loam	753.8	7.9	
Doylestown silt loam	554.9	5.8	
Reaville channery silt loam	481.6	5.1	76.0
Bowmansville-Knauers silt loams	449.8	4.7	
Culleoka-Weikert channery silt loams	366.2	3.8	
Urban land-Abbottstown complex	338.4	3.6	
Bedington channery silt loam	331.8	3.5	
Buckingham silt loam	220.9	2.3	
Lansdale loam	204.6	2.1	
Lehigh channery silt loam	132.9	1.4	
Chalfont silt loam	49.5	0.5	
Duncannon silt loam	47.7	0.5	
Raritan silt loam	30.0	0.3	
Weikert-Culleoka complex	24.7	0.3	
Mount Lucas silt loam	18.6	0.2	
Towhee silt loam	12.9	0.1	
Udorthents, shale and sandstone	11.3	0.1	
Penn-Klinesville channery silt loams	9.5	0.1	
Urban land-Reaville complex	8.4	0.1	
Fountainville silt loam	8.0	0.1	
Towhee-Glenville silt loams	6.9	0.1	
Rowland silt loam	6.7	0.1	
Urban land-Lansdale complex	5.1	0.1	
Lawrenceville silt loam	4.9	0.1	
Klinesville very channery silt loam	0.3	0.0	
Urban land-Udorthents	0.3	0.0	
	9,520.6	100.0	

Lake Galena Watershed Land Use Summary(1992)

Category	Acres	Percent
Deciduous Forest	3,708.9	37.4%
Pasture/Hay	3,698.2	37.3%
Row Crops	1,157.7	11.7%
Mixed Forest	629.5	6.3%
Open Water	372.9	3.8%
Low Intensity Residential	155.3	1.6%
Evergreen Forest	111.5	1.1%
Commercial/Industrial/Transportation	50.9	0.5%
Emergent Herbaceous Wetlands	22.4	0.2%
High Intensity Residential	8.7	0.1%
Woody Wetlands	3.3	0.0%
Transitional	0.4	0.0%
	9,919.7	100.0%

Lake Galena Watershed Land Use Summary(1992) - Recategorized

Category	Acres	Percent
Low Intensity Residential	155.3	
High Intensity Residential	8.7	
Commercial/Industrial/Transportation	50.9	
Urban	214.8	2.2
Deciduous Forest	3,708.9	
Mixed Forest	629.5	
Evergreen Forest	111.5	
Forest	4,449.9	44.9
Pasture/Hay	3,698.2	
Row Crops	1,157.7	
Agriculture	4,855.9	49.0
Woody Wetlands	3.3	
Emergent Herbaceous Wetlands	22.4	
Wetlands	25.8	0.3
Transitional	0.4	0.0
Open Water	372.9	3.8
Sum of Sums	9,919.7	100.0

Lake Galena Watershed Land Use Summary(2000)

Category	Acres	Percent
Deciduous Forest	2,859.2	28.8%
Hay/Pasture	2,149.3	21.7%
Row Crops	1,466.5	14.8%
Low Density Mixed	1,381.5	13.9%
Mixed Forest	859.6	8.7%
Water	414.8	4.2%
Transitional	411.5	4.1%
Mined Land	121.5	1.2%
Coniferous Forest	107.6	1.1%
Woody Wetland	70.2	0.7%
High Density Mixed	54.2	0.5%
Emergent Wetland	25.7	0.3%
	9,921.6	100.0%

Lake Galena Watershed Land Use Summary(2000) - Recategorized

Category	Acres	Percent
Low Density Mixed	1,381.5	
High Density Mixed	54.2	
Mined Land	121.5	
Urban	1,557.2	15.7
Deciduous Forest	2,859.2	
Mixed Forest	859.6	
Coniferous Forest	107.6	
Forest	3,826.4	38.6
Hay/Pasture	2,149.3	
Row Crops	1,466.5	
Agriculture	3,615.9	36.4
Woody Wetland	70.2	
Emergent Wetland	25.7	
Wetlands	95.9	1.0
Transitional	411.5	4.1
Water	414.8	4.2
Sum of Sums	9,921.6	100.0

Lake Galena Watershed Land Use Summary(1992) - Major Categories

Category	Acres	Percent
Urban	214.8	2.2
Forest	4,449.9	44.9
Agriculture	4,855.9	49.0
Wetlands	25.8	0.3
Transitional	0.4	0.0
Open Water	372.9	3.8
Total	9,919.7	100.0

Lake Galena Watershed Land Use Summary(2000) - Major Categories

Category	Acres	Percent
Urban	1,557.2	15.7
Forest	3,826.4	38.6
Agriculture	3,615.9	36.4
Wetlands	95.9	1.0
Transitional	411.5	4.1
Open Water	414.8	4.2
Total	9,921.6	100.0

APPENDIX B

Lake Water Quality Data

Lake Galena
ALI Project Nos. 1005-10 & 1005-16

Prepared by Aqua Link, Inc.

Lake Water Quality Data

Parameter:	Units of Measure:
pH (pH)	Expressed in Standard Units (s.u.)
Alkalinity (Alk)	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO3)
Hardness	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO3)
Conductivity (Cond)	Expressed in micromhos per cm (umhos/cm)
Conductivity (Cond)	Expressed in microsiemens per cm (uS/cm)
Specific Conductance (Sp Cond)	Expressed in micromhos per cm (umhos/cm) @ 25.0 degrees Celsius
Total Phosphorus (TP)	Expressed as milligrams per liter as phosphorus (mg/l as P)
Dissolved Reactive Phosphorus (DRP)	Expressed in milligrams per liter as phosphorus (mg/l as P)
Nitrate (NO3)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Nitrite (NO2)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Ammonia nitrogen (NH3)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Kjeldahl Nitrogen (TKN)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Suspended Solids (TSS)	Expressed in milligrams per liter (mg/l)
Turbidity	Expressed in ntu's (nephelometric turbidity units)
Color	Expressed in Pt/Co Units
Oil & Grease	Expressed in milligrams per liter (mg/l)
Iron (Fe) total/dissolved	Expressed in milligrams per liter (mg/l)
Manganese (Mn) total/dissolved	Expressed in milligrams per liter (mg/l)
Dissolved Oxygen (Dissol Oxy)	Expressed in milligrams per liter (mg/l)
Temperature (Temp)	Expressed in degrees Celsius (degrees C)
Secchi Disk Depth	Expressed in meters (m)
Chlorophyll-a	Expressed in micrograms per liter (ug/l)
Fecal coliform bacteria (FC)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Fecal streptococcus bacteria (FS)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Phytoplankton	Expressed as number of organisms per liter (No.per ml)
Phytoplankton	Expressed as biomass in micrograms per liter (ug/l)

Lake Galena

ALI Project Nos. 1005-10 & 1005-16

1999 Lake Galena Water Summary Report

2000 Lake Galena Water Summary Report

Prepared by Aqua Link, Inc.

Lake Water Quality Data - Historical

Station No. 1 (FXB Inc.) = LG1 (ALI) = WQ01 (PA DEP)

Station	Sampler	(Layer)		Date	NO3/NO2	NH3	TKN	TN*	TP	DRP	Chl-a	TSS	SD	
		Depth	Type		(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(m)
				01/01/85										
WQ01	FXB	e	c	08/21/85	0.10	0.10	0.10	0.20	0.030	0.015	36.30	12.0		
WQ01	FXB	e	c	07/17/91	0.50	0.50	1.50	2.00	0.070	0.050	86.97	21.0		
WQ01	FXB	e	c	10/22/85	0.85	0.48	1.00	1.85	0.070	0.030	2.50	11.0		
WQ01	FXB	e	c	05/19/86	1.30	0.01	0.70	2.00	0.030	0.020	3.29	3.0		
WQ01	FXB	e	c	08/18/86	1.20	0.01	2.60	3.80	0.030	0.010	34.89	20.0		
WQ01	FXB	e	c	10/29/86	0.50	0.38	1.00	1.50	0.050	0.040	6.85	10.0		
WQ01	FXB	e	c	05/19/88	1.20	0.10	1.40	2.60	0.240	0.050	10.09	8.0		
WQ01	FXB	e	c	09/30/88	0.50	0.50	2.20	2.70	0.260	0.030		2.0		
WQ01	FXB	e	c	10/27/88	0.50	0.44	2.20	2.70	0.050	0.050	16.34	12.0		
WQ01	FXB	e	c	06/20/89	0.70	0.10	1.00	1.70	0.100	0.050	46.46	7.0		
WQ01	FXB	e	c	07/12/89	0.10	0.50	1.00	1.10	0.100	0.050	134.83	20.0		
WQ01	FXB	e	c	07/28/89	0.10	0.30	1.00	1.10	0.100	0.050		11.0		
WQ01	FXB	e	c	08/10/89	0.20	0.10	3.00	3.20	0.100		0.27	8.0		
WQ01	FXB	e	c	08/24/89	0.10	0.10	1.00	1.10	0.100		6.68	9.0		
WQ01	FXB	e	c	09/05/89	0.10	0.10	1.00	1.10	0.100	0.050	3.74	18.0		
WQ01	FXB	e	c	09/21/89	0.10	0.20	1.00	1.10	0.100		44.86	22.0		
WQ01	FXB	e	c	10/05/89	0.40	0.60	1.30	1.70	0.100	0.050	18.69	12.0		
WQ01	FXB	e	c	10/20/89	0.30	0.50	1.60	1.90	0.100		14.69	16.0		
WQ01	FXB	e	c	11/02/89	0.60	0.40	0.90	1.50	0.100		1.07	10.0		
WQ01	FXB	e	c	11/15/89	0.60	0.30	0.90	1.50	0.100		0.00	16.0		
WQ01	FXB	e	c	11/30/89	0.60	0.50	1.00	1.60	0.100		0.27	14.0		
WQ01	FXB	e	c	08/01/91	0.50	0.50	1.20	1.70	0.070	0.060	66.05	14.0		
WQ01	FXB	e	c	08/14/91	0.50	0.50	1.20	1.70	0.050	0.050	39.08	9.0		
WQ01	FXB	e	c	08/27/91	0.50	0.50	1.20	1.70	0.050	0.050	42.36	14.0		
WQ01	FXB	e	c	09/10/91	0.50	0.50	0.70	1.20	0.070	0.050	35.83	4.0		
WQ01	FXB	e	c	09/24/91	0.50	0.50	0.80	1.30	0.050	0.050	26.60	8.0		
WQ01	FXB	e	c	10/08/91	0.50	0.50	0.70	1.20	0.070	0.050	11.98	19.0		
WQ01	FXB	e	c	10/22/91	0.50	0.50	1.00	1.50	0.060	0.050	8.38	10.0		
WQ01	FXB	e	c	06/25/92	0.99	b	0.10	0.30	1.29	0.038	0.005	6.03	2.0	
WQ01	FXB	e	c	06/30/92	0.87	b	0.10	0.60	1.47	0.027	0.004	5.90	5.6	
WQ01	FXB	e	c	07/14/92	0.48	b	0.10	0.60	1.08	0.034	0.001	32.40	4.4	
WQ01	FXB	e	c	07/28/92	0.14	b	0.10	0.70	0.84	0.034	0.005	20.41	5.2	
WQ01	FXB	e	c	08/11/92	0.02	b	0.10	0.75	0.77	0.042	b	0.001	29.64	6.0

Lake Galena

ALI Project Nos. 1005-10 & 1005-16

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2000 Lake Galena Water Summary Report

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Lake Water Quality Data - Historical

Station No. 1 (FXB Inc.) = LG1 (ALI) = WQ01 (PA DEP)

Station	Sampler	(Layer) Depth	Type	Date	NO3/NO2 (mg/l)	NH3 (mg/l)	TKN (mg/l)	TN* (mg/l)	TP (mg/l)	DRP (mg/l)	Chl-a (ug/l)	TSS (mg/l)	SD (m)
WQ01	FXB	e	c	08/25/92	0.01	b	0.10	0.68	0.69	0.044	0.003	36.42	8.0
WQ01	FXB	e	c	09/08/92	0.01	b	0.10	0.68	0.69	0.056	0.004	41.72	13.6
WQ01	FXB	e	c	09/29/92	0.01		0.40	0.80	0.81	0.075	0.002	20.74	12.0
WQ01	FXB	e	c	10/13/92	0.06		0.43	0.79	0.85	0.058	0.016	6.19	14.0
WQ01	FXB	e	c	10/28/92	0.13		0.49	0.76	0.89	0.062	0.014	14.59	12.8
WQ01	FXB	e	c	01/19/93	1.90		0.34	0.42	2.32	0.071	0.034	3.09	b 8.0 1.00
WQ01	FXB	e	c	03/31/93	1.30		0.75	1.28	2.58			19.32	12.0 0.70
WQ01	FXB	e	c	04/19/93	1.20		0.09	0.50	1.70	0.053	0.001	6.93	12.5 0.40
WQ01	FXB	e	c	05/11/93	0.80		0.10	0.57	1.37			18.33	b 8.0 1.40
WQ01	FXB	e	c	05/25/93	0.60		0.07	0.11	0.71		0.031	8.61	11.0
WQ01	FXB	e	c	06/08/93	0.50		0.11	1.28	1.78	0.033	0.001	6.01	b 8.0 1.40
WQ01	FXB	e	c	06/22/93	0.60		0.07	0.86	1.46	0.008	0.001	12.08	7.0 1.60
WQ01	FXB	e	c	07/08/93	0.20		0.34	1.84	2.04	0.001	0.001	15.74	8.0 1.30
WQ01	FXB	e	c	07/27/93	0.00		0.10	0.91	0.91	0.056	0.005	43.79	11.0 0.70
WQ01	FXB	e	c	08/10/93	0.00	b	0.07	0.26	0.26	0.045	0.010	28.93	13.0 0.80
WQ01	FXB	e	c	08/25/93	0.00		0.12	0.43	0.43	0.049	0.015	17.71	b 8.0 1.00
WQ01	FXB	e	c	09/15/93	0.00		0.31	0.58	0.58	0.075	0.034	5.46	b 8.0 1.40
WQ01	FXB	e	c	09/29/93	0.11		0.31	0.36	0.47	0.081	0.072	8.78	10.0
WQ01	FXB	e	c	06/14/94	0.31	b	0.10	1.76	2.07	0.043	0.007	10.49	7.0 1.20
WQ01	FXB	e	c	06/28/94	0.14	b	0.10	0.70	0.84	0.058	0.013	13.23	16.0 1.40
WQ01	FXB	e	c	07/12/94	0.01	b	0.10	0.77	0.78	0.053	0.005	27.44	8.8 0.80
WQ01	FXB	e	c	07/26/94	0.02	b	0.10	0.56	0.58	0.047	0.009	19.62	2.8 1.10
WQ01	FXB	e	c	08/09/94	0.01	b	0.10	0.81	0.82	0.043	0.011	27.19	4.8 0.90
WQ01	FXB	e	c	08/29/94	0.01	b	0.10	0.63	0.64	0.045	0.003	25.33	3.2 1.00
WQ01	FXB	e	c	09/13/94	0.02		0.11	1.04	1.06	0.068	0.006	28.58	10.8 0.80
WQ01	FXB	e	c	09/29/94	0.02		0.20	0.96	0.98	0.054	0.006	11.39	2.8 0.80
WQ01	FXB	e	c	07/14/97	0.19	b	0.10	0.45	0.64	0.042	b 0.001	21.70	7.6 1.40
WQ01	FXB	e	c	08/18/97	0.03	b	0.10	1.62	1.65	0.049	0.002	37.10	9.6 0.90
WQ01	FXB	e	c	06/22/98	0.19	b	0.10	0.74	0.93	0.071	0.009	62.40	5.2 1.00
WQ01	FXB	e	c	07/21/98	0.01	b	0.10	0.86	0.87	0.055	0.002	53.90	9.4 0.70
WQ01	FXB	e	c	08/19/98	0.04	b	0.10	0.66	0.70	0.050	0.006	39.50	10.5 1.00
WQ01	FXB	e	c	06/22/99	0.13	b	0.10	0.76	0.89	0.059	0.002	33.80	10.4 0.80
WQ01	FXB	e	c	07/12/99	0.01	b	0.10	0.76	0.77	0.064	0.004	32.50	6.4 0.85
WQ01	FXB	e	c	08/17/99	0.01	b	0.10	0.64	0.65	0.038	b 0.001	22.40	9.2 0.75

Lake Galena

ALI Project Nos. 1005-10 & 1005-16

1999 Lake Galena Water Summary Report

2000 Lake Galena Water Summary Report

Prepared by Aqua Link, Inc.

Lake Water Quality Data - Historical

Station No. 1 (FXB Inc.) = LG1 (ALI) = WQ01 (PA DEP)

Station	Sampler	(Layer)	Type	Date	NO3/NO2		NH3	TKN	TN*	TP	DRP	Chl-a	TSS	SD
					(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(mg/l)	(m)	
WQ01	FXB	e		06/21/00	0.07	b	0.10	2.33	2.40	0.051	0.006	23.10	9.5	0.70
WQ01	FXB	e		07/18/00	0.01	b	0.10	0.87	0.88	0.049	0.004	24.50	8.3	
WQ01	FXB	e		08/22/00	0.01	b	0.10	0.74	0.75	0.043	0.002	24.50	8.5	0.70
LG1	ALI	e	d	04/28/05					0.98	0.047		21.50	6.0	0.7
LG1	ALI	e	d	06/22/05					0.54	0.018		23.10	6.0	1.7
LG1	ALI	e	d	07/27/05					0.69	0.043		28.90	12.0	1.1
LG1	ALI	e	d	08/29/05					0.85	0.033		74.80	12.0	0.5
LG1	ALI	e	d	10/28/05					1.58	0.055		23.70	6.0	0.7
				12/31/05										
<<insert>>														
				Mean	0.36		0.24	0.97	1.30	0.063	0.021	24.91	9.9	0.98
				Min	0.00		0.01	0.10	0.20	0.001	0.001	0.00	2.0	0.40
				Max	1.90		0.75	3.00	3.80	0.260	0.072	134.83	22.0	1.65
				No.	70		70	70	75	72	61	73	75	34

Note(s): TIN denotes total inorganic nitrogen and is the sum of nitrite, nitrate, and ammonia nitrogen
 TN denotes total nitrogen and is the sum of total Kjeldahl nitrogen and nitrite and nitrate nitrogen
 TN:TP denotes the ratio of total nitrogen and total phosphorus
 TIN:DRP denotes the ratio of total inorganic nitrogen and dissolved reactive phosphorus
 b denotes less than the detection limit
 e denotes epilimnion
 c denotes composite sample
 g denotes grab sample

Outliers - TP concentrations of 0.809, 1.381 & 0.398 mg/L as P for 3/31/93, 5/1/93 & 5/25/93, respectively, removed from data set - apparent reporting or laboratory error.

Outliers - DRP concentrations of 0.305 & 0.153 mg/L as P for 3/31/93 & 5/1/93, respectively, removed from data set - apparent reporting or laboratory error.

Lake Galena
ALI Project Nos. 1005-10 & 1005-16

Station No. 1 = LG1 (Dam)
Station No. 2 = LG2 (Uplake)

Insitu Water Quality Data

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS g/L	Salinity ppt	ORP mV	Conversions	
													Depth (feet)	Temp (Degrees F)
4/28/2005	10:33:36	1	0.0	13.1	104.6	11.01	171	221	6.99	143.7	0.11	232	0.1	55.5
4/28/2005	10:34:08	1	1.0	13.0	104.7	11.02	169	219	6.56	142.4	0.1	240	3.3	55.4
4/28/2005	10:35:10	1	2.0	13.0	104.5	11.00	169	219	6.96	142.4	0.1	250	6.6	55.4
4/28/2005	10:35:53	1	3.0	13.0	104.6	11.02	168	219	7.23	142.4	0.1	253	9.8	55.3
4/28/2005	10:36:40	1	4.0	13.0	104.6	11.02	169	219	7.50	142.4	0.1	257	13.1	55.3
4/28/2005	10:37:46	1	5.0	13.0	104.7	11.03	168	219	7.74	142.4	0.1	260	16.4	55.3
4/28/2005	10:39:10	1	6.0	12.8	101.3	10.71	170	222	7.91	144.3	0.11	264	19.7	55.0
4/28/2005	10:47:48	1	7.0	11.8	82.2	8.89	158	211	7.86	137.2	0.1	245	23.1	53.2
4/28/2005	10:48:34	1	8.0	10.8	72.8	8.07	156	214	7.78	139.1	0.1	249	26.2	51.4
4/28/2005	10:54:03	1	9.0	10.3	71.8	8.05	153	212	7.99	137.8	0.1	258	29.6	50.5
4/28/2005	11:01:32	1	10.0	10.1	60.9	6.86	154	215	7.72	139.8	0.1	252	32.9	50.1
4/28/2005	11:02:16	1	11.0	9.9	51.1	5.78	154	216	7.64	140.4	0.1	257	36.1	49.8
4/28/2005	11:02:56	1	12.0	9.7	43.1	4.89	159	224	7.56	145.6	0.11	247	39.4	49.5
<<insert>>														
			0.0	9.7	43.1	4.89	153	211	6.56	137.2	0.10	232	0.1	49.5
			12.0	13.1	104.7	11.03	171	224	7.99	145.6	0.11	264	39.4	55.5
			12.0	3.3	61.6	6.14	18	13	1.43	8.4	0.01	32	39.3	6.0
			13	13	13	13	13	13	13	13	13	13	13	13

Lake Galena
ALI Project Nos. 1005-10 & 1005-16

Station No. 1 = LG1 (Dam)
Station No. 2 = LG2 (Uplake)

Insitu Water Quality Data

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS g/L	Salinity ppt	ORP mV	Conversions	
													Depth (feet)	Temp (Degrees F)
6/24/2005	11:08:16	1	0.0	24.2	140.1	11.75	282	287	7.61	186.6	0.14	363	0.0	75.5
6/24/2005	11:09:10	1	1.0	24.1	146.6	12.31	281	286	7.87	185.9	0.14	370	3.3	75.4
6/24/2005	11:09:45	1	2.0	23.7	139.2	11.78	281	288	7.93	187.2	0.14	372	6.6	74.6
6/24/2005	11:10:13	1	3.0	23.2	103	8.80	279	290	7.36	188.5	0.14	376	9.8	73.7
6/24/2005	11:10:42	1	4.0	22.0	56	4.89	270	286	6.95	185.9	0.14	381	13.1	71.6
6/24/2005	11:11:56	1	5.0	18.8	8.4	0.78	246	279	6.27	181.4	0.13	390	16.4	65.8
6/24/2005	11:12:48	1	6.0	16.7	6.1	0.59	234	278	6.09	180.7	0.13	390	19.7	62.1
6/24/2005	11:13:39	1	7.0	15.6	5.2	0.52	229	278	6.03	180.7	0.13	270	23.0	60.1
6/24/2005	11:14:58	1	8.0	14.8	4.7	0.47	222	276	6.15	179.4	0.13	84	26.2	58.5
6/24/2005	11:15:59	1	9.0	14.3	4	0.41	219	276	6.32	179.4	0.13	36	29.5	57.6
6/24/2005	11:17:09	1	9.5	14.0	3.5	0.36	221	279	6.51	181.4	0.13	7	31.2	57.2
<<insert>>														
Min			0.0	14.0	3.5	0.36	219	276	6.03	179.4	0.13	7	0.0	57.2
Max			9.5	24.2	146.6	12.31	282	290	7.93	188.5	0.14	390	31.2	75.5
Max - Min			9.5	10.2	143.1	11.95	63	14	1.90	9.1	0.01	383	31.2	18.3
Count			11	11	11	11	11	11	11	11	11	11	11	11

Lake Galena
ALI Project Nos. 1005-10 & 1005-16

Station No. 1 = LG1 (Dam)
Station No. 2 = LG2 (Uplake)

Insitu Water Quality Data

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS g/L	Salinity ppt	ORP mV	Conversions	
													Depth (feet)	Temp (Degrees F)
7/27/2005	10:22:35	1	0.0	29.5	144.3	10.99	297	274	8.68	178.1	0.13	443	0.0	85.1
7/27/2005	10:23:57	1	1.0	29.0	138.4	10.63	294	273	8.85	177.5	0.13	453	3.3	84.3
7/27/2005	10:24:49	1	2.0	28.6	125.5	9.72	289	271	8.82	176.2	0.13	462	6.6	83.4
7/27/2005	10:25:34	1	3.0	27.7	98.4	7.73	286	272	8.49	176.8	0.13	478	9.8	81.9
7/27/2005	10:27:00	1	4.0	26.3	29.5	2.38	277	270	7.55	175.5	0.13	512	13.1	79.4
7/27/2005	10:28:29	1	5.0	24.9	9.7	0.80	266	266	7.19	172.9	0.13	479	16.4	76.9
7/27/2005	10:29:19	1	6.0	23.1	6.7	0.57	253	263	7.01	171.0	0.12	446	19.7	73.7
7/27/2005	10:30:22	1	7.0	20.5	6.2	0.56	237	259	6.81	168.4	0.12	380	23.0	68.9
7/27/2005	10:30:53	1	8.0	15.8	5.8	0.57	226	274	6.45	178.1	0.13	7	26.2	60.5
7/27/2005	10:31:29	1	9.0	13.9	5.4	0.56	221	280	6.04	182.0	0.13	-55	29.5	57.1
7/27/2005	10:31:56	1	10.0	13.5	5	0.52	220	281	5.99	182.7	0.13	-71	32.8	56.4
7/27/2005	10:33:21	1	11.0	13.2	4	0.41	216	279	6.23	181.4	0.13	-93	36.1	55.8
7/27/2005	10:33:41	1	12.0	13.1	3.7	0.39	217	281	6.31	182.7	0.13	-96	39.4	55.7
<<insert>>														
Min			0.0	13.1	3.7	0.39	216	259	5.99	168.4	0.12	-96	0.0	55.7
Max			12.0	29.5	144.3	10.99	297	281	8.85	182.7	0.13	512	39.4	85.1
Max - Min			12.0	16.4	140.6	10.60	81	22	2.86	14.3	0.01	608	39.4	29.4
Count			13	13	13	13	13	13	13	13	13	13	13	13

Lake Galena
ALI Project Nos. 1005-10 & 1005-16

Station No. 1 = LG1 (Dam)
Station No. 2 = LG2 (Uplake)

Insitu Water Quality Data

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS g/L	Salinity ppt	ORP mV	Conversions	
													Depth (feet)	Temp (Degrees F)
8/29/2005	10:47:06	1	0.0	25.2	142.2	11.71	253	252	8.80	163.8	0.12	390	0.0	77.3
8/29/2005	10:48:03	1	1.0	25.0	134.2	11.09	252	252	8.74	163.8	0.12	399	3.3	77.0
8/29/2005	10:48:40	1	2.0	24.9	124.4	10.29	252	253	8.67	164.5	0.12	406	6.6	76.9
8/29/2005	10:50:01	1	3.0	24.9	117.7	9.74	252	253	8.66	164.5	0.12	413	9.8	76.8
8/29/2005	10:50:41	1	4.0	24.9	111.2	9.21	254	254	8.60	165.1	0.12	418	13.1	76.8
8/29/2005	10:51:21	1	5.0	24.8	101.7	8.43	253	254	8.48	165.1	0.12	425	16.4	76.7
8/29/2005	10:52:01	1	6.0	24.3	56.7	4.74	254	257	7.96	167.1	0.12	452	19.7	75.8
8/29/2005	10:52:48	1	7.0	19.8	14.1	1.28	241	267	7.31	173.6	0.13	-29	23.0	67.7
8/29/2005	10:53:32	1	8.0	16.2	3.1	0.31	218	262	6.76	170.3	0.12	-104	26.2	61.1
8/29/2005	10:54:18	1	9.0	14.5	1.8	0.18	213	267	6.36	173.6	0.13	-118	29.5	58.0
8/29/2005	10:55:29	1	10.0	13.7	1.1	0.11	215	274	6.17	178.1	0.13	-134	32.8	56.7
8/29/2005	10:56:06	1	11.0	13.4	1.1	0.12	217	279	6.14	181.4	0.13	-139	36.1	56.1
8/29/2005	10:56:06	1	11.0	13.4	1.1	0.12	217	279	6.14	181.4	0.13	-139	36.1	56.1
<<insert>>														
	Min		0.0	13.4	1.1	0.11	213	252	6.14	163.8	0.12	-139	0.0	56.1
	Max		11.0	25.2	142.2	11.71	254	279	8.80	181.4	0.13	452	36.1	77.3
	Max - Min		11.0	11.8	141.1	11.60	41	27	2.66	17.6	0.01	591	36.1	21.1
	Count		13	13	13	13	13	13	13	13	13	13	13	13

Lake Galena
ALI Project Nos. 1005-10 & 1005-16

Station No. 1 = LG1 (Dam)
Station No. 2 = LG2 (Uplake)

Insitu Water Quality Data

Date M/D/Y	Time hh:mm:ss	Site	Depth m	Temp C	DO% %	DO Conc mg/L	Cond uS/cm	SpCond uS/cm	pH s.u.	TDS g/L	Salinity ppt	ORP mV	Conversions	
													Depth (feet)	Temp (Degrees F)
10/28/2005	9:27:44	1	0.0	12.2	86.9	9.31	178	235	7.71	152.8	0.11	297	0.0	54.0
10/28/2005	9:28:52	1	1.0	12.3	86.7	9.29	178	235	7.69	152.8	0.11	298	3.3	54.0
10/28/2005	9:29:27	1	2.0	12.3	86.5	9.26	177	234	7.67	152.1	0.11	300	6.6	54.0
10/28/2005	9:30:06	1	3.0	12.3	86.1	9.22	177	235	7.66	152.8	0.11	301	9.8	54.0
10/28/2005	9:30:46	1	4.0	12.3	86.1	9.22	177	233	7.65	151.5	0.11	302	13.1	54.0
10/28/2005	9:31:47	1	5.0	12.2	84.7	9.07	177	234	7.62	152.1	0.11	304	16.4	54.0
10/28/2005	9:32:40	1	6.0	12.2	82.3	8.83	177	234	7.59	152.1	0.11	306	19.7	53.9
10/28/2005	9:33:32	1	7.0	12.1	80	8.60	177	234	7.55	152.1	0.11	309	23.0	53.8
10/28/2005	9:34:07	1	8.0	12.0	76.7	8.25	175	233	7.52	151.5	0.11	310	26.2	53.7
10/28/2005	9:34:50	1	9.0	12.0	73.5	7.93	176	234	7.48	152.1	0.11	312	29.5	53.5
10/28/2005	9:35:27	1	9.5	11.9	70	7.56	181	242	7.47	157.3	0.12	110	31.2	53.3
8/29/2005	10:56:06	1	11.0	13.4	1.1	0.12	217	279	6.14	181.4	0.13	-139	36.1	56.1
8/29/2005	10:56:06	1	11.0	13.4	1.1	0.12	217	279	6.14	181.4	0.13	-139	36.1	56.1
<<insert>>														
Min			0.0	11.9	1.1	0.12	175	233	6.14	151.5	0.11	-139	0.0	53.3
Max			11.0	13.4	86.9	9.31	217	279	7.71	181.4	0.13	312	36.1	56.1
Max - Min			11.0	1.6	85.8	9.19	42	46	1.57	29.9	0.02	451	36.1	2.8
Count			13	13	13	13	13	13	13	13	13	13	13	13

Carlson's Trophic State Index - All Data

Station	Date	Secchi (meters)	Chl-a* (ug/l)	TP* (mg/l as P)	TSI Values			Mean TSI Values		
					Secchi	Chl-a	TP	Secchi	Chl-a	TP
LG1	4/28/2005	0.7	21.5	0.047	65.6	60.7	59.7	60.9	65.3	57.1
	6/22/2005	1.7	23.1	0.018	52.8	61.4	45.8			
	7/27/2005	1.1	28.9	0.043	58.1	63.6	58.4			
	8/29/2005	0.5	74.8	0.033	70.0	72.9	54.6			
	10/28/2005	0.7	23.7	0.055	64.3	61.6	62.0			
<<insert>>										
	Min	0.68	21.50	0.047	52.8	60.7	45.8			
	Max	1.65	74.80	0.055	70.0	72.9	62.0			
	Mean	0.94	34.40	0.039	-----	-----	-----			
	Median	0.74	23.70	0.043	-----	-----	-----			
	Stds	na	na	na	-----	-----	-----			
	Std	0.41	20.35	0.013	-----	-----	-----			
	Count	5	5	5	5	5	5			

Note(s): * values reported at 1.0 meter

Carlson's Trophic State Index - Summer Data

Station	Date	Secchi (meters)	Chl-a* (ug/l)	TP* (mg/l as P)	TSI Values			Mean TSI Values		
					Secchi	Chl-a	TP	Secchi	Chl-a	TP
LG1	6/22/2005	1.7	23.1	0.018	52.8	61.4	45.8	58.7	67.3	53.8
	7/27/2005	1.1	28.9	0.043	58.1	63.6	58.4			
	8/29/2005	0.5	74.8	0.033	70.0	72.9	54.6			
<<insert>>										
	Min	1.65	23.10	0.018	52.8	61.4	45.8			
	Max	1.65	74.80	0.043	70.0	72.9	58.4			
	Mean	1.10	42.27	0.031	-----	-----	-----			
	Median	1.14	28.90	0.033	-----	-----	-----			
	Stds	na	na	na	-----	-----	-----			
	Std	0.47	23.13	0.010	-----	-----	-----			
	Count	3	3	3	3	3	3			

Note(s): * values reported at 1.0 meter

APPENDIX C

Primer on Lake Ecology & Watershed Dynamics

Glossary

Algae - Mostly aquatic, non-vascular plants that float in the water or attach to larger plants, rocks, and other substrates. Also called phytoplankton, these individuals are usually visible only with a microscope. They are a normal and necessary component of aquatic life, but excessive numbers can make the water appear cloudy and colored.

Alkalinity - The acid-neutralizing capacity of water. It is primarily a function of the carbonate, bicarbonate, and hydroxide content in water. The lower the alkalinity, the less capacity the water has to absorb acids without becoming more acidic.

Ammonia (NH₃) - A nitrogen-containing substance which may indicate recently decomposed plant or animal material.

Benthos - The communities of aquatic life which dwell in or on the bottom sediments of a water body.

Chlorophyll - Pigments (mostly green) in plants, including algae, that play an important part in the chemical reactions of photosynthesis. A measurement of chlorophyll-a (one type of chlorophyll) is commonly used as a measure of the algae content of water.

Conductivity (Cond) - A measure of water's capacity to convey an electric current. It is related to the total amount of dissolved charged substances in the water. Therefore, it can be used as a general indicator of the quality of the water and can also suggest presence of unidentified material in the water. It is often used as a surrogate for salinity measurements.

Combined Sewer Overflow (CSO) - Discharges of combined sewage and stormwater into water bodies during very wet or storm weather. These discharges occur to relieve the sewer system as it becomes overloaded with normal sewer flow and increased storm run-off. The term is also used to denote a pipe that discharges those overflows.

Dissolved oxygen (DO) - Oxygen that is dissolved in the water. Certain amounts are necessary for life processes of aquatic animals. The oxygen is supplied by the photosynthesis of plants, including algae, and by aeration. Oxygen is consumed by animals and plants at night, and bacterial decomposition of dead organic matter (plant matter and animal waste).

Effluent - Liquids discharged from sewage treatment plants, septic systems, or industrial sources to surface waters.

Epilimnion - The warmer, well-lit surface waters of a lake that are thermally separated from the colder (hence denser), water at the bottom of the lake when a lake is stratified.

Eutrophication - The acceleration of the loading of nutrients to a lake by natural or human-induced causes. The increased rate of delivery of nutrients results in increased production of algae and consequently, poor water transparency. Human-induced (cultural) eutrophication may be caused by input of treated sewage to a lake, deforestation of a watershed, or the urbanization of a watershed.

Fecal Coliform Bacteria - Bacteria from the intestines of warm-blooded animals. Most of the bacteria are not in themselves harmful, so they are measured or counted as an indicator of the possible presence of harmful bacteria.

Groundwater - Water stored beneath the surface of the earth. The water in the ground is supplied by the seepage of rainwater, snowmelt, and other surface water into the soil. Some groundwater may be found far beneath the earth surface, while other groundwater may be only a few inches from the surface. Groundwater discharges into lowland streams to maintain their baseflow.

Hydrology - The science dealing with the properties, distribution and circulation of water. The term usually refers to the flow of water on or below the land surface before reaching a stream or man-made structure.

Hypolimnion - The dark, cold, bottom waters of a lake that are thermally separated from the warmer (hence less dense) surface waters when a lake is stratified.

Invertebrates - Animals without internal skeletons. Some require magnification to be seen well, while others such as worms, insects, and crayfish are relatively large. Invertebrates living in stream and lake sediments are collected as samples to be identified and counted. In general, more varied invertebrate communities indicate healthier water bodies.

Limiting nutrient - The nutrient that is in lowest supply relative to the demand. The limiting nutrient will be exhausted first by algae which require many nutrients and light to grow. Inputs of the limiting nutrient will result in increased algal production, but as soon as the limiting nutrient is exhausted, growth stops. Phytoplankton growth in lake waters of temperate lowland areas is generally phosphorus limited.

Limnology - Scientific study of inland waters.

Littoral zone - portion of a water body extending from the shoreline lakeward to the greatest depth occupied by rooted plants.

Loading rate - Addition of a substance to a water body; or the rate at which the addition occurs. For example, streams load nutrients to lakes at various rates as in "500 kilograms per year (500 kg/yr)" or "227 pounds per year (227 lb/yr)."

Macrophytes - rooted and floating aquatic plants, larger (macro-) than the phytoplankton.

Mesotrophic - A condition of lakes that is characterized by moderate concentrations of nutrients, algae, and water transparency. A mesotrophic lake is not as rich in nutrients as a eutrophic lake, but richer in nutrients than an oligotrophic lake.

Monomictic - A lake which has one mixing and one stratification event per year. If a lake does not freeze over in the winter, the winter winds will mix the waters of the lake. In summer, the lake resists mixing and becomes stratified because the surface waters are warm (light) and the bottom waters are cold (dense). Deep lakes in the Puget lowlands are monomictic lakes.

Nitrate, nitrite (NO₃, NO₂) - Two types of nitrogen compounds. These nutrients are forms of nitrogen that algae may use for growth.

Nitrogen - One of the elements essential as a nutrient for growth of organisms.

Non-point source pollution - Pollution that originates from diffuse areas and unidentifiable sources, such as agriculture, the atmosphere, or ground water.

Nutrients - Elements or compounds essential for growth of organisms.

Oligotrophic - A condition of lakes characterized by low concentrations of nutrients and algae and resulting good water transparency. An oligotrophic lake has less nutrients than a mesotrophic or eutrophic lake.

Pathogens -Microorganisms that can cause disease in other organisms or humans, animals, and plants. Pathogens include bacteria, viruses, fungi, or parasites found in sewage, in runoff from farms or city streets, and in water used for swimming. Pathogens can be present in municipal, industrial, and nonpoint source discharges.

Pelagic Zone - Deep, open water area of a lake away from the edge of the littoral zone towards the center of the lake.

pH - Measure of the acidity of water on a scale of 0 to 14, with 7 representing neutral water. A pH less than 7 is considered acidic and above 7 is basic.

Phosphorus - One of the elements essential as a nutrient for the growth of organisms. In western Washington lakes, it is usually the algae nutrient in shortest supply relative to the needs of the algae. Phosphorus occurs naturally in soils, as well as in organic material. Various measures of phosphorus in water samples are made, including total-phosphorus (TP) and the dissolved portion of the phosphorus (orthophosphorus).

Photic zone - The lighted region of a lake where photosynthesis occurs.

Phytoplankton - Floating, mostly microscopic algae (plants) that live in water.

Point-source Pollution - An input of pollutants into a water body from discrete sources, such as municipal or industrial outfalls.

Primary Treatment - The first stage of wastewater treatment involving removal of debris and solids by screening and settling.

Pump Station -A structure used to move wastewater uphill, against gravity.

Regulator -A structure that controls the flow of wastewater from two or more input pipes to a single output. Regulators can be used to restrict or halt flow, thus causing wastewater to be stored in the conveyance system until it can be handled by the treatment plant.

Salmonids - Salmon, trout, char and whitefish species of fish.

Secchi depth - Measure of transparency of water obtained by lowering a 10 cm black and white disk into water until it is no longer visible.

Secondary Treatment - Following primary treatment, bacteria are used to consume organic wastes. Wastewater is then disinfected and discharged through an outfall.

Separation -A method for controlling combined sewer overflow whereby the combined sewer is separated into both a sanitary sewer and a storm drain, as is the practice in new development.

Sewage -That portion of wastewater that is composed of human and industrial wastes from homes, businesses, and industries.

Standard - A legally established allowable limit for a substance or characteristic in the water, based on criteria. Enforcement actions by the appropriate agencies can be taken against parties who cause violations.

Stratification of lakes - A layering effect produced by the warming of the surface waters in many lakes during summer. Upper waters are progressively warmed by the sun and the deeper waters remain cold. Because of the difference in density (warmer water is lighter), the two layers remain separate from each other: upper waters "float" on deeper waters and wind induced mixing occurs only in the upper waters. Oxygen in the bottom waters may become depleted. In autumn as the upper waters cool, the whole lake mixes again and remains mixed throughout the winter, or until it freezes over.

Stormwater -Water that is generated by rainfall and is often routed into drain systems.

Thermocline - Depth in a stratified lake where the greatest change in temperature occurs. Separates the epilimnion from the hypolimnion

Total suspended solids (TSS) - Particles, both mineral (clay and sand) and organic (algae and small pieces of decomposed plant and animal material), that are suspended in water.

Toxic -Causing death, disease, cancer, genetic mutations, or physical deformations in any organism or its offspring upon exposure, ingestion, inhalation, or assimilation.

Transparency - A measure of the clarity of water in a lake, which is measured by lowering a standard black and white Secchi disk into the water and recording the depth at which it is no longer visible. Transparency of lakes is determined by the color of the water and the amount of material suspended in it. Generally in colorless waters of the Puget lowland, the transparency of the water in summer is determined by the amount of algae present in the water. Suspended silt particles may also have an effect, particularly in wet weather.

Trophic status - Rating of the condition of a lake on the scale of oligotrophic-mesotrophic-eutrophic (see definition of these terms).

Turbidity - Cloudiness of water caused by the suspension of minute particles, usually algae, silt, or clay.

Wastewater -Total flow within the sewage system. In combined systems, it includes sewage and stormwater.

Water Column - Water in a lake between the surface and sediments. Used in vertical measurements used to characterize lake water.

Watershed - The areas that drain to surface water bodies, including lakes, rivers, estuaries, wetlands, streams, and the surrounding landscape.

Water of Statewide Significance - Legal term from the state Shoreline Management act, which recognizes particular bodies of water and sets criteria and standards for their protection.

Zooplankton - Small, free swimming or floating animals in water, many are microscopic.

Primer on Lake Ecology & Watershed Dynamics

Prepared by:

Aqua Link, Inc.

The water quality of a lake is often described as a reflection of its surrounding watershed. The term lake collectively refers to reservoirs (man-made impoundments), natural lake systems and smaller ponds (man-made or naturally created). Water from the surrounding watershed enters a lake as streamflow, surface runoff and groundwater. The water quality of these water sources is greatly influenced by the characteristics of the watershed such as, geology, soils, topography and land use. Of these characteristics, changes in land use (e.g., forested, agriculture, silviculture, residential, commercial, industrial) can significantly alter the water quality of lakes.

Nutrients (e.g., phosphorus, nitrogen, carbon, silicon, calcium, potassium, magnesium, sulfur, sodium, chloride, iron) are primarily transported to lakes via streamflow, surface runoff and groundwater, while sediments are mainly conveyed by streamflow and surface runoff. As streamflow and surface runoff enter a lake, their overall velocity decreases, which allow transported sediments to settle to the lake bottom. Many of these incoming nutrients may be bound to sediment particles and subsequently will also settle to the lake bottom. Very small sediment particles such as, clays, may resist sedimentation and subsequently pass through the lake without settling.

Once within the lake, water quality is further modified through a complex set of physical, chemical and biological processes. These processes are significantly affected by the lake's morphological characteristics (morphology). Some of the more important morphological characteristics of lakes are surface area, shape, depth, volume and bottom composition. In addition, the hydraulic residence time (i.e., the lake's flushing rate) also greatly affects these processes and is directly related to the lake's volume and the annual volume of water flowing into the lake.

With respect to nutrients, phosphorus and nitrogen are generally considered the most important nutrients in freshwater lakes. Phosphorus and, to a lesser degree, nitrogen typically determine the overall amount of aquatic plants present. Aquatic plants adsorb and convert available nutrients into energy, which is then used for additional growth and reproduction. In lakes, aquatic plants are mainly comprised of phytoplankton (free-floating microscopic plants or algae) and macrophytes (higher vascular plants). The most readily available form of phosphorus is dissolved orthophosphate (analytical determined as dissolved reactive phosphorus), while ammonia ($\text{NH}_3\text{-N}$) and nitrate ($\text{NO}_3\text{-N}$) are the most readily available forms of nitrogen.

The transfer and flow of energy in lakes is ultimately controlled by complex interactions between various groups of aquatic organisms (both plants and animals). A simplistic diagram of these interactions among aquatic organisms is shown as Figure 1. In Figure 1, algae (phytoplankton) and aquatic macrophytes (plants) capture energy from the sun and convert this energy into chemical energy through the process known as photosynthesis. During photosynthesis, carbon dioxide, nutrients, water and captured sunlight energy are used to produce organic compounds (chemical energy), which are then used to support further growth and reproduction.

Energy continues to flow upward through the food chain. Algae are primarily grazed upon by zooplankton. Zooplankton are tiny aquatic animals that are barely visible to the naked eye. Next, zooplankton serve as prey for planktivorous (plankton-eating) fish and larger invertebrates (macroinvertebrates). In turn, planktivores are consumed by piscivorous (fish-eating) fish. Overall, these aquatic organisms (zooplankton, macroinvertebrates and fish) derive energy by breaking down organic matter through the process known as respiration. During respiration, organic matter, water and dissolved oxygen are converted into carbon dioxide and nutrients.

At the bottom of the food chain (Figure 1), particulate organic waste products (excrement) from aquatic organisms along with dead aquatic organisms settle to the lake bottom and are subsequently feed upon by other organisms. Organisms that live or reside along the lake bottom are referred to as benthivores. After settling to the lake bottom, dead organic materials and organic waste products are now called detritus. Some benthivorous fish (catfish and carp) and microorganisms (bacteria, fungi and protozoans) feed upon detritus. Aquatic organisms that feed upon detritus in lakes are referred to as decomposers. Decomposers obtain energy by breaking down detritus (dead organic matter) via the process of respiration. During decomposition, some of the nutrients are recycled back into lake water and can now once again be used by algae and aquatic plants for growth and reproduction. Any unused detritus will accumulate and eventually become part of the lake sediments, thereby increasing the organic content of these sediments.

Ultimately, the amount of nutrients in lakes controls the overall degree of aquatic productivity (Figure 1). Lakes with low levels of nutrients and low levels of aquatic productivity are referred to as oligotrophic. Oligotrophic lakes are typically clear and deep with low quantities of phytoplankton and rooted aquatic plants. In these lakes, the deeper, colder waters are generally well-oxygenated and capable of supporting coldwater fish such as trout. Conversely, lakes with high nutrient levels and high levels of aquatic productivity are referred to as eutrophic. Eutrophic lakes are generally more turbid and shallower due to the deposition of sediments and the accumulation of detritus. If deep enough, the bottom waters of eutrophic lakes are generally less oxygenated or may be devoid of dissolved oxygen (anoxic). Eutrophic lakes are often capable of supporting warmwater fish such as bluegill and bass. Mesotrophic lakes lie somewhere in between oligotrophic and eutrophic lakes. These lakes contain moderate levels of nutrients and moderate levels of aquatic productivity.

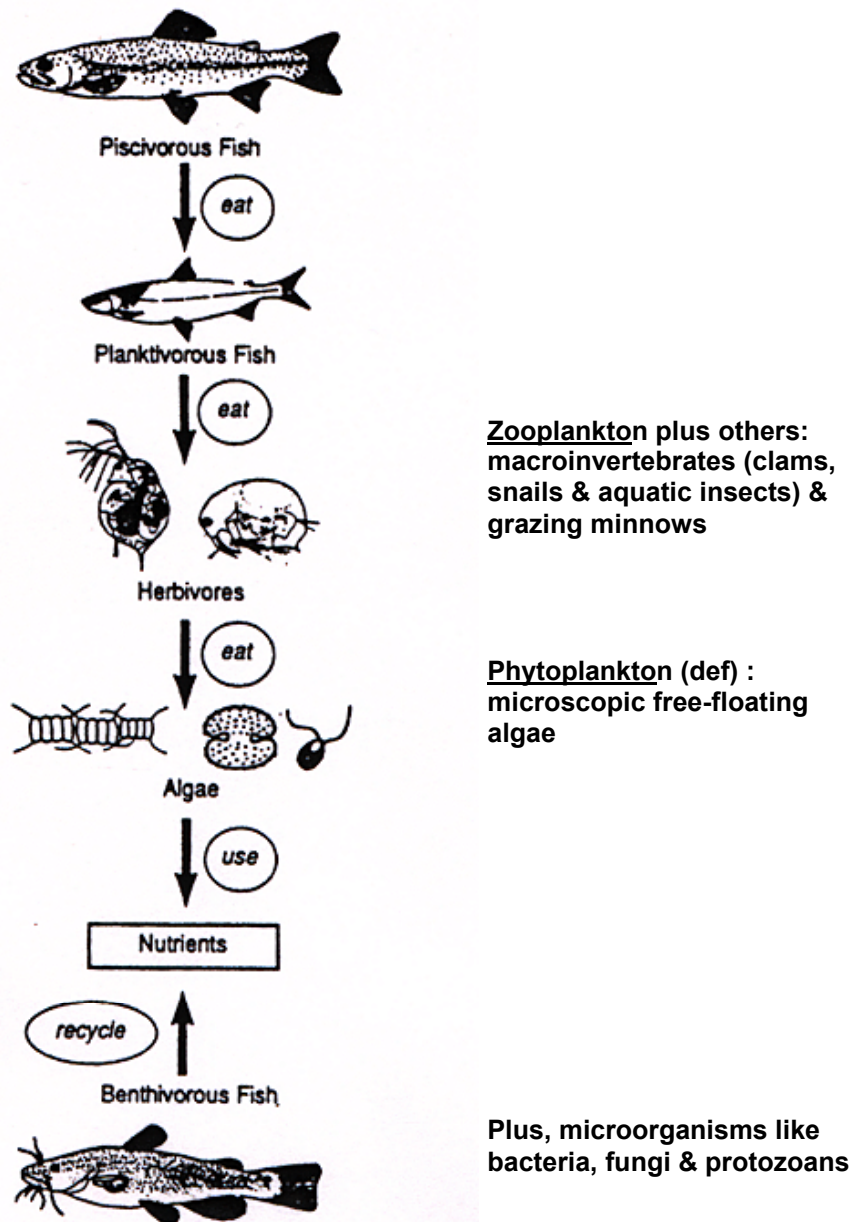


Figure 1 Aquatic Food Chain

In some instances, the flow of energy through the food web may be disrupted. In hyper-eutrophic (highly eutrophic) lakes, aquatic productivity is extremely high and is dominated by very large numbers of a few, undesirable species. The phytoplankton community is typically comprised largely by blue-green algae during the summer months. Many species of blue-green algae are not readily grazed upon by the zooplankton community. Under these conditions, the blue-green algae community is allowed to flourish due to the lack of predation, while the zooplankton community collapses. Decreases in zooplankton biomass in a lake may in turn adversely affect the lake's fishery. In addition, shallow lake areas may be completely infested with dense stands of aquatic macrophytes and dominated by common carp, catfish or other rough fish.

APPENDIX D

Stream Water Quality & Discharge Data

Stream Data Overview

<u>Parameter:</u>	<u>Units of Measure:</u>
pH (pH)	Expressed in Standard Units (s.u.)
Alkalinity (Alk)	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO ₃)
Hardness (Hard)	Expressed in milligrams per liter as calcium carbonate(mg/l as CaCO ₃)
Conductivity (Cond)	Expressed in microSiemens per cm (uS/cm)
Specific Conductance Sp (Cond)	Expressed in microSiemens per cm (uS/cm) @ 25.0 degrees Celsius
Total Phosphorus (TP)	Expressed as milligrams per liter as phosphorus (mg/l as P)
Dissolved Reactive Phosphorus (DRP)	Expressed in milligrams per liter as phosphorus (mg/l as P)
Oxidation-Reduction Potential (ORP)	Expressed in milliVolts (mV)
Total Dissolved Solids	Expressed in milligrams per liter (mg/l)
Nitrate (NO ₃)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Nitrite (NO ₂)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Ammonia nitrogen (NH ₃)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Kjeldahl Nitrogen (TKN)	Expressed in milligrams per liter as nitrogen (mg/l as N)
Total Suspended Solids (TSS)	Expressed in milligrams per liter (mg/l)
Turbidity	Expressed in ntu's (nephelometric turbidity units)
Color	Expressed in Pt/Co Units
Oil & Grease	Expressed in milligrams per liter (mg/l)
Total Petroleum Hydrocarbons (TPH)	Expressed in milligrams per liter (mg/l)
Metals	Expressed in milligrams per liter (mg/l)
Dissolved Oxygen (Dissol Oxy)	Expressed in milligrams per liter (mg/l) or percent saturation (%)
Temperature (Temp)	Expressed in degrees Celsius (degrees C)
Secchi Disk Depth	Expressed in meters (m)
Chlorophyll-a	Expressed in micrograms per liter (ug/l)
Fecal coliform bacteria (FC)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Fecal streptococcus bacteria (FS)	Expressed as number of organisms per one hundred milliliters (No./100 ml)
Phytoplankton	Expressed as number of organisms per milliliter (No.per ml)
Phytoplankton	Expressed as biomass in micrograms per liter (ug/l)
Zooplankton	Expressed as number of organisms per liter (No.per liter)
Zooplankton	Expressed as biomass in micrograms per liter (ug/l)
Stream Velocity	Expressed in feet per second (fps)
Stream Discharge	Expressed in cubic feet per second (cfs)
Metals:	
Silver (Ag)	Lead (Pb)
Arsenic (As)	Antimony (Sb)
Beryllium (Be)	Selenium (Se)
Cadmium (Cd)	Thallium (Tl)
Chromium (Cr)	Zinc (Zn)
Copper (Cu)	Mercury (Hg)
Nickel (Ni)	

Lake Galena & NBNC WIP Project
ALI Project No. 1005-16

Prepared by Aqua Link, Inc.

Stream Stations - Proceeding Downstream to Upstream

Station	Stream	Gage Installed	Description
NBNC	North Branch Neshaminy Creek	Yes	Just upstream of Swamp Road (Route 313) bridge crossing.
HC	Hardiacken Creek	Yes	Just downstream of New Galena Road bridge crossing.

Water Quality & Stream Discharge Data + Loading Calculations

Station	Date	Flow Regime	Stage (ft)	Q* (cfs)		TP (mg/l as P)	Nitrate + Nitrite (mg/l as N)	TKN (mg/l as N)	TN* (mg/l as N)		TSS (mg/l)	Calculated Loadings		
												TP (kg/d)	TN* (kg/d)	TSS (kg/d)
NBNC	5/12/2009	Base	0.70	8.9	b	0.010	1.40	0.34	1.74	b	3.0	0.22	38.0	65
	6/5/2009	Storm	0.95	31.5		0.090	1.10	0.21	1.31		15.0	6.94	101.0	1,156
	6/12/2009	Storm	0.86	23.4		0.090	0.65	0.27	0.92		20.0	5.15	52.6	1,144
	6/16/2009	Storm	1.04	39.6		0.150	0.56	0.24	0.80		29.0	14.55	77.6	2,813
	6/19/2009	Storm	2.20	144.5		0.490	0.41	0.89	1.30		302.0	173.17	459.4	106,731
<<insert>>														
Base	Value			8.9		0.010	1.40	0.34	1.74		3.0	3.58	69.5	611
	Count			1		1	1	1	1		1	1	1	1
Storm	Min			23.4		0.090	0.41	0.21	0.80		15.0	5.15	52.6	1,144
	Max			144.5		0.490	1.10	0.89	1.31		302.0	173.17	459.4	106,731
	Mean			59.7		0.205	0.68	0.40	1.08		91.5	49.95	172.7	27,961
	Median			35.6		0.120	0.61	0.26	1.11		24.5	10.74	89.3	1,984
	Stds			56.9		0.192	0.30	0.33	0.26		140.5	82.25	192.2	52,519
	Std			49.2		0.166	0.26	0.28	0.23		121.6	71.23	166.5	45,483
	Count			4		4	4	4	4		4	4	4	4

Water Quality & Stream Discharge Data + Loading Calculations

Station	Date	Flow Regime	Stage (ft)	Q* (cfs)		TP (mg/l as P)	Nitrate + Nitrite (mg/l as N)	TKN (mg/l as N)	TN* (mg/l as N)		TSS (mg/l)	Calculated Loadings		
												TP (kg/d)	TN* (kg/d)	TSS (kg/d)
HC	5/12/2009	Base	0.68	4.4	b	0.010	1.80	0.21	2.01	b	3.0	0.11	21.7	32
	6/5/2009	Storm	0.87	14.7		0.060	2.60	0.29	2.89		10.0	2.15	103.6	358
	6/12/2009	Storm	0.77	9.3		0.060	1.90	0.24	2.14		7.0	1.36	48.5	159
	6/16/2009	Storm	1.01	22.2		0.110	1.70	0.28	1.98		11.0	5.97	107.5	597
	6/19/2009	Storm	1.78	63.7		0.250	1.80	0.80	2.60		143.0	38.95	405.1	22,278
<<insert>>														
Base	Value			4.4		0.010	1.80	0.21	2.01		3.0	1.13	62.7	195
	Count			1		1	1	1	1		1	1	1	1
Storm	Min			9.3		0.060	1.70	0.24	1.98		7.0	1.36	48.5	159
	Max			63.7		0.250	2.60	0.80	2.89		143.0	38.95	405.1	22,278
	Mean			27.4		0.120	2.00	0.40	2.40		42.8	12.11	166.2	5,848
	Median			18.4		0.085	1.85	0.29	2.37		10.5	4.06	105.6	478
	Stds			24.7		0.090	0.41	0.27	0.42		66.9	18.01	161.5	10,955
	Std			21.4		0.078	0.35	0.23	0.36		57.9	15.59	139.9	9,487
	Count			4		4	4	4	4		4	4	4	4

Comparison of Mean Concentrations

Station	Flow Regime	TP (mg/l as P)	TN* (mg/l as N)	TSS (mg/l)
NBNC	Base	0.010	1.74	3.0
	Storm	0.205	1.08	91.5
HC	Base	0.010	2.01	3.0
	Storm	0.120	2.40	42.8

Station	Flow Regime	TP (mg/l as P)	TN* (mg/l as N)	TSS (mg/l)	Ranking			
					TP	TN*	TSS	Total Pts
NBNC	Base	0.010	1.74	3.0	1.5	1	1.5	4.0
HC	Base	0.010	2.01	3.0	1.5	2	1.5	5.0
					3.0	3.0	3.0	
					9.0			

Station	Flow Regime	TP (mg/l as P)	TN* (mg/l as N)	TSS (mg/l)	Ranking			
					TP	TN*	TSS	Total Pts
NBNC	Storm	0.205	1.08	91.5	2	1	2	5.0
HC	Storm	0.120	2.40	42.8	1	2	1	4.0
					3.0	3.0	3.0	
					9.0			

Comparison of Mean Loadings & Mean Discharges

Station	Flow Regime	Q (cfs)	TP (kg/d as P)	TN* (kg/d as N)	TSS (kg/d)
NBNC	Base	8.9	3.58	69.5	611
	Storm	59.7	49.95	172.7	27,961
HC	Base	4.4	1.13	62.7	195
	Storm	27.4	12.11	166.2	5,848

Station	Flow Regime	Mean Q (cfs)	TP (kg/d as P)	TN* (kg/d as N)	TSS (kg/d)	Ranking				TP (kg/yr as P)	TN* (kg/yr as N)	TSS (kg/yr)
						TP	TN*	TSS	Total Pts			
NBNC	Base	8.9	3.58	69.5	611	2	2	2	6	1,306	25,361	222,986
HC	Base	4.4	1.13	62.7	195	1	1	1	3	412	22,869	71,333
						3	3	3				
						9						
NBNC	Storm	59.7	49.95	172.7	27,961	2	2	2	6	18,232	63,020	10,205,723
HC	Storm	27.4	12.11	166.2	5,848	1	1	1	3	4,419	60,651	2,134,574
						3	3	3				

Lake Galena & NBNC WIP Project
ALI Project No. 1005-16

Streamflow vs Stage

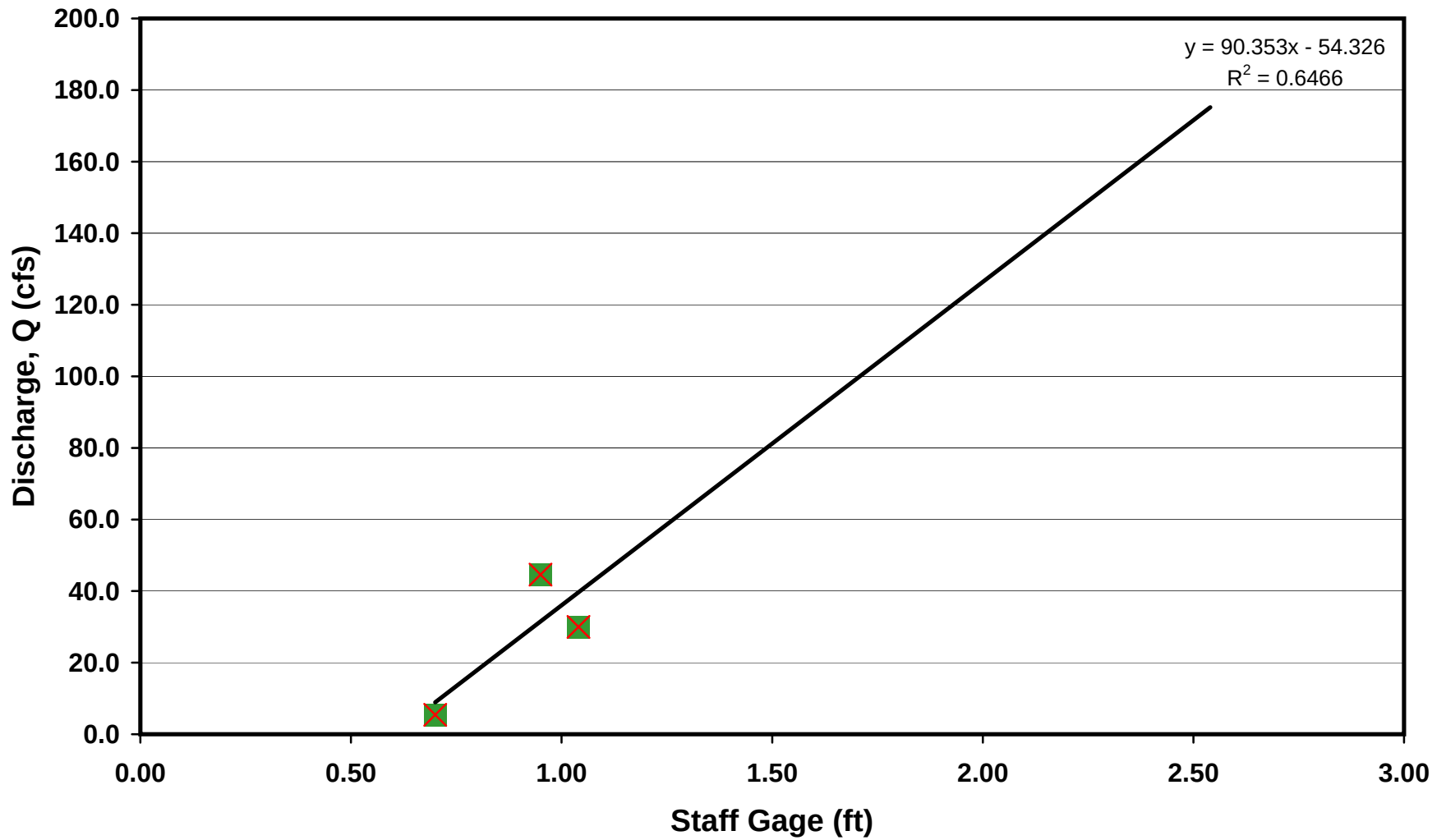
Rating Curve Development

Station	Date	Stage (ft)	Q (Measured) (cfs)	Station	Date	Stage (ft)	Q (Measured) (cfs)
NBNC	5/12/2009	0.70	5.45	HC	5/12/2009	0.68	3.72
	6/5/2009	0.95	44.62		6/5/2009	0.87	16.29
	6/16/2009	1.04	30.00		6/16/2009	1.01	21.25
<<insert>>				<<insert>>			
	Min	0.70	5.45		Min	0.68	3.72
	Max	1.04	44.62		Max	1.01	21.25
	Mean	0.90	26.69		Mean	0.85	13.75
	Median	0.95	30.00		Median	0.87	16.29
	Stds	0.18	19.79		Stds	0.17	9.04
	Std	0.14	16.16		Std	0.14	7.38
	Count	3	3		Count	3	3

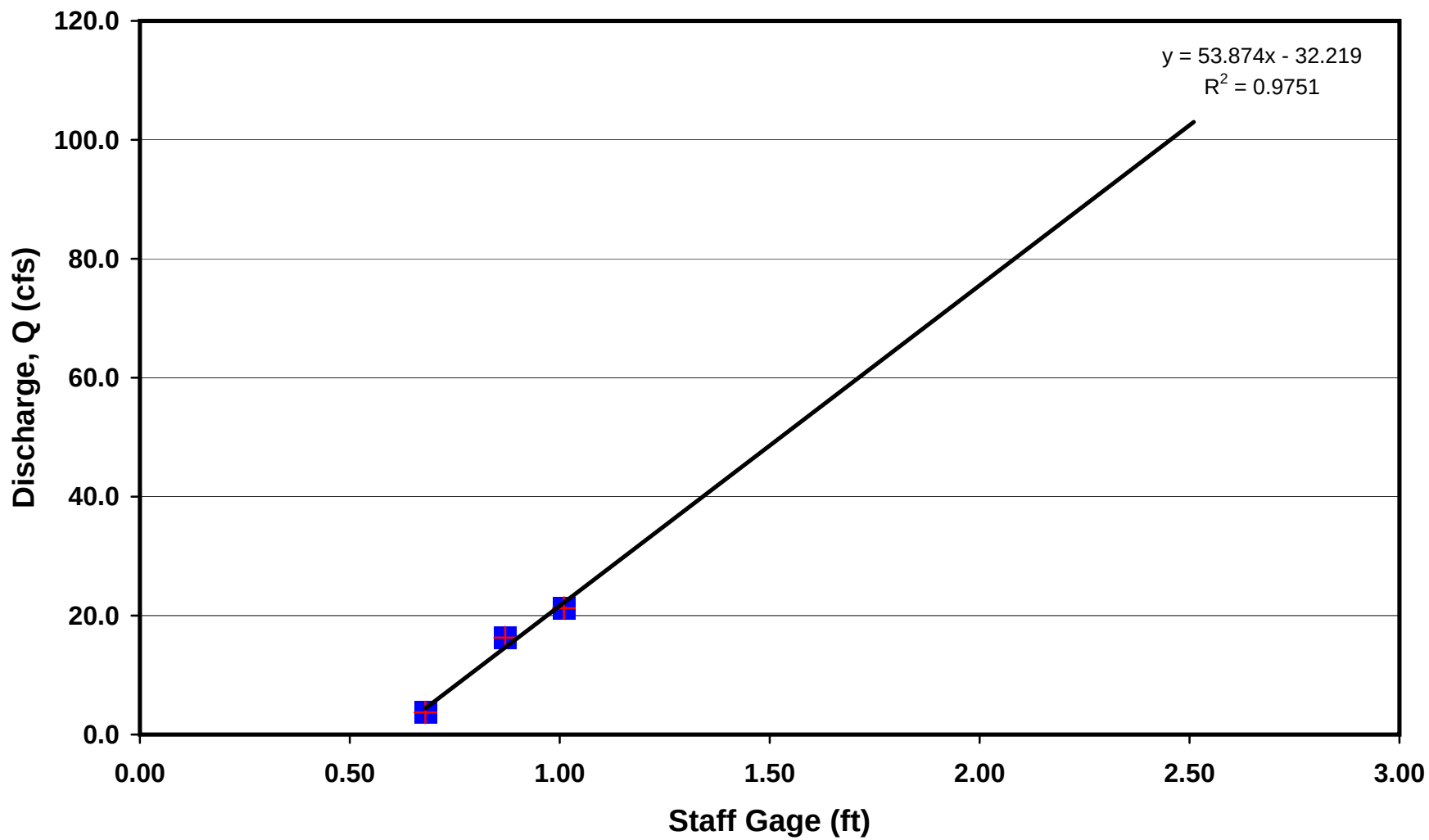
Predicted Q Values (Based upon Rating Curves)

Station	Date	Stage (ft)	Q (Predicted) (cfs)	Station	Date	Stage (ft)	Q (Predicted) (cfs)
NBNC	5/12/2009	0.70	8.92	HC	5/12/2009	0.68	4.42
	6/5/2009	0.95	31.51		6/5/2009	0.87	14.65
	6/12/2009	0.86	23.38		6/12/2009	0.77	9.26
	6/16/2009	1.04	39.64		6/16/2009	1.01	22.19
	6/19/2009	2.20	144.45		6/19/2009	1.78	63.68
<<insert>>				<<insert>>			
	Min	0.70	8.92		Min	0.68	4.42
	Max	2.20	144.45		Max	1.78	63.68
	Mean	1.15	49.58		Mean	1.02	22.84
	Median	0.95	31.51		Median	0.87	14.65
	Stds	0.60	54.23		Stds	0.44	23.76
	Std	0.54	48.51		Std	0.39	21.26
	Count	5	5		Count	5	5

NBNC - Q vs. Stage Rating Curve



HC - Q vs. Stage Rating Curve



APPENDIX E

Agriculture Land Evaluation Data

Survey and Funding Application for Lake Galena and North Branch Neshaminy Watershed Properties

Watershed Survey

The purpose of this project is to identify problems in the Neshaminy Creek Watershed regarding water quality. Lake Galena provides many resources to the residents of Bucks County and therefore special attention is being given to decrease hyper-eutrophic conditions. It would be a great help to the Bucks County Conservation District if you could take just a few minutes and fill out this survey to allow us to collect baseline data for the current conditions of the watershed. **Please answer all survey questions regarding only property within the watershed (see attached map for watershed boundaries)** . For cropland and livestock producers, information about your operations is important for this project on not only land that you own but also rent. All information is completely confidential and will only be used for the purpose of the Conservation District's research.

Funding Opportunities

If you have erosion and/or runoff concerns and are interested in receiving funding to address those concerns, please make sure to mark the appropriate box below this paragraph. Any persons are allowed to fill out an application to be reviewed for funding, keeping in mind that the property you are requesting funding for must be in the boundaries of the watershed. A conservation plan is not required to apply for funding. This project can help to fund BMP's which include, but are not limited to diversions, waterways, terraces, streambank restoration/stabilization, streambank fencing, riparian buffers, filter strips, ag waste management, silage leachate management, stream crossing, prescribed grazing, strip cropping, and contour strips. Money for conservation plan development and nutrient management plan development will also be considered. **Any changes that can be made to your property which will improve water quality will be considered for funding.** If you are not interested in applying for BMP funding, please still complete and return the survey to the Bucks County Conservation District using the enclosed prestamped envelope.

--	--

Please check this box if you want to be considered for full or partial BMP funding on your owned or rented property

1	Property Owner Information
---	----------------------------

Property Owner Name	Phone Number	(Night)
Street Name	City	State
		Zip code
Operator Name (if different from Property Owner)	Operator Phone Number	Total acres on the property

2	Livestock
---	-----------

Are there any animals on this property? ____ Yes (answer the next seven questions) ____ No (move to part 3)

Do you have a current conservation, or nutrient management plan? ____ Yes ____ No

If yes, which kind of plan do you have? _____

Do you follow a rotational grazing plan (moving animals from paddock to paddock allowing sufficient rest periods for those paddocks in order to maintain vegetative cover)? _____ Yes _____ No

Which of the following best describes your ag waste management system? _____ Lagoon (answer part a) _____ Manure stacking (answer part b)

a. Please circle which kind of lagoon you have: cement lined earthen base

b. Please circle all that apply to your manure stacking system

covered with a tarp or roof	cement base	earthen base hauled within 100 days	earthen base not hauled for greater than 100 days

Do you have any barnyard runoff controls? ____ Yes ____ No

If so, please briefly explain what controls are being taken:

Do you use phytase in any of your animal feeds? ____ Yes ____ No

Do you have a vegetated buffer between outdoor manure storage areas and and water sources such as streams, drainages ditches, wells, springs, etc.? ____ Yes ____ No

How many acres of the property are designated for animal use?

Animals on your operation - please allow one line per animal type.

[illegible]

3 Cropland	
Is this land currently being used for crop production? ____ Yes (answer the next three questions) ____ No (move to part 4) How many acres of the property are designated for cropland? _____ List the crops grown and the current crop rotation including the form of tillage used.	
4 Existing BMPs (Best Management Practices)	
The purpose of this project is to improve water quality within the Neshaminy Creek Watershed. Although we are looking to implement new BMP's it is important to understand any BMP's that are currently functioning on your property. Please circle any of the following BMP's that exist on this property: ☐ Diversions/Terraces/Grassed Waterways ☐ No-till ☐ Conservation Tillage ☐ Contour Farming/Stripcropping ☐ Cover Crop Please list any additional BMP's on the property:	
5 Agricultural Land Conversion	
How many acres (if any) of agricultural land have been converted to (in the last 10 years):	Wetland Forestland
6 Existing Resource Concerns	
Describe any problems or concerns on the property including those associated with erosion, storm water, stream bank and stream water concerns. Please make sure to evaluate erosion and sedimentation problems from crop fields, animal concentration areas, pastures, and barnyards. If applying for funding any additional expressed concerns about the property will also be evaluated.	
7 Potential BMP funding	
<i>Please answer question 7 only if you are interested in applying for funding.</i> If selected for funding, what BMP's would you like to see implemented on your property?	
<i>Please use the enclosed prestamped envelope and send this completed form to the Bucks County Conservation District. This form can also be electronically sent using the link on the Bucks County Conservation District website found at http://www.bucksccd.org.</i> <i>If you have any additional questions about this survey/application feel free to contact the Bucks County Conservation District via e-mail at http://bucksccd.org or via telephone at 215 - 345- 7577.</i> <i>Thank you for your time and your cooperation!</i>	

Participant #	Ranking	Proposed BMP	Details	Total Installation Cost			Planning/Design/Construction Supervision				TOTAL Cost	
				Total Ac/Ft	Est. Cost/Unit	TOTAL	Hours			TOTAL		
							WS	ACT	NRCS			
40	1	Streambank Stabilization	bioeng for gully	200	ft	\$46.08	\$9,215.09	16.5	20.25	15	\$1,186.50	\$10,401.59
		Streambank Fencing	fence out stream	350	ft	\$8.57	\$3,000.00	5.5	6.75	5	\$395.50	\$3,395.50
		Streambank Stabilization	live stakes, riprap banks, riprap and rebar.	125	ft	\$48.00	\$6,000.00	18	10		\$504.00	\$6,504.00
50	3	Terraces/Diversions/Waterways	diversion	400	ft	\$10.46	\$4,185.19	2	39	14	\$1,228.00	\$5,413.19
25	2	Streambank Stabilization	6 rock barbs	200	ft	\$77.35	\$15,470.00	30	6	10	\$998.00	\$16,468.00
45	2	Terraces/Diversions/Waterways	100' grassed waterway, 400' grassed waterway	0.34	ac	\$9,000.00	\$3,099.17	1	10		\$198.00	\$3,297.17
		Terraces/Diversions/Waterways	diversion by road	200	ft	\$8.00	\$1,600.00	1	3		\$72.00	\$1,672.00
		Terraces/Diversions/Waterways	diversion	2000	ft	\$8.00	\$16,000.00	1	8		\$162.00	\$16,162.00
44	2	Ag Waste	manure stacking pad	1	no	\$28,325.93	\$28,325.93	1	8	1	\$197.00	\$28,522.93
		Terraces/Diversions/Waterways	grassed waterway	0.48	ac	\$9,000.00	\$4,338.84	1	8		\$162.00	\$4,500.84
		Nutrient Management	HUA	7500	ft2	\$2.50	\$18,750.00	1	4		\$90.00	\$18,840.00
		Nutrient Management	gutters	600	ft	\$13.00	\$7,800.00	1	3		\$72.00	\$7,872.00
		Nutrient Management	Act 38 NMP	1	no	\$1,200.00	\$1,200.00	1	4		\$90.00	\$1,290.00
46	2	Ag Waste	Manure stacking pad	1	no	\$28,325.93	\$28,325.93	1	8		\$162.00	\$28,487.93
5	1	Ag Waste	Manure stacking pad	1	no	\$28,325.93	\$28,325.93	1	8		\$162.00	\$28,487.93
		Nutrient Management	Act 38 NMP	1	no	\$1,200.00	\$1,200.00	1	4		\$90.00	\$1,290.00
		Nutrient Management	heavy use area	7500	ft2	\$2.50	\$18,750.00	1	3		\$72.00	\$18,822.00
		Terraces/Diversions/Waterways	diversin 1&2	300	ft	\$8.00	\$2,400.00	1	6		\$126.00	\$2,526.00
		Terraces/Diversions/Waterways	waterway 700'	0.48	ac	\$9,000.00	\$4,320.00	1	6		\$126.00	\$4,446.00
37	3	Cropland protection	cover crops	100	ac	\$25.00	\$2,500.00	1	2		\$54.00	\$2,554.00
1	3	Conservation Tillage	no-till	100	ac	\$30.00	\$3,000.00	1	2		\$54.00	\$3,054.00
		Cropland protection	cover crops	100	ac	\$25.00	\$2,500.00	1	2		\$54.00	\$2,554.00
		Conservation Tillage	no-till	100	ac	\$30.00	\$3,000.00	1	2		\$54.00	\$3,054.00
2	1	Terraces/Diversions/Waterways	sediment basin, 100' spillway, 200' diversion and 580' lined and 350' grassed waterway	1230	ft	\$36.11	\$44,413.40	1	42	32	\$2,054.00	\$46,467.40
		Streambank Fencing	fence out cattle from stream	1700	ft	\$5.00	\$8,500.00	8	8		\$288.00	\$8,788.00
		Streambank Stabilization	stream access for cattle	75	ft	\$26.67	\$2,000.00	8	6	3	\$357.00	\$2,357.00
		Stream Buffer	15' buffer, adjacent to cropland	570	ft	\$2.81	\$1,600.00	16			\$288.00	\$1,888.00
		Stream Buffer	half 15', half 35'	570	ft	\$2.81	\$1,600.00	16			\$288.00	\$1,888.00
		Stream Buffer	35' buffer	570	ft	\$2.81	\$1,600.00	16			\$288.00	\$1,888.00
15	2	Terraces/Diversions/Waterways	225' start of stream, in cropland.	0.15	ac	\$9,000.00	\$1,394.63	1	6		\$126.00	\$1,520.63
		Terraces/Diversions/Waterways	diversions	300	ft	\$8.00	\$2,400.00	1	6		\$126.00	\$2,526.00
		Cropland protection	field borders	0.64	ac	\$265.00	\$170.34	1	2		\$54.00	\$224.34
		Conservation Tillage	no-till soybeans and corn	15	ac	\$30.00	\$450.00	1	2		\$54.00	\$504.00
		Strip-Contour Farming	contour farming	15	ac	\$10.00	\$150.00	1	2		\$54.00	\$204.00
51	1	Cropland protection	obstruction removal	0.52	ac	\$2,300.00	\$1,188.02	1	2		\$54.00	\$1,242.02
		Ag Waste	stack pad	1	no	\$11,627.31	\$11,627.31	1	5		\$108.00	\$11,735.31
		Nutrient Management	HUA	7500	ft2	\$2.50	\$18,750.00	1	4		\$90.00	\$18,840.00
						\$309,149.77	163	258	80	\$10,538.00	\$319,687.77	

APPENDIX F

Stormwater Management Facility Evaluation Data

ID	Code	Project Name (design year)	location	GPS		GPS		Type of Facility	Drainage Area (acres)	CN/c
				Latitude	Longitude	Northing	Easting			
New Britain Township										
1	26008	Fox Pond (1997)		40.33339	75.19475	374,610.8	2,680,765	infiltration basin	1.00	66.0
2	26010	Gilmore Tract (2000)	159 King Road	40.33647	75.19034	375,770.6	2,681,963	detention basin	5.60	62.2
3	26003	Fountainville Center (2001)	Ferry & Swamp Roads	40.34177	75.15336	378,000.1	2,692,210	wetland basin 1	15.51	73.0
4	26002			40.34130	75.15300	377,830.5	2,692,317	wetland basin 2	6.74	85.0
5	26009	O'Toole Property (2005)	King Road	40.33529	75.19344	375,313.6	2,681,111	subsurface detention	0.10	0.85
6	26001	AA Self-Storage	Swamp Road & King Road	40.35018	75.16727	380,949.2	2,688,245			
7	26004	single family home	Chapman Road	40.33554	75.16163	375,664.8	2,689,973			
8	26006	Shrine cemetary	Czestochowa	40.32318	75.18151	371,001.0	2,684,564			
9	26007	Shrine cemetary	Czestochowa	40.32122	75.18389	370,267.3	2,683,922			
10	26011	single family home	Baskin & Fretz Roads	40.35318	75.19079	381,852.0	2,681,661			
11	26012	Driving Range	Swamp Road	40.34513	75.15817	379,185.5	2,690,835			
Plumstead Township										
12	34001	North Branch Subdivision (1990)	Rt413 & Danboro-PtPleasant Rd	40.38141	75.10976	392,795.9	2,703,925	detention pond	72.60	81.0
13	34017	Windtree/Applewood Est. (1995)	open space at Curly Hill Rd	40.38415	75.12630	393,655.9	2,699,292	wet pond	22.25	75.8
14	34020		Windtree Drive	40.38647	75.12915	394,476.4	2,698,472	WQ basin 1	22.33	78.1
15	34019		Windtree Drive	40.38682	75.12851	394,610.3	2,698,648	WQ basin 2	6.85	80.7
16	34018		Curly Hill Road, near Sanderling	40.38579	75.12550	394,257.6	2,699,496	WQ basin 3	26.57	74.9
17	34029	Bucks Country Gardens (1998)	1057 N. Easton Road	40.35842	75.13996	384,172.0	2,695,765	regional wet pond/dam	119.73	0.40
18	34105			40.35876	75.14019	384,294.1	2,695,697	wetland basin	2.65	0.61
19	34008	Cen.Bucks Middle School 5 (2000)	Old Easton Road & Danboro Pike	40.36149	75.13389	385,339.7	2,697,423	detention basin A	9.47	78.5
20	34009			40.36478	75.13148	386,560.3	2,698,058	detention basin BCE	41.40	69.6
21	34005	Ridgeview Subdivision (only basin at Ridgetop Rd)	Burnt House Road & Danboro Pike	40.35834	75.12846	384,239.4	2,698,970	Report information not available	20.11	79.2

ID	Code	Project Name (design year)	location	GPS		GPS		Type of Facility	Drainage Area (acres)	CN/c
				Latitude	Longitude	Northing	Easting			
22	34104	Second Baptist Church (2005)	Swamp & Stump Roads	40.36026	75.18218	384,497.0	2,683,984	bioretention 1	2.75	0.48
		SWM facilities are in series. Each area represents area ONLY to that facility. Total Area represents total treatment of all 3 facilities which pass through the basin as a final step.						bioretention 2	2.09	0.23
								detention basin	0.21	0.23
									5.04	0.37
23	34106	George's Tool Rental	Easton Road & Avenue A	40.35370	75.13785	382,472.7	2,696,404	detention basin	1.093	0.72
24	34030	Timberly Farms (2006)		40.38118	75.13221	392,523.3	2,697,679	detention basin 2	37.56	77.0
25	34088	Central Bucks Athletic (2002)	Durham Road, Rte 413	40.39329	75.11800	397,052.7	2,701,503	filter basin	8.09	78.9
26	34024	Estates at Brookside (1989)	Swamp Road (north of King)	40.35344	75.17048	382,111.8	2,687,316	detention basin 1a	21.78	77.9
27	34025			40.35562	75.17089	382,899.5	2,687,177	detention basin 1b	6.75	78.0
28	34023			40.35214	75.16881	381,651.8	2,687,794	detention basin 2	8.37	77.8
29	34022			40.35363	75.16480	382,224.3	2,688,895	detention basin 3	18.52	76.4
30	34102	Country Greene (1991)	Potters Lane	40.38735	75.13196	394,773.8	2,697,680	detention basin 1	7.49	81.5
31	34021	basin 3 and Myers tract discharge to Tohickon Watershed		40.38780	75.13002	394,954.8	2,698,217	detention basin 2	11.98	81.7
32	34101	Huntington Valley Bank	Route 611 & Old Easton Road	40.38153	75.14515	392,547.4	2,694,070			
33	34103	Fountainville Executive Offices	Swamp & Ferry Roads	40.34326	75.15241	378,551.3	2,692,458			
34	34028	CBSD Elementary School	Rte 611	40.36132	75.14529	385,183.6	2,694,248			
35	34107	Penn Engineering	Old Easton Road	40.36243	75.13846	385,645.9	2,696,139			
36	34108			40.36316	75.13970	385,903.1	2,695,785			
37	34026	Brookside East	Curly Hill Road, near Swamp Rd	40.35056	75.16349	381,119.8	2,689,294			

APPENDIX G

Stream & Riparian Assessment Data

Stream Segment GPS Data

Stream Reach	Stream Segment Nodes	Latitude	Longitude	Photographs
A-B	A1	40.39095	-75.10223	A1-Up, A1-Down
	A2	40.38566	-75.10842	A2-Up, A2-Down
	A3	40.38412	-75.10985	A3-Up, A3-Down
	A4	40.38331	-75.11137	A4-Up, A4-Down
	A5	40.37976	-75.11723	A5-Up, A5-Down
	A6	40.37545	-75.12511	
B-C	B1	40.37471	-75.12452	B1-Up, B1-Down & B1-A
	B2	40.37413	-75.12663	B2-Up, B2-Down & B2-A
	B3	40.37327	-75.12807	B3-Up, B3-Down, B3-A & B3-B
	B4	40.37117	-75.13045	B4-Up, B4-Down
	B5	40.36567	-75.13916	
C-D	C1	40.3652	-75.13873	C1-Up, C1-Down
	C2	40.36291	-75.1423	C2-Up, C2-Down & C2-A
	C3	40.36006	-75.14722	C3-Up, C3-Down
	C4	40.35455	-75.15373	
D-E	D1	40.35499	-75.15429	D1-Up, D1-Down
	D2	40.35049	-75.15833	D2-Up, D2-Down
	D3	40.34745	-75.16144	D3-Up, D3-Down
	D4	40.33895	-75.16845	

Riparian Rating:

[illegible]

Watershed Problems - GPS Data

Problem ID	Stream Reach	Stream Segment	Segment Wide Problem	Latitude	Longitude	Photographs	Description	Improvements	Eroding Bank Est. (feet)
PA1	A-B	A2-A3	yes	40.38494	-75.10845	PA1	SBE SCW RBP - Segment wide problem	RBW & BSP BSB BS FDS if needed in localized areas	1,650
PA2	A-B	A3-A4	yes	40.38357	-75.11054	PA2	SBE SCW RBP - Segment wide problem	RBW & BSP BSB BS FDS if needed in localized areas	725
PA3	A-B	A4-A5	yes	40.38125	-75.11456	PA3	SBE SCW RBP - Segment wide problem	RBW & BSP BSB BS FDS if needed in localized areas	3,200
PA4	A-B	A5-A6	yes	40.37665	-75.12259	PA4 a-c	SBE SCW RBP - Segment wide problem	RBW & BSP BSB BS FDS if needed in localized areas	5,700
PB1	B-C	B1-B2	yes	40.37471	-75.12563	PB1	SBE SCW RBP - Segment wide problem	RBW & BSP BSB BS FDS if needed in localized areas	1,300
PB2	B-C	B2-B3	yes	40.373682	-75.127754	PB2	SBE SCW RBP - Segment wide problem	RBW & BSP BSB BS FDS if needed in localized areas	350
PB3	B-C	B3-B4	yes	40.37241	-75.12929	PB3	SBE SCW RBP - Segment wide problem	RBW & BSP BSB BS FDS if needed in localized areas	2,100
PC1	C-D	C1-C2		40.36377	-75.14117	PC1 a-d	SBE RBN SWR - trailer park w/ bank erosion (350 ft RL & 200 ft RR)	RBW RBH BSB	550
PC2	C-D	C3-C4		40.35907	-75.14874	PC2 a-c	SBE RBP - 4 ft vert cut on outer bend (150 ft RL) + manure horses	RBW BSB BYI	150
PC3	C-D	C3-C4		40.35678	-75.15111	PC3 a-c	AGR SWR - sm delta in channel (RL) due to ag row corn runoff	NMP	0
PC4	C-D	C3-C4		40.35591	-75.15248	PC4 a-b	Other - stream encroachment with trucks & misc. equipment	remove	0
PD1	D-E	D1-D2		40.35325	-75.15567	PD1	AGL SBE - 900 ft of stream channel	EF PSC - 1,800 feet of fencing	1,800
PD2	D-E	D1-D2		40.35226	-75.15692	PD2	SBE RBP - 3 - 4 ft vert cut on outer bend (75 ft RL)	RBW BSB	75
PD3	D-E	D1-D2		40.35247	-75.15749	PD3	SBE RBP - 3 - 4 ft vert cut on outer bend (125 ft RR)	RBW BSB	125
PD4	D-E	D3-D4		40.34251	-75.16421	PD4	SBE - 5 ft vert cut (100 ft RR)	BSP (live staking)	100

17,825

NPS Problems

Corrective Measures

SBE	Streambank erosion	RBW	Riparian buffer (trees & shrubs)
LBE	Lake bank erosion	RBH	Riparian buffer (grass & herb. plantings)
SCE	Stream channel erosion (incision)	BSP	Bank stabilization (plantings only)
SCW	Stream channel widening	BSB	Bank stabilization (bioengineering)
RBN	Riparian buffer - none	BS	Bank stabilization (gabions, rip rap)
RBP	Riparian buffer - poor	FDS	Flow deflecting structures
AGL	Agriculture - livestock	FHS	Fish habitat structures
AGH	Agriculture - horses	SCR	Stream Channel Restoration
AGP	Agriculture - pasture erosion	EF	Exclusionary fencing
AGR	Agriculture - row crops	PSC	Protected stream crossing
AGM	Agriculture - manure	OSWS	Off-stream water source
BYR	Barnyard runoff	SOI	Stormwater outlet improvements
SS	Septic systems	DGRI	Dirt & gravel road improvements
SWR	Stormwater runoff	NMP	Nutrient management plans
LOG	Logging	BYI	Barnyard improvements
AMD	Acid mine drainage		
RDE	Roadside ditch erosion		
RSE	Road surface erosion		



Stream & Riparian Visual Assessment

Project Name: _____
Project No. _____
Initials: _____

Stream Name: _____
Date: _____
Time: _____

Stream Reach: _____ - _____

Stream Segment: _____ - _____

Flow Conditions: _____ Baseflow _____ Stormflow

Location in the Watershed: _____ Headwaters _____ Middle _____ Lower

Distances Reported: _____ Measuring Tape _____ Range Finder _____ Estimated

Mean Stream Width: _____ ft.

GPS Information for Segment (record in d.ddddd):

Upstream point of Segment: _____ Waypoint ID _____ Lat. _____ Long. _____
Downstream point of Segment: _____ Waypoint ID _____ Lat. _____ Long. _____

Photograph Information:

Upstream Photograph ID _____ Other _____
Downstream Photograph ID _____ Other _____

Land Uses (Estimate Percentage):

_____ Urban/Commercial _____ Residential (lawn) _____ Residential (forest)
_____ Park & Fields (lawn) _____ Ag Row Crop _____ Ag Pasture (fallow)
_____ Forest _____ Field (scrub & shrub) _____ Meadow
_____ Other (describe): _____

1. Riparian Buffer Width									
Poor		Marginal			Good			Excellent	
0 – 9 feet 0 - 3 yards		> 9 - 60 feet > 3 - 20 yards			> 60 - 150 feet > 20 - 50 yards			150+ feet 50+ yards	
1	2	3	4	5	6	7	8	9	10

2. Riparian Vegetation Type									
Poor		Marginal			Good			Excellent	
Grasses & herb. plants (grazed or mowed)		Grasses & herb. plants (full height)			Shrub or Shrub & grass mix			Forest or Forest mix w/ shrubs &/or grass	
1	2	3	4	5	6	7	8	9	10

3. Riparian Vegetation Density									
Poor		Marginal			Good			Excellent	
Vegetation very sparse Covers < 25% of ground Large bare spots visible		Vegetation somewhat sparse Covers 25-50% of ground Several bare spots are visible			Vegetation fairly thick Covers 50-80% of ground Few bare spots			Vegetation thick Covers > 80% of ground No bare spots	
1	2	3	4	5	6	7	8	9	10

4. Bank Vegetation Type									
Poor		Marginal			Good			Excellent	
Grasses & herb. plants (grazed or mowed)		Grasses & herb. plants (full height)			Shrub or Shrub & grass mix			Trees or trees mix w/ shrubs &/or grass	
1	2	3	4	5	6	7	8	9	10
5. Bank Vegetation Density									
Poor		Marginal			Good			Excellent	
Vegetation very sparse Covers < 25% of bank Large bare spots visible		Vegetation somewhat sparse Covers 25-50% of bank Several bare spots are visible			Vegetation fairly thick Covers 50-80% of bank Few bare spots			Vegetation thick Covers > 80% of ground No bare spots	
1	2	3	4	5	6	7	8	9	10
6. Bank Stability									
Poor		Marginal			Good			Excellent	
Unstable, Severe undercutting or erosion Bare roots visible Vertical slopes		Largely unstable, High level of undercutting or erosion Some bare roots visible Steep slopes			Moderately stable, Low level of undercutting or erosion Banks are healing Moderate slopes			Stable No areas of erosion No bank failure Gently sloping (low banks)	
1	2	3	4	5	6	7	8	9	10

7. Channel Modification									
Poor		Marginal			Good			Excellent	
Channel – highly modified Concrete channel Both sides modified		Channel – slightly modified One side of channel has been rip rapped or hard stabilized			Channel – slight alterations Occasional modifications are present but overall free-flowing			Channel - not modified Stream is completely free- flowing on both sides	
1	2	3	4	5	6	7	8	9	10
8. In-Stream Cover (undercut banks, overhanging vegetation, pools, logs & rocks)									
Poor		Marginal			Good			Excellent	
Virtual no habitat		Infrequent habitats, Habitats are further than 25 yards apart			Frequent habitats, Habitats are within 10 yards of one another			Many habitats Continuous throughout stream	
1	2	3	4	5	6	7	8	9	10
9. Embeddedness									
Poor		Marginal			Good			Excellent	
Rocks deeply stuck into sediments Rocks barely visible		Rocks more than ½ surrounded by sediments Rocks can not be easily flipped			Rocks partially surrounded by sediments Rocks can be easily flipped			Rocks free from sediments Little sediments along stream bottom	
1	2	3	4	5	6	7	8	9	10
10. Shading (Canopy Cover)									
Poor			Good				Excellent		
Little to no canopy < 25% of stream shaded			Partial coverage of canopy 25 - 75% of stream shaded				Nearly complete canopy coverage > 75% of stream shaded		
1	2	3	4	5	6	7	8	9	10

***** SCORE *****				
A. Total Number of Points Scored (Add Number of Points Scored in 1 through 10*)				pts
B. Total Number of Possible Points				100 pts.
C. Score (divide A by B & multiply by 100)				%
Score	0 - 35%	36 - 65%	66 - 85%	86 - 100%
Rating	Poor	Marginal	Good	Excellent

Personal Rating of Stream Segment:

Poor Marginal Good Excellent (circle one)

Livestock Access to Stream:

Yes No (circle one)

Brief Description of Stream Segment:

Suggestions for Improving the Stream Segment:

☐ Riparian Buffer Needed (trees & shrubs): Right Bank _____ ft / yd Left Bank _____ ft / yd

☐ Riparian Buffer Needed (grasses & herb.): Right Bank _____ ft / yd Left Bank _____ ft / yd

Distance Determined: _____ Measuring Tape _____ Range Finder _____ Estimated

Sketch of Assessed Stream Segment



Watershed Assessment - Problem Areas

Project Name: _____
Project No. _____
Initials: _____

Stream Name: _____
Date: _____
Time: _____

Stream Reach (if applicable): _____ - _____
Stream Segment (if applicable): _____ - _____

Flow Conditions: _____ Baseflow _____ Stormflow
Distances Reported: _____ Measuring Tape _____ Range Finder _____ Estimated
Mean Stream Width: _____ ft.

GPS Information (record in d.ddddd):

Location of Problem Area: _____ Waypoint ID _____ Lat. _____ Long. _____

Photograph Information:

Photograph ID	_____	Description	_____
Photograph ID	_____	Description	_____
Photograph ID	_____	Description	_____
Photograph ID	_____	Description	_____
Photograph ID	_____	Description	_____

Land Uses (Estimate Percentage):

_____ Urban/Commercial	_____ Residential (lawn)	_____ Residential (forest)
_____ Park & Fields (lawn)	_____ Ag Row Crop	_____ Ag Pasture (fallow)
_____ Forest	_____ Field (scrub & shrub)	_____ Meadow
_____ Other (describe): _____		

Type of Problem (Circle):

SBE	Streambank erosion	AGM	Agriculture – manure
LBE	Lake bank erosion	BYR	Barnyard runoff
SCE	Stream channel erosion (incision)	SS	Septic systems
SCW	Stream channel widening	SWR	Stormwater runoff
RBN	Riparian buffer - none	LOG	Logging
RBP	Riparian buffer – poor	CON	Construction
AGL	Agriculture – livestock	AMD	Acid mine drainage
AGH	Agriculture – horses	RDE	Roadside ditch erosion
AGP	Agriculture - pasture erosion	RSE	Road surface erosion
AGR	Agriculture - row crops		
OTH	Other _____		

Suggestions for Improving the Problem Area:

RBW Riparian buffer (trees & shrubs)
RBH Riparian buffer (grass & herb.)
BSP Bank stabilization (plantings only)
BSB Bank stabilization (bioengineering)
BS Bank stabilization (gabions, rip rap)
FDS Flow deflecting structures
FHS Fish habitat structures
SCR Stream Channel Restoration

EF Exclusionary fencing
PSC Protected stream crossing
OSWS Off-stream water source
SOI Stormwater outlet improvements
DGRI Dirt & gravel road improvements
NMP Nutrient management plans
BYI Barnyard improvements

OTH Other _____

Sketch of Problem Area (please provide dimensions):



APPENDIX H

AVGWLF & Predict Modeling Results



AVGWLF Overview

The recognition of the importance of non-point sources of pollution has led to increased efforts over the last two decades to identify and quantify non-point source pollutant loads, especially at the watershed level. Typical techniques for determining the extent and magnitude of non-point source pollution problems include long-term surface water monitoring and computer-based simulation modeling. Due to the time and expense associated with surface water monitoring, however, simulation modeling has been relied upon more frequently to provide needed information for the development and implementation of non-point source control programs. Watershed simulation models, in fact, are commonly considered to be essential tools for evaluating the sources and controls of sediment and nutrient loading to surface waters. Such models provide a framework for integrating the data that describe the processes and land-surface characteristics that determine pollutant loads transported to nearby water bodies.

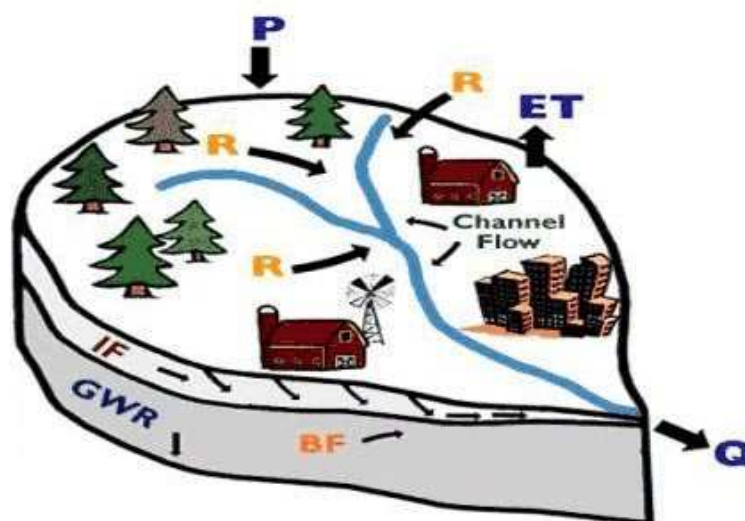
The utilization of watershed models, however, is a difficult, tedious task because of the broad spatial and temporal scales that must be considered, as well as the large amount of data that must be compiled, integrated, analyzed, and interpreted. Fortunately, the last two decades of model development have coincided with rapid advancements in the development and use of geographic information system (GIS) technology. This technology provides the means for compiling, organizing, manipulating, analyzing, and presenting spatially-referenced model input and output data. Due to the many inherent benefits, GIS software has been used to support literally hundreds of watershed modeling efforts over the last 10-15 years.

Over the last 5-10 years, the Pennsylvania Department of Environmental Protection (DEP) has recognized the indispensability of GIS technology, and has endeavored to integrate it into all of the agency's internal program areas. Towards this end, Penn State has been assisting DEP in the development and implementation of various GIS-based watershed assessment tools. One such tool facilitates the use of the GWLF model via a GIS software (ArcView) interface. This tool (called AVGWLf) has recently been selected by DEP to help support its ongoing TMDL projects within Pennsylvania. The general approach in such projects is to: 1) derive input data for GWLF for use in an "impaired" watershed, 2) simulate nutrient and sediment loads within the impaired watershed, 3) compare simulated loads within the impaired watershed against loads simulated for a nearby "reference" watershed that exhibits similar landscape, development and agricultural patterns, but which also has been deemed to be unimpaired, and 4) identify and evaluate pollution mitigation strategies that could be applied in the impaired watershed to achieve pollutant loads similar to those calculated for the reference watershed. The primary bases of comparison between impaired and reference watersheds are the average annual nutrient and sediment loads estimated for each.

THE GWLF MODEL

The core watershed simulation model for this GIS-based application is the GWLF (Generalized Watershed Loading Function) model developed by Haith and Shoemaker (1987). The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values.

AVGWLF



GWLF is considered to be a combined distributed/lumped parameter watershed model. For surface loading, it is distributed in the sense that it allows multiple land use/cover scenarios, but each area is assumed to be homogenous in regard to various attributes considered by the model. Additionally, the model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words there is no spatial routing. For sub-surface loading, the model acts as a lumped parameter model using a water balance approach. No distinctly separate areas are considered for sub-surface flow contributions. Daily water balances are computed for an unsaturated zone as well as a saturated sub-surface zone, where infiltration is simply computed as the difference between precipitation and snowmelt minus surface runoff plus evapotranspiration.

With respect to the major processes simulated, GWLF models surface runoff using the SCS-CN approach with daily weather (temperature and precipitation) inputs. Erosion and sediment yield are estimated using monthly erosion calculations based on the USLE algorithm (with monthly rainfall-runoff coefficients) and a monthly composite of KLSCP values for each source area (e.g., land cover/soil type combination). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine sediment yield for each source area. Surface nutrient losses are determined by applying dissolved N and P coefficients to surface runoff and a sediment coefficient to the yield portion for each agricultural source area. Point source discharges can also contribute to dissolved losses and are specified in terms of kilograms per month. Manured areas, as well as septic systems, can also be considered. Urban nutrient inputs are all assumed to be solid-phase, and the model uses an exponential accumulation and washoff function for these loadings. Sub-surface losses are calculated using dissolved N and P coefficients for shallow groundwater contributions to stream nutrient loads, and the sub-surface sub-model only considers a single, lumped-parameter contributing area. Evapotranspiration is determined using daily weather data and a cover factor dependent upon land use/cover type. Finally, a water balance is performed daily using supplied or computed precipitation, snowmelt, initial unsaturated zone storage, maximum available zone storage, and evapotranspiration values.

In addition to the original model algorithms described above, a new streambank erosion

routine was also implemented as part of AVGWLF. This routine is based on an approach often used in the field of geomorphology in which monthly streambank erosion is estimated by first calculating a watershed-specific lateral erosion rate using the equation of the form

$$LER = aq^{0.6}$$

where **LER** = an estimated lateral erosion rate

a = an empirically-derived constant related to the mass of soil eroded from the streambank depending upon various watershed conditions, and

q = monthly stream flow in cubic meters per second.

After a value for **LER** has been computed, the total sediment load generated via streambank erosion is then calculated by multiplying the above erosion rate by the total length of streams in the watershed (in meters), the average streambank height (in meters), and the average soil bulk density (in kg/m³).

For execution, the model requires three separate input files containing transport-, nutrient-, and weather-related data. The transport (TRANSPRT.DAT) file defines the necessary parameters for each source area to be considered (e.g., area size, curve number, etc.) as well as global parameters (e.g., initial storage, sediment delivery ratio, etc.) that apply to all source areas. The nutrient (NUTRIENT.DAT) file specifies the various loading parameters for the different source areas identified (e.g., number of septic systems, urban source area accumulation rates, manure concentrations, etc.). The weather (WEATHER.DAT) file contains daily average temperature and total precipitation values for each year simulated.

GIS-BASED DERIVATION OF INPUT DATA FOR GWLF

As described previously, the use of GIS software for deriving input data for watershed simulation models such as GWLF is becoming fairly standard practice due to the inherent advantages of using GIS for manipulating spatial data. In this case, a customized interface developed by Penn State for the ArcView GIS package is used to parameterize input data for the GWLF model (Evans et al., 2002). In utilizing this interface, the user is prompted to identify required GIS files and to provide other information related to "non-spatial" model parameters (e.g., beginning and end of the growing season; and the months during which manure is spread on agricultural land). This information is subsequently used to automatically derive values for required model input parameters which are then written to the TRANSPRT.DAT and NUTRIENT.DAT input files needed to execute the GWLF model. Also accessed through the interface is a statewide weather database that contains twenty (25) years of temperature and precipitation data for seventy-eight (78) weather stations around Pennsylvania. This database is used to create the necessary WEATHER.DAT input file for a given watershed simulation.

Information sources for GWLF model parameterization

WEATHER.DAT file

Historical weather data from National Weather Service monitoring stations

TRANSPORT.DAT file

Basin size

GIS/derived from basin boundaries

Land use/cover distribution

GIS/derived from land use/cover map

Curve numbers by source area

GIS/derived from land cover and soil maps

USLE (KLSCP) factors by source area

GIS/derived from soil, DEM, and land cover

ET cover coefficients

GIS/derived from land cover

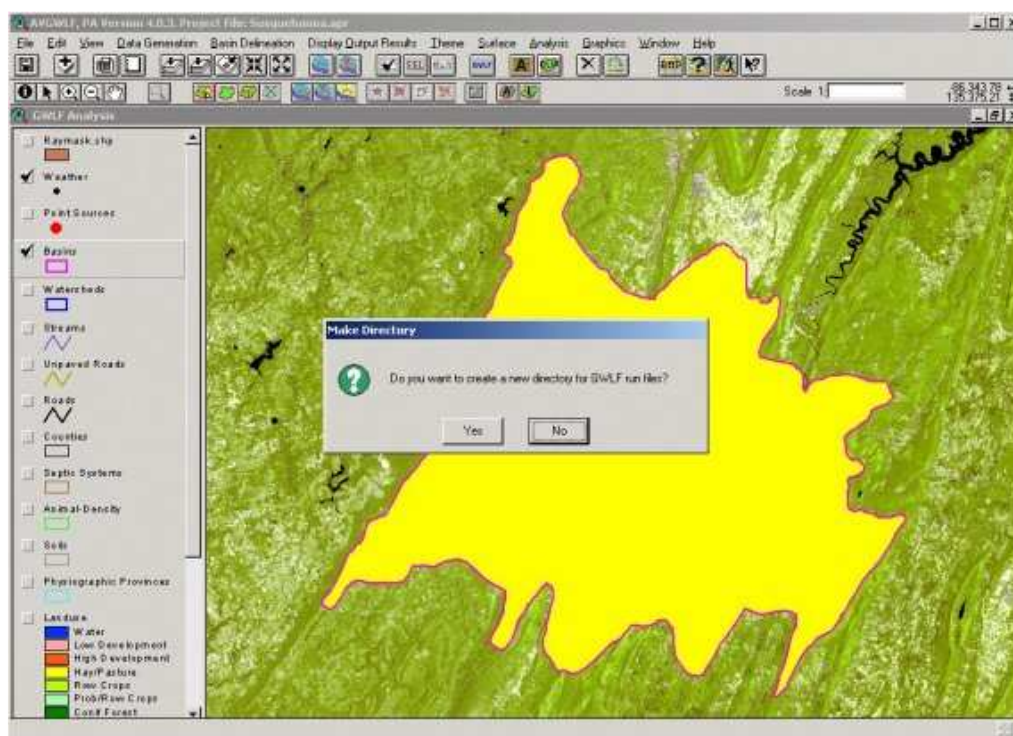
Erosivity coefficients

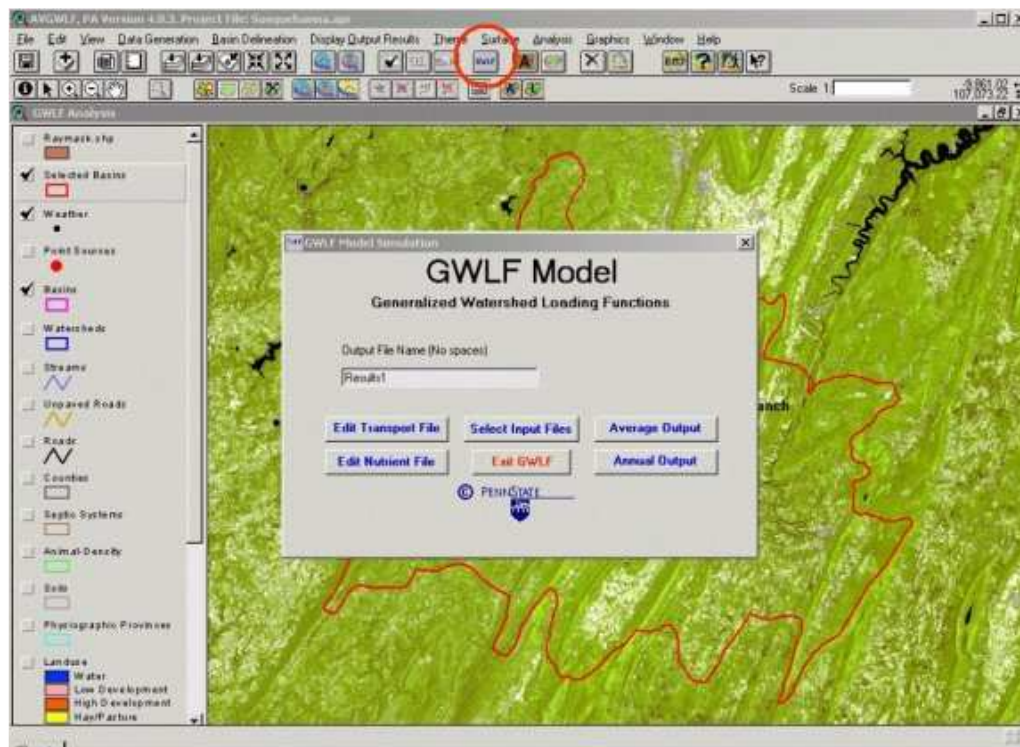
GIS/ derived from physiography map

Daylight hrs. by month	Computed automatically for state
Growing season months	Input by user
Initial saturated storage	Default value of 10 cm
Initial unsaturated storage	Default value of 0 cm
Recession coefficient	Default value of 0.1
Seepage coefficient	Default value of 0
Initial snow amount (cm water)	Default value of 0
Sediment delivery ratio	GIS/derived from basin size
Soil water (available water capacity)	GIS/derived from soil map

NUTRIENT.DAT file

Dissolved N in runoff by land cover type	Default values/adjusted using AEU density
Dissolved P in runoff by land cover type	Default values/adjusted using AEU density
N/P concentrations in manure runoff	Default values/adjusted using AEU density
N/P buildup in urban areas	Default values (from GWLF Manual)
N and P point source loads	GIS/derived from NPDES point coverage
Background N/P concentrations in GW	GIS/derived from new background N map
Background P concentrations in soil	GIS/derived from soil P loading map
Background N concentrations in soil	Based on map in GWLF Manual
Months of manure spreading	Input by user
Population on septic systems	GIS/derived from census tract map
Per capita septic system loads (N/P)	Default values (from GWLF Manual)





LITERATURE CITED

Evans, B.M., D.W. Lehning, K.J. Corradini, G.W. Petersen, E. Nizeyimana, J.M. Hamlett, P.D. Robillard, and R.L. Day, 2002. [A Comprehensive GIS-Based Modeling Approach for Predicting Nutrient Loads in Watersheds](http://www.spatialhydrology.com). J. Spatial Hydrology, Vol. 2, No. 2., (www.spatialhydrology.com).

Haith, D.A. and L.L. Shoemaker, 1987. Generalized Watershed Loading Functions for Stream Flow Nutrients. Water Resources Bulletin, 23(3), pp. 471-478.

Mean Annual Load Data Editor

Load Data Type	Total Sed (lbs)	Total N (lbs)	Total P (lbs)
UPLAND EROSION/RUNOFF			
Row Crops	1008980	6448	1253
Hay/Pasture	149590	3437	377
High Density Urban	3103	226	27
Low Density Urban	118017	541	86
Unpaved Road	0	0	0
Other	1719990	7542	1242
STREAMBANK EROSION	1343758	67	30
GROUNDWATER/SUBSURFACE		46646	646
POINT SOURCE DISCHARGE		0	0
SEPTIC SYSTEMS		529	71
TOTAL	4343438	79072	5980
BASIN AREA	9405	Acres	

Agricultural Land BMP Scenario Editor

Land Use	Acres		BMP1	BMP2	BMP3	BMP4	BMP5	BMP6	BMP7	BMP 8
Row Crops	1465	% Existing	8	50	5	0	0	0		5
		% Future	22	65	6	0	0	0		7
Hay/Pasture	2147	% Existing				0	0	0	1	5
		% Future				0	0	4	1	9
Agricultural Land on Slope > 3%	1,167	Acres								
Streams in Agricultural Areas	4.8	Miles								
Total Stream Length	28.2	Miles								
Unpaved Road Length	1.0	Miles								
			Existing	Future						
Stream Miles with Vegetated Buffer Strips			0.4	3.5						
Stream Miles with Fencing			0.0	0.4						
Stream Miles with Stabilization			0.0	3.3						
Unpaved Road Miles w/E & S Controls			0.0	0.0						

	% Existing	% Future	
AWMS (Livestock)	0.0	23.0	
AWMS (Poultry)	0.0	0.0	
Runoff Control	0.0	13.0	
Phytase in Feed	0.0	0.0	

Urban Land BMP Scenario Editor

High Density Urban					
	Acres	1465	% Impervious Surface	50	
Constructed Wetlands		Bioretention Areas		Detention Basins	
% Existing	8	% Existing	0	% Existing	0
% Future	62	% Future	11	% Future	0
% Drainage Area Used	5	% Drainage Area Used	6	% Drainage Area Used	3
Impervious Acres Drained	4.9	Impervious Acres Drained	2.9	Impervious Acres Drained	0.0
CW Acres Required	0.5	BA Acres Required	0.3	DB Acres Required	0.0

Low Density Urban					
	Acres	1324	% Impervious Surface	25	
Constructed Wetlands		Bioretention Areas		Detention Basins	
% Existing	9	% Existing	6	% Existing	15
% Future	14	% Future	13	% Future	15
% Drainage Area Used	3	% Drainage Area Used	6	% Drainage Area Used	2
Impervious Acres Drained	16.6	Impervious Acres Drained	23.2	Impervious Acres Drained	0.0
CW Acres Required	2.0	BA Acres Required	5.6	DB Acres Required	0.0

Vegetated Stream Buffers				
			Existing	Future
Stream miles in high density urban areas	.1	Stream miles in high density urban areas w/buffers	.1	.1
		High Density Urban Streambank Stabilization	0	0
Stream miles in low density urban areas	1.4	Stream miles in low density urban areas w/buffers	0	.1
		Low Density Urban Streambank Stabilization	0	.1

Septic Systems and Point Source Discharge Scenario Editor

Number of persons on septic systems	Existing	989		
	Future	989		
Spetic systems converted by treatment type %	Secondary	0	Tertiary	0
	Existing Point Source Load		No	
		Primary	Secondary	Tertiary
Distribution of pollutant discharge by treatment type %	Existing	0	0	0
	Future	0	0	0
		Primary to Secondary	Primary to Tertiary	Secondary to Tertiary
Distribution of treatment upgrades %		0	0	0

Rural and Urban BMP Load Reduction Efficiency Editor

BMP Type	Nitrogen	Phosphorus	Sediment	Pathogens
BMP 1	0.25	0.36	0.35	
BMP 2	0.50	0.38	0.64	
BMP 3	0.23	0.40	0.41	
BMP 4	0.95	0.94	0.92	
BMP 5	0.96	0.98	0.92	
BMP 6	0.70	0.28		
BMP 7	0.43	0.34	0.13	
BMP 8	0.44	0.42	0.71	
Vegetated Buffer Strips	0.64	0.52	0.58	0.70
Streambank Fencing	0.56	0.78	0.76	1.00
Streambank Stabilizatio	0.95	0.95	0.95	
Unpaved Roads (lbs/ft)	0.02	0.0035	2.55	
AWMS (Livestock)	0.75	0.75		0.75
AWMS (Poultry)	0.14	0.14		0.14
Runoff Control	0.15	0.15		0.15
Phytase in Feed		0.21		

Urban BMP Load Reduction Efficiency Editor				
BMP Type	Nitrogen	Phosphorus	Sediment	Pathogens
Constructed Wetlands	0.53	0.51	0.88	0.71
Bioretention Areas	0.46	0.61	0.10	0.82
Detention Basins	0.40	0.51	0.93	0.71

Pathogen Loads

Wastewater BMP Load Reduction Efficiency Editor

	Nitrogen	Phosphorus
Conversion of Septic Systems to Secondary Treatment Plant	0.14	0.10
Conversion of Septic Systems to Tertiary Treatment Plant	0.56	0.60
Conversion of Primary Treatment to Secondary Treatment	0.14	0.10
Conversion of Primary Treatment to Tertiary Treatment	0.56	0.60
Conversion of Secondary Treatment to Tertiary Treatment	0.42	0.50

BMP Cost Editor

Agricultural Cost Editor

Conservation Tillage (per acre)	\$30.00
Cropland Protection (per acre)	\$25.00
Grazing Land Management (per acre)	\$360.00
Streambank Fencing (per acre)	\$10.00
Streambank Fencing (per mile)	\$45,250.00
Streambank Stabilization (per foot)	\$50.00
Vegetated Buffer Strip (per mile)	\$1,500.00
Terraces and Diversions (per acre)	\$900.00
AWMS Livestock (per AEU)	\$2,500.00
AWMS Poultry (per AEU)	\$520.00
Runoff Control (per AEU)	\$300.00
Phytase in Feed (per AEU)	\$2.50
Nutrient Management (per acre)	\$110.00
Ag to Wetland Conversion (per acre)	\$5,000.00
Unpaved Roads (per foot)	\$5.58
Ag to Forest Conversion (per acre)	\$5,000.00

Urban Cost Editor

Constructed Wetlands (per acre)	\$13,400.00
Bioretention Areas (per acre)	\$8,000.00
Detention Basins (per acre)	\$10,700.00

Septic System and Point Source Upgrades

Conversion of Septic Systems to Centralized Sewage Treatment (per home)	\$15,000.00
Conversion From Primary to Secondary Sewage Treatment (per capita)	\$250.00
Conversion From Primary to Tertiary Sewage Treatment (per capita)	\$300.00
Conversion From Secondary to Tertiary Sewage Treatment (per capita)	\$150.00

Estimated Load Reductions

		Existing (lbs)		
UPLAND EROSION/RUNOFF		Total Sed (lbs)	Total N (lbs)	Total P (lbs)
	Row Crops	1008980	6448	1253
	Hay/Pasture	149590	3437	377
	High Density Urban	3103	226	27
	Low Density Urban	118017	541	86
	Unpaved Roads	0	0	0
	Other	1719990	7542	1242
STREAMBANK EROSION		1343758	67	30
GROUNDWATER/SUBSURFACE			46646	646
POINT SOURCE DISCHARGE			0	0
SEPTIC SYSTEMS			529	71
FARM ANIMALS			13636	2248
TOTALS		4343438	79072	5980

	Future (lbs)		
LAND EROSION/RUNOFF	Total Sed (lbs)	Total N (lbs)	Total P (lbs)
Row Crops	527985	3325	733
Hay/Pasture	145342	3282	367
High Density Urban	2550	192	23
Low Density Urban	102718	463	74
Unpaved Roads	0	0	0
Other	1719990	7542	1242
STREAMBANK EROSION	1179886	59	26
GROUNDWATER/SUBSURFACE		46638	644
POINT SOURCE DISCHARGE		0	0
SEPTIC SYSTEMS		529	71
FARM ANIMALS		11068	1850
TOTALS	3678471	73097	5030
PERCENT REDUCTIONS	15.3	21.6	46.8
TOTAL SCENARIO COST	\$2,593,043.30		
Ag BMP Cost (%)	4.8		
WW Upgrade Cost (%)	0.0		
Urban BMP Cost (%)	19.2		
Stream Protection Cost (%)	71.0		
Unpaved Road Protection Cost (%)	0		
Source	Existing (orgs/month)	Future (orgs/month)	
Farm Animals	1.753e+15	1.069e+15	
WWTP	0.000e+00	0.000e+00	
Septic Systems	1.409e+13	1.409e+13	
Urban Areas	1.649e+16	1.415e+16	
Wildlife	1.354e+12	1.354e+12	
Totals	1.826e+16	1.524e+16	
PERCENT REDUCTIONS		16.53	
TOTAL SCENARIO COST	\$2,593,043.30		

