LAKE WALLENPAUPACK
WATERSHED MANAGEMENT PLAN

December 2006

PREPARED FOR:

**Lake Wallenpaupack Watershed
Management District**

PREPARED BY:

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Watershed Management Plan

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Executive Summary

In 1979, the Lake Wallenpaupack Watershed Management District (LWWMD) was formed to provide guidance in the protection and improvement of water quality in Lake Wallenpaupack and its tributaries. The goals of the LWWMD include performing diagnostic studies to evaluate Lake Wallenpaupack and its watershed and implementing a continuing watershed management program. The Pennsylvania Power and Light Company, now known as PPL Corporation (PPL), assisted in the formation of the LWWMD, assigns a representative to sit on the Board of Directors, and provides funding to the LWWMD to conduct yearly water quality monitoring of the lake.

In 1980 and 1981, the LWWMD received an EPA Phase I Clean Lakes Program Grant to fund a Diagnostic/Feasibility Study, which involved water quality monitoring. This study identified the source and magnitude of point and nonpoint pollution inputs to Lake Wallenpaupack. Based on this study, the trophic classification of the lake was determined to be eutrophic. The product of this study was a comprehensive watershed management plan written in 1982 which included urban stormwater management policies. Since the Phase I Study, Lake Wallenpaupack has been monitored annually to establish and document water quality trends.

An EPA Phase II Lake Restoration Project for the lake began in 1987 and was completed in 1993. As part of the Phase II project, agricultural waste storage and management facilities were constructed, stormwater control projects were undertaken, and stormwater ordinances were developed for the townships in the lake's watershed. In 1998 and 1999, LWWMD received two EPA Grants totaling $2.2 million. This grant money was used for environmental education seminars, GIS mapping of the watershed, development of pollutant budgets for the lake, long-term data analysis and streambank stabilization projects.

The following actions are recommended for improving the water quality in Lake Wallenpaupack:

1. The municipalities in the Lake Wallenpaupack watershed should update their Act 537 Sewage Facilities Plans to ensure adequate wastewater planning for potential residential, commercial, and industrial development. In particular, Dreher, Lake, Lehigh, Madison, Palmyra (Wayne Co.), and Sterling Townships have Act 537 Plans that are greater than 20 years old that are in need of updating.

2. Decentralized wastewater recommendations should be included in municipal ordinances, comprehensive plans, and Act 537 Plan revisions in the Lake Wallenpaupack watershed. Palmyra Township is currently updating their Act 537 Plan to include decentralized wastewater treatment facilities.

3. The LWWMD should continue to maintain a good relationship with the operators of the wastewater treatment facilities within the watershed, monitor the DMRs for each treatment plant, and encourage the facility owners to continue to maintain their equipment and upgrade their systems as necessary.

4. Stormwater best management practices (BMPs) should continue to be implemented in developed areas of the Lake Wallenpaupack watershed, in accordance with the Pennsylvania BMP Manual. The BMPs should be able to not only store and slow stormwater flows, but should also provide water quality treatment. Nonpoint source problem areas in need of stormwater BMPs are listed in Appendix B and shown on Map 1 in Appendix C.

5. Wherever possible, Low-Impact Development (LID) techniques should be encouraged or required for new development in the Lake Wallenpaupack watershed.

6. The LWWMD, Conservation Districts, and watershed residents should monitor new construction sites in the watershed to make sure Erosion and Sedimentation Pollution Controls are being properly used.

7. The Act 167 Stormwater Management Plan for the Lake Wallenpaupack watershed should be updated. The update should include provisions to encourage Low-Impact Development.

8. Each municipality in the Lake Wallenpaupack watershed should adopt the model stormwater ordinance from the Pennsylvania NPDES Phase II regulations and the updated Act 167 Plan.

9. The LWWMD should work with the watershed municipalities to update and improve their ordinances and comprehensive plans to regulate development in a manner that protects and conserves water resources. In particular, the following ordinances and plans should be considered for development and implementation: stormwater ordinance, tree ordinance, riparian buffer ordinance, steep slopes ordinance, natural landscaping/noxious weed ordinance, pet waste ordinance, wildlife feeding ordinance, groundwater protection ordinance, Open Space Plan, Greenways Plan, and Comprehensive Plan.

10. The LWWMD should continue to pursue funding to implement additional agricultural BMPs in the watershed, based on the documented nonpoint source problem areas identified during the watershed investigations (See Appendix B and C).

11. Erosion and sedimentation pollution control plans should be required for all logging and timber operations within the Lake Wallenpaupack watershed, and silvicultural BMPs should be implemented in order to reduce nutrient and sediment loadings.

12. LWWMD should seek funding through the PA DEP's Growing Greener program or other funding sources to repair the streambank and shoreline erosion problem areas in the Lake Wallenpaupack watershed (See Appendix B and C). Whenever possible, bioengineering and natural channel restoration techniques should be

used in the restoration process. Property owners should work with LWWMD, PPL, and the County Conservation Districts to address these problems.

13. Waterfront property owners within the Lake Wallenpaupack watershed should assess their properties for shoreline erosion problems that may be contributing pollutants to Lake Wallenpaupack. A Homeowner's Streambank and Shoreline Restoration Handbook is available on the LWWMD website at http://www.wallenpaupackwatershed.org.

14. Protective vegetative buffers should be maintained or restored along all wetlands and streams in the watershed to reduce streambank erosion and protect the functionality and quality of the wetlands.

15. The LWWMD should continue monitoring Lake Wallenpaupack and its tributaries in order to maintain the long-term water quality database.

16. An updated, comprehensive macrophyte survey should be performed throughout Lake Wallenpaupack, paying special attention to the cove and inlet areas. The goal of the survey should be to document the species composition and extent of aquatic plant populations in the lake, and to detect the presence of any non-native, invasive species.

17. The LWWMD should consider working with the PA Fish and Boat Commission to conduct an updated fisheries survey for Lake Wallenpaupack. If possible, a biomanipulation study should be performed as well.

18. PPL should strive to reduce frequent fluctuations in lake levels in order to reduce shoreline erosion around the lake. In addition, PPL should allow continuous coldwater discharge during the summer so the lake can maintain normal discharge levels.

19. The LWWMD should continue to implement watershed public education programs using the environmental education materials developed as part of the FY1998 and FY1999 EPA Grant projects.

20. The LWWMD needs to focus direct attention to organizational development in several key areas including fundraising, organizational structure, partnerships, and technical capacity. The LWWMD should develop an Organizational Development Plan to serve as a companion document to the Watershed Management Plan that specifically addresses these needs.

21. The LWWMD should seek funding via existing grant programs and private donations for their ongoing lake protection and restoration efforts. In addition, LWWMD should develop a funding source via boating user fees to provide a steady source of revenue.

22. The LWWMD should develop a lake user fee system to provide stable long-term funding for the LWWMD's activities.

1.0 Introduction

Lake Wallenpaupack, located in Pike and Wayne Counties in northeastern Pennsylvania, is approximately 5,700 acres in size. The area that is now Lake Wallenpaupack was once only a creek, known to the Leni-Lenape Indians as "Wallenpaupack" which means "the stream of swift and slow water". In 1926, the Pennsylvania Power and Light Company, now PPL Corporation (PPL), dammed Wallenpaupack Creek with a concrete dam and built the lake to supply water power for a hydroelectric power plant. PPL's Wallenpaupack Hydroelectric Plant is capable of generating 44,000 kilowatts of electricity. The power plant is located downstream of the Lake Wallenpaupack dam just above the confluence of the Wallenpaupack Creek and Lackawaxen River.

Since its creation, Lake Wallenpaupack has become a vital recreational and economic resource in the Pocono Mountains region. The lake's watershed encompasses 219 square miles spread over four counties and 14 townships. The Lake Wallenpaupack watershed is shown in Figure 1.1. Although the lake has been classified as borderline eutrophic in past years and continues to experience periodic blue-green algae blooms, it continues to be one of the major recreational water resources in Pennsylvania.

1.1 Lake Wallenpaupack Watershed Management District Accomplishments

In September 1979, Pike and Wayne counties and the 14 townships in the Lake Wallenpaupack watershed formed the Lake Wallenpaupack Watershed Management District (LWWMD) in response to water quality problems in the lake. The LWWMD is a multi-governmental, nonprofit corporation that manages the Lake Wallenpaupack watershed and addresses water quality problems. It was the first watershed management district in Pennsylvania.

Since the formation of the LWWMD, numerous studies and implementation projects have occurred in the watershed. A brief description of some of the more important projects is provided below:

- Phase I Diagnostic Feasibility Study - This study was conducted using EPA Clean Lakes Program funding and included lake and stream monitoring which was used to develop a lake and watershed management plan.

- Phase II Restoration Program - This program was conducted using EPA Clean Lakes Program funding and included the implementation of agricultural BMPs, water control structures, streambank stabilization projects, and urban stormwater projects. Public education was an important part of this project.

- 319 Nonpoint Source Program - LWWMD received PA DEP-funded 319 nonpoint source control grants in 1995 and 1997 to continue the installation of watershed BMPs and continue the environmental education program. As part of the 1995 319 project, a successful high school curriculum was developed for use at the Wallenpaupack High School.

- 104(b)3 Program - LWWMD received an EPA funded 104(b)3 grant and has been using this money to design and construct streambank, shoreline and stormwater BMPs.

- Biostimulation Study - PPL Corporation funded a biostimulation study of Lake Wallenpaupack water to determine what pollutant sources (stormwater runoff, wastewater treatment plant effluent, animal waste runoff, etc.) are most likely to stimulate algae growth.

- Long-Term Water Quality Data Analysis - All existing lake water quality data for Lake Wallenpaupack was reviewed for the period of 1980 through 2000. The main purpose of the evaluation was to prepare all existing water quality data for use in the development of the TMDL for Lake Wallenpaupack.

- In 1998 and 1999, the LWWMD received a total of $2,200,000 from the two EPA grants. These grants were administered by the EPA and were used for watershed investigations, the development of pollutant budgets for Lake Wallenpaupack, additional lake and stream water quality monitoring, public education seminars and workshops, and the design and construction of Best Management Practices (BMPs) throughout the watershed to control nonpoint sources of pollution to Lake Wallenpaupack.

In 1990, the Lake Wallenpaupack Watershed Management Plan won the "Watershed of the Year" award from the Conservation Districts of Pennsylvania. It also won first place in the "Take Pride in Pennsylvania" award. The environmental curriculum that was developed for the Wallenpaupack Area School District under the 319 Grant Project won the 1998 Governor's Award for Environmental Excellence in Environmental Education.

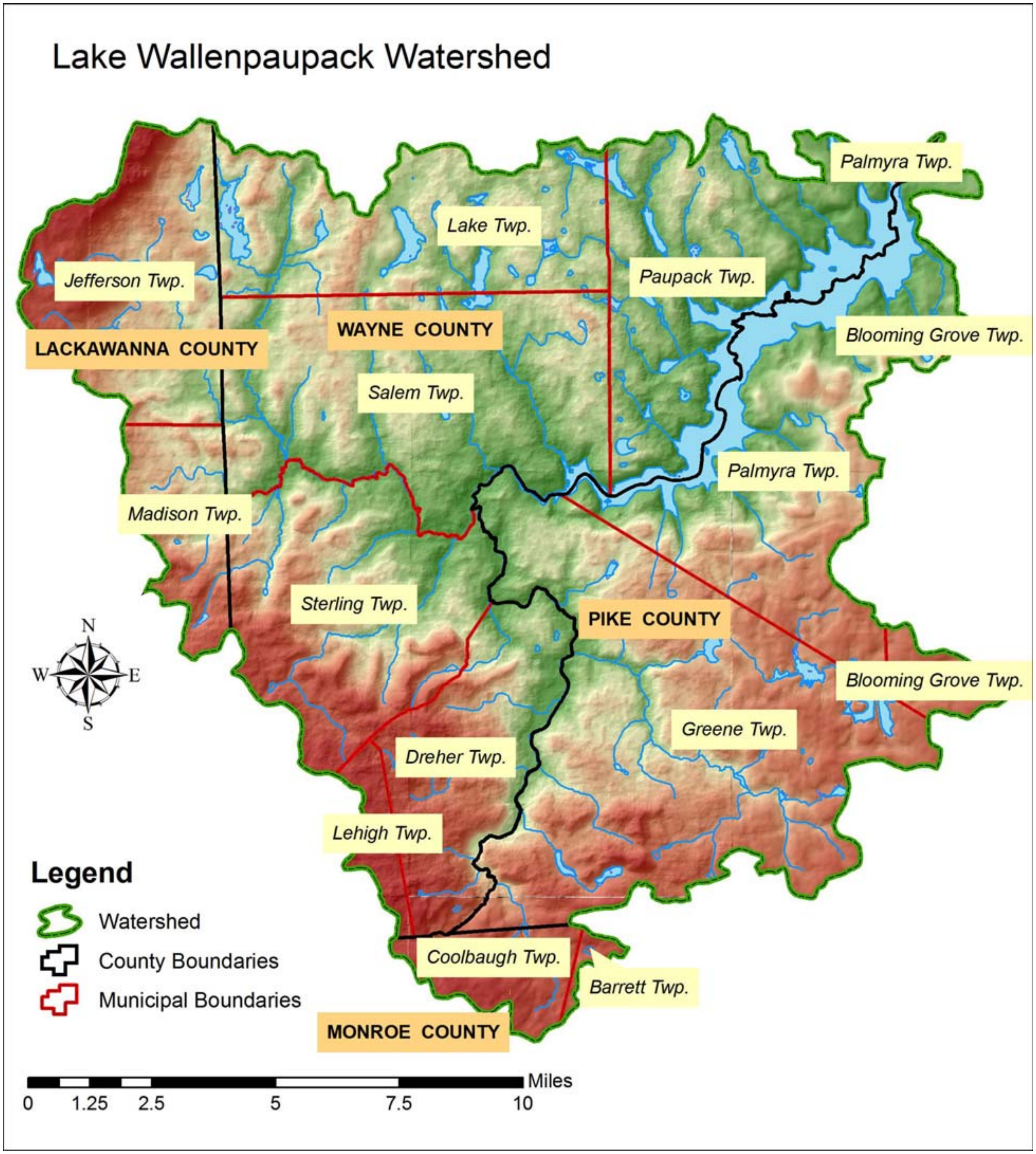

Figure 1.1 Lake Wallenpaupack Watershed

1.2 Goals and Objectives

The original Lake Wallenpaupack Watershed Management Plan was prepared in December 1981 as part of an EPA-funded Phase I Diagnostic-Feasibility Study under the Clean Lakes Program. Key recommendations of the original Watershed Management Plan included:

1. Review effluent monitoring reports (DMRs) of wastewater treatment plants in the watershed,

2. Prepare and Act 167 Stormwater Management Plan for the Lake Wallenpaupack watershed,

3. Require septic haulers in the watershed to be licensed,

4. Conduct educational workshops, as needed,

5. Conduct field investigations to identify nonpoint source pollution problem areas,

6. Obtain funding for and implement Best Management Practices (BMPs) throughout the watershed, and

7. Continue to monitor water quality in Lake Wallenpaupack.

Each of the above recommendations from the original Watershed Management Plan has been implemented.

Any watershed management plan should be a working document, updated regularly as watershed conditions change. This 2006 update of the Lake Wallenpaupack Watershed Management Plan was prepared as part of an EPA grant to conduct watershed education activities, develop a website for LWWMD, and implement portions of the original Watershed Management Plan. The updated Plan includes:

- An evaluation of all past water quality studies (and other studies), including a summary of water quality in the lake.

- An evaluation and summary of stream water quality data that is generated as part of the Growing Greener Stream Monitoring project, including pollutant and hydrologic budgets. This information will be used to target the implementation of BMP projects to areas in the watershed that are contributing the most pollutants.

- A review of all background information on watershed characteristics.

- A review of all existing policies that are in the current plan. The policies will be evaluated and updated as necessary to make the updated Plan a usable document for the next 10 years or more.

- A review of all the BMPs that have been installed in the watershed along with a list of remaining problem areas and a description of the need for additional BMPs.

- Recommendations for pertinent ordinances to be developed and adopted by each municipality in the watershed. Ordinances that will be addressed include ordinances for steep slopes, tree removal, erosion and sediment control (earth disturbance ordinances), riparian corridor protection, wetland protection, and septic system maintenance.

- Additional recommendations to help improve the water quality in Lake Wallenpaupauck.

1.3 Lake Wallenpaupack Watershed Characteristics

Lake Wallenpaupack is approximately 5,700 acres in size and has a watershed that encompasses 219 square miles spread over four counties and 14 townships. The political boundaries within the Lake Wallenpaupack watershed are shown in Figure 1.1. The townships located within the watershed are as follows:

<u>Wayne County</u>
Paupack Township
Salem Township
Dreher Township
Lake Township
Sterling Township
Lehigh Township
Palmyra Township

<u>Pike County</u>
Palmyra Township
Greene Township
Blooming Grove Township

<u>Monroe County</u>
Coolbaugh Township
Barrettt Township

<u>Lackawanna County</u>
Jefferson Township
Madison Township

The lake has approximately 52 miles of shoreline and has an average depth of 29.5 feet. Major lake tributaries include Wallenpaupack Creek (East Branch, Main Stem, and West Branch), Ariel Creek, Purdy Creek, and Mill Brook. Water discharges from Lake Wallenpaupack via Wallenpaupack Creek, eventually flowing into the Lackawaxen River. The Lackawaxen River joins the Delaware River at Lackawaxen. General watershed characteristics are discussed in the following sections.

The Lake Wallenpaupack watershed is used extensively for recreation by visitors and residents alike. Activities include boating, fishing, waterskiing, swimming, camping, hiking, nature viewing, and picnicking in the summer and skiing, snowshoeing, and snowmobiling in the winter. The fall foliage season attracts numerous "leaf peepers" to the region.

1.3.1 Land Use

The vast majority of the land use in the Lake Wallenpaupack watershed (70.1 percent) is forested or undeveloped land, as shown in Table 1.1 and Figure 1.2. The next greatest land use is agricultural land use, which makes up 14.7 percent of the watershed. Agricultural lands consist mainly of cropland and pastureland. Residential land makes up less than four percent of the watershed; however, it is likely that some of the forested areas include scattered residential land use. Commercial land use, including gravel pits and quarries, makes up an additional one percent of the watershed. Wetlands make up nearly four percent of the watershed and open water makes up seven percent.

Table 1.1
Land Use in the Lake Wallenpaupack Watershed

Land Use	Area (acres)	Relative Percent of Watershed Area
Open Water	10,213	7.0%
Residential	4,960	3.4%
Commercial	1,459	1.0%
Forest/Undeveloped	102,128	70.1%
Agricultural	21,447	14.7%
Wetland	5,690	3.9%
Total	**145,897**	**100.0%**

1.3.2 Topography, Geology and Soils

Two physiographic provinces exist within the northeast region of Pennsylvania: the Ridge and Valley, and the Allegheny Plateau. The southeastern portion of the Allegheny Plateau is a distinct subsection commonly referred to as the Pocono Plateau. The Pocono Plateau covers all of Monroe, Pike, and Wayne Counties, and includes Lake Wallenpaupack. The landscape of the Pocono Plateau is more diverse than the rest of the Allegheny Plateau. It is characterized by rough terrain and an abundance of lakes and streams created by glacial scouring of the land which disrupted the internal drainage.

The Lake Wallenpaupack watershed is bound along the northwest by the Moosic Mountians. Elevations in the watershed vary from 2300 feet above mean sea level (MSL) in the northwest to 2200 feet above MSL in the south to 1190 feet above MSL at the top of the spillway gates at the dam. Slopes in the watershed range from 0 percent to over 22 percent, with a mean of 2.8 percent. Topography in the Lake Wallenpaupack watershed is shown in Figure 1.3.

Since the beginning of the Pleistocene era, the Upper Delaware area has been affected by three glacial episodes which have influenced the landforms, mineral resources, and drainage of the area. Glaciated areas are characterized by poor drainage, abundance of wetlands, and stony to extremely stony soils. Glacial deposits consisting of unsorted clay, gravel, pebbles, sand, mud, and boulders, form a patchy cover over most of Wayne and Pike Counties (PaDER, 1981).

In Pike County, the soils are mainly from the Culvers-Cattaraugua-Morris association (US Soil Conservation Service, 1969). This soil association is gently sloping to moderately steep. The soils are generally deep and range from well-drained to somewhat poorly drained. The soils were formed in reddish or brownish glacial till that was derived from red sandstone and shale. Large areas of the association are very stony. Much of the association is underlain by a well-developed fragipan that slows movement of water through the soil. In general, the soils are of moderate fertility.

The soils of Wayne County are relatively young with slight or weak development. They are all acidic and are not very fertile. Most of the soils are formed on material deposited by the Wisconsin glacier. Bedrock outcrops and ledges are numerous. The soils on the mountains and plateaus contain many boulders, stones, and rock fragments. Most of the soils are wet, shallow, slowly permeable, and steep. In general, they are not suitable for septic systems.

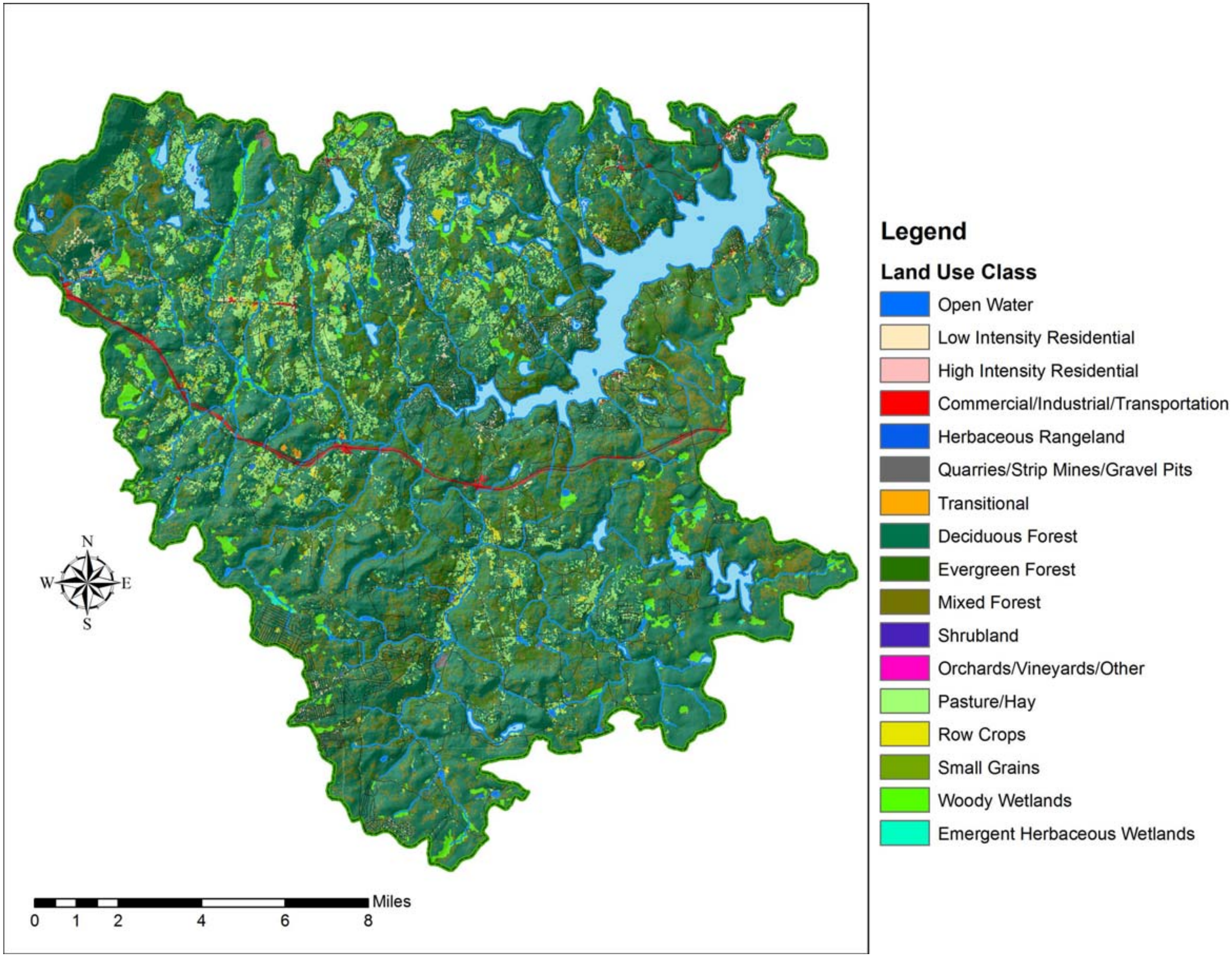

Figure 1.2 Land Use in the Lake Wallenpaupack Watershed

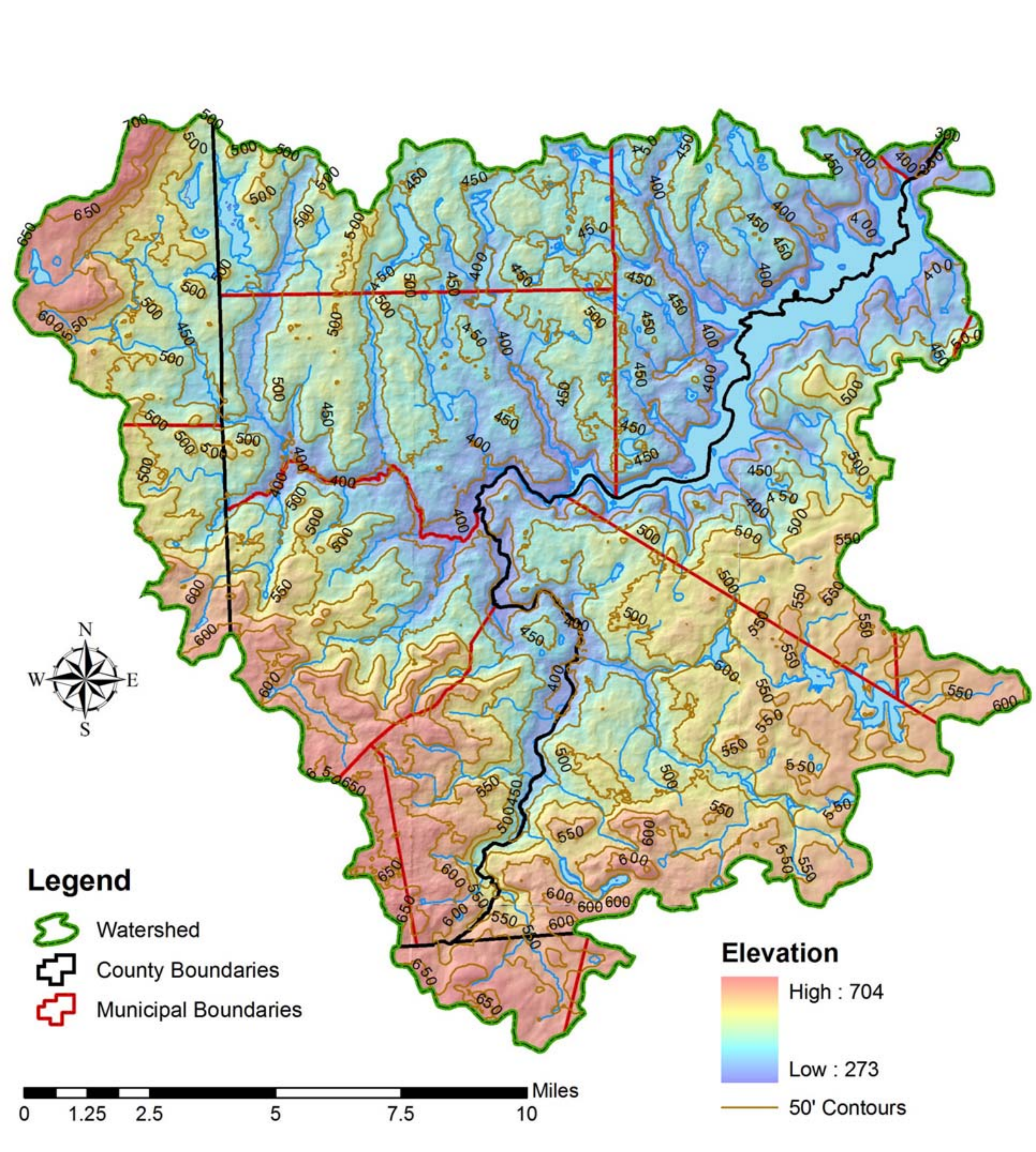

Figure 1.3 Topography in the Lake Wallenpaupack Watershed

1.3.3 Climate and Rainfall

The Lake Wallenpaupack watershed experiences four distinct seasons with a comfortable climate. Seasonal temperatures average in the low to mid-teens during the winter, and the seventies in the summer. Winter snowfall amounts range from 55 to 75 inches depending on location and elevation.

The long-term average annual rainfall amount measured at the Lake Wallenpaupack Superintendent's office in Paupack is 41.23 inches. Precipitation has been measured regularly at Lake Wallenpaupack since 1980, as shown in Table 1.2. Between 1980 and 1999 rainfall data were collected in Paupack, PA by Paul Buehler. From 2000 until the present, rainfall data were collected in Hawley at the Lake Superintendent's office of PPL. The rainfall at Paupack or PPL may not be representative of the entire Lake Wallenpaupack watershed since the rolling topography creates numerous micro-climates in the region. However, the general trends are representative of the area.

Table 1.2
Annual Precipitation Totals at Paupack Station, Lake Wallenpaupack Watershed

Month	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
January	0.3	0.6	3.5	3.6	1.3	1.0	3.2	3.7	1.9	1.0	4.2	2.1	1.9	1.9	4.4	2.8	8.8	2.2	2.5	5.7	3.5	1.2	1.4	2.3	2.7	7.1
February	0.9	8.3	2.7	3.6	3.4	2.1	3.4	0.7	2.9	0.7	2.1	1.7	1.7	2.1	2.3	1.6	1.8	1.3	4.3	1.4	2.7	1.9	0.6	3.6	1.7	2.7
March	4.3	0.4	1.8	5.2	3.9	1.9	3.4	1.4	1.6	2.1	2.1	3.2	2.9	5.0	5.1	2.2	2.8	2.9	4.3	4.2	3.4	4.8	3.6	2.5	2.2	4.2
April	5.0	4.3	4.8	9.7	5.8	2.2	6.0	5.9	2.1	1.5	2.1	2.9	2.7	5.6	3.1	1.8	4.7	2.3	4.3	2.1	3.1	1.6	3.4	2.1	4.6	5.2
May	0.9	4.5	2.3	2.9	8.0	4.5	4.0	2.8	6.3	11	6.4	2.9	3.7	0.9	2.8	2.0	3.6	2.2	4.5	2.7	4.3	3.1	7.6	4.2	5.5	1.2
June	4.1	3.6	5.6	5.4	2.8	4.3	8.7	3.4	1.2	7.7	3.7	3.1	4.9	2.0	5.0	2.2	4.9	2.4	7.7	2.1	7.4	3.4	4.5	6.4	2.8	3.9
July	4.6	3.6	2.9	2.6	7.6	3.7	5.5	4.7	6.3	1.1	4.5	2.0	4.6	1.0	4.3	2.9	7.0	3.0	3.2	1.3	3.3	2.0	1.0	3.7	4.4	1.9
August	2.0	1.2	2.3	1.6	2.0	2.4	4.2	4.4	3.5	4.6	6.6	2.0	4.6	1.7	7.4	1.3	1.7	6.0	2.5	2.8	2.4	1.6	3.2	2.7	6.3	2.6
September	1.2	6.4	2.1	1.7	1.6	8.6	1.3	8.4	2.1	4.6	2.3	3.1	3.3	5.3	5.0	2.7	4.4	3.9	1.9	10.6	2.9	3.5	4.0	8.1	11	0.6
October	3.2	3.5	0.9	3.2	2.1	1.3	2.5	3.8	2.3	5.2	4.0	3.5	2.2	3.9	1.4	7.7	5.4	1.7	2.4	2.4	1.6	0.8	7.6	5.0	2.2	11
November	3.0	1.8	3.4	4.5	1.6	6.4	4.7	2.8	4.0	2.9	3.4	3.6	2.8	4.0	4.7	5.7	3.3	3.7	1.4	2.8	2.5	1.5	3.8	3.1	4.6	3.7
December	0.8	2.7	1.4	6.6	3.1	2.5	3.4	1.3	0.9	0.8	4.7	2.9	5.9	2.5	2.2	1.7	5.7	3.7	0.8	1.6	3.8	1.9	4.4	5.5	3.5	3.4
Total Annual	**30**	**41**	**34**	**51**	**43**	**41**	**50**	**43**	**35**	**43**	**46**	**33**	**41**	**36**	**48**	**34**	**54**	**35**	**40**	**40**	**41**	**27**	**45**	**49**	**52**	**47**
Average Montly	**2.5**	**3.4**	**2.8**	**4.2**	**3.6**	**3.4**	**4.2**	**3.6**	**2.9**	**3.6**	**3.8**	**2.7**	**3.4**	**3.0**	**4.0**	**2.9**	**4.5**	**2.9**	**3.3**	**3.3**	**3.4**	**2.3**	**3.8**	**4.1**	**4.3**	**3.9**
Minimum Montly	**0.3**	**0.4**	**0.9**	**1.6**	**1.3**	**1.0**	**1.3**	**0.7**	**0.9**	**0.7**	**2.1**	**1.7**	**1.7**	**0.9**	**1.4**	**1.3**	**1.7**	**1.3**	**0.8**	**1.3**	**1.6**	**0.8**	**0.6**	**2.1**	**1.7**	**0.6**
Maximum Montly	**5.0**	**8.3**	**5.6**	**9.7**	**8.0**	**8.6**	**8.7**	**8.4**	**6.3**	**11**	**6.6**	**3.6**	**5.9**	**5.6**	**7.4**	**7.7**	**8.8**	**6.0**	**7.7**	**10.6**	**7.4**	**4.8**	**7.6**	**8.1**	**11**	**11**

1.3.4 Population Trends and Socio-Economic Structure

The Lake Wallenpaupack watershed has seen a dramatic increase in population during the past 35 years with additional growth expected, as shown in Table 1.3. Only townships with the majority of their land area falling within the watershed are included in the table. The township that has grown most rapidly is Paupack Township in Wayne County, with a 359 percent increase in population since 1970. According to the Pike County Industrial Development Corporation, Pike County is the fastest growing County in Pennsylvania.

Table 1.3
Historical and Projected Population for Municipalities Within the Lake Wallenpaupack Watershed

Place	US Census Population				Percent Change 1970-2000	Percent Change 1990-2000	Projected Population
	1970	1980	1990	2000			2010
Pennsylvania			11,881,643	12,281,054		3	
Pike County			27,966	46,302		66	60,059
Greene	1,023	1,462	2,097	3,149	208	50	
Palmyra	1,204	1,722	1,976	3,145	161	59	
Wayne County			39,944	47,722		19	53,902
Dreher	705	743	1,022	1,280	82	25	
Lake	1,755	2,453	3,287	4,361	148	33	
Lehigh	637	884	1,178	1,639	157	39	
Palmyra	528	773	905	1,127	113	25	
Paupack	644	1,379	1,696	2,959	359	74	
Salem	1,581	2,538	2,933	3,664	132	25	
Sterling	526	730	974	1,251	138	28	
Total Watershed Population	**8,603**	**12,684**	**16,068**	**22,575**	**173**	**40**	**27,134**

Source: US Census Bureau, Pike County Industrial Development Corporation, and Wayne County Economic Development Corporation

As shown in Figure 1.4, population growth in the watershed as a whole increased most rapidly between 1990 and 2000. The rate of population growth in Pike and Wayne Counties is significantly higher than the growth rate in Pennsylvania as a whole. Within townships in the Lake Wallenpaupack watershed the percent of change between 1990 and 2000 ranged from 25 to 74 percent while throughout Pennsylvania, only a three percent increase in population occurred during the same time period.

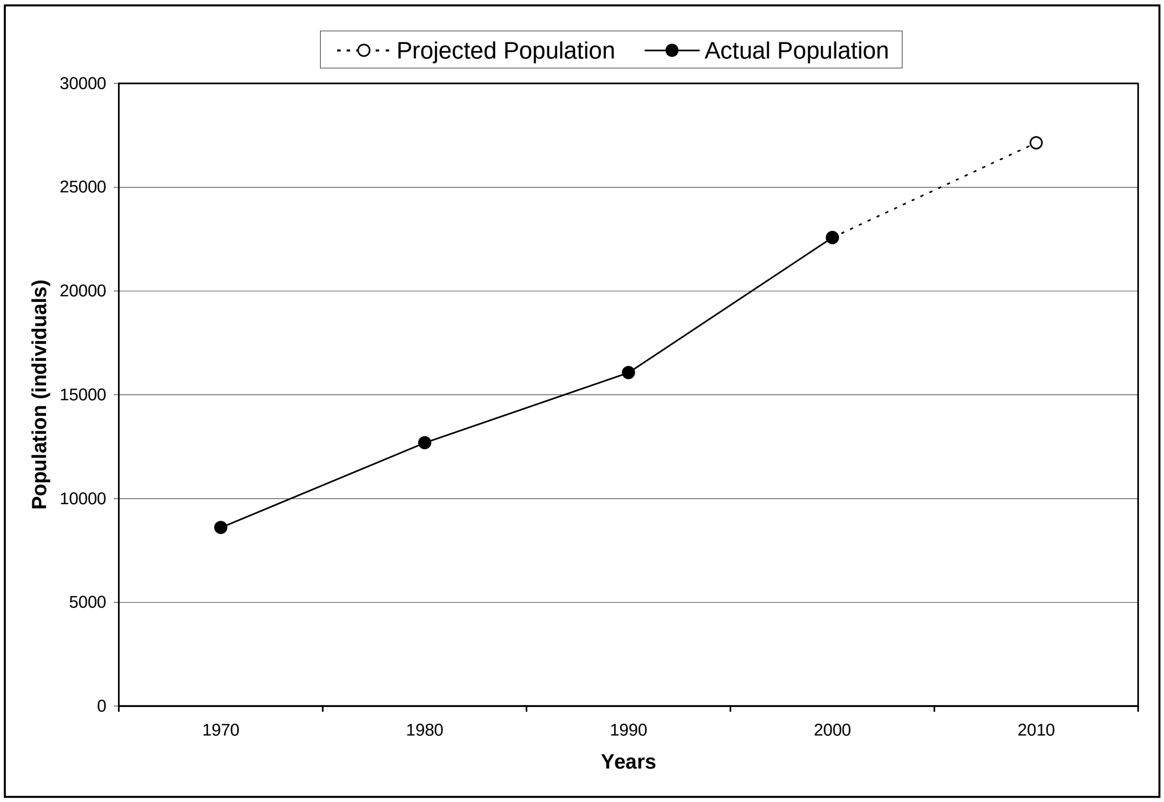

Figure 1.4 Population Growth in the Lake Wallenpaupack Watershed

A large percentage of the housing units in the majority of the Lake Wallenpaupack watershed municipalities are seasonal homes, as shown in Table 1.4. The majority of these homes are located on Lake Wallenpaupack or other smaller water bodies or tributaries within the watershed. This is significant because as the summer population increases, lake use increases, which can lead to water quality problems. In addition, older septic systems along the lake shores are prone to failure during times of heavy use. The vast majority of the homes in the watershed were built prior to 1989, with the largest housing boom occurring in the 1980s. Since the design life of an average septic system is 15-25 years, most of the systems in the watershed are increasingly likely to be problematic during the peak usage.

The summer peak population was estimated by assuming that all available seasonal homes are occupied by an average maximum of five individuals. Although this situation would probably only occur on a busy holiday weekend, it is technically possible. According to this rationale, on peak summer weekends the watershed population could potentially triple or quadruple.

Table 1.4 Housing Units and Peak Summer Population in the Lake Wallenpaupack Watershed				
Municipality	**Total Number of Housing Units**	**Percentage of Total Housing Units Considered Seasonal**	**2000 Permanent Population**	**2000 Summer Peak Population**
Pike County				
Greene	2,781	49%	3,149	9,894
Palmyra	3,838	61%	3,145	14,830
Wayne County				
Dreher	931	43%	1,280	3,295
Lake	3,524	51%	4,361	13,401
Lehigh	2,454	72%	1,639	10,454
Palmyra	576	17%	1,127	1,622
Paupack	3,398	63%	2,959	13,589
Salem	2,757	45%	3,664	9,839
Sterling	639	21%	1,251	1,916
Total	**20,898**	**47% (average)**	**22,575**	**78,840**

Source: 2000 US Census

As shown in Table 1.5, the percentage of seasonal homes in the Lake Wallenpaupack watershed has decreased between 1990 and 2000. This indicates a trend mirrored in lakeside communities across the country in which more and more seasonal homes are being converted to year-round residences, and an increasing percentage of the population in formerly seasonal communities are becoming permanent. In the Lake Wallenpaupack watershed, both the percentage of households with at least one member over 60 and the percentage of households with at least one member under 18 has remained virtually the same in the last decade. However, the average median age of household members has decreased within the watershed townships. This indicates that it is not retirement-age people who are converting seasonal to year-round homes, nor is it families with children, but rather young or middle-aged people without children.

Table 1.5 Recent Population Trends in the Lake Wallenpaupack Watershed		
Parameter	**1990**	**2000**
Average percentage of seasonal homes	55	47
Average percentage of households with at least one person over age 60	41	40
Average percentage of households with at least one person under age 18	34	33
Average median age in township	47	41

Source: 1990 and 2000 US Census

The Lake Wallenpaupack area economy is highly dependent on tourism, and the lake itself is the economic backbone of the region. Therefore, maintaining good lake water quality is critical for the health of both the ecology and the economy of the surrounding area. Although tourism is most significant during the summer months, autumn foliage and winter sports are a growing draw for visitors.

The most common industries within the Lake Wallenpaupack watershed are educational, health and social services, and tourism-related industries such as food services, resorts, real estate, construction, and retail trade, as shown in Table 1.6. Unemployment in the region fluctuates seasonally from year to year, with the highest unemployment rates occurring in the late winter and early spring, as one would expect from a tourist-based economy. Wayne County is more rural than Pike County overall, with a higher percentage of agriculture. Most of the active farms practice dairy and/or livestock production.

Table 1.6
Industry in Which Civilian Population Over Age 16 was Employed in Pike and Wayne Counties during 2000

Industry	Relative Percent	
	Pike County	Wayne County
Agriculture, forestry, fishing and hunting, and mining	0.7	3.4
Construction	8.9	9.3
Manufacturing	10.0	10.6
Wholesale trade	3.2	3.0
Retail trade	14.0	14.9
Transportation and warehousing, and utilities	6.5	5.4
Information	2.9	2.6
Finance, insurance, real estate, and rental and leasing	7.4	4.3
Professional, scientific, management, administrative, and waste management services	7.5	6.4
Educational, health and social services	18.2	19.2
Arts, entertainment, recreation, accommodation and food services	10.8	10.2
Other services (except public administration)	5.0	5.9
Public administration	4.7	5.0

Source: 2000 US Census

The average per capita income in the watershed is lower than the statewide average, as shown in Table 1.7. However, average home values are higher within the watershed than the statewide average, presumably due to the presence of lakefront and second homes in the area. Median contract rent figures are also higher than the statewide average. The average commute time to work in Pike County is 46 minutes, which is the highest in the Commonwealth. The average commute time to work in Wayne County is 26 minutes. This indicates that the majority of the residents of Pike County are most likely traveling out of the watershed to nearby metropolitan areas to work, which is reflected in the higher per capita incomes in Pike County as compared to Wayne County.

Table 1.7
2000 Income and Housing Averages for Residents of the Lake Wallenpaupack Watershed

Location	Per Capita Income (US dollars)	Median Owner-Occupied House Value (US dollars)	Median Contract Rent (US dollars)
Pike County	20,315	118,300	589
Greene Township	20,253	106,500	577
Palmyra Township	20,110	125,700	608
Wayne County	16,977	102,100	397
Dreher Township	15,945	107,100	533
Lake Township	16,274	102,800	522
Lehigh Township	15,910	105,700	596
Palmyra Township	19,359	114,500	633
Paupack Township	18,251	121,700	632
Salem Township	16,947	112,000	511
Sterling Township	17,889	115,700	557
Watershed Average	17,882	112,411	574
Commonwealth of Pennsylvania	20,880	97,000	438

1.3.5 Lake Access and Lake Use

With its 52 miles of shoreline, Lake Wallenpaupack is the largest lake in Northeastern Pennsylvania. The lake is used extensively for water related activities such as swimming, fishing, and boating. It is one of the few lakes in the Pocono region that is large enough to allow water-skiing. Lake Wallenpaupack is within vacationing distance of millions of inhabitants of the Mid-Atlantic States. Philadelphia, New York City, Trenton, and Scranton-Wilkes Barre are all located within 100 miles of Lake. Wallenpaupack. The lake receives substantial use by residents of New York City.

Principal highways used to access the Lake Wallenpaupack watershed are Interstates 84 and 380, US Route 6 and State Routes 191, 196, 296, 348, 390, 402, 507, and 590. Public access to Lake Wallenpaupack is provided by many resorts and motels, public recreation areas, picnic and nature areas that surround the lake, as shown in Table 1.8. Although the lake has been classified as borderline eutrophic in past years and continues to experience periodic blue-green algae blooms, it continues to be one of the major recreational water associated resources in Pennsylvania.

Table 1.8 Public Access to Lake Wallenpaupack	
Recreation Areas With Public Boat Launches	**Picnic and Nature Areas**
Mangan Cove Access Area (PPL and PFBC) Caffrey Campground (PPL) Wilsonville Campground (PPL) Ironwood Point Campground (PPL) Ledgedale Campground (PPL)	Five Mile Point Tafton Dike Observation Area Lake Wallenpaupack Overlook Beech House Creek Wildlife Refuge Shuman Point Natural Area Ledgedale Natural Area PPL Visitors Center Palmyra Township Swimming Beach

PPL owns the entire shoreline of Lake Wallenpaupack, and has the authority to place limits on lake use activities. Certain lake activities require permits from PPL. Currently permissible public uses include:

- Private boating in strict accordance with PA Fish and Boat Commission regulations as may be changed from time to time
- Personal watercraft
- Fishing/ice fishing (individual) in strict accordance with PA Fish and Boat Commission regulations as may be changed from time to time
- Ice skating
- Camping or picnicking in designated recreational areas
- Walking, hiking or fishing on PPL shoreline property, unless posted by PPL

Usage of Lake Wallenpaupack has increased dramatically since the mid 1980's and the number of boat registrations in Pike and Wayne Counties has at least doubled since 1985. The number of boat slips on Lake Wallenpaupack has increased by at least 250 percent during this time.

2.0 Existing Conditions – Lake Wallenpaupack Water Quality

Lake water quality is a direct reflection of the water quality of the watershed area. The term "watershed" is defined as all lands that eventually drain or flow into a lake (..."all waters that are shed to a lake"). Potential sources of water to lakes are streams (tributaries), surface runoff (overland flow from lakeside properties), groundwater (interflow), and precipitation. The water quality of these water sources are greatly influenced by watershed characteristics including soils, geology, vegetation, topography, climate, and land use. A Lake Ecology and Watershed Management Primer is included in Appendix A.

2.1 Lake Characteristics and Impairments

Lake Wallenpaupack is approximately 5,700 acres in size and has a watershed that encompasses 219 square miles spread over four counties and 14 townships. The lake has approximately 52 miles of shoreline. The lake has a volume of 7.31 billion cubic feet, a maximum depth of 52 feet (15.8 m) and an average depth of 29.5 feet (8.99 m), based on USGS information and information prepared by PPL.

Lake Wallenpaupack is designated as a high quality cold water fishery. Located in Watershed 01C of the Pennsylvania State Water Plan, Lake Wallenpaupack was included on the 1996 Section 303(d) list as impaired due to nutrients, suspended solids, and mercury. The impairment listings were based on data from an EPA Clean Lakes Project-funded Diagnostic Feasibility Study initiated in 1980, which evaluated the environmental condition of the lake. The 303(d) list indicates that agricultural runoff and atmospheric deposition are the causes of the impairments.

2.2 Lake Operations

Lake Wallenpaupack is a reservoir created by the Tafton Dike hydroelectric dam, which is owned and operated by the PPL Corporation. PPL dammed Wallenpaupack Creek and built Lake Wallenpaupack in 1926 to supply water for a hydroelectric power plant. PPL owns the entire shoreline of Lake Wallenpaupack. The Wallenpaupack hydroelectric plant includes a dam with a reservoir and a powerhouse that contains two units with a total capacity of 44 megawatts. The dam is 1,275 feet long and 70 feet high. Water from the lake travels to the power plant through a 3½-mile pipeline that is more than 14 feet in diameter. In July 2005, the Federal Energy Regulatory Commission renewed PPL's operating license for the Lake Wallenpaupack Hydroelectric Project.

PPL's target summer lake elevation level is 1,180 to 1,187 feet. The dam crest is at 1,200 feet. The normal first-of-month lake level targets (in feet) are as follows:

January – 1,183.0	July – 1,185.0 to 1,186.5
February – 1,182.0	August – 1,183.0
March – 1,181.5	September – 1,181.0
April – 1,182.3	October – 1,179.0
May – 1,185.6	November – 1,181.0
June – 1,187.0	December – 1,182.0

2.3 Lake Monitoring Program and Methodology

The water quality of Lake Wallenpaupack has been monitored yearly from 1980 to present by the LWWMD. The water quality monitoring has become more complete and frequent since 1988, and annual summary reports evaluating the water quality of Lake Wallenpaupack have been prepared since 1989. The lake water quality monitoring program has included measurement of the following parameters:

Dissolved Oxygen and Temperature Profiles	Chlorophyll a
Secchi Disk Transparency	Pheophytin a
Total Unfiltered Phosphorus	Phytoplankton
Total Filtered Phosphorus	Zooplankton
Unfiltered Orthophosphorus	pH
Filtered Orthophosphorus (dissolved reactive phosphorus)	Alkalinity
Nitrate + Nitrite Nitrogen	Fecal Coliform
Ammonia Nitrogen	Fecal Streptococcus
Total Kjeldahl Nitrogen	Total Suspended Solids

It should be noted that not all of the parameters listed above have been monitored every year. Lake Wallenpaupack has been monitored at five sampling stations throughout the lakes as shown in Figure 2.1. The stations are located at Wilsonville (#1), Epply Island (#2), Nemanie (#3), White Beauty (#4), and Ledgedale (#5). Samples have generally been collected monthly at Stations #1, #2, #4, and #5 from May through October. At Station #3, samples have generally been collected twice a month from May through October and once per month from November through April. Beginning in 2002, stations #2 and #4 were dropped from the sampling regime, and the monitoring program continued with three stations instead of five. In 2006, station #1 was dropped from the monitoring program.

Samples have been collected at the surface, the middle of the thermocline, and the bottom of the lake during each sampling date. All lake data that has been collected over the monitoring period has been entered into a database for analysis. An evaluation of all available water quality data was completed and is summarized in this Management Plan.

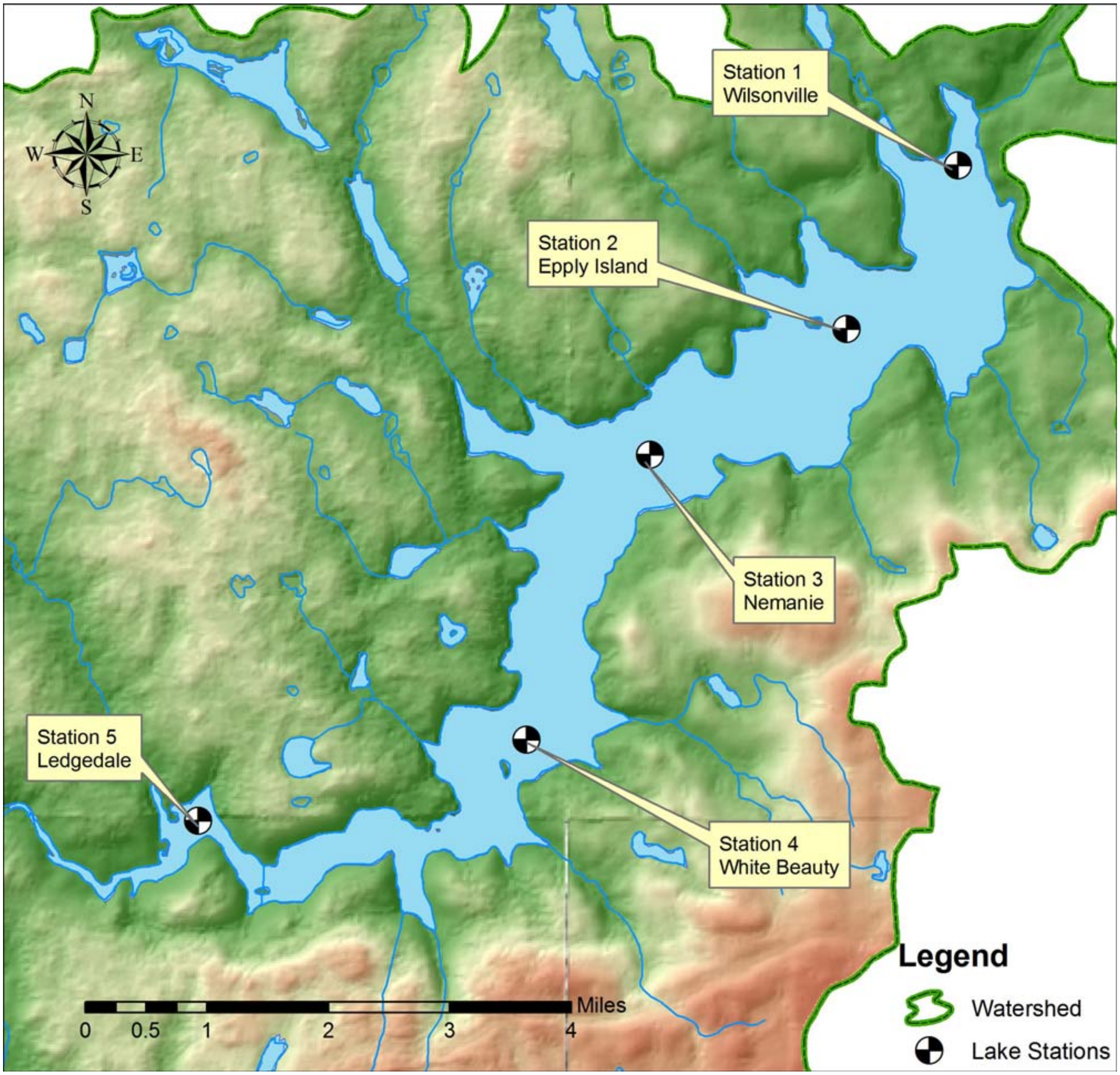

Figure 2.1 Location of Sampling Stations at Lake Wallenpaupack

2.4 Lake Water Quality Trends

From 1976 to 1980, the water quality in Lake Wallenpaupack was reported to have declined rapidly. Since then, the water quality in Lake Wallenpaupack has not continued to deteriorate and appears to have improved slightly during more recent years, especially with respect to a reduction in total phosphorus concentrations in the lake. These improvements coincide with the ongoing installation of Best Management Practices within the Lake Wallenpaupack watershed that began in 1987. While average growing season total phosphorus concentrations at Station 3 have remained around 0.020 mg/L since the mid 1980s, maximum concentrations have decreased compared to the early 1980s. Average growing season Secchi disk transparencies have generally been higher (more favorable) over the past fifteen years, compared to those in the early 1980s. Chlorophyll a concentrations have been increasing in recent years; however, concentrations were markedly lower during 2004.

A Long-Term Water Quality Analysis Report was prepared in 2006 that includes a detailed evaluation of all water quality data that has been collected on Lake Wallenpaupack for the period of 1980 through 2006. The main water quality parameters that were evaluated as part of this study include dissolved oxygen, phosphorus, nitrogen, chlorophyll a, transparency, pH, alkalinity, phytoplankton, and zooplankton. Water quality data were statistically compared to each other and to precipitation. Based on this study, the following conclusions were made:

1. The water quality in Lake Wallenpaupack appeared to improve in the late 1980s and early 1990s. This water quality improvement is most likely due to the implementation of Best Management Practices throughout the watershed.

2. Although the phosphorus levels in the lake are lower than they were in the early 1980s, the phosphorus concentrations appear to still be high enough to cause algal blooms. In particular, the magnitude and frequency of chlorophyll a peaks have been increasing, the amount of bluegreen algae has been increasing, and the magnitude and frequency of phytoplankton peaks have been increasing. Based on the results of the biostimulation studies, both phosphorus and nitrogen cause significant algal growth in Lake Wallenpaupack water. Therefore, it is important to control both nutrients (especially the dissolved reactive forms) from entering Lake Wallenpaupack. Future BMPs should concentrate on controlling both phosphorus and nitrogen.

3. Zooplankton populations in Lake Wallenpaupack are low and the size of the zooplankton are small as well. This indicates that planktivorous fish are overgrazing on the larger zooplankton. If larger zooplankton were present in Lake Wallenpaupack, they may help to control the phytoplankton population in the lake. Biomanipulation and fisheries management should be considered to promote zooplankton growth.

It has been determined over the long-term monitoring period that the water quality at Station 3 in Lake Wallepaupack is fairly representative of the water quality throughout the lake. In addition, Station 3 is the only station that has been consistently and frequently monitored throughout the period of record. Therefore, the graphs and analyses in the following sections refer to Station 3 data except where otherwise stated. A more in-depth analysis and discussion of water quality trends in Lake Wallenpaupack from 1980-2006 can be found in the Lake Wallenpaupack Water Quality Evaluation and Long-Term Trend Analysis Technical Report (November 2006).

2.4.1 Nutrients (Phosphorus and Nitrogen)

<u>Phosphorus</u>
An analysis of mean seasonal total phosphorus concentrations in the surface water throughout the period of record shows that all stations exhibited similar trends. Station 5, farthest upstream, tended to have consistently higher mean concentrations of total phosphorus while Station 3, mid-lake, tended to be most representative of overall conditions.

The long-term average epilimnetic (surface) total phosphorus concentration at Station 3 was 0.023 mg/L. The average surface total phosphorus concentrations at Station 3 in Lake Wallenpaupack have varied somewhat since 1980, but they continue to be stabilized since 1989. The average surface total phosphorus concentrations have been decreasing over the past 25 years. The average concentrations have varied between 0.017 mg/L in 1993 and 0.034 mg/L in 1982, as illustrated in Figure 2.2. Average seasonal surface total phosphorus concentrations have fallen below the EPA threshold criteria for eutrophy of 0.030 mg/L during every year since 1984.

Total phosphorus concentrations in the hypolimnion of Lake Wallenpaupack tended to increase during the period of lake stratification due to the release of phosphorus from the sediments under anoxic conditions.

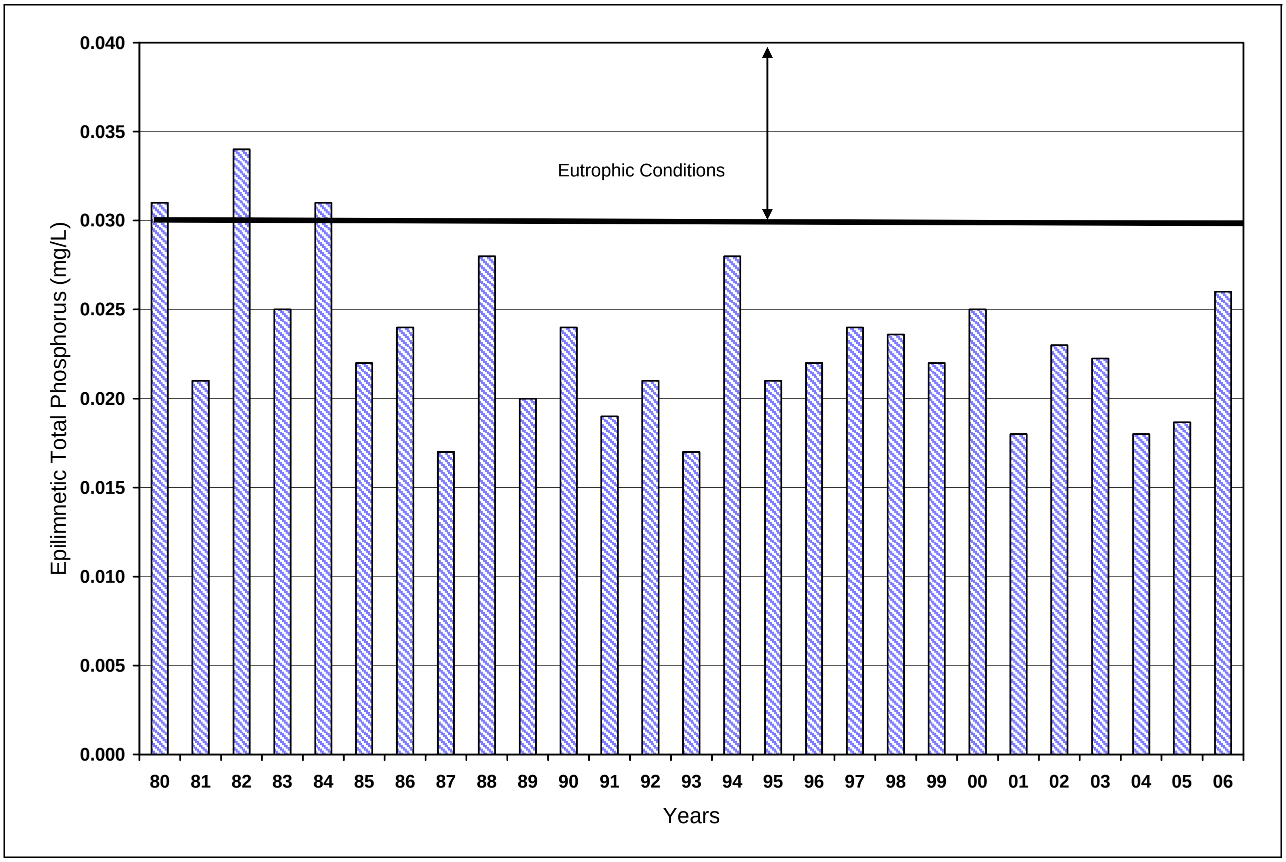

Figure 2.2 Trends in Seasonal Average Epilimnetic Total Phosphorus Concentrations at Station 3 in Lake Wallenpaupack

<u>Nitrogen</u>

Total nitrogen is a measure of both the inorganic (ammonia, nitrate, and nitrite) and organic forms of nitrogen. This measurement determines the total amount of nitrogen in a lake, and examining trends in total nitrogen in conjunction with trends in other water quality parameters can provide an indication of whether or not nitrogen may be limiting algal growth in the lake. The long term average surface total nitrogen concentration during the growing season at Station 3 in Lake Wallenpaupack was 0.51 mg/L.

As shown in Figure 2.3, a general increase in seasonal average total nitrogen occurred between 1992 and 2002, but this trend did not continue in recent years. This trend mirrors the trends in chlorophyll <u>a</u> concentrations and phytoplankton densities seen during this time period, which supports the theory that Lake Wallenpaupack may be nitrogen-limited during part of the year. The majority of the nitrogen in Lake Wallenpaupack has historically occurred in the organic form, most likely entering the lake via runoff from agricultural operations and wastewater treatment plant discharges.

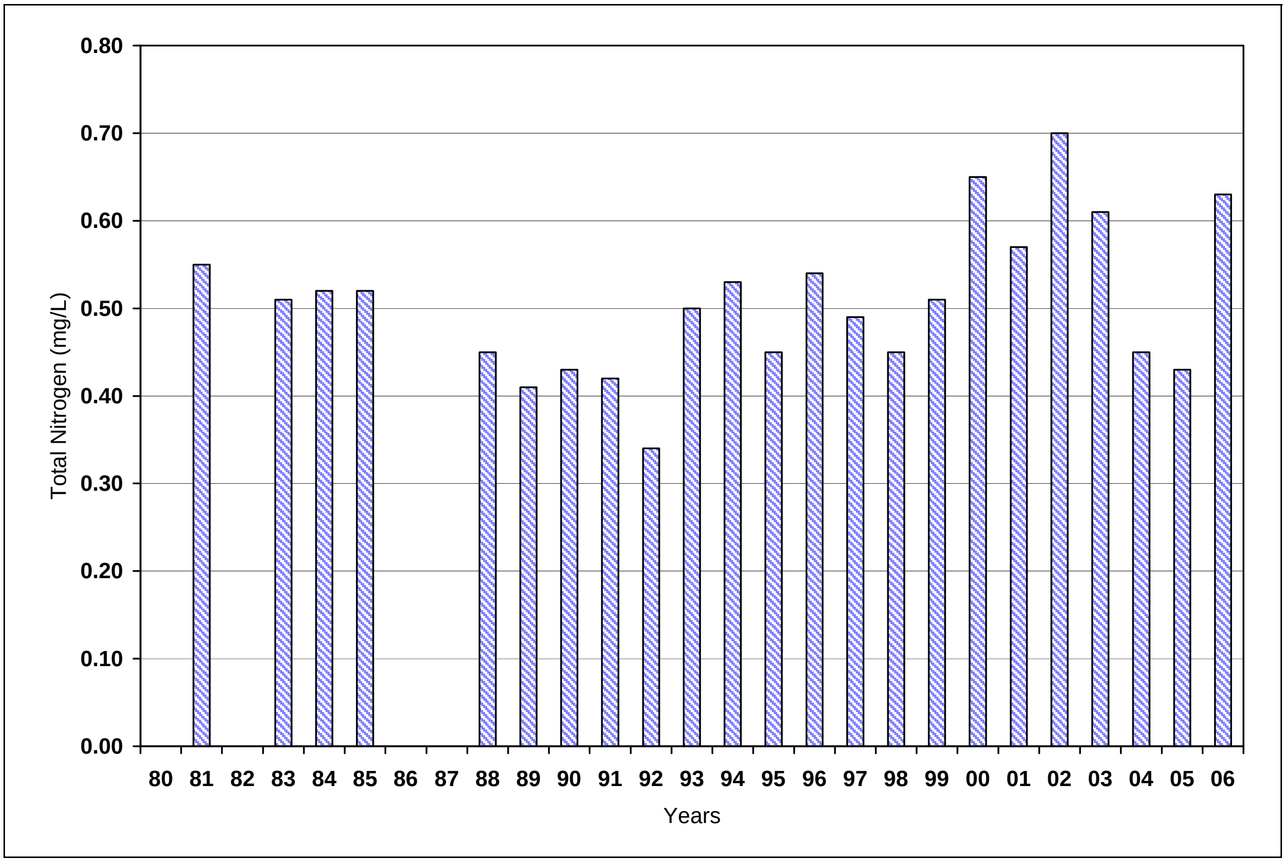

Figure 2.3 Trends in Seasonal Average Total Nitrogen Concentrations at Station 3 in Lake Wallenpaupack

The absence of detectable ammonia nitrogen is common in the surface waters of Lake Wallenpaupack because algae and macrophytes quickly use any available ammonia for growth and reproduction. However, during the growing season, ammonia is produced as a by-product of microbial decomposition and tends to accumulate below the thermocline.

2.4.2 Secchi Disk

Average growing season transparencies continue to show an increasing (improving) trend in Lake Wallenpaupack since 1980, as illustrated in Figure 2.4. Higher Secchi disk transparencies indicate greater water clarity. Average growing season transparencies at Station 3 varied between 1.3 meters in 1980 and 2.57 meters in 1993. The average growing season Secchi disk transparency at Station 3 between 1980 and 2006 was 2.07 meters. Transparencies have been generally in the mesotrophic range since 1987.

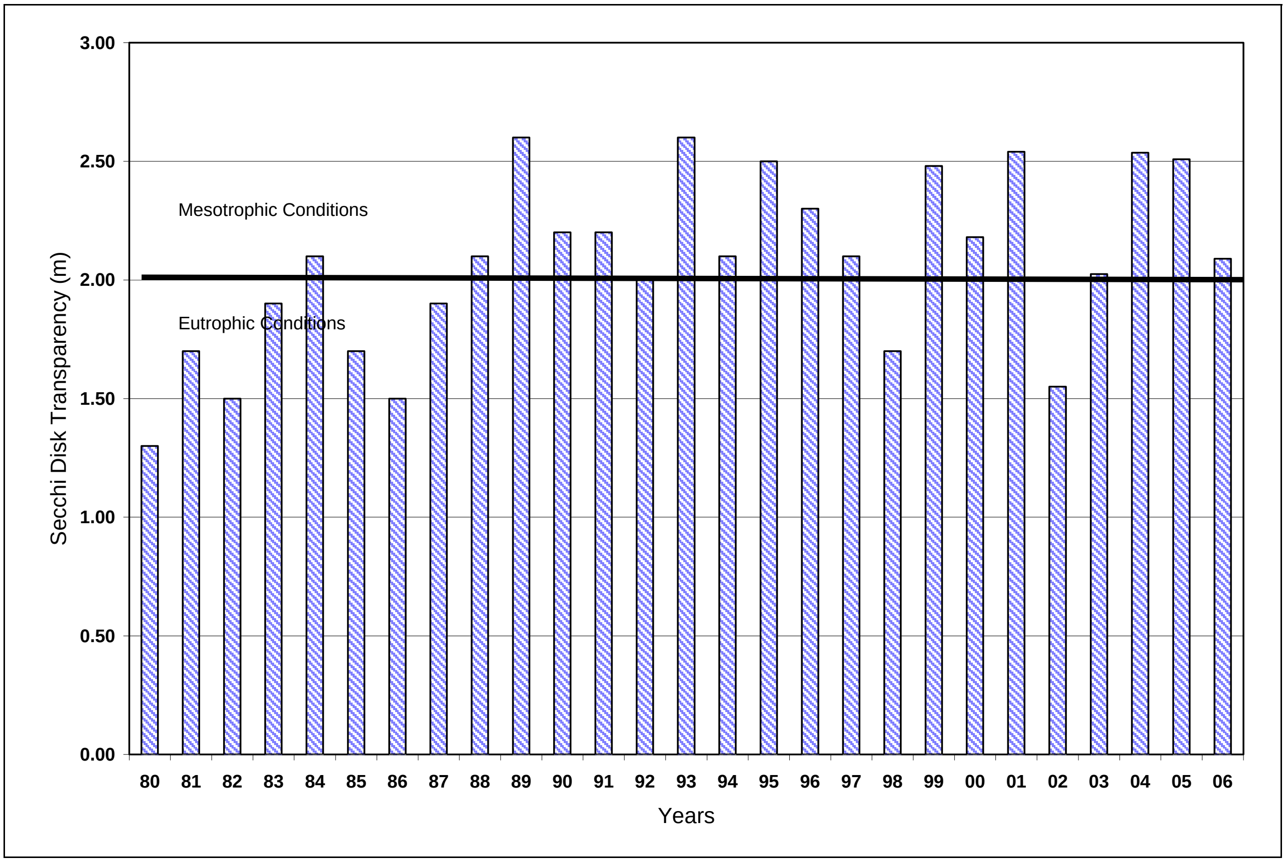

Figure 2.4 Trends in Seasonal Average Secchi Disk Transparency at Station 3 in Lake Wallenpaupack

2.4.3 Chlorophyll a

The average growing season chlorophyll a concentrations have varied considerably at Station 3 since 1980, as shown in Figure 2.5. The average chlorophyll a concentrations range between 4 µg/L in 1989 and 22 µg/L in 2002. The long-term average chlorophyll a concentration in Lake Wallenpaupack is 12.06 µg/L. Climatic conditions, both favorable and unfavorable, have a strong effect on the phytoplankton population, and therefore, the chlorophyll a concentration, in Lake Wallenpaupack. An apparent trend of increasing chlorophyll a concentrations in Lake Wallenpaupack has occurred since the early 1990s.

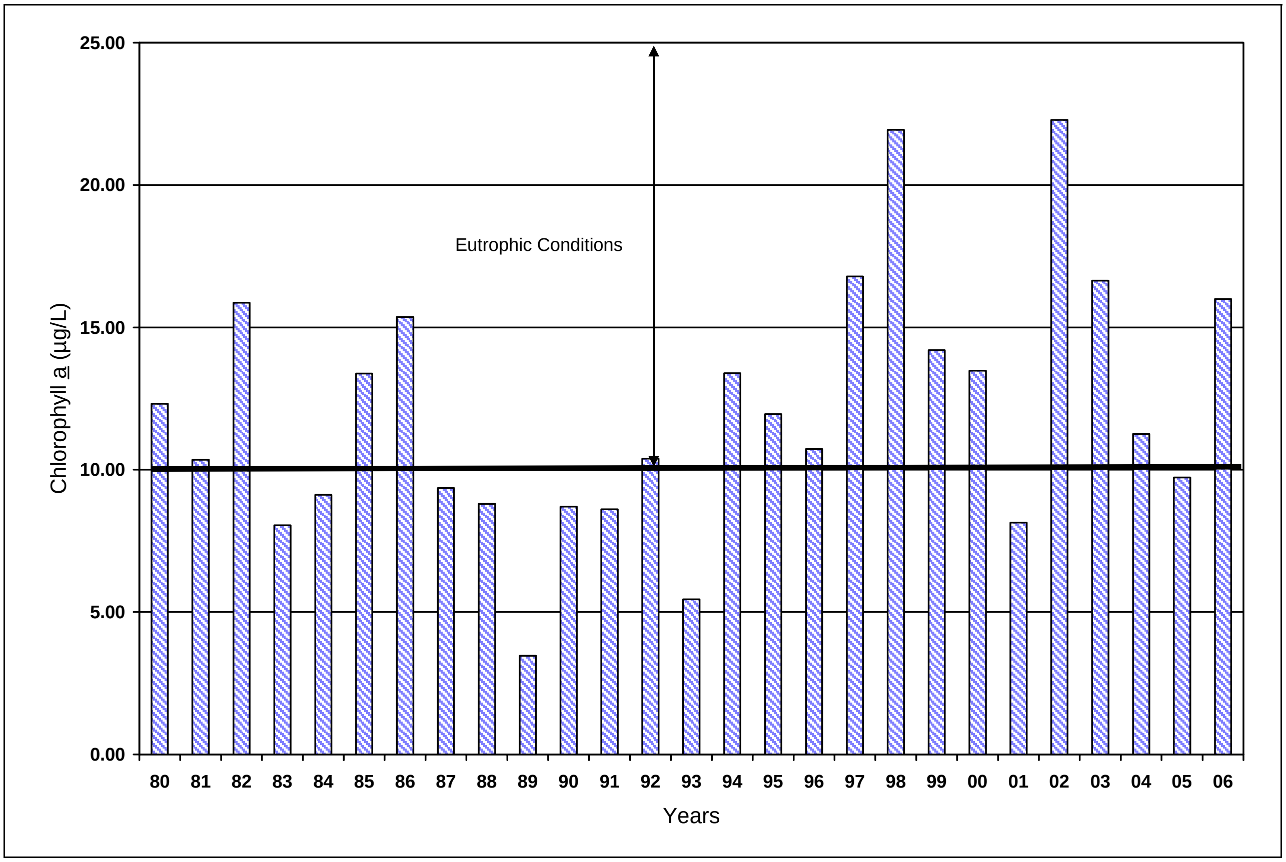

Figure 2.5 Trends in Seasonal Average Chlorophyll a Concentrations at Station 3 in Lake Wallenpaupack

Average chlorophyll a concentrations have generally been higher since 1987 when the implementation of watershed BMPs was initiated by the Lake Wallenpaupack Watershed Management District. Since total phosphorus concentrations have not corresponded well to chlorophyll a concentrations in recent years, this deviation indicates that something other than phosphorus may be limiting algal growth.

2.4.4 Phytoplankton

A general increase in both the average phytoplankton density during the growing season and the peak phytoplankton density during the growing season had been documented over the period of record in Lake Wallenpaupack, as shown in Figure 2.6. The low numbers of algae in 1980 through 1985 are most likely due to the fact that a lower powered microscope was used to identify the algae during this period. Most likely the actual number of algae in the lake during this period was much higher. Beginning in 1986, a higher powered microscope was used for identification of algae and algae numbers increased significantly.

Overall, total algae populations and bluegreen algae populations have been steadily increasing. In particular, peak phytoplankton densities have increased since 1997, although considerable variation exists. Additionally, the peak phytoplankton densities have been occurring later in the year (late August to September) in recent years compared to earlier years (July).

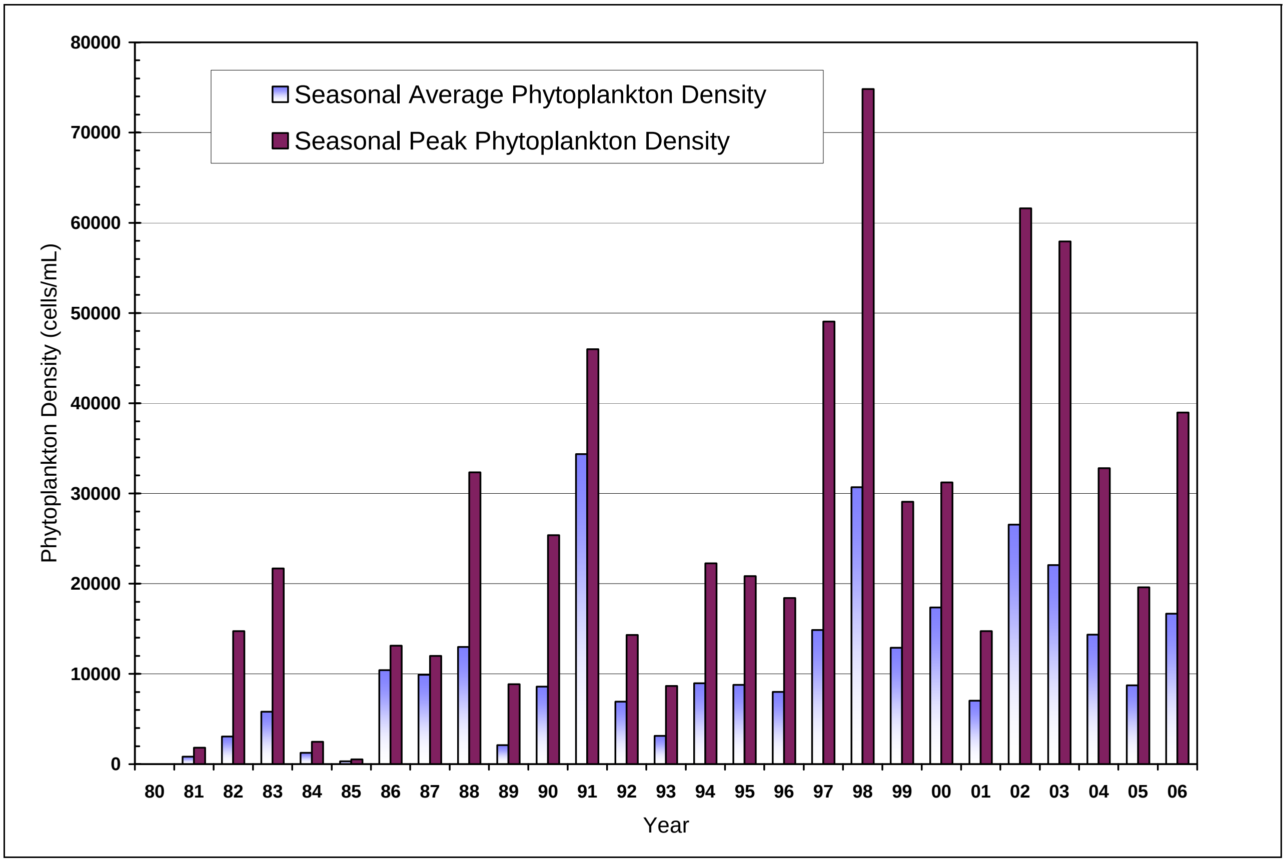

Figure 2.6 Trends in Seasonal Average and Peak Phytoplankton Density at Station 3 in Lake Wallenpaupack

2.4.5 Zooplankton

Zooplankton populations in Lake Wallenpaupack have been variable over the period of record. Seasonal average zooplankton biomass and seasonal peak zooplankton biomass over the past 19 years is shown in Figure 2.7, although it should be noted that zooplankton collection and analysis methodologies have varied throughout the study period, making year-to-year comparisons somewhat unreliable. Zooplankton biomass was high in both 1993 and 1997, and biomass has been low in the past several years. It is difficult to determine what the cause of the trends might be, although both 1993 and 1997 were years when the seasonal average phytoplankton densities were relatively low. Zooplankton populations are strongly influenced by weather conditions, the availability of food sources, and fish populations. Zooplankton prefer not to eat blue-green phytoplankton, so their numbers tend to be low when blue-green algae populations are high.

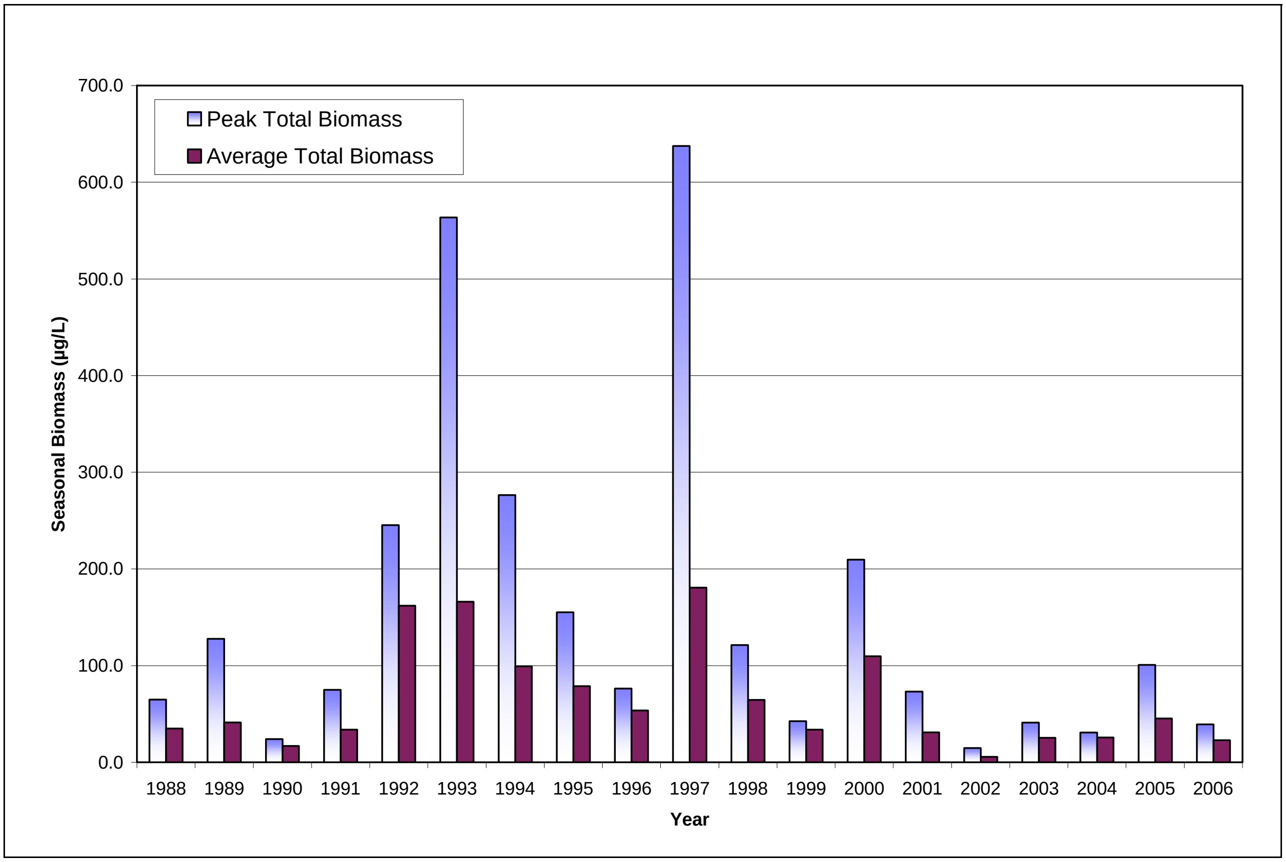

Figure 2.7 Trends in Seasonal Average and Peak Zooplankton Biomass at Station 3 in Lake Wallenpaupack

Lake Wallenpaupack zooplankton was dominated by rotifers throughout most of the study period. In general, the size of zooplankton in Lake Wallenpaupack is relatively small and suggests that the zooplankton are being excessively consumed by herbivorous fish. There is no apparent relationship between percent composition of zooplankton in Lake Wallenpaupack with water chemistry, phytoplankton abundance, or climate.

2.4.6 Trophic State Index

The average growing season TSI values were examined to determine if the trophic state of Lake Wallenpaupack has changed during the 1980-2006 monitoring period. Indices were calculated from seasonal averages of Secchi disk transparency, total phosphorus concentrations, and chlorophyll a concentrations at Station 3. The total phosphorus and Secchi disk transparency TSI values indicate that the productivity of Lake Wallenpaupack was generally lower in the most recent 17 years (1990-2006) than in the previous ten years (1980s). Conversely, however, the chlorophyll a TSI values indicate that Lake Wallenpaupack has generally been more productive in recent years. TSI values for each year are presented in Figure 2.8.

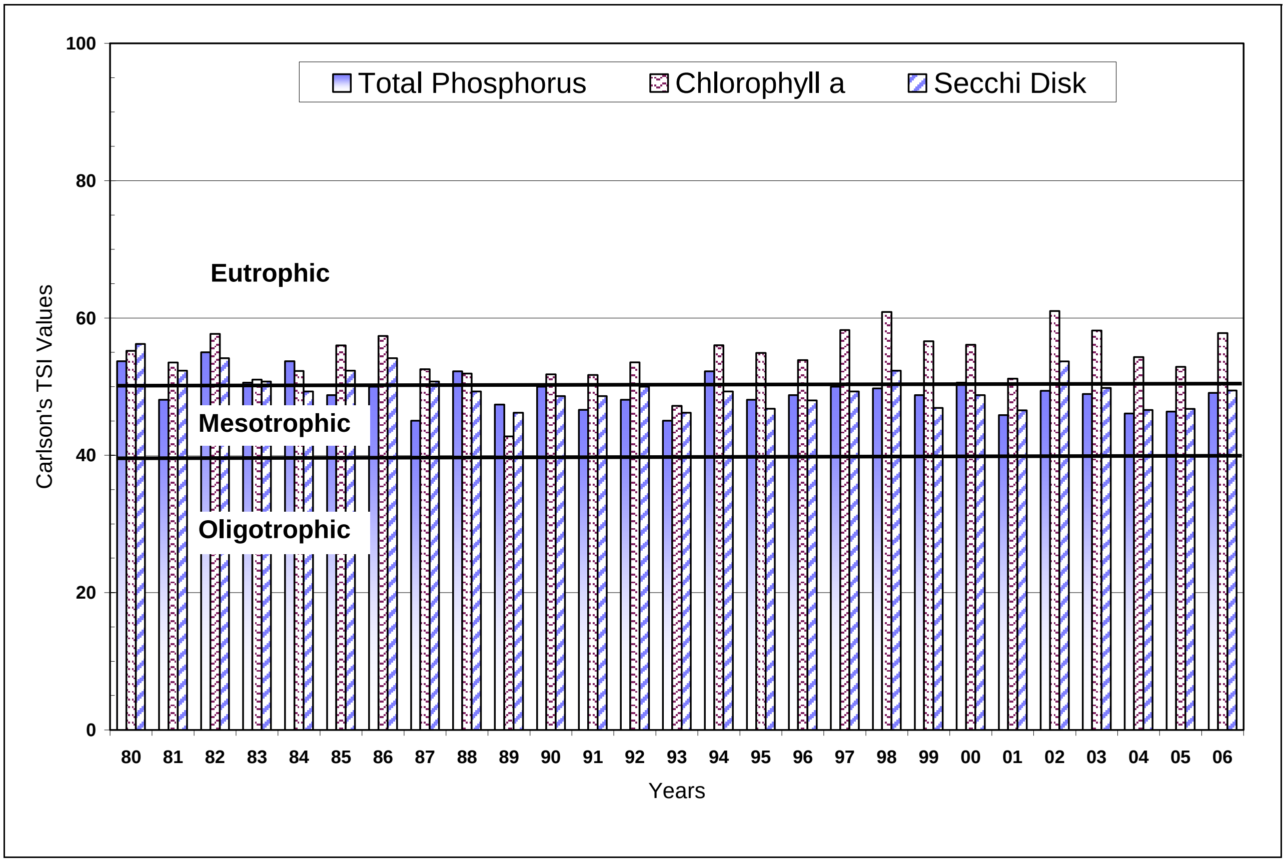

Figure 2.8 Seasonal Trends in Carlson's TSI Values at Station 3 in Lake Wallenpaupack

2.4.7 Dissolved Oxygen

Lake Wallenpaupack typically begins showing signs of thermal stratification in early May. Strong stratification of the water column is common in the lake from mid- to late May through September. During the period of stratification, the thermocline occurs at a depth of approximately 6.0 to 9.0 meters throughout the growing season at Station 3. Dissolved oxygen concentrations in the bottom half of the hypolimnion are usually depleted by microbial activity to levels below 2 mg/L from mid-summer until the fall turnover, depending on weather conditions. It is not uncommon for the bottom 2 to 3 meters of the hypolimnion to remain nearly anoxic (without oxygen) during the peak summer months at Stations 1 and 3. The anoxia usually occurs to a much lesser extent at Station 5, because Station 5 is shallower and influenced to a greater extent by nearby inlets. There does not appear to be any major trend towards a greater or a lesser degree of summer hypolimnetic low oxygen conditions over the period of record.

Coldwater fish such as trout, walleye, and northern pike function best at temperatures below 22ºC (71.6ºF) and dissolved oxygen levels above 5.0 mg/L. During the summer stratification period in Lake Wallenpaupack, these fish probably experience some stress as surface water temperatures warm and bottom water dissolved oxygen concentrations decline. Coldwater fish most likely find refuge around cold springs near shore and at the bottom of the epilimnion in open water. The bottom of the epilimnion is a desirable location for coldwater fish because temperatures are cooler than at the surface while dissolved oxygen concentrations are still high enough to allow life-sustaining activities. The coldwater fish in Lake Wallenpaupack may also migrate during these times of stress to Wallenpaupack Creek and other significant tributaries to the lake where dissolved oxygen levels are higher and water temperatures are generally cooler.

2.4.8 Fisheries

Lake Wallenpaupack is a two-story fishery that can support cold, cool, and warm water species. The species are limited by the lake's low productivity, the lack of suitable habitat, and the lack of fish screens on the hydro-station's water supply tube. The Pennsylvania Fish and Boat Commission (PAFBC) have conducted fishery surveys to monitor species composition and abundance. The fish were collected using electrofishing, trapnets, and constant mesh sinking gillnets. Walleye were also collected in order to determine the concentration of mercury.

Based on the PAFBC surveys, there has been little change in the composition and abundance of fish species over time. The species collected in past surveys include: alewife (*Alosa pseudoharengus*), golden shiner (*Notemigonus crysoleucas*), spottail shiner (*Notropis hudsonius*), margined madtom (*Notorus insignis*), brown trout (*Salmo trutta*), brown trout-seeforellen, rainbow trout (*Oncorhyncus mykiss*), yellow perch (*Perca flavescens*), walleye (*S. vitruem vitruem*), striped bass (*Morone saxatilis*), chain pickerel (*Esox niger*), smallmouth bass (*Micropterus dolomieui*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), black crappie (*Pomoxis nigromaculatus*), rock bass (*Ambloplites rupestris*), redbreast sunfish (*Lepomis auritus*), redear sunfish (*Lepomis microlophus*), channel catfish (*Ictalurus punctatus*), brown bullhead (*Ameiurus nebulosus*), yellow bullhead (*Ameiurus natalis*), common carp (*Cyprinus carpio*),white sucker (*Catostomus commersoni*), muskellunge (*Esox masquinongy*) (never collected in surveys, but was caught during the Mount Pleasant Fish Culture Station's annual walleye spawning operation), and northern pike (*Esox lucius linnaeus*).

The examination of mercury concentrations in the walleye of Lake Wallenpaupack began as part of a 1990 statewide study. The study found mercury levels of 1.19 ppm, which is above the U.S. Food and Drug Administration action level of 1.00 ppm. This finding resulted in an advisory warning against the consumption of legal size walleye. In 1991, mercury levels were 1.23 and 1.33 ppm. Studies conducted from 1992-1996 showed decreased mercury levels, which coincided with the decreased size and age of the fish sampled. At that time, the advisory was changed to allow the consumption of fish between 15 to less than 19 inches in length. In 1998 and 1999, more sampling was conducted. The results showed mercury levels below 1.0 ppm in walleye from 15 to 27 inches in length; however, the advisory has not yet been lifted.

Based on the surveys conducted, the PAFBC made several recommendations including the improvement of fish habitat. The PAFBC suggest that Lake Wallenpaupack be placed in the Big Bass Program. Recommendations were also made in regards to fisheries management. Continued annual stocking was suggested for brown trout, walleye, and striped bass. Stocking of channel catfish has been temporarily suspended to assess whether or not natural reproduction is occurring.

Several species have self-sustaining natural populations and for that reason management actions were not suggested. These species include: alewife, yellow perch, and chain pickerel. Bluegill, pumpkinseed, rock bass, redbreast sunfish, black crappie, redear sunfish, green sunfish, brown bullhead, yellow bullhead, were not being stocked and no changes in management were suggested. Rock bass dominated the sunfish community, but bluegill and pumpkinseed also provided important fisheries. Margined madtom were not thought to be permanent lake species. Muskellunge was stocked in 1971, 1972, and 1992, but continued stocking was not recommended. Though northern pike has been found in Lake Wallenpaupack, they have not been stocked nor should they be stocked in the future, according to the PAFBC reports. Common carp had a low abundance and there was no evidence of natural reproduction; no management changes are going to be made. In addition, stocking was not recommended for golden shiner or spottail shiner, which have had consistently low populations. The stocking of rainbow trout has been unsuccessful and, therefore, was terminated. Smallmouth bass and largemouth bass do not need to be stocked currently. The combined smallmouth and largemouth bass fisheries qualifies for inclusion in the Big Bass Program. Due to the use of Lake Wallenpaupack for tournament fishing, there is some concern that Big Bass would eliminate tournament fishing.

2.4.9 Macrophytes

Macrophytes are aquatic plants (weeds) that are either attached to the bottom of the lake or float on the surface of the lake. Extensive macrophyte surveys of Lake Wallenpaupack have never been conducted. However, as part of the EPA funded Phase II Lake Restoration Project, a partial macrophyte study was conducted in the summer of 1989. The entire shoreline was evaluated to locate and identify macrophytes in the lake. Based on the results of the macrophyte survey, the aquatic plant growth in Lake Wallenpaupack appears to be normal and not excessive. The rock and gravel shoreline of the lake with steep drop-offs, combined with the constant wave action and human activity, prevents aquatic vegetation from taking root in much of the lake. Macrophytes were found in shallower cove areas and along portions of the lake shoreline, as expected.

Eurasian milfoil was not found during the 1989 macrophyte survey. Eurasian milfoil is a non-native exotic weed that is carried from lake to lake by boats that contain fragments of the plant attached to their boats in their bilge water.

2.4.10 Lake Sediment Sampling

F. X. Browne, Inc. collected lake sediment samples at five locations to prepare one composite lake sediment sample. This process was conducted a total of three times. Sediment samples were analyzed and entered into a spreadsheet as part of the TMDL data collection. The sediment data results are presented in Table 2.1. Of particular interest is that the total phosphorus and organic nitrogen were highest during the summer months, when the lake was stratified. This indicates that nitrogen and phosphorus are released from the sediments under anoxic conditions. Table 2.2 shows the percent composition of the sediment samples.

Table 2.1
Sediment Sampling Data for Lake Wallenpaupack

Date	Station	TP	TDP	TOrthoP	DOrthoP	THydP	DHydP	TIP	TOrg P	DOrgP	TNO3	DNO3	TNO2	DNO2	TNH3	DNH3	TKN	DKN	TOrgN	DOrgN	TS	THg
7/29/99	1	182	0.28	<1	<0.2	170	0.27	170	12		<1	<0.2	<1	<0.2	13	0.4	1200	1.7	1187	1.300	116,000	<0.1
	2	134	0.4	<1	<0.2	120	0.39	120	14		<1	<0.2	<1	<0.2	12	<0.1	1100	1.3	1088	1.200	129,000	<0.1
	3	161	0.54	<1	<0.2	150	0.52	150	11		<1	<0.2	<1	<0.2	12	0.4	1200	2	1188	1.600	146,000	<0.1
	4	190	0.25	<1	<0.2	170	0.24	170	20		<1	<0.2	<1	<0.2	5.4	<0.1	740	1.1	725	1.000	169,000	<0.1
	5	255	0.28	<1	<0.2	220	0.28	220	35		<1	<0.2	<1	<0.2	7.6	<0.1	790	1.9	782	1.800	210,000	<0.1
10/27/99	1	20	2	5	1	10	0.9	15	5		<1	<1	<1	<1	21	13	440	82	420	69.000	158,000	<0.1
	2	20	2	10	0.9	10	0.6	19.5	<0.5		<1	<1	<1	<1	24	18	380	87	360	69.000	147,000	<0.1
	3	20	1	7	1	10	0.6	17	3		<1	<1	<1	<1	32	19	460	62	430	43.000	197,000	<0.1
	4	10	0.7	3	0.7	7	<0.5	9.5	<0.5		<1	<1	<1	<1	15	15	390	47	380	32.000	292,000	<0.1
	5	9	1	3	1	5	0.9	8	1		<1	<1	<1	<1	19	17	370	44	350	27.000	347,000	<0.1
5/30/00	1	11	1.1	7	0.9	7	0.7		4	0.4	<5	<5	<5	<5	8	1.7	940	6	930		86,000	<0.1
	2	5	0.5	<2	<0.5	3	<0.5		2	0.05	<5	<5	<5	<5	11	1.1	210	4	200		122,000	<0.1
	3	5	0.6	5	<0.5	5	<0.5		<0.5	0.1	<5	<5	<5	<5	8.5	1.1	470	4	460		169,000	<0.1
	4	5	0.9	4	<0.5	5	<0.5		<0.5	4	<5	<5	<5	<5	8.2	1.7	140	4	130		313,000	<0.1
	5	8	0.5	6	<0.5	5	<0.5		3	<0.5	<5	<5	<5	<5	8.4	2	590	4	580		370,000	0.2

All units are mg/L

TP = Total Phosphorus
TDP = Total Dissolved Phosphorus
TOrthoP = Total Ortho-Phosphorus
DOrthoP = Total Dissolved Ortho-Phosphorus
THydP = Total Hydrolyzed Phosphorus
DHydP = Dissolved Hydrolyzed Phosphorus
TIP = Total Inorganic Phosphorus
TOrgP - Total Organic Phosphorus
DOrgP = Dissolved Organic Phosphorus
TNO3 = Total Nitrate
DNO3 = Dissolved Nitrate
TNH3 = Total Ammonia Nitrogen
DNH3 = Dissolved Ammonia Nitrogen
TKN = Total Kjeldahl Nitrogen
DKN = Dissolved Kjeldahl Nitrogen
TOrgN = Total Organic Nitrogen
DOrgN = Dissolved Organic Nitrogen
TS = Total Solids
T Hg = Total Mercury
TNO2 = Total Nitrite
DNO2 = Dissolved Nitrite

Table 2.2 Percent Composition of Lake Wallenpaupack Sediment				
Date	**Station**	**%Sand**	**%Silt**	**%Clay**
10/27/99	1	80	3	18
	2	47	10	43
	3	44	13	44
	4	44	11	45
	5	37	11	53
5/30/00	1	23	53	25
	2	36	48	15
	3	25	55	21
	4	44	47	9
	5	26	61	13

2.5 Algal Assay

An algal assay study was performed on Lake Wallenpaupack water using two types of algae: the green alga *Selenastrum* and the bluegreen alga *Anabaena*. A variety of studies were performed to determine the response of algae in Lake Wallenpaupack water to the additions of nitrogen, phosphorus, wastewater treatment plant effluent, shallow groundwater, animal waste runoff, and residential land runoff.

The results of the algal assays indicate that at certain times during the growing season, algae growth in Lake Wallenpaupack is limited by nitrogen and at other times algal growth is limited by phosphorus. In all cases, the maximum algal growth was obtained when both nitrogen and phosphorus were added.

The growth of the alga *Selenastrum* increased in response to the addition of all forms of point and nonpoint source pollution. The higher algal growth occurred when tertiary treated wastewater treatment plant effluent and animal waste runoff were added. Moderate algal growth occurred when residential runoff was added. The lowest algal growth occurred when Wallenpaupack Creek, Ariel Creek, road runoff, and shallow groundwater were added.

The results indicate that both nitrogen and phosphorus should be controlled to reduce the algae populations in Lake Wallenpaupack. The results also indicate that wastewater treatment plant effluent and animal waste runoff produce the highest algal growth.

2.6 Watershed Education Surveys

As part of the FY 1998 EPA Grant Project, three different surveys were developed in order to identify environmental concerns among Lake Wallenpaupack watershed stakeholders. The surveys were designed to obtain citizen opinions on environmental problems and solutions within the watershed, including township supervisors, township planning commission members, and the township engineers. The surveys were also intended to determine whether the fourteen townships located within the Lake Wallenpaupack Watershed are implementing the recommendations of the Act 167 study, if they have adopted the model stormwater ordinance, and if they are enforcing the stormwater ordinance.

Surveys were received from all sources. Over 200 citizen surveys were sent out; 111 were returned. Boating was the most common lake use reported, followed by fishing and swimming. 79 percent of respondents reported having a septic system, and 25 percent said they didn't know when the system was installed. When asked if they believe that development within their township is having a negative impact on local streams and Lake Wallenpaupack, 80 percent said no. Although 25 percent of respondents said they have a lawn down to the water's edge, 33 percent said that they would be interested on learning how to provide for or enhance water quality and wildlife habitat on their property, and 71 percent ranked the importance of maintaining good water quality in Lake Wallenpaupack as very important.

One Township Engineer Survey was returned. The engineer felt that more attention should be paid in his Township to addressing stormwater quality issues, and that the lack of a program for cleaning out catchbasins, culverts, and stormwater management facilities was a problem. He also believed sediment from eroding streambanks to be the greatest source of pollution to the local streams and Lake Wallenpaupauck, followed by runoff from construction sites and paved areas.

Nine Township Official surveys were completed, representing three different townships. Approximately half of the respondents said that they would support the enactment of a new, more protective stormwater ordinance in their township. The majority of the respondents were not sure whether or not existing stormwater management practices in their township were sufficient to protect water quality. The respondents blamed a wide range of nonpoint pollution sources for water quality problems, but runoff from construction sites and paved areas topped the list. Overwhelmingly, the respondents ranked the importance of stormwater management in their township as very important.

3.0 Pollution Sources in the Lake Wallenpaupack Watershed

Water pollution can be classified into two categories: point source pollution and nonpoint source pollution. Point source pollution originates from one easily identifiable source. An example of point source pollution is a discharge pipe from a wastewater treatment plant. Nonpoint source pollution has no specific point of origin and is often dispersed over the landscape. Stormwater runoff is a nonpoint source of water pollution.

Stormwater runoff is the water that runs off the surface of the land from rain or melting ice and snow. The type of land on which the rain falls affects the volume of stormwater runoff that is generated. In forests and grassy fields, most of the rain that falls percolates into the soil or evaporates into the air and only a small amount of stormwater runoff is generated. As an area becomes more developed, with more impervious area, the amount of water that percolates into the ground or evaporates into the air decreases, and the amount of stormwater runoff increases.

Stormwater runoff can negatively affect water quality, aquatic biota, and stream temperature. As the stormwater runoff travels across the land, it picks up pollutants such as soil particles, oil and grease, nutrients, and toxic chemicals. It carries these pollutants to nearby streams and lakes. These pollutants can cause many water quality problems. Increased sediments can significantly alter the ecology of the water body. Sediments clog the gills of fish and smother newly-laid fish eggs and other aquatic life. Stormwater runoff from developed areas increases the stream temperature and can stress or kill temperature-sensitive aquatic life. Sediments often carry chemicals such as phosphorus, nitrogen and toxins which further pollute the water. Excessive stormwater runoff also increases the amount of water in streams, resulting in flooding and streambank erosion.

3.1 Nonpoint Source Pollution

Nonpoint source pollution constitutes the majority of the nitrogen and phosphorus loadings to Lake Wallenpaupack. The LWWMD has conducted nonpoint source watershed investigations throughout the watershed and installed a number of nonpoint source Best Management Practices (BMPs), as described below.

3.1.1 Watershed Investigations

Watershed investigations can be used to detect stormwater management opportunities, streambank and shoreline erosion problems, riparian buffer restoration opportunities, agricultural problem area sites, invasive species infestations, and other potential sources of water quality problems.

F. X. Browne, Inc. and the LWWMD conducted watershed investigations of the 219 square mile Lake Wallenpaupack watershed to assess present conditions and to develop a comprehensive list of problem areas. Initial watershed investigations were completed in 2000 before Hurricane Ivan struck the region. Hurricane Ivan caused widespread flooding across the region, leading to significant erosion of streambanks, shorelines, and roadsides. Watershed investigations were performed to identify Lake Wallenpaupack shoreline erosion areas in 1999 and again in 2006.

Additionally, the LWWMD revisited the watershed investigation sites from the initial survey in 2006 two years after Hurricane Ivan. New problem areas were also identified during the 2006 survey.

Roadside bank erosion problem area

Data were obtained by researching existing information and conducting field investigations throughout the watershed. Over 350 hours were spent collecting information and locating 176 problem areas. Once the problem areas were identified, they were documented and plotted on the appropriate USGS quadrangles. The UTM coordinates were determined for each site, and a GIS database was developed to accurately map the sites. The list of problem areas and the location map were used by the LWWMD as tools for site selection and implementation of Best Management Practices.

Preliminary data were collected by conducting a survey of existing information. Organizations such as the National Resource Conservation Service (NRCS), county conservation districts, Trout Unlimited, homeowner associations, and PennDOT were contacted to obtained lists of known problem areas. Field investigations were then undertaken to document the extent of the known problems and locate other areas of concern.

Roadside in need of repair and stormwater management

The Lake Wallenpaupack watershed was divided into 39 subwatersheds. Each of the subwatersheds was assessed for problems associated with streambank and shoreline erosion, community and urban stormwater systems, and other potential areas of concern. Photos were taken of most areas to document the problem areas. To further explicate the situation, a hand drawing was prepared for each site along with a description of the area, a severity ranking of the problem, and any additional comments necessary to describe the problem.

Streambank erosion problem area along Wallenpaupack Creek before restoration

The data obtained in the investigation were collated based on subwatershed and subdivided into categories based on problem type. All of the identified problems were categorized as either streambank, shoreline, stormwater (roadside) or agricultural problem areas. One septic system problem area was also found. Included with each field data sheet is a subwatershed map showing the location of the problem area and any photos taken during the field investigations.

The watershed investigations focused only on areas with public access. Due to limited accessibility, stream walks were not done along the entire lengths of the streams. It is likely that there are many more problems with streambank erosion and instability than those noted in this study.

Additional watershed investigations were conducted by LWWMD staff and board members during 2006 in each of the original subwatersheds in order to document any new problem areas that may have arisen during the last few years (post-Hurricane Ivan). Twenty-five new problem areas were found. In addition, a shoreline survey of Lake Wallenpaupack was conducted during late 2006 in order to document any severe shoreline erosion areas. The shoreline survey was conducted by traveling the entire length of the Lake Wallenpaupack shoreline in a boat and observing the condition of the shoreline. Eleven shoreline erosion areas were found. GPS readings and photographs were taken and a watershed investigation form was filled out at each site.

Barnyard in need of heavy use area protection

A list of all of the identified problem areas during the watershed investigations is provided in Appendix B. The list includes the type of problem area, location, and brief description of the problem. The problem areas are included on Map 1 in Appendix C.

3.1.2 Success Stories – Existing Nonpoint Source BMPs

Best Management Practices (BMPs) are structural and non-structural measures that are used to reduce nonpoint source pollution and restore natural water drainage conditions to a developed environment. BMPs can be incorporated into new developments and can be added to existing developments. When used correctly, stormwater BMPs mimic the natural environment by increasing infiltration of stormwater into the soil and groundwater; filtering sediment, nutrients, and other pollutants from runoff; and reducing erosion. BMPs can be structural, such as stormwater detention basins or agricultural waste storage facilities, or institutional, such as public education programs and ordinances.

Between 1984 and 1998, 48 BMPs were installed in the Lake Wallenpaupack watershed using funding from various sources, including an EPA Clean Lakes Phase II Restoration Program grant, a PA DEP 319 Nonpoint Source Program grant, and an EPA funded 104(b)3 grant.

Grassed waterway installed on Kraeger Farm

The LWWMD FY1998 and FY1999 EPA grant projects funded the design and construction of 21 additional BMPs in the Lake Wallenpaupack watershed between 1998 and 2006. Under this project, a BMP Committee was formed within the LWWMD to evaluate potential BMP based on the results of the watershed investigations. Some of the projects were evaluated upon request of private landowners in the watershed. A ranking system was developed that was used to prioritize 34 potential BMP projects.

Agricultural waste facility on Held Farm, Jefferson Township

After the BMP evaluation process was complete and a BMP was approved for a problem area site, contracts were prepared for signature by the LWWMD and the property owner for each project. Contract development included a description of the project, preparation of an operation and maintenance list, development of a detailed project sketch, and development of a detailed project budget. Nutrient Management Plans were required to be completed for each agricultural project, and a NMP was developed for each farm that didn't already have one.

Appendix D lists all the BMPs that have been implemented in the Lake Wallenpaupack watershed, including the cost of the BMP (design and construction), the township where the BMP was completed, and a brief description of each project. Not listed in the table are the many public education programs that have been developed for the Lake Wallenpaupack watershed, including fact sheets, brochures, school curricula, workshops, surveys, the Lake Management Handbook, the Homeowner's Streambank and Shoreline Stabilization Handbook, and various water quality reports. Educational programs are discussed in Section 4.7.

In total, 69 BMPs have been installed in the Lake Wallenpaupack watershed totaling $1,880,830. Overall, 37 agricultural, 7 streambank, 4 shoreline, and 21 stormwater BMPs have been implemented. Photos and descriptions of many of the BMPs are listed on the LWWMD website at http://www.wallenpaupackwatershed.org. The BMP locations are shown on Map 1 in Appendix C.

Rock-lined channel designed to reduce stormwater erosion along roadside in Paupack Township

Butternut Creek Before Stabilization

Butternut Creek After Stabilization

3.1.3 Effectiveness of BMP Controls Study

As part of the FY 1999 EPA Grant Project, a BMP effectiveness study was conducted. The goal of this study was to determine the effectiveness of two BMPs that were installed as part of the FY1998 EPA Grant Project: the Bakker Marine project and the Krautter Agricultural BMP project.

Bakker Marine is located in Paupack Township, Wayne County, PA. The marina has a large paved parking lot and covered boat storage area. Stormwater from these impervious areas was running off the site and causing erosion and flooding along roadsides in the Walt's Landing development, as shown in the photos below. A detention basin existed on the site but was not functioning properly, leading to excessive sheet flow across area fields and right into lake. Many area homes had flooded basements and property damage during heavy rains.

Poorly-functioning Detention Basin Adjacent To Bakker Marine Before BMPs Installed

Roadside and Flooding during rain event before BMPs installed

For the project, the existing detention basin was converted to a constructed stormwater wetland system to receive and treat the site runoff. The project was constructed in 2000. The wetland consists of six sediment forebays and a large basin. The outlet of the wetland is directed into a rock channel along the roadside. The goal of the BMP is to not only slow the stormwater velocity, but also to retain some stormwater for nutrient and sediment removal and peak flow reduction. The photos below show the constructed wetland post-construction and after wetland plant establishment.

It should be noted that it took several years for the wetland plantings to become well established, but they are thriving now.

Sediment Forebay at Constructed Wetland Inlet – after BMP installation

Wetland Plantings Help Filter Stormwater and Trap Sediment

The water quality monitoring at Bakker Marine began soon after construction. Samples were collected at the inlet and the outlet of the wetland system during three separate storm events. However, the data from the first set of samples were not used since the vegetation was slow to establish and no nutrient reduction was achieved. The sampling re-commenced once the vegetation was established with much better results. The data were then evaluated to determine the efficiency of the system.

The results are shown in the table below. As shown in Table 3.1, good nutrient reduction was achieved for both total phosphorus, nitrate+nitrite nitrogen, and total suspended solids.

Table 3.1
Bakker Marine Water Quality Monitoring Results

Parameters	Bakker Marina		Percent Reduction
	Inlet	Outlet	
Total Phosphorus (mg/L)	0.366	0.199	46
Ammonia Nitrogen (mg/L)	0.1	0.1	0
Nitrate+Nitrite Nitrogen (mg/L)	0.185	0.09	51
Total Nitrogen (mg/L)	0.82	0.66	20
Total Suspended Solids (mg/L)	18	11.1	38

Krautter Farm Project

The Carroll Krautter farm is located in Greene Township, Pike County, PA. The farm primarily raises livestock. The farm had lots of open manure piles and loose soils, as shown in the photo below.

Krautter farm is located near a pond and a tributary to Wallenpaupack Creek. As part of this project, an agricultural waste facility with a roof was constructed. In addition, water diversion and heavy use area protection was installed on the property.

Manure Pile in Uncovered Storage Area Before BMP Construction

Inside of Agricultural Waste Facility After BMP Construction

At the Krautter Farm project, both pre-construction and post-construction stormwater samples were collected at the outlet of the agricultural waste facility. The data were analyzed to determine the efficiency of the BMP. As shown in Table 3.2, good nutrient reduction was achieved for total phosphorus and total suspended solids, and exceptionally good reduction was achieved for each of the nitrogen compounds.

Table 3.2
Krautter Farm Water Quality Data Results

Parameters	Krautter Farm		Percent Reduction
	Pre-Construction	Post-Construction	
Total Phosphorus (mg/L)	9.95	4.09	59
Ammonia Nitrogen (mg/L)	10.95	0.38	97
Nitrate+Nitrite Nitrogen (mg/L)	18.48	0.91	95
Total Nitrogen (mg/L)	78.98	9.91	87
Total Suspended Solids (mg/L)	832.5	357	57

3.2 Point Sources

The National Pollutant Discharge Elimination System (NPDES) Program, under Clean Water Act, requires permits for the discharge of pollutants from point sources. Permitted point sources include discharges from municipal sewer systems, storm water systems, and wastewater treatment plants. Fourteen permitted point sources exist in the Lake Wallenpaupack watershed. The permit limits and design flows for these treatment facilities are listed in Table 3.3 and their locations are shown in Figure 3.1.

Table 3.3
Permit Limits and Design Flows for NPDES Permitted Facilities in the Lake Wallenpaupack Watershed (2003*)

Permit ID	Facility Name	Design Parameter			
		Flow (MGD)	Average Monthly TSS (mg/L)	Average Monthly NH3-N (mg/L)	Average Monthly TP (mg/L)
PA 0060038	Julia Ribuado Nursing Home WTP	0.0125	30	3 (9 mg/l 11/1-4/30)	1
PA 0033430	Roamingwood Sewer and Water Assoc.	1.755	30	2 (6 mg/l 11/1-4/30)	0.5
PA 0060542	Wallenpaupack Lake Estates	0.65	30	3 (9 mg/l 11/1-4/30)	1
PA 0034428	Caesers Cove Haven Resort	0.094	30	3 (9 mg/l 11/1-4/30)	1
PA 0031364	Wallenpaupack Area School District	0.04	30	3 (9 mg/l 11/1-4/30)	2
PA 0060216	John T. Howe, Inc.	0.0485	30	3 (9 mg/l 11/1-4/30)	1
PA 0061654	Newfoundland Elementary School WWTP	0.1	30	3 (9 mg/l 11/1-4/30)	1
PA 0041912	Edwin, Inc.	0.07	30	3 (9 mg/l 11/1-4/30)	1
PA 0035891	Escape Property Owners Assoc.	0.98	15	3 (9 mg/l 11/1-4/30)	1
PA 0032123	Promised Land State Park	0.2	30	3 (9 mg/l 11/1-4/30)	0.5
PA 0063479	P&S Development Company	0.03	10	1.5 (4.5 mg/L 11/1-4/30)	1
PA 0060721	Pocono Plateau Christian Assoc.	0.015	30	13 (20 mg/l 11/1-4/30)	1
PA 0060348	PennDOT Safety Rest Site 62	0.015	30	9 (no limit 11/1-4/30)	1
PA 0064190 †	DSV Inc., J&J Lounge	0.0015	20		1

* From the Lake Wallenpaupack TMDL Report (US EPA, 2005); † New discharge as of October 2004

Figure 3.1 Wastewater Treatment Plant Locations in the Lake Wallenpaupack Watershed

As part of the Lake Wallenpaupack Water Quality Evaluation and Long-Term Trend Analysis (F. X. Browne, Inc. 2006), treatment plant effluent data from 1994 through 2000 were summarized and the number of excursions for each treatment plant was tabulated. During the five year period of record, most treatment plants had at least one excursion of at least one parameter. As part of the FY98 EPA project, composited effluent water samples were collected from some of the treatment plants in the watershed on three separate occasions and analyzed for BOD, phosphorus, nitrogen, and mercury. These parameters are not routinely analyzed for each treatment plants but are required for TMDL modeling.

Observations for several of the treatment facilities are listed below:

1. The wastewater treatment facility at The Escape experienced seven of the 12 dissolved oxygen excursions during 1998. The lowest value reported was 2 mg/l in January, 1999. No dissolved oxygen excursions were reported for the last three months of the review period.

2. The Julia Ribaudo Home facility has exceeded the LWWMD recommended average monthly total phosphorus limit of 0.5 mg/l for 44 months since January 1994 (70% noncompliance rate). The PA DEP NPDES permit limit of 1.0 mg/l total phosphorus was exceeded during 17 times (27% noncompliance rate). The discharge compliance history is improving with respect to all parameters except total phosphorus. Since January 1997, there has been only one CBOD and one pH excursion. The discharger has an ongoing problem complying with the LWWMD recommended limit of 0.5 mg/l total phosphorus.

3. Edwin Inc. (Lakeside Waters Edge) discharges effluent that is consistently above the LWWMD recommended average monthly total phosphorus limit of 0.5 mg/l. However, the discharge rarely exceeds the PA DEP average monthly total phosphorus permit limit of 1.0 mg/l.

4. P & S (Hamlin Village) is a new discharge. Data are available for 1999 only. No violations were reported. The location of this treatment facility is not shown in Figure 31.

5. PA DOT (I-84 Rest Stop) has not been required to monitor or report the concentration of dissolved oxygen or total phosphorus or the mass loading of CBOD5, suspended solids or ammonia in its effluent since August 1997. DMRs dating back to January 1995 were reviewed.

6. Wallenpaupack School District (Newfoundland Elementary School) has been in compliance with all effluent limits since September, 1998.

7. The Wallenpaupack Lake Estates treatment has exceedances of the LWWMD recommended average monthly total phosphorus limit of 0.5 mg/l and the PA DEP average monthly total phosphorus permit limit of 1.0 mg/l that span the period of record.

3.3 Hydrologic and Pollutant Budgets

3.3.1 Tributary Monitoring Program

During the Phase I Study of Lake Wallenpaupack in 1980 and 1981, the four major tributaries that flow into Lake Wallenpaupack (the Main Stem of the Wallenpaupack Creek, the West Branch Wallenpaupack Creek, Purdy Creek, and Ariel Creek) were monitored during dry and wet weather to develop pollutant loadings to Lake Wallenpaupack. Over the past twenty years, Lake Wallenpaupack and its watershed have changed a lot. Development has increased in the watershed, but LWWMD has been working diligently to implement BMPs to reduce pollutant loading to the lake. In order to document the watershed changes LWWMD reinstated a comprehensive watershed monitoring program in 2004 to re-evaluate the water quality in the lake's tributary streams.

LWWMD installed state-of-the-art automated sampling units on six tributaries to Lake Wallenpaupack. The sampling units are connected to telephone lines to allow remote operation and retrieval of data. The samplers recorded water level data every fifteen minutes and are capable of collecting samples at programmed intervals during storm events. Water level data was converted to flow data based on rating curves develop at each sampling location. During the study, twelve dry weather samples and eleven wet weather samples were analyzed for nutrient and sediment concentrations. The stream data were used to develop pollutant budgets, as discussed in Section 3.3.4 below.

Table 3.4 shows the average dry and wet weather water quality monitoring results for the six major tributaries to Lake Wallenpaupack during the period of 2004 through 2005. Dry weather nutrient concentrations, particularly phosphorus, were consistently higher in Ariel Creek than in the other tributaries. The highest wet weather total phosphorus, total nitrogen, and total suspended solids concentrations occurred in the Main Stem of Wallenpaupack Creek. The wet weather averages were higher than the dry weather averages for all three parameters in all six streams. This indicates the need for better stormwater management within the Lake Wallenpaupack watershed.

Table 3.4
Average Water Quality Concentrations in Lake Wallenpaupack Tributaries (mg/L)

Station	Total Phosphorus		Total Nitrogen		Total Suspended Solids	
	Dry	Wet	Dry	Wet	Dry	Wet
Ariel Creek	0.056	0.150	0.88	1.48	3.3	53.6
Purdy Creek	0.031	0.219	0.54	1.46	2.6	39.0
Mill Brook	0.018	0.154	0.24	1.17	2.4	91.6
Diamond Run	0.032	0.109	0.36	0.88	2.8	33.5
West Branch WC	0.023	0.125	0.49	0.96	3.1	58.2
Main Stem WC	0.015	0.375	0.47	2.01	2.6	179.7

3.3.2 Atmospheric Monitoring

F. X. Browne, Inc. researched methods of atmospheric deposition sampling and designed a sample collection unit based on that research. The collection unit was built using a wooden stand and a set of plastic containers with lids that could be removed as needed. A detailed set of guidelines for sampling were developed and sample collection was coordinated with LWWMD representatives. The sampling unit was constructed near the PPL Superintendent's office. The sampler was destroyed during the construction of the PPL Learning Center and had to be rebuilt. Photos of the sampler are shown below.

Atmospheric monitoring sampler

Atmospheric monitoring sampler at PPL

Samples were collected during a total of six dry events and six wet events. One of the wet events was a data outlier and was not used. Wet deposition samples were collected during rain events and analyzed for total phosphorus, total nitrogen, total suspended solids, and total mercury. Dry deposition samples were collected during extended dry periods (i.e. 4-5 days without rain). The dry samplers were washed in the laboratory, and the wash water was analyzed for the same parameters as the wet deposition samples. The final result of the experiment is a quantification of the amount of phosphorus, nitrogen, suspended solids, and mercury entering Lake Wallenpaupack via the atmosphere.

The atmospheric monitoring and stream monitoring data collected during this project were used to develop pollutant loadings to Lake Wallenpaupack. Table 3.5 shows the results of the atmospheric monitoring program at Lake Wallenpaupack.

Table 3.5
Atmospheric Monitoring Results

Sample Type	DATE	TP (Mg/L)	TN (mg/L		THg (mg/L)		TSS Mg/L
Rain	3/28/2000	0.038	0.60	<	0.0002	<	1.0
Rain	7/18/2000	0.012	0.41	<	0.0002		2.4
Rain	8/7/2000	0.042	1.56	<	0.0002		4.8
Rain	10/17-24/2005	0.049	1.76	<	0.0002		1.6
Rain	8/30/2006	0.065	0.48	<	0.0002	<	1.0
Average		**0.041**	**0.96**		**0.0002**		**2.2**
Min		0.012	0.41		0.0002		1.0
Max		0.065	1.76		0.0002		4.8
Sample Type	**DATE**	**TP (Mg/L)**	**TN (mg/L**		**THg (mg/L)**		**TSS Mg/L**
Air	9/2/05-9/9/05	0.311	2.47	<	0.0002		21.6
Air	9/30/05-10/7/05	0.415	5.17	<	0.0002		21.6
Air	7/25/06-7/27/06	0.058	0.7	<	0.0002		5.6
Air	8/3/06-8/7/06	0.199	1.86	<	0.0002		30.4
Air	8/29/06-8/30/06	0.056	0.42	<	0.0002		4
Air	10/05/06-10/10/06	0.23	2.57	<	0.0002		9.6
Average		**0.212**	**2.20**		**0.0002**		**15.5**
Min		0.056	0.42		0.0002		4.0
Max		0.415	5.17		0.0002		30.4

TP = Total Phosphorus THg = Total Mercury
TN = Total Nitrogen TSS = Total Suspended Solids

The above data were used to calculate the wet and dry direct deposition pollutant loads to Lake Wallenpaupack, as shown in Table 3.6. These pollutant loads were then used in conjunction with the stream data and wastewater treatment facility data to calculate the total pollutant loads for the lake. The pollutant loading discussion is presented in Section 3.3.4.

Table 3.6
Atmospheric Deposition Pollutant Loads to Lake Wallenpaupack

Pollutant	Wet Deposition (lbs/year)	Dry Deposition (lbs/year)	Total Pollutant Load (lbs/year)
Total Phosphorus	2,183	1,029	3,212
Total Nitrogen	51,117	10,683	61,800
Total Suspended Solids	117,144	83,182	200,326
Total Mercury	5.3	6.4	11.7

3.3.3 Hydrologic Budget

A hydrologic budget was prepared for the Lake Wallenpaupack watershed using data obtained from the six stream monitoring stations described in Section 3.3.1. Based on stream level data collected at 15 minute intervals every day in 2004 and 2004 at all six stations, the total annual discharge for the six sampling stations was calculated and is provided in Table 3.7. Annual discharge for non-monitored areas was estimated based on an average flow per area basis.

Table 3.7
Tributary Flows and Estimated Flows for Non-monitored Areas to Lake Wallenpaupack

Sub-Watershed	Drainage Area (acres)	Annual Baseflow Discharge (million gallons)		Annual Stormflow Discharge (million gallons)		Total Annual Discharge (million gallons)	
		2004	2005	2004	2005	2004	2005
Ariel Creek	7,712	3193	9986	2994	7217	6,187	17,203
Diamond Run	640	352	373	307	306	658	679
Mill Brook	3,018	1,967	619	862	2,131	2,829	2,751
Purdy Creek	5,829	2420	2,036	1866	1,665	4,286	3,701
Main Stem WC	44,343	39,822	32,042	28,116	31,284	67,938	63,325
West Branch WC	45,468	35,762	70,549	24,443	28,488	60,205	99,037
Non-monitored Area	27,710	21,626	23,363	12,791	8,497	34,417	31,860
Total	**134,720**	**105,142**	**138,968**	**71,378**	**79,588**	**176,520**	**218,556**

The average annual rainfall in the Lake Wallenpaupack watershed is 41.23 inches per year. In 2004, 52 inches of rain fell in the watershed and in 2005, 47 inches of rain fell in the watershed. Based on these rainfall amounts, the total estimated volume of rain that fell directly on Lake Wallenpaupack in 2004 was 8,048 million gallons per year and in 2005 was 7,274 million gallons per year. The hydrologic budget for the lake for 2004 and 2005 is provided in Table 3.8.

Table 3.8
Hydrologic Budget for Lake Wallenpaupack for 2004 and 2005

	2004	2005
Tributary Inputs (MG/year)	176,520	218,556
Precipitation (MG/year)	8,048	7,274
Total (MG/year)	**184,568**	**225,830**

3.3.4 Pollutant Budget

A pollutant budget for Lake Wallenpaupack was developed based on measured point source loads from the 14 treatment plants that are located in the watershed and nonpoint source loads measured at the six monitoring stations.

Nonpoint source pollutant loads to Lake Wallenpaupack via the six major tributaries were determined by calculating the total loadings from the automatic sampler data for each subwatershed. Table 3.9 shows the annual total phosphorus load, Table 3.10 shows the annual total nitrogen load, and Table 3.11 shows the annual total suspended solids load for each subwatershed for 2004 and 2005. Nonpoint source pollutant loads from non-monitored areas were estimated based on data from monitored areas.

Table 3.9
Annual Total Phosphorus Nonpoint Source Loads for Lake Wallenpaupack Sub-watersheds

Station	2004		2005	
	(lbs/yr)	(percent)	(lbs/yr)	(percent)
Ariel Creek	5,240	3	7,613	3
Diamond Run	373	0	378	0
Mill Brook	1,404	1	2,832	1
Purdy Creek	4,036	2	3,569	2
Main Stem WC	92,964	45	101,903	45
West Branch WC	32,359	16	43,254	19
Non-monitored Areas	68,625	33	68,625	30
Total	**205,000**	**100**	**228,175**	**100**

Table 3.10
Annual Total Nitrogen Nonpoint Source Loads for Lake Wallenpaupack Sub-watersheds

Station	2004		2005	
	(lbs/yr)	(percent)	(lbs/yr)	(percent)
Ariel Creek	60,426	4	91,442	5
Diamond Run	3,307	0	3,367	0
Mill Brook	12,358	1	22,047	1
Purdy Creek	33,635	2	29,460	2
Main Stem WC	627,747	42	650,372	38
West Branch WC	342,030	23	516,668	30
Non-monitored Areas	398,025	27	398,025	23
Total	**1,477,528**	**100**	**1,711,380**	**100**

Table 3.11 Annual Total Suspended Solids Nonpoint Source Loads for Lake Wallenpaupack Sub-watersheds				
Station	**2004**		**2005**	
	(lbs/yr)	**(percent)**	**(lbs/yr)**	**(percent)**
Ariel Creek	1,427,107	2	1,887,639	2
Diamond Run	93,904	0	94,327	0
Mill Brook	698,478	1	1,641,382	2
Purdy Creek	659,696	1	586,019	1
Main Stem WC	43,023,631	50	47,605,430	50
West Branch WC	12,795,943	15	15,660,007	17
Non-monitored Areas	26,901,000	31	26,901,000	29
Total	**85,599,758**	**100**	**94,375,804**	**100**

As described and presented in Section 3.3.2 above, the pollutant loadings for both wet deposition (rain) and dry deposition (fallout) were calculated based on measured data. The tributary pollutant loadings were calculated from measured stream flow data and average wet weather and average dry weather pollutant concentrations. These loadings include nonpoint source loadings from streambank erosion, surface water runoff, and septic systems in the watersheds upgradient of the sampling stations. Treatment plant loadings were calculated and subtracted from the estimated nonpoint source loadings to separate the point and nonpoint source pollutant loads. Additionally, the nonpoint source loads were separated into three categories: stormwater runoff from all land used, streambank erosion, and septic systems.

Based on a detailed report prepared for the Minnesota Pollution Control Agency entitled *Detailed Assessment of Phosphorus Sources to Minnesota Watersheds* (Barr Engineering Co., 2004), approximately 2.4 percent of the nonpoint source load for total phosphorus is attributable to streambank erosion during dry, low flow water years, 11 percent of the nonpoint source load for total phosphorus is attributable to streambank erosion during average flow water years, and 40 percent of the nonpoint source load for total phosphorus is attributable to streambank erosion during wet, high flow water years. Both 2004 and 2005 were wet, high flow water years; therefore, a factor of 40 percent was used to estimate the total phosphorus nonpoint source pollutant load due to streambank erosion. The 40 percent factor was also applied to total nitrogen and total suspended solids.

The pollutant loads from septic systems were estimated using the estimate population on failing septic systems as described in the EPA TMDL report (USEPA, 2005) and pollutant loading rates from septic system for total phosphorus, total nitrogen, and total suspended solids presented in *Design Manual – Onsite Wastewter Treatment and Disposal Systems* (USEPA 1980).

Based on the above information, the pollutant budgets for Lake Wallenpaupack were calculated for 2004 and 2005 and are presented in Tables 3.12 and 3.13, below.

Table 3.12 Pollutant Budget for Lake Wallenpaupack for 2004						
Pollutant Source	**TP**		**TN**		**TSS**	
	lbs/yr	**%**	**lbs/yr**	**%**	**lbs/year**	**%**
Point Sources	1,550	0.7	45,285	2.9	35,391	0.0
Wet Deposition	2,183	1.0	51,117	3.3	117,144	0.1
Atmospheric Fallout	1,029	0.5	10,683	0.7	83,182	0.1
Nonpoint Sources						
Streambank Erosion	81,380	39.1	572,897	37.2	34,225,747	39.9
Septic Systems	16,764	8.1	50,292	3.3	536,449	0.6
Stormwater Runoff (all land uses)	105,306	50.6	809,054	52.6	50,802,171	59.2
Total Loadings	**208,212**	**100.0**	**1,539,328**	**100.0**	**85,800,084**	**100.0**

Table 3.13 Pollutant Budget for Lake Wallenpaupack for 2005						
Pollutant Source	**TP**		**TN**		**TSS**	
	lbs/yr	**%**	**lbs/yr**	**%**	**lbs/year**	**%**
Point Sources	1,550	0.7	45,285	2.6	35,391	0.0
Wet Deposition	2,183	0.9	51,117	3.3	117,144	0.1
Atmospheric Fallout	1,029	0.4	10,683	0.7	83,182	0.1
Nonpoint Sources						
Streambank Erosion	90,650	39.2	666,438	37.6	37,736,165	39.9
Septic Systems	16,764	7.2	50,292	2.8	536,449	0.6
Stormwater Runoff (all land uses)	119,211	51.5	949,365	53.5	56,067,799	59.3
Total Loadings	**231,387**	**100.0**	**1,773,180**	**100.0**	**94,576,130**	**100.0**

Based on the pollutant budgets for Lake Wallenpaupack for 2004 and 2005, nonpoint sources of pollution are the major sources of pollutants to the lake. In 2004 and 2005, both extremely wet years, streambank erosion accounted for approximately 39 percent of the total phosphorus load to the lake, while stormwater runoff from all land uses contributed about 50 percent of the total phosphorus load. Septic systems contributed 7 to 8 percent of the total phosphorus load.

In order to improve the water quality of Lake Wallenpaupack, additional BMP are needed to reduce pollutant loadings to the lake. Streambank stabilization BMPs should be a top priority for the LWWMD. Additionally, priority should be given to BMPs in the Main Branch subwatershed, the West Branch subwatershed, and direct drainage areas since these areas appear to contribute the greatest percentage of pollutant to the lake.

4.0 Lake and Watershed Management Plan

Management of a lake is integrally related to management of the surrounding watershed. Watershed management is the process of protecting the lakes, streams, and wetlands in the watershed from point and nonpoint source pollution. It is accomplished by developing an understanding of key factors that affect the water quality of lakes, streams and wetlands and by following a plan of action to prevent, reduce, or minimize those activities within a watershed that may negatively impact water quality. Watershed management consists of many diverse activities including controlling point and nonpoint source pollution, monitoring water quality, adopting ordinances and policies, educating stakeholders, and controlling growth and development in a watershed.

Nonpoint source pollution is typically addressed by incorporating watershed Best Management Practices (BMPs) to reduce the amount of nutrients and sediments entering lakes and streams in the watershed. Examples of watershed BMPs include wastewater management, streambank stabilization, stormwater management, agricultural BMPs, riparian corridor restoration, site development erosion and sedimentation control, and municipal planning.

Recommended watershed management practices for the Lake Wallenpaupack watershed are discussed in the following sections, including:

- Wastewater Management
  - Act 537 Wastewater Planning
  - Decentralized Wastewater Treatment and Disposal
  - Management of Existing Centralized Wastewater Facilities
- Developed Land Management
  - Management of Existing Development
  - Management of New Development
  - Environmental Planning
- Agriculture Management
- Silviculture Management
- Aquatic Ecosystem Restoration
  - Streambank Restoration
  - Shoreline Restoration
  - Wetlands Protection and Restoration
- In-Lake Management
  - Lake and Watershed Monitoring
  - Macrophyte Survey
  - Fisheries Survey
  - Lake Operation
- Public Education and Outreach

4.1 Wastewater Management

Wastewater from wastewater treatment facilities and septic systems is a significant nonpoint source of pollution in the Lake Wallenpaupack watershed. On-lot wastewater treatment problems exist primarily where conventional septic leach fields were installed in areas of seasonal high and normal high water tables, shallow bedrock, and low permeability soils.

4.1.1 Act 537 Wastewater Planning

The Pennsylvania Sewage Facilities Act (Act 537) was enacted to correct existing sewage disposal problems and prevent future problems. Act 537 requires proper planning in all types of sewage disposal situations, and when a new land development project is proposed, municipalities are required to revise their official plan (unless the project is exempt from planning). Local municipalities are largely responsible for administering the Act 537 sewage facilities program. To assist local municipalities in fulfilling this responsibility, the PA DEP provides technical assistance, financial assistance, and oversight.

The municipalities in the Lake Wallenpaupack watershed should update their Act 537 Sewage Facilities Plans to ensure adequate wastewater planning for potential residential, commercial, and industrial development. All Act 537 Plans should contain an evaluation of wastewater needs, and should include provisions for encouraging the implementation of decentralized wastewater treatment and disposal systems. The Act 537 Plans should include a physical description of the municipal planning area, a description of current wastewater systems, an evaluation of wastewater treatment needs, an evaluation of alternatives, and recommended plans to address problem areas.

Table 4.1 shows the status of Act 537 Plan updates for each municipality in the Lake Wallenpaupack watershed. Six of the 14 townships in the watershed have Act 537 Plans that are greater than 20 years old. Updating these plans should be a priority. Six townships have Act 537 Plans that are between 10 and 20 years old. These plans are due to be updated as well. Jefferson Township recently updated their Act 537 Plan and Palmyra Township is currently in the process of updating their plan to include decentralized wastewater treatment and disposal.

Table 4.1 Lake Wallenpaupack Watershed Act 537 Plan Status			
Municipality	**County**	**Plan Approval Date**	**Plan Status**
Barrett Twp	Monroe	4/8/1996	Needs updating
Blooming Grove Twp	Pike	7/31/1991	Needs updating
Coolbaugh Twp	Monroe	11/6/1995	Needs updating
Dreher Twp	Wayne	10/2/1976	Serious need of update
Greene Twp	Pike	6/28/1996	Needs updating
Jefferson Twp	Lackawanna	5/9/2006	Recently updated
Lake Twp	Wayne	10/2/1979	Serious need of update
Lehigh Twp	Wayne	10/2/1976	Serious need of update
Madison Twp	Lackawanna	8/1/1971	Serious need of update
Palmyra Twp	Pike	3/29/1979	Currently updating
Palmyra Twp	Wayne	10/2/1979	Serious need of update
Paupack Twp	Wayne	7/26/1988	Needs updating
Salem Twp	Wayne	7/5/1990	Needs updating
Sterling Twp	Wayne	10/2/1979	Serious need of update

As part of the Act 537 Plan updates, each township should conduct soil suitability mapping of on-site soil-based disposal system suitability in their township using Geographic Information Systems (GIS) to compare data layers. The soils, slopes, geology, and groundwater resources in the Township should be analyzed and compared to the current Pennsylvania Department of Environmental Protection on-site disposal system design standards. The end result of the suitability mapping study will be a set of maps depicting specific areas within the townships where on-lot wastewater systems can be constructed. The mapping should delineate areas where conventional septic fields, raised sand mounds, drip irrigation systems, or spray irrigation systems should be allowed. Areas that are unsuitable for soil-based wastewater disposal facilities should also be identified.

The soil suitability maps can then be compared to the known septic system uses in each area to determine likely failures. When failing systems are found, the proper type of replacement system can be recommended based on the suitability mapping. Field site visits will be required in order to confirm the soil suitability for soil-based wastewater disposal. Septic system management and replacement programs should be developed in order to assist residents in addressing their septic system problems.

Because significant areas of the Lake Wallenpaupack watershed consist of soils that are not suitable for conventional on-lot septic systems, alternative on-lot wastewater systems should be considered. The township Act 537 Plans should include discussions of alternative design options for on-lot wastewater disposal, such as elevated sand mounds, infiltration chamber systems, drip irrigation systems, low-pressure pipe systems, spray irrigation systems, or constructed wastewater treatment wetland systems. In addition, several technologies exist that may help accelerate the wastewater treatment process and result in better pretreatment, including septic tank effluent filters and aerobic treatment units. As with any conventional septic system installation, soil testing is critical to determining the practicality of installing a specific wastewater system. Soil testing requirements should be included in the Act 537 Plans as well.

4.1.2 Decentralized Wastewater Treatment and Disposal

A decentralized wastewater system is defined by the US EPA as "An onsite or cluster wastewater system that is used to treat and dispose of relatively small volumes of wastewater, generally from individual or groups of dwellings and businesses." A centralized wastewater system uses gravity or pressure sewers to transport all of the wastewater in the area to one location for treatment and disposal, usually to a stream discharge.

As the need for upgrading larger wastewater treatment facilities is increasing and costs are rising, decentralized treatment options are becoming more and more attractive, especially in waterfront communities. In their report entitled "Response to Congress on Use of Decentralized Wastewater Treatment Systems", the US EPA indicated concern about the gap between wastewater needs and available federal-state funding. The report indicated the need to identify and implement alternatives to costly centralized treatment and collection systems. The conclusion of the EPA report states that "adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals."

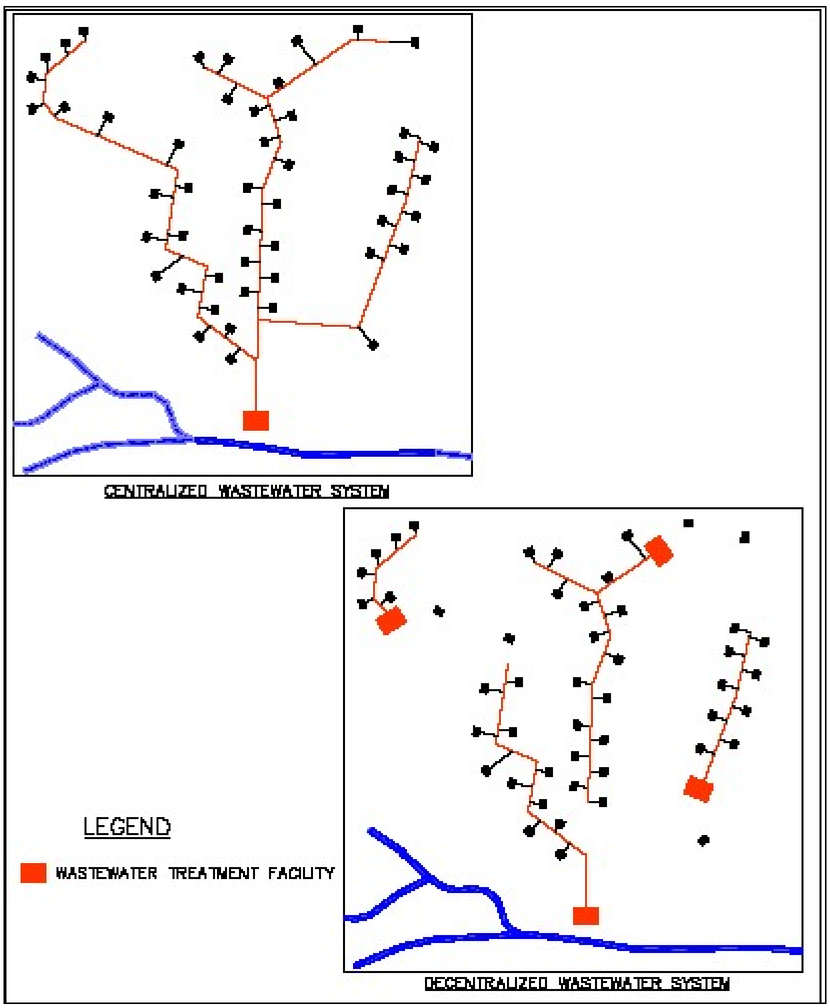

Figure 4.1: Comparison of a centralized and decentralized wastewater system

Decentralized wastewater disposal consists of a system of clusters, as shown in Figure 4.1. Wastewater from each cluster is transported to a smaller wastewater system for treatment and disposal. A decentralized wastewater system breaks up the service area into smaller clusters. Instead of one centralized treatment facility, there are two or more smaller, decentralized wastewater treatment facilities. The cluster treatment systems, being smaller due to the reduced cluster wastewater flow, may be on-site systems such as a mound, drip system, or spray irrigation system. It could also be a small package treatment plant that discharges to a stream.

There are several advantages to decentralized wastewater systems:

1. Decentralized systems usually do not promote uncontrolled growth like centralized systems often do.

2. Decentralized systems often are less expensive to construct and operate. They reduce the length of sewers needed and do not sewer unpopulated areas.

3. Decentralized systems, consisting of a series of smaller wastewater flows, have a greater potential for on-site disposal. Most centralized wastewater systems require a wastewater treatment plant with stream discharge because of the larger wastewater flows being treated.

4. If on-site treatment and disposal is feasible, decentralized systems, by using on-site soil disposal, provide better treatment, better meet EPA and DEP water quality antidegradation requirements, and recharge groundwater.

In existing communities located near sensitive environmental areas such as rivers, lakes, and wetlands, decentralized systems can offer distinct benefits. Waterfront communities often run into water quality problems when seasonal residences that were originally built on soils unsuitable for on-lot wastewater treatment begin to age and have septic system failures. In addition, waterfront homes are increasingly being converted to year-round residences whose wastewater systems are insufficient to treat the increased usage. Since waterfront real estate is usually at a premium, very little land and money may exist for the construction of a centralized treatment facility, so a series of smaller, decentralized systems may be the best option. Decentralized systems can be targeted toward clusters of homes with the most serious problems, leaving newer, well-functioning septic systems out of the loop.

There are, however, several disadvantages to decentralized wastewater systems. They usually require more up-front soils testing to locate suitable sites. They may also require slightly higher engineering design fees. Although system maintenance is typically lower than a centralized system, it could be more complicated for multiple cluster systems.

Decentralized wastewater recommendations should be included in municipal ordinances, comprehensive plans, and Act 537 Plan revisions in the Lake Wallenpaupack watershed.

4.1.3 Management of Existing Centralized Wastewater Facilities

Although wastewater treatment plants within the Lake Wallenpaupack watershed are contributing to the pollutant loadings to the lake, in general, these treatment plants are operating within their permit limits. In fact, most of the treatment plants are producing effluent with a phosphorus concentration of 0.5 mg/L. All of the treatment plants are operating well below their design flows.

The LWWMD and all of the wastewater treatment plants in the watershed have been working together to ensure that the facilities are all meeting and exceeding their permit criteria. The treatment plant operators voluntarily submit their Discharge Monitoring Reports (DMRs) to the LWWMD each month for review. At a recent monthly LWWMD board meeting, the Board of Directors presented plaques of accommodation to operators of the following wastewater treatment facilities: The Escape, Pocono Plateau Camp, Wallenpaupack Lake Estates, P & S Development-Hamlin Fun Center, Roamingwood Sewer & Water, John T. Howe Inc., Applied Water-84 Rest Stop-Penn DOT, Promised Land State Park, Wallenpaupack Area School District, and Cove Haven.

Recent awards ceremony honoring treatment plant operators in the Lake Wallenpaupack watershed

The LWWMD should continue to maintain a good relationship with the wastewater treatment facilities, monitor the DMRs for each treatment plant, and encourage the facilities to continue to maintain their equipment and upgrade as necessary.

4.2 Developed Land Management

4.2.1 Management of Existing Development

The main source of nonpoint source pollutant loadings to Lake Wallenpaupack is soil erosion and stormwater runoff. Section 3.1 described the watershed investigations performed in the Lake Wallenpaupack watershed and identified a variety of erosion and stormwater runoff problems. The watershed problem areas identified in Section 3.1 should be corrected. These problem areas consist of roads, culverts, gullies, drainage ditches, driveways, unvegetated lakeshore and streambank areas, and agricultural lands that contribute eroded soil and polluted stormwater to Lake Wallenpaupack.

Control of soil erosion and stormwater runoff from existing areas of the watershed can be accomplished by retrofitting existing stormwater facilities, adding new stormwater facilities, implementing homeowner practices, installing shoreline and streambank vegetated buffers, and mitigating erosion and stormwater runoff from existing dirt, gravel, and paved roads. The BMPs in the Pennsylvania Stormwater Best Management Practices Manual (PADEP, 2006) shall be considered in stormwater management efforts.

Retrofit Existing Stormwater Problem Areas

Historically, stormwater management has focused on reducing the frequency and severity of downstream flooding by reducing the peak discharge from post-developed sites. More recently, stormwater management has been redefined to include the removal of pollutants, thereby improving and protecting the quality of downstream waters.

According to the Pennsylvania Stormwater Best Management Practices Manual (PADEP, 2006), the following set of principles should be considered in managing stormwater and erosion from existing development:

1. Manage stormwater as a resource;
2. Preserve and utilize existing natural features and systems;
3. Manage stormwater as close to the source as possible;
4. Sustain the hydrologic balance of surface and ground water;
5. Disconnect, decentralize and distribute sources and discharges;
6. Slow runoff down, and not speed it up;
7. Prevent potential water quality and quantity problems;
8. Minimize problems that cannot be avoided;
9. Integrate stormwater management into the initial site design process; and
10. Inspect and maintain all BMPs.

The best methods to control erosion and polluted stormwater runoff from stormwater problem areas in the Lake Wallenpaupack watershed will be specific to each site. The above-mentioned guidelines should be used to target areas that would be appropriate for stormwater retrofits (reconstructing existing stormwater management facilities to provide better water quality treatment.)

In developed areas, stormwater management should primarily focus on urban stormwater controls such as sand filters, bioretention systems, bioswales, water quality inlets, and infiltration structures. These stormwater controls do not require vast areas of land, and therefore can be integrated into existing urban settings. The LWWMD should target large parking lots that do not currently have stormwater facilities to implement these BMPs. Reducing the amount of impervious surfaces in the watershed and maximizing natural drainage systems will reduce the amount and velocity of stormwater runoff from developed areas.

Existing older stormwater detention basins should be retrofitted wherever possible to naturalized basins or constructed wetlands that utilize natural vegetation to filter and treat stormwater runoff. Older stormwater designs often detain, but fail to treat stormwater, and can be a breeding ground for mosquitoes. More naturalized stormwater systems, such as bioretention areas and constructed wetlands, provide habitat for insects and other animals that eat mosquito larvae, which helps to keep mosquito breeding to a minimum. In addition, catch basins and sediment forebays should be installed on existing facilities when feasible to remove course sediments from the stormwater entering the facility. Many structural stormwater treatment facilities fail because they get clogged with course sediments.

In addition, existing stormwater facilities should be maintained on a regular schedule to ensure optimum performance. Stormwater catch basins should be cleaned after major storm events or at least once every three months. Sediment forebays should be cleaned out every 1 to 5 years.

<u>Homeowner/Commercial Site Practices</u>

Section 3.1 identifies many nonpoint source problem areas located in public areas around the watershed. There are, however, many private areas that have significant erosion and stormwater runoff problems. Many of the homes in the watershed are located on small, steep-sloped, and/or highly impervious lots. An important element of the management plan, therefore, should be to inform homeowners and commercial establishments about erosion and stormwater problems and provide information that will help them correct and retrofit problem areas on their home and commercial sites.

Homeowners and owners of commercial establishments should be encouraged to implement environmentally-friendly practices on their sites. The following practices should be encouraged:

1. Keep site disturbance to a minimum; especially avoid the removal of natural vegetation and the exposure of bare soil. Seed and mulch any bare soil in the yard and especially near shoreline areas to prevent loss of soil during rain storms,

2. Leave naturally vegetated areas along the lake shore, streams, and road ditches. Plant deep rooted woody, native vegetation along lake shores, streambeds and road ditches.

3. Stabilize steep slopes with ground cover, mulches or stone,

4. Minimize the use of herbicides, pesticides and fertilizers on yards and gardens,

5. Do not cut down trees unless absolutely necessary. Trees provide many environmental benefits including soil stabilization, nutrient uptake, and evapotranspiration of stormwater.

6. Direct roof runoff to dry pits or rain barrels to reduce the amount of stormwater that enters the storm sewer system. Using a rain barrel or cistern gives the homeowner the advantage of water use reduction by storing rain water for watering gardens or lawns during dry periods. B.t.i mosquito larvicide (sometimes called B.t.i. donuts) can be used to ensure that the rain barrels do not turn into mosquito breeding areas. These “donuts” are EPA-approved and readily available in hardware and gardening stores.

7. Stencil storm inlets to educate homeowners that anything that goes down the storm sewer eventually drains directly into the lake.

8. Wash cars and trucks on grassy areas or use a commercial car wash. This practice will reduce the amount of phosphorus and detergent that runs down the driveway into a nearby storm sewer and eventually into the lake.

9. Initiate a leaf management program. If leaves are left in the street too long, nutrients leach from the leaves and are carried into the storm sewers and eventually into the lake with stormwater runoff. Homeowners should be encouraged or required to bag leaves in biodegradable bags.

Most homeowners and owners of commercial establishments do not realize that they should be implementing these practices. Implementation of these practices can best be accomplished by including a description of these practices in fact sheets, newsletters and websites as part of the public education program recommended in Section 7.7.

<u>Road Repair and Maintenance</u>

Roads can have a negative impact on the natural community in watersheds. Roads change the hydrology of the watershed by redirecting water from its otherwise natural flow patterns. Roads increase nonpoint source pollution by increasing the amount of impervious surfaces, thereby preventing infiltration of stormwater into the ground. Roads also create an unnatural disturbance that promotes the growth of invasive plant species. Sediment washing from dirt and gravel roads or eroded roadsides can be a significant source of nonpoint source pollution in rural areas in the Lake Wallenpaupack watershed.

Traditional thinking in road maintenance has been to get water off of the roads and into low-lying areas such as streams by the quickest means possible. However, this results in excess nutrients and sediment entering streams. Inadequate drainage structures such as improperly sized culverts can cause downstream erosion. All watershed roads should be graded and the road edges well vegetated.

Road and highway maintenance is important in this watershed since many roads, including State highways 507 and 590, run adjacent to Lake Wallenpaupack and its tributaries. Many smaller roads are within the direct drainage areas of these water bodies. Many roadside erosion sites were noted during the watershed investigations for this project. Roadside erosion sites should be repaired using methods such as grassed swales, riprap swales, bank stabilization, bioengineering techniques, level spreaders, and other methods. Roadside swales should be properly maintained and should always be immediately stabilized if they are disturbed.

Properly sized culverts at stream crossings and under driveways and cross streets are imperative, as well as adequate roadside drainage structures. Emergency procedures should be established to handle accidental spills such as cargo fuel or other materials. The use of ice melting materials, such as calcium chloride and magnesium chloride, is necessary on occasion to ensure safe driving conditions. These chemicals should be used only when necessary and only in amounts required to provide effective results.

4.2.2 Management of New Development

In areas of future development or redevelopment of the Lake Wallenpaupack watershed, stormwater management controls should be implemented that maximize infiltration of stormwater into the ground. These stormwater control measures typically require larger tracts of land and therefore should be incorporated or designed as part of the land development planning process. If an existing commercial establishment changes ownership and the new owner needs approvals from the local municipality, local ordinances should be in place to require improving stormwater runoff quality from the site before approvals are granted.

All stormwater management in the Lake Wallenpaupack watershed should comply fully with federal NPDES Phase II stormwater and Erosion and Sedimentation Pollution Control regulations, and should incorporate provisions from the Pennsylvania BMP Manual and Lake Wallenpaupack Watershed Act 167 Plan. In addition, the LWWMD should encourage property owners to pursue conservation easements for undeveloped sensitive lands within the watershed.

NPDES Phase II

In 1972, the National Pollutant Discharge Elimination System (NPDES) program was established under the authority of the Clean Water Act. Phase I of the NPDES stormwater program was established in 1990. It required NPDES permit coverage for large or medium municipalities that had populations of 100,000 or more.

Phase II of the NPDES Stormwater program was signed into law in December 1999. This regulation builds upon the existing Phase I program by requiring smaller communities (less than 100,000 population) and public entities that own and operate an municipal separate storm sewer system (MS4) to apply and obtain an NPDES permit for stormwater discharges. The Phase II regulations are administered by agencies designated within the individual states, and each state developed their own permits. In Pennsylvania, individual and general permits for stormwater discharges are granted through the Department of Environmental Protection.

Under the Phase II NPDES regulations, any earth disturbance of greater than one acre requires an NPDES permit and an erosion and sedimentation pollution control plan. For a Phase II permit, EPA regulation (40CFR 122.34) requires permittees at a minimum to develop, implement, and enforce a stormwater program designed to reduce the discharge of pollutants to the maximum extent practicable. Many individual landowners engaging in small projects are unaware of these regulations. The LWWMD and the municipalities in the watershed should strive to educate landowners about the stormwater regulations.

Erosion and Sedimentation Pollution Control Plans

Erosion and sedimentation pollution control plans are required for all earthmoving activities, large and small. Federal Phase II Stormwater regulations require any project disturbing more than one acre of land to obtain an NPDES Permit. The County Conservation Districts review the erosion and sedimentation control plans for any construction projects that propose the disturbance of one or more acres of land to ensure their adequacy and subsequently enforce their proper execution. Smaller projects, although they do not require a federal permit, do require an adequate erosion and sedimentation control plan. However these plans are generally not reviewed. Enforcement of the activities at these smaller sites is more difficult due to the unsure timing of the actual earthmoving and the general lack of project information.

It is likely that the Conservation Districts will effectively enforce proper erosion and sedimentation pollution control for all large projects that require formal project review. The LWWMD should assist the Conservation Districts with inspecting smaller projects to ensure proper installation and maintenance of erosion and sedimentation controls. Local citizens and developers should be made aware of the erosion and sedimentation control regulations. Watershed residents should be made aware that site development or any earthmoving activities that lack or have inadequate erosion and sedimentation controls should be immediately reported to the Conservation Districts. Additionally, all municipalities should help with enforcement of implementation of erosion control plans by using building permits and certificates of occupancy as leverage to require proper plan implementation.

Low-Impact Development (LID)

Whenever possible, low impact development concepts should be incorporated into all new development plans. Low impact development is an innovative, ecosystem-based approach to land development and stormwater management. The general goals of low impact development are to reduce the amount of impervious area on a site and to infiltrate and treat stormwater runoff. Low impact development mimics the pre-development hydrology and controls the peak flow, volume, and quality of stormwater runoff. It does this by minimizing the effective impervious area (the impervious area that produces stormwater runoff) and directing stormwater runoff onto vegetated areas that treat, infiltrate, and evaporate the runoff. Pilot projects have shown that LID is not only effective, it is also cost-efficient.

Wherever possible in the Lake Wallenpaupack watershed, LID techniques should be incorporated into the design of new building sites, utilizing such innovative best management practices as rain gardens, rain barrels, bioretention facilities, and porous pavement. The amount of impervious surfaces at the development site should be reduced. This can be accomplished through narrower street and sidewalk designs, alternative development arrangements, curb removal, and the inclusion of filter strips and grassed waterways along streets and parking lots.

BMP Manual

The Pennsylvania DEP published the Pennsylvania Stormwater Best Management Practices Manual (BMP Manual) in December 2006. The BMP manual can be viewed on the PA DEP Stormwater Management website. The purpose of the manual is to establish recommended guidance for stormwater management in Pennsylvania utilizing BMPs. The manual provides the planning concepts and design standards to guide those involved with planning, designing, reviewing, approving, and constructing land development projects in Pennsylvania. The goal of the manual is to improve water quality and protect water resources through improved stormwater runoff management.

The BMP Manual advances the most recent innovations in stormwater management focusing on preserving on site and off site pre-construction hydraulic conditions. Water quality components composed of structural and non-structural techniques and technologies are emphasized and integrated into the manual. In an effort to coordinate stormwater management identified in the manual, the DEP will also publish a Stormwater Management Model Ordinance that incorporates basic stormwater management components outlined in the manual.

The BMP Manual contains two control guidelines that are recommended to restore natural hydrology. Following the guidelines will help sustain stream base flow and prevent increased frequency of damaging bank full flows. The guidelines will also help prevent increases in peak runoff rates for larger events (2-year through 100-year) on both a site-by-site and watershed basis. Control Guideline 1 (CG-1) is applicable to any size of the Regulated Activity. Use of CG-1 is recommended where site conditions offer the opportunity to reduce the increase in runoff volume. Control Guideline 2 (CG-2) is independent of site constraints and should be used if CG-1 is not followed. This method is not applicable to Regulated Activities greater than one (1) acre or for projects that require design of stormwater storage facilities.

All the municipalities in the Lake Wallenpaupack watershed should incorporate the new BMP technologies into their stormwater management planning efforts, especially with respect to Low Impact Development techniques.

<u>Stormwater Ordinances and 167 Plans</u>

The Pennsylvania Department of Environmental Protection mandated that all designated stormwater management watersheds (including the Wallenpaupack Creek watershed) adopt updated Act 167 Stormwater Management Plans. These plans help to control flooding caused by increased development and also help to improve water quality by requiring water quality BMPs as part of stormwater management plans. An Act 167 plan was developed for the Lake Wallenpaupack watershed in 1989 that meets the regulatory requirements of the federal Part II NPDES regulations. All of the municipalities in the Lake Wallenpaupack watershed adopted the model stormwater ordinance in the Act 167 Plan.

The existing Act 167 Plan for the Lake Wallenpaupack watershed should be updated to incorporate provisions from the new Pennsylvania BMP Manual and require its use in all new development. The stormwater ordinance in conjunction with the DEP BMP Manual should require that low impact development concepts be incorporated into all new development plans. This new plan will represent the most effective, watershed-wide stormwater management planning for the Lake Wallenpaupack Watershed and should be adopted immediately upon release by all municipalities within the watershed.

The following actions are recommended as part of the Act 167 Plan update:

1. Update demographics and other information in original Act 167 Plan.

2. Review and revise stormwater model to develop the stormwater peak rate criteria for the watershed using 2006 watershed data.

3. Re-run EPA water quality model for Lake Wallenpaupack (used by EPA to develop Lake Wallenpaupack TMDL) based on the latest pollutant loadings developed by F.X. Browne, Inc. using 2004-2005 stream monitoring data.

4. Revise TMDL based on the results of the revised water quality model and the new pollutant loadings developed over the past two years.

5. Revise Lake Wallenpaupack Watershed Management Plan based on the new TMDL.

6. Develop model stormwater management ordinance for Townships to adopt. The Act 167 results will be integrated into the new DEP model stormwater ordinance to develop a model stormwater management ordinance specific to Lake Wallenpaupack. The model ordinance will encourage the use of low impact site development concepts and will contain the following criteria:

    a. Stormwater peak rate control
    b. Stormwater volume control
    c. Stormwater water quality control

7. Develop and hold workshops to explain low impact site development concepts and the model ordinance to Township officials, engineers, planners, and developers.

8. Make presentations to all the Townships in the watershed to get them to adopt the model stormwater management ordinance.

9. Prepare final document, the Updated Act 167 Stormwater Management Plan.

<u>Conservation Easements</u>

Conservation Easements help preserve open space, protect critical areas from development, and concentrate development in areas that are already disturbed. A conservation easement is a voluntary agreement that allows a landowner to limit the type or amount of development on their property while retaining private ownership of the land. The easement is signed by the landowner, who is the easement donor, and a land trust or conservancy, who is the party receiving the easement. The easement applies to all future owners of the land. By granting a conservation easement, a landowner can assure that the property will be protected from unwanted development forever, while maintaining ownership of the land. An additional benefit of granting a conservation easement is that the donation of an easement may provide significant financial advantage to the donor.

Residents of the Lake Wallenpaupack watershed who own land within the watershed, especially in critical areas such as lake shorelines, wetlands, and riparian areas around streams, should be encouraged to develop conservation easements to protect the property against future development. The development pressure is extremely high in the watershed, but if protective measures are in place, the sensitive areas can be protected. The LWWMD should work with the Delaware Highlands Conservancy and the Wildlands Conservancy to target areas for conservation easements and to offer workshops for watershed residents on conservation easements.

4.2.3 Environmental Planning

The zoning ordinance, subdivision and land development ordinance, and comprehensive plan are the three major documents that define and implement municipal land planning under the Pennsylvania Municipal Planning Code. The LWWMD should work with the watershed municipalities to update and improve their ordinances and comprehensive plans to regulate development in a manner that protects and conserves water resources.

The LWWMD should work with the watershed municipalities to ensure that their existing and future ordinances and plans are being implemented properly. Developing progressive and well-designed planning documents is futile if they are not well implemented. Ordinance definitions must be clear, concise, and accurate for ordinances to be effective. All environmental regulation definitions should be checked and revised as necessary. Particular attention should be given to the definition of “wetlands” and “waters” as well as methodology for their delineation.

<u>Ordinances</u>

The development and implementation of municipal planning, ordinances, and regulations that help protect the quality of Lake Wallenpaupack should be encouraged in each watershed township. The following ordinances should be considered for each township:

Stormwater Ordinance: Restricts stormwater runoff from new development sites, requiring the maintenance of pre-development conditions. The adoption and implementation of a municipal stormwater ordinance should top the list of priorities for each watershed township. The townships should adopt the model Pennsylvania Department of Environmental Protection (PADEP) Municipal Stormwater Ordinance, under USEPA's Phase II stormwater rules.

Tree Ordinance: Preserves the mature trees in each watershed township. In addition, the ordinance should include provisions to limit the size, type, and number of trees that can be cut within a buffer zone of any water body. This will help to preserve the riparian buffers along the lakes and streams in the watershed that help to stabilize streambanks, filter nutrients in stormwater runoff, maintain proper water temperature, provide habitat, and contribute leaf litter to streams that many stream organisms require for food or shelter.

Riparian Buffer Ordinance: Requires vegetated buffers along wetlands, streams, and lake and pond shorelines for all new construction projects. A buffer of approximately 75 feet should be sufficient to protect water quality along wetlands and streams. A 50-foot buffer is more realistic for lake and pond shorelines. The purpose of the riparian buffer would be to (1) eliminate major earthmoving activities close to the waterbody, (2) filter and infiltrate stormwater runoff before it reaches the water, and (3) maintain stabilized streambanks and shorelines to prevent erosion. It is recommended that the Riparian Corridor Conservation District Model Ordinance developed by Montgomery County, Pennsylvania be modified and adopted for use in the Bushkill Creek Watershed. A summary of the model ordinance is provided in Appendix I.

Steep Slopes Ordinance - Regulates the development intensity in areas of steeply sloping terrain to limit soil loss, erosion, excessive stormwater runoff, degradation of surface water, and to maintain the natural topography and drainage patterns of the land.

Natural Landscaping/Noxious Weed Ordinance: Promotes the use of native vegetation, including native grasses and wildflowers, in managed yards and landscapes to preserve and restore natural plant communities and discourage the colonization of noxious (non-native, invasive) weeds. It is important to include provisions for maintaining buffers in riparian and drainage areas so that the ordinance is not misinterpreted, resulting in removal of vegetation in such areas.

Pet Waste Ordinance: Requires pet owners to clean up after their pets and dispose of the waste in a proper trash receptacle for both water quality and aesthetic reasons. Pet waste can be a significant source of nutrient loading to water bodies when it is washed into surface waters from residential areas with stormwater runoff.

Wildlife Feeding Ordinance: Bans residents or visitors from feeding or otherwise encouraging nuisance wildlife congregation. As with pet waste, droppings from wildlife such as Canada geese can be a significant source of nutrient and bacteria loading to water bodies. Feeding waterfowl and other wildlife encourages resident populations.

Groundwater Protection Ordinance: Protects public health and safety by minimizing contamination of shallow/surficial aquifers, and preserving and protecting existing and potential sources of drinking water supplies.

<u>Open Space Planning</u>

Open space is defined as land which is not intensively developed for residential, commercial, industrial or institutional use. Open space can be either publicly or privately owned. It includes agricultural and forest land, public parks and preserves, vacant lots water bodies, and wetlands. Open space areas add natural beauty, provide recreational opportunities, provide wildlife habitat, and protect natural hydrological flows. Open space areas often increase the property values of surrounding areas. While larger developments often receive more attention, smaller developments are slowing consuming open space in the Lake Wallenpaupack watershed, and encroaching upon important natural and recreational systems highly valued by the community.

Each of the Townships in the Lake Wallenpaupack watershed should develop Open Space Plans that establish a framework by which the municipalities can: 1) inventory and evaluate natural areas and important open space, 2) prioritize areas for protection, and 3) match high-priority sites with appropriate protection and management strategies.

Greenways Planning

The goal of Greenways Planning is to concentrate new development in existing developed areas, and to restore and protect open space areas around the rivers, lakes, and ridges as interconnected, undeveloped "greenways." A Greenways Plan for the Lake Wallenpaupack watershed could employ a "hub and spoke" concept, wherein the lake serves as a hub, or concentrated recreation area, with multiple spokes (river corridors) connecting other recreational areas. Using this concept, headwater areas and riparian buffers will be preserved, recreational opportunities will be enhanced within the watershed, sustainable growth patterns will be established, and watershed protection education opportunities among watershed residents will be increased.

A Greenways Plan could be developed by the LWWMD, and adopted by each of the municipalities and all four counties in the Lake Wallenpaupack watershed should pass a resolution to adopt the Two Rivers Area Greenway Plan. Such a Plan will only be effective with widespread participation, since the connectivity of greenway areas in neighboring municipalities is critical for the success of the program. The Greenways Plan should include an action plan and information on potential funding sources for the implementation of the plan.

Comprehensive Planning

The Comprehensive Plan encompasses, as the name suggests, all relevant township planning for a desired predetermined period into the future. A well developed Comprehensive Plan should call for other plans and measures discussed in this section, as well as many other municipal needs which are not necessarily environmentally connected. Each of the Townships in the Lake Wallenpaupack watershed should develop or revise their Comprehensive Plans to incorporate measures intended to protect the Lake Wallenpaupack watershed, including the implementation of the ordinances and Plans listed above.

4.3 Agriculture Management

Nonpoint source pollution from agricultural runoff is a source of nutrient (phosphorus and nitrogen) and sediment loadings to Lake Wallenpaupack. Pollutant loadings from agricultural land uses can be reduced by the implementation of both traditional and innovative agricultural best management practices. A number of successful agricultural management BMPs have already been installed in the Lake Wallenpaupack watershed, including rock-lined channels, manure storage facilities, water control structures, revegetation and improved horticultural practices, and nutrient management plans. The LWWMD should continue to pursue funding to implement additional agricultural BMPs in the watershed, based on the documented nonpoint source problem areas documented during the watershed investigations.

Agricultural BMPs should include conservation tillage, integrated pest management, contour farming, critical area planting, terracing, strip cropping, crop rotation, grade stabilization structures, streamside fencing, buffer strips, stormwater diversions, drainage facilities, livestock watering and feed facilities (loafing pads), planned grazing systems, optimum fertilization practices, and nutrient and conservation management plans.

A number of programs are available to help landowners fund BMPs on their own property. These programs are federally-funded United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) programs administered through the County Conservation Districts. The programs include the Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentive Program (WHIP), and Wetlands Reserve Program (WRP).

4.4 Silviculture Management

The control of nutrients and sediments from both large and small timber operations within the Lake Wallenpaupack watershed is essential for improving the water quality in Lake Wallenpaupack. When properly implemented, forestry management practices will reduce erosion and sedimentation during timbering operations and will ensure the regeneration of forest stands following the timbering operations. The three components of good forest management include proper planning, proper forest operations, and protection of existing and future forest values. Erosion and sedimentation pollution control plans should be required for all logging and timber operations within the Lake Wallenpaupack watershed.

More specifically, timbering best management practices such as properly designed, stabilized, and adequately drained logging roads, skid trails, and log landings, sediment basins, stream crossings, culverts, diversion ditches, storm drain systems, grassed waterways, stream crossings, water bars, and forest buffers should be implemented in accordance with Pennsylvania's Special Protection Waters Handbook. Timbering should only take place during dry seasons. Timbered land reclamation and retirement efforts should be required including constructing water bars, mulching and seeding logging roadways and all disturbed areas, and replanting stream buffers.

The Healthy Forests Reserve Program (HFRP) is a federally-funded voluntary cost share/ easement program established for the purpose of restoring and enhancing forest ecosystems to 1) promote the recovery of threatened and endangered species, 2) improve biodiversity; and 3) increase vegetative cover. Forest landowners should be encouraged to contact their County Conservation District to find out about this program.

4.5 Aquatic Ecosystem Restoration

Aquatic ecosystems such as lakes, streams, and wetlands are critical to the health of a watershed. Aquatic ecosystems not only provide plant and animal habitat, they also help preserve water quality, reduce flooding, and recharge groundwater. Structural and vegetative erosion control measures reduce the quantity of sediment washing off streambanks and shorelines and entering the water. Vegetation on slopes retards runoff, traps sediment, and filters nutrients and other pollutants as stormwater moves toward lakes, streams, and wetlands. Shoreline and streamside vegetation dissipates the erosive energy of waves and stream currents.

Streambank and shoreline re-vegetation projects can greatly improve bank stability and reduce erosion. A Homeowner’s Streambank and Shoreline Restoration Handbook is available on the LWWMD website at http://www.wallenpaupackwatershed.org.

4.5.1 Streambank Restoration

Streambank erosion is one of the major sources of nonpoint source pollution in watersheds. Certain nutrients as well as many other “pollutants” adhere to eroded soil particles and are transported to the streams and downstream surface waters. Restoration of eroded streambanks is a cost-effective way to significantly reduce sediment and nutrient loadings to Lake Wallenpaupack. By using bioengineering (vegetative) or a combination of bioengineering and structural engineering streambank stabilization techniques, the erosion problem can be corrected while the stabilized streambank can serve as a vegetative buffer and, in many cases, a restored riparian corridor. Riparian buffers along the streams will reduce the quantities of sediments and nutrients that enter the streams via stormwater runoff.

Adequately vegetated or buffered streams remove pollutants from stormwater runoff. In addition to pollutant removal, stream buffers reduce water temperature, maintain stream flow during dry seasons, stabilize streambanks, decrease erosion potential, provide valuable wildlife habitat, provide improved in-stream aquatic habitat, provide flood control, and enhance the natural landscape by providing visually appealing “green belts.”

A variety of methods are designed to stabilize eroded streambanks and reduce continued erosion and sedimentation. Some methods reduce the amount and velocity of water in the stream, others involve relatively high cost structural controls such as rip-rap and gabions, and still others involve relatively low-cost controls such as willow twigs, grasses, shrubs, or wetland vegetation. Lower cost, bioengineering approaches should be used wherever practical to stabilize the severely eroded streambank areas noted on the nonpoint source problem area map. Where warranted, a structural stabilization element should be included in the overall project design to ensure long term stabilization and to provide adequate protection against high streamflows and high flow velocities.

A permanent wooded buffer along all streambanks is the most desirable buffer to provide stable ground cover and shading of the stream channel. Warm season grasses should be planted to establish an effective temporary buffer until the more permanent shrubby and woody buffer can become established. A narrow strip of warm season grasses should be maintained between the wooded buffer and any tilled fields to provide maximum filtration for agricultural runoff. In addition, for both existing and new development, the protection, development, and enhancement of stream buffers should be encouraged. A riparian stream conservation ordinance should be adopted by all the municipalities in the Lake Wallenpaupack watershed for this purpose.

Nonpoint source problem area #52
Streambank is in need of restoration

It is important for property owners within the Lake Wallenpaupack watershed to assess their properties for uncontrolled streambank erosion problems that may be contributing pollutants to Lake Wallenpaupack. A number of streambank erosion sites were documented during the watershed investigations (Section 3.1, Appendix B), and are shown on the nonpoint source problem area map in Appendix C. In particular, the problem area site on the East Branch of Wallenpaupack Creek (# 52) is a priority that should be targeted for restoration due to the severity of the problem and the likelihood of restoration success.

The LWWMD should seek funding through the PA DEP's Growing Greener program or other funding sources to repair the streambank erosion problem areas on a site-by-site basis. Priority should be given based on the severity of the problem, site accessibility, and the likelihood of success. However, care must be taken that streambank restoration projects are installed properly. If improperly installed, structural measures can result in more harm than good. Changing the geometry and flow patterns of a stream channel can result in severe upstream and downstream erosion problems. Complex structural projects should be undertaken with the assistance of a professional.

4.5.2 Shoreline Restoration

Waterfront property owners within the Lake Wallenpaupack watershed should assess their properties for shoreline erosion problems that may be contributing pollutants to Lake Wallenpaupack. Traditionally, most shoreline stabilization projects have used structural methods. Concrete barriers, bulkheads, rock riprap and other hard structures are still used to prevent water from coming into contact with the land or to prevent eroded sediment from entering the water. Although these methods are sometimes effective and provide immediate results, they are quite costly, difficult for homeowners to implement on their own, and do not provide wildlife benefits. Concrete structures do not filter water or take up nutrients like vegetation. Without the stabilizing root structures of vegetation, topsoil is still lost above the structural barrier.

Over the last 20 years, restoration practitioners have pioneered the use of native vegetation and other natural materials to achieve stabilization without the negative consequences of structural stabilization. These new methods closely replicate the natural state of the streambank or shoreline environment, providing hydrological, ecological, and aesthetic benefits that structural methods do not.

Soil bioengineering combines traditional engineering methods with the use of vegetation and natural materials to achieve streambank and shoreline protection. Bioengineering techniques generally cost less than structural techniques and unlike, structural measures, improve with time. Bioengineering projects restore the natural look and feel of a shoreline habitat. The result is not only an attractive property feature, but improved wildlife habitat, water quality, and fish habitat. Many homeowners may be hesitant about conducting a bioengineering project by themselves. In this case, the homeowner can consult with a design professional to assist with the project.

Mangan Cove shoreline erosion project before stabilization

Shoreline erosion stabilization and stable boat access at Kingston property

As described in Section 3.1.3, two separate shoreline erosion surveys were conducted in the Lake Wallenpaupack watershed. The shoreline erosion problem areas listed in Appendix B and shown on Map 1 in Appendix C should be stabilized using bioengineering techniques wherever possible. PA DEP Growing Greener grant funds should be pursued to fund the shoreline restoration projects.

In addition, PPL should be encouraged to maintain a more steady lake level in order to reduce shoreline erosion problems. When the lake level increases and decreases frequently, it causes erosion along the shoreline. Fewer lake level changes would cause less erosion.

4.5.3 Wetlands Protection and Restoration

Many natural wetlands still exist in the Lake Wallenpaupack watershed, especially along the main stream channels. Approximately 11 percent of the watershed is either open water or wetland land-use. Natural wetlands provide a critical ecological benefit to the watershed by filtering stormwater runoff, reducing flood potential, and providing habitat for both aquatic and terrestrial wildlife species.

All natural wetland areas within the Lake Wallenpaupack watershed should be preserved and protected from impacts of development, pollution, and invasive/exotic species. Protective vegetative buffers should be maintained around all wetland areas to protect the functionality and quality of the wetlands. The width of wetland buffers should be based on the quality of the wetlands and should vary between 50 to 150 ft extending outward from the edge of the wetlands as delineated by a qualified professional wetlands scientist. Residents should be educated on the values of wetlands and should be discouraged from removing trees or vegetation from them. Wetlands should not be filled, excavated, or developed unless proper permits have been obtained from both the Pennsylvania Department of Environmental Protection and the United States Army Corps of Engineers. Once a wetland is destroyed, it is very costly to re-construct and a reconstructed wetland never functions quite the same way as a natural wetland.

4.6 In-Lake Management

Although watershed management practices are most likely the best means of reducing nonpoint source pollution and improving the water quality in Lake Wallenpaupack, in-lake management options should be considered as well. The recommended in-lake options are discussed below.

4.6.1 Lake and Watershed Monitoring

Lake Wallenpaupack has been monitored during every year from 1980 through 2006. This extensive long-term monitoring database has allowed for analyses of trends in water quality. Continued monitoring will allow any future water quality trends to be easily detected.

The stream monitoring program initiated as part of the EPA Grant project should be continued as long as funding allows. The automated samplers are still in place and would only require funding for power, sample analysis, and data analysis. Long-term monitoring of the inflow streams would be extremely beneficial in documenting any lake improvements from the installation of BMPs in the watershed.

4.6.2 Macrophyte Survey

A macrophyte (aquatic plant) survey was performed in Lake Wallenpaupack in 1989 but since then no formal survey has been completed. An updated, comprehensive macrophyte survey should be performed throughout Lake Wallenpaupack, paying special attention to the cove and inlet areas. The goal of the survey should be to document the species composition and extent of aquatic plant populations in the lake, and to detect the presence of any non-native, invasive species such as Eurasian watermilfoil, water chestnut, curly-leaf pondweed, or any other invasive aquatic plants. If any invasive species are found, appropriate management measures should be immediately initiated. A macrophyte survey should be performed at the lake at least every five years, or even more frequently if invasive species are found.

4.6.3 Fisheries Survey

The fishery in Lake Wallenpaupack is diverse and includes cold, cool, and warmwater species, including several species of sport fish, as described in Section 2.4.8. According to the Lake Wallenpaupack Long-Term Monitoring Report, there is no apparent relationship between percent composition of zooplankton in Lake Wallenpaupack with water chemistry, phytoplankton abundance, or climate. However, zooplankton populations have been diminishing in both mean length and quantity in recent years, and it is therefore suspected that the lake's fishery may be unbalanced, dominated by smaller forage fish such as alewives. Alewives feed extensively on zooplankton, and can be present in large schools. Although they are a native species, they are not always a welcome addition to a lake because they compete with the young of other fishes for food and they eat larval fish. The LWWMD should work together with the PAFBC to conduct an updated fisheries survey for Lake Wallenpaupack.

It is possible that biomanipulation of the lake via eliminating certain fish species or restructuring the fish community to improve the zooplankton population may be effective in Lake Wallenpaupack. Biomanipulation seeks to control algal blooms by increasing zooplankton populations to promote heavy grazing of algae.

4.6.4 Lake Operation

As mentioned in Section 4.5.2 above, PPL should strive to reduce frequent fluctuations in lake levels in order to reduce shoreline erosion around the lake. In addition, suggestions have been made in past PAFBC reports in regards to the re-licensing of PPL's hydro-station. One such recommendation is to allow continuous coldwater discharge during the summer so the lake can maintain normal discharge levels. Another suggestion is to install fish screens on the withdrawal tube.

4.7 Public Education and Outreach

Public education and public participation are important aspects of any lake and watershed management program. The development of environmental education programs designed for school-aged children and adults is an effective watershed management approach. The LWWMD should publicize and encourage citizen involvement and practices benefiting the watershed whenever possible. This will serve the dual purpose of improving stakeholder involvement within the watershed, and increasing the LWWMD's visibility within the community.

A comprehensive environmental education program was developed as part of the FY1998 and FY1999 EPA Grant projects. The materials and information produced as part of these grants should be utilized to their fullest extent. The LWWMD should continue to implement watershed public education programs, including the following programs and activities:

1. Disseminate the fact sheets and brochures developed under the EPA Grant projects, including the Household Products and Lawn and Garden Care fact sheets, LWWMD flyer, and Aquatic Ecosystem Restoration, Stormwater Management, Watershed Management brochure, and Best Management Practices brochures. Donations of copying services or printer cartridges should be sought for printing the brochures. Brochures can be disseminated at area events or as "extras" in the newspapers.

2. Create a brief flyer discussing homeowner streambank and shoreline restoration measures that directs the reader to the Lake Wallenpaupack Homeowner

Streambank and Shoreline Restoration Handbook posted on the LWWMD website.

3. Continue to work with the Wallenpaupack Area School District to implement the existing watershed management curriculum and direct field activities for area-wide schools, nature centers, and summer camps.

4. Periodically write columns for the local newspapers or magazines on watershed management issues.

5. Develop an online newsletter that can be emailed to watershed stakeholders on a monthly basis.

6. On an annual basis, present the Create-an-Ecosystem workshops developed under the FY1999 grants to first through eighth grade students in the Wallenpaupack Area School District. Donations of copying services or printer cartridges should be sought for printing the presentation handouts.

7. Conduct additional watershed education workshops for township officials, township staff, municipal engineers, area-wide consulting firms, planners, surveyors, developers, realtors, and homeowners.

8. Conduct volunteer lake monitoring workshops on an annual basis in order to encourage area watershed associations to monitor their lakes and add to the Lake Wallenpaupack watershed water quality database.

9. Create a developers certification program that would require developers to undergo a training program in low-impact development techniques and a commitment to protect and respect critical natural resources. The certification program could provide marketing and branding appeal to developers looking to distinguish themselves among consumers and municipalities.

10. Coordinate with local realtors to distribute educational “Welcome to the Watershed” materials to new home buyers and renters,

11. Install signs informing drivers that "You Are Entering/Leaving the Lake Wallenpaupack Watershed" placed strategically along roads in the watershed to raise awareness of watershed protection issues among the local population and visitors alike.

12. Install watershed education signs and/or kiosks at public boat launches to forge an awareness of the relationship of the watershed to the water quality of Lake Wallenpaupack.

5.0 Implementation Strategies

5.1 LWWMD Capacity Building and Organizational Development

Because the LWWMD is the key organization for carrying out the Lake Wallenpaupack Watershed Management Plan, the maintenance of a strong organization is central to its ability to effectively implement the Plan. The LWWMD needs to focus direct attention to organizational development in several key areas including membership, fundraising, organizational structure, partnerships, and technical capacity. The LWWMD should develop an Organizational Development Plan to serve as a companion document to the Watershed Management Plan that specifically addresses these needs. The following broad recommendations should be included in the Organizational Development Plan:

- Create a newsletter, to be sent out quarterly online and/or in print, for disseminating information about the organization, Lake Wallenpaupack, and its watershed activities,

- Create a sustainability plan to ensure that the LWWMD does not rely only on grants for major funding,

- Hold an annual fundraising event such as an annual dinner or banquet to increase public visibility and guarantee an annual revenue stream,

- Create a corporate membership program – directly target corporate contributions and memberships, including area marinas, restaurants, inns, and other prominent local businesses.

- Disseminate existing brochures created under the EPA Grant projects and participate in educational events such as field days in order to improve the LWWMD's visibility in the community,

- Build in-house technical capacity by sending LWWMD staff and officers to conferences for both networking and educational purposes,

- Periodically sponsor a developer's roundtable that would allow a dialogue between area developers, planners, natural resource professionals, and other stakeholders concerning ways that these groups can work collaboratively to achieve common and individual goals,

- Strengthen ties to key partners; specifically, the County Conservation Districts, watershed municipalities, property owners associations, land trusts, hunting and fishing groups, planning commissions, and funding agencies (PA DEP, U.S. EPA, PA DCNR), and

- Encourage each watershed municipality to form an Environmental Advisory Council. The LWWMD should have at least one member on each township EAC to provide a liaison between the LWWMD and municipal governance.

The Organization Development Plan should also include a section on fundraising, as discussed in section 5.2.

5.2 Fundraising

5.2.1 User Fees

The LWWMD should develop a lake user fee system to provide stable, long-term funding of the LWWMD's activities.

5.2.2 Grant Programs

A list of possible funding sources for implementing the Lake Wallenpaupack Watershed Mangement Plan is provided in Table 5.1. The three primary funding sources for implementing the Plan are the Pennsylvania Department of Environmental Protection (PA DEP) Growing Greener Program, the EPA's 319 Nonpoint Source Program, and the Pennsylvania Department of Conservation and Natural Resources (PA DCNR) Community Conservation Partnership Program (C2P2) Grants. The Growing Greener Program provides funding to perform watershed protection projects, implement best management practices, and develop public education programs. The 319 Nonpoint Source program is administered in Pennsylvania through the Growing Greener Program, and provides funds for watershed management projects and public education programs. The PA DCNR C2P2 Grants fund parks and recreation planning, public recreation area improvements, and land acquisition of critical natural areas.

Table 5.1 **Possible Funding Sources for Lake Wallenpaupack Watershed**		
Name of Grant Program	**Description of Grant Program**	**Administering Agency**
Growing Greener	Funds watershed assessments, watershed organization development, technical assistance, watershed protection or restoration implementation, and education/outreach programs	PA DEP
319 Nonpoint Source Grants	Funds watershed management and public education projects	US EPA
C2P2 Community Conservation Grants	Funds land acquisition for public open space areas, park and recreation projects, municipal master planning, and natural area inventories.	PA DCNR
Conservation Reserve Enhancement Program (CREP)	Provides cost-share payments for installation of riparian buffers and conservation easements on farms	PACD
Wetlands Reserve Program (WREP)	Provides cost-share payments for placing wetlands under conservation easements	USDA
Flood Control Grants	Flood management projects	US NRCS
Watershed Protection and Flood Prevention (Small Watershed) Grants	Funds watershed improvements (watershed protection, flood prevention, sedimentation control, habitat enhancement, and recreation planning) in watersheds less than 250,000 acres.	USDA NRCS
PA Flood Protection Programs	Funds design and construction of flood protection projects that are justifiable under state capital budget process.	PA DEP Bureau of Waterways Engineering
PA Department of Community and Economic Development Grants	Various community-based grants, including: Intermunicipal Projects Grants, Industrial Sites Reuse Program (Brownfields) Grants, Land Use Planning and Technical Assistance Program, Local Government Capital Projects Loan Program, Municipalities Financial Recovery Act Program	PA DCED
PA Infrastructure Investment Authority (PennVest) Loans	Low-interest loans for repair of on-lot septic systems, and improvement of community drinking water and wastewater facilities	Penn Vest
Act 537 Sewage Facility Planning Grants	Grants for up to 50% of the costs to prepare or update a municipal Act 537 Plan	PA DEP Bureau of Water Supply
Act 167 Stormwater Management Grants	Funds stormwater planning and ordinances for cooperative efforts between municipalities at the watershed level	PA DEP Bureau of Watershed Conservation

Table 5.1 **Possible Funding Sources for Lake Wallenpaupack Watershed**		
Name of Grant Program	**Description of Grant Program**	**Administering Agency**
Rivers, Trails, and Conservation Assistance Program	Funds conservation planning, trail development, and greenways development	National Park Service
PA Recreation Trails Funding	Programs that fund acquisition and development of recreation trails via National Recreational Trails Funding (Symms NRTA) and Rails to Trails Program	PA DCNR
Land and Water Conservation Fund	Provides matching grants to state and local governments for the acquisition and development of outdoor public recreation areas and facilities	National Park Service and PA DCNR
Nutrient Management Plan Development Incentive Program	Grants to farmers for preparing nutrient management plans; low-interest loans to implement agricultural BMPs	County Conservation District
Agricultural Conservation Easement Purchase Program	Provides funds for the purchase of development rights on farmland to ensure that land will be available for agricultural use indefinitely	PA Bureau of Farmland Preservation
Rivers Conservation Program	Funds implementation of approved conservation plan	PA DCNR
Forest Legacy Program	Federal program in cooperation with state foresters. Supports property acquisition and conservation easements in sensitive forest lands	USDA Forest Service
Stream Improvement Program	Provides design and construction assistance to eliminate imminent threats to flooding and streambank erosion	PA DEP Bureau of Waterways Engineering

5.3 Priority Action Plan

The following actions are recommended for improving the water quality in Lake Wallenpaupack:

1. The municipalities in the Lake Wallenpaupack watershed should update their Act 537 Sewage Facilities Plans to ensure adequate wastewater planning for potential residential, commercial, and industrial development. In particular, Dreher, Lake, Lehigh, Madison, Palmyra (Wayne Co.), and Sterling Townships have Act 537 Plans that are greater than 20 years old that are in need of updating.

2. Decentralized wastewater recommendations should be included in municipal ordinances, comprehensive plans, and Act 537 Plan revisions in the Lake Wallenpaupack watershed. Palmyra Township is currently updating their Act 537 Plan to include decentralized wastewater treatment facilities.

3. The LWWMD should continue to maintain a good relationship with the operators of the wastewater treatment facilities within the watershed, monitor the DMRs for each treatment plant, and encourage the facility owners to continue to maintain their equipment and upgrade their systems as necessary.

4. Stormwater best management practices (BMPs) should continue to be implemented in developed areas of the Lake Wallenpaupack watershed, in accordance with the Pennsylvania BMP Manual. The BMPs should be able to not only store and slow stormwater flows, but should also provide water quality treatment. Nonpoint source problem areas in need of stormwater BMPs are listed in Appendix B and shown on Map 1 in Appendix C.

5. Wherever possible, Low-Impact Development (LID) techniques should be encouraged or required for new development in the Lake Wallenpaupack watershed.

6. The LWWMD, Conservation Districts, and watershed residents should monitor new construction sites in the watershed to make sure Erosion and Sedimentation Pollution Controls are being properly used.

7. The Act 167 Stormwater Management Plan for the Lake Wallenpaupack watershed should be updated. The update should include provisions to encourage Low-Impact Development.

8. Each municipality in the Lake Wallenpaupack watershed should adopt the model stormwater ordinance from the Pennsylvania NPDES Phase II regulations and the updated Act 167 Plan.

9. The LWWMD should work with the watershed municipalities to update and improve their ordinances and comprehensive plans to regulate development in a manner that protects and conserves water resources. In particular, the following ordinances and plans should be considered for development and implementation: stormwater ordinance, tree ordinance, riparian buffer ordinance, steep slopes ordinance, natural landscaping/noxious weed ordinance, pet waste ordinance, wildlife feeding ordinance, groundwater protection ordinance, Open Space Plan, Greenways Plan, and Comprehensive Plan.

10. The LWWMD should continue to pursue funding to implement additional agricultural BMPs in the watershed, based on the documented nonpoint source problem areas identified during the watershed investigations (See Appendix B and C).

11. Erosion and sedimentation pollution control plans should be required for all logging and timber operations within the Lake Wallenpaupack watershed, and silvicultural BMPs should be implemented in order to reduce nutrient and sediment loadings to Lake Wallenpaupack.

12. LWWMD should seek funding through the PA DEP's Growing Greener program or other funding sources to repair the streambank and shoreline erosion problem areas in the Lake Wallenpaupack watershed (See Appendix B and C). Whenever possible, bioengineering and natural channel restoration techniques should be used in the restoration process.

13. Waterfront property owners within the Lake Wallenpaupack watershed should assess their properties for shoreline erosion problems that may be contributing pollutants to Lake Wallenpaupack. Property owners should work with LWWMD, PPL, and their County Conservation Districts to address these problems. A Homeowner's Streambank and Shoreline Restoration Handbook is available on the LWWMD website at http://www.wallenpaupackwatershed.org.

14. Protective vegetative buffers should be maintained or restored along all wetlands and streams in the watershed to reduce streambank erosion and protect the functionality and quality of the wetlands.

15. The LWWMD should continue monitoring Lake Wallenpaupack and its tributaries in order to maintain the long-term water quality database.

16. An updated, comprehensive macrophyte survey should be performed throughout Lake Wallenpaupack, paying special attention to the cove and inlet areas. The goal of the survey should be to document the species composition and extent of aquatic plant populations in the lake, and to detect the presence of any non-native, invasive species.

17. The LWWMD should consider working with the PA Fish and Boat Commission to conduct an updated fisheries survey for Lake Wallenpaupack. If possible, a biomanipulation study should be performed as well.

18. PPL should strive to reduce frequent fluctuations in lake levels in order to reduce shoreline erosion around the lake. In addition, PPL should allow continuous coldwater discharge during the summer so the lake can maintain normal discharge levels.

19. The LWWMD should continue to implement watershed public education programs using the environmental education materials developed as part of the FY1998 and FY1999 EPA Grant projects.

20. The LWWMD needs to focus direct attention to organizational development in several key areas including fundraising, organizational structure, partnerships, and technical capacity. The LWWMD should develop an Organizational Development Plan to serve as a companion document to the Watershed Management Plan that specifically addresses these needs.

21. The LWWMD should seek funding via existing grant programs and private donations for their ongoing lake protection and restoration efforts. In addition, LWWMD should develop a funding source via boating user fees to provide a steady source of revenue.

22. The LWWMD should develop a lake user fee system to provide stable long-term funding for the LWWMD's activities.

6.0 References

Barr Engineering Co. 2004. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds, Volume 1: Executive Summary and Report. Prepared for the Minnesota Pollution Control Agency.

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Appendix A

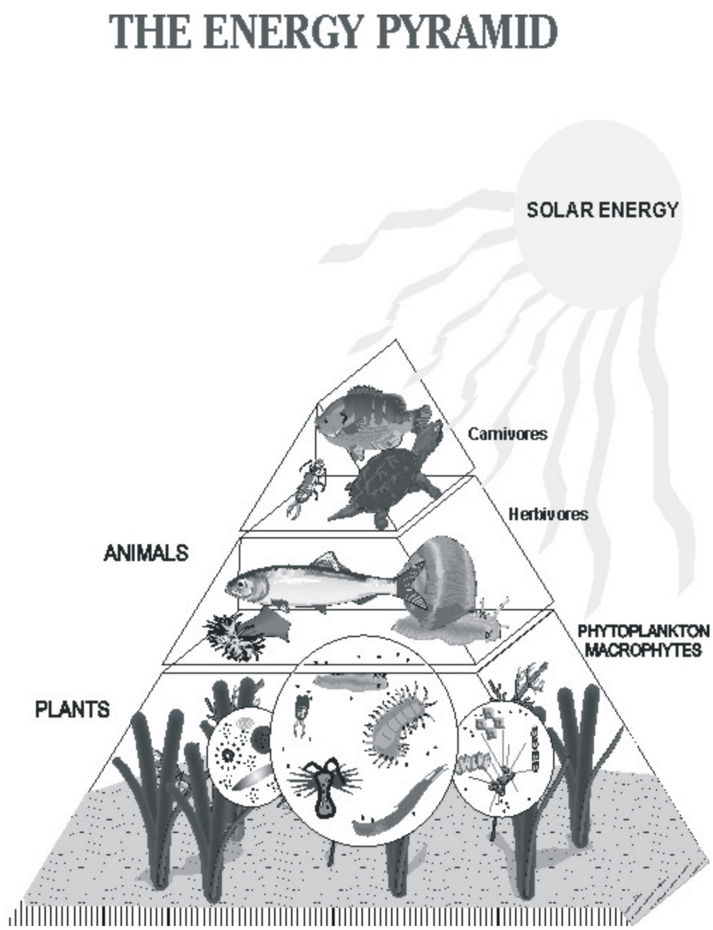
Lake Ecology and Watershed Management Primer

Lake Ecology and Watershed Management Primer

Ecological Cycle

In a lake, a basic ecological cycle exists. Nutrients such as phosphorus and nitrogen along with sunlight are used by aquatic plants - algae (microscopic aquatic plants) and macrophytes (large aquatic plants) - to grow. Small aquatic animals such as invertebrates (rotifers, protozoa, etc.), snails, and insects eat the algae and reproduce. Small forage fish eat the small animals, and in turn are eaten by larger game fish and other animals.

In a healthy lake, there is a balance to this ecological system. However, when too many nutrients enter a lake, the algae and/or large aquatic plants grow to a point of excess.



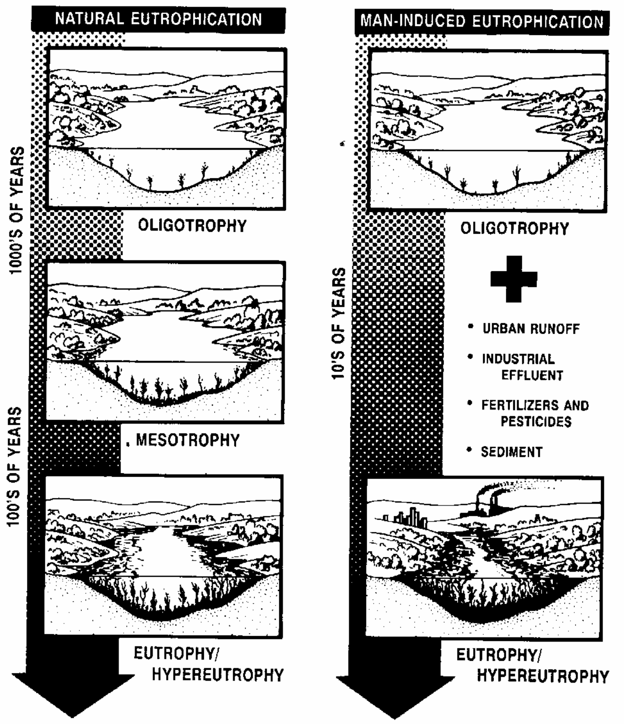
When the small animals eat all of the algae and weeds in a lake and are in turn eaten by the small and large fish, then the lake has a healthy fishery. This relationship is called the ecological pyramid. With a larger algae population, one would expect a larger population of fish. But the problem is that the excessive plant life is not transferred up the food chain. The small aquatic animals do not eat much of the excess algae (they do not like some of the algae, especially the blue-green algae). Therefore, algae and other plants build up in the lake, which destroys the ecological balance in the lake. This can result in a reduction in the fish population. It often results in a change in the type of fish found in the lake.

In order to understand the processes that occur in a lake, we must first understand the concept of lake succession or aging.

Lake Succession Over Time

All lakes go through an aging process called ecological succession. It is a natural process whereby a lake starts out as an "ecologically" young lake with little vegetation (such as algae and aquatic plants), low nutrients, clear water, and very little unconsolidated (loose) sediment on the bottom. It should be noted that ecological age is different than chronological age. The chronological age is simply the number of years a lake has existed. The ecological age is a measure of the physical, chemical, and biological conditions of a lake. A lake may be young in chronological years (i.e. built only 3 years ago) but it could be ecologically old in the sense of having lots of algae and aquatic plants and bottom sediments.

As a lake ages, more nutrients and sediments enter the lake due to erosion and stormwater runoff from the lake's watershed. As nutrients and sediments enter a lake, several things occur. First, the additional nutrients, such as phosphorus and nitrogen, cause an increase in the amount of algae and aquatic weeds. Second, the additional sediment entering the lake settles to the bottom of the lake, increasing the amount of sediment on the lake's bottom.



Thus as a lake ages, it slowly starts to fill up with sediments, algae and aquatic weeds. Initially, the aquatic vegetation is submergent vegetation, beneath the water surface. As the lake fills up further with sediment, emergent vegetation appears above the water surface.

Ultimately, the lake fills in completely with incoming sediment from the watershed and from dead algae, aquatic plants, and animals. The lake transforms into a pond or swamp and eventually, over hundreds or thousands of years, into a forest.

Lake Aging

Lake succession or aging is a natural process that occurs in all lakes. However, the influence of man's activities in the watershed can significantly accelerate the aging process.

The lake aging process is accelerated by:

Wastewater Treatment Plant Discharges
Malfunctioning Septic Systems
Agricultural Activities (cropland and pastureland)
Construction Activities
Developed Land
Roadways
Streambank Erosion
Landfills

Human activities in a watershed can contribute sediments and nutrients (phosphorus and nitrogen) to a lake, resulting in accelerated aging or what is known as "cultural eutrophication". Human-induced influences can significantly increase the rate at which a lake ages.

Lake Classification

Lakes are classified by the amount of nutrients (or food) contained in the lake. The Greek word for food is “trophic”. Therefore, lakes are classified by their “trophic” or food/nutrient state. For example:

Oligo = little (few nutrients)
Meso = medium (moderate amounts of nutrients)
Eu = too much (too many nutrients)

The trophic state refers to the “ecological” age of the lake, not its chronological age. An oligotrophic lake is a lake that is ecologically young. A eutrophic, or ecologically old lake, could be only two years old.

Lakes are classified by nutrient level and the presence of aquatic plants as described below.

Oligotrophic lake
- ecologically young lake
- low level of nutrients
- low population of algae and aquatic plants

Mesotrophic lake
- ecologically middle-aged lake
- moderate level of nutrients
- moderate population of algae and aquatic plants

Eutrophic lake
- ecologically old lake
- high level of nutrients
- high population of algae and aquatic plants

Lake Problems

Excessive amounts of nutrients entering a lake from its watershed cause algae blooms, excessive aquatic plants (macrophytes), lake siltation (settling of sediments in lake, loss of lake volume and capacity), and fishery problems (low dissolved oxygen levels change the fish populations from game fish species to undesirable fish species such as carp). This results in loss of recreation and other lake uses, and can reduce property values around the lake.

Lake problems are caused by both point sources and nonpoint sources of pollution. Point sources are specific outlets or pipes such as the discharge from a wastewater treatment plant. Nonpoint sources cannot be traced to a specific point of origin, but are more diffuse. Nonpoint sources of pollution contribute overland runoff from the surrounding land uses, which carries nutrients and sediment into nearby receiving waters.

Appendix B

Nonpoint Source Problem Areas in the Lake Wallenpaupack Watershed

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
1	Paupack	Wayne	Shoreline	Many roots exposed with deep undercutting. Banks 4' high
2	Palmyra	Pike	Streambank	Unnamed direct tributary (intermittant) causing bank erosion at Chipmunk Drive Crossing
3	Palmyra	Pike	Stormwater	Roadside erosion. Problem identified in Spring 2003, Corrected with a new culvert when revisited in September 2006
4	Paupack	Wayne	Stormwater	Approximately 330 feet of roadside erosion along dirt road in Woodland Hills Association
5	Palmyra	Pike	Stormwater	Approximately 90 feet of eroded area along "square" ditch and scour erosion at the end of the culvert that crosses Coutls Road identified in Spring 2003. Problem appeared to be fixed in September 2006
6	Palmyra	Pike	Stormwater	Total of 440 feet of erosion along Lynns Hill Road in Spinner Point identified in Spring of 2003. Problem was corrected during September 2006 site visit.
7	Palmyra	Pike	Stormwater	16 feet of erosion along an unnamed dirt road.
8	Palmyra	Pike	Stormwater	500 feet of eroded roadside along dirt road off of Route 507 in Sunset Ridge
9	Palmyra	Pike	Stormwater	Approximately 65 feet of eroded roadside
10	Palmyra	Pike	Stormwater	Approximately 65 feet of eroded roadside along Paupack Point Road
11	Paupack	Wayne	Stormwater	150 feet of eroded road
12	Salem	Wayne	Stormwater	500 feet of eroded roadside along Cherry Street in Capri Estates. During initial visit, road was dirt but by September 2006, road was paved. Roadside swales still need stabilizing
13	Salem	Wayne	Stormwater	465 feet of eroding roadside swales. Sides of Terrace Drive , a dirt road, is are washing out.
14	Palmyra	Pike	Stormwater	75 feet of road washout along Route 507 below Tanglewood Lakes. In September 2006, the area was vegetated and deemed not a siginficant problem
15	Palmyra	Pike	Stormwater	270 feet of eroded roadside along Gumbletown Road

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
16	Palmyra	Pike	Stormwater	30 feet of erosion along side of road at bottom of hill on Route 507
17	Palmyra	Pike	Stormwater	60 feet of roadside erosion identified during initial visit along Route 507 but fixed by September 2006 visit.
18	Paupack	Wayne	Stormwater	210 feet of 10-12 foot bank on side of road eroding along Paupack Point Road
19	Palmyra	Pike	Stormwater	Roadside erosion along Route 507
20	Salem	Wayne	Stormwater	25 feet of eroding swale along Ledgedale Road
21	Paupack	Wayne	Stormwater	105 feet of eroding swale along Finn Swamp Road
22	Palmyra	Pike	Stormwater	Road washout along dirt road that connects to Wallenpaupack Middle School Road
23	Palmyra	Pike	"Sewage"	Failing septic system along dirt road that connects to Wallenpaupack Middle School Road
24	Palmyra	Pike	Stormwater	15 feet of road and banks washed out along Route 390. Problem was no longer visible in September 2006
25	Palmyra	Pike	Stormwater	110 feet of eroding swale along Gumbletown Road near Fairview Lake.
26	Greene	Pike	Stormwater	105 feet of bank erosion along Old Greentown Road
27	Greene	Pike	Stormwater	585 feet of eroded roadway and stormwater runoff areas along Old Greentown Road
28	Greene	Pike	Stormwater	A township cinder area was eroding into a nearby stream during initial visit, but in September 2006, the cinder area was contained and the area was vegetated.
29	Greene	Pike	Stormwater	24 feet of erosion along Old Greentown Road.
30	Greene	Pike	Streambank	Erosion is occurring along Lake Paupack Drive and is entering the outlet stream of Lake Paupack directly.
31	Greene	Pike	Stormwater	16 feet of erosion along Lake Paupack Road
32	Greene	Pike	Stormwater	72 feet of erosion along Lake Paupack Road
33	Greene	Pike	Stormwater	1600 feet of erosion along dirt road near Sky View Lake

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
34	Greene	Pike	Stormwater	Stormwater runoff from forested area was causing erosion above and bleow a culver crossing Route 390 during initial investigations; however by April 2006 the problem was corrected.
35	Greene	Pike	Stormwater	108 feet of eroding swale along Sawmill Road at intersection of Roemerville Road
36	Greene	Pike	Stormwater	110 feet of swale that crosses Sawmill Road was eroded during initial investigation but was rocklined by April 2006. Also, a catch basin was installed.
37	Greene	Pike	Stormwater	15 feet of road and banks washed out along Route 390. Problem was no longer visible in September 2006
38	Greene	Pike	Stormwater	36 feet of bank eroding into culvert under German Valley Road
39	Greene	Pike	Stormwater	40 feet of erosion upslope of road culvert
40	Greene	Pike	Stormwater	180 feet of erosion along Mozzette Road
41	Greene	Pike	Stormwater	33 feet of erosion along Mozzette Road
42	Greene	Pike	Stormwater	35 feet of erosion along Mountain View Road initially found but was stabilized by Township by August 2006
43	Greene	Pike	Stormwater	165 feet of erosion along Mountain View Road initially found has been Stabilized by the Township by August 2006
44	Greene	Pike	Stormwater	10 feet of erosion along Mountain View Road initially found but was stabilized by Township by August 2006
45	Greene	Pike	Stormwater	Portion of Mountain View Road washed out during initial visit but fixed by August 2006
46	Greene	Pike	Stormwater	16 feet of Erosion along Lake Russel Road found during initial visit. New culverts were installed and the area is well vegetated during August 2006 visit
47	Greene	Pike	Stormwater	500 feet of erosion along Carlton Hill Road found during intial visit was well vegetated during August 2006 visit

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
48	Greene	Pike	Stormwater	Erosion along Lake Russel Road found during initial visit was well vegetated during August 2006 visit
49	Greene	Pike	Stormwater	42 feet of eroded swale along Pine Grove Road found during initial visit has be stabilized with riprap and vegetation by August 2006 visit
50	Dreher	Wayne	Stormwater	100 feet of eroded ditch along Route 196 found during initial visit was stabilzed with riprap by August 2006 visit
51	Dreher	Wayne	Streambank	60 feet of severe erosion along Wallenpaupack Creek
52	Dreher	Wayne	Streambank	420 feet of severe erosion with banks up to 10 foot high along Wallenpauapck Creek
53	Greene	Pike	Streambank	25 feet of eroded unnamed tributary to Wallenpaupack found during initial visit is now rocklined and well vegetated
54	Dreher/Greene	Pike/Wayne	Streambank	165 feet of moderate bank erosion up to 5 feet high along Wallenpaupack Creek
55	Dreher/Greene	Pike/Wayne	Streambank	420 feet of moderate erosion along Wallenpaupack Creek
56	Dreher/Greene	Pike/Wayne	Streambank	150 feet of erosion along Wallenpaupack Creek with undercutting of trees.
57	Greene	Pike	Stormwater	Roadside Erosion along Wallenpaupack Drive in Lake Wallenpaupack Estates
58	Greene	Pike	Stormwater	Stormwater runoff from various dirt roads in Legdedale that carry sediment directly to the lake
59	Greene	Pike	Stormwater	55 feet of erosion below culvert on Rier Dirve East in Lake Wallenpaupack Estates
60	Salem	Wayne	Stormwater	Roadside erosion throughout the Sterling Shore Development
61	Greene	Pike	Stormwater	500 feet of roadside and road erosion along dirt road in French Manor
62	Greene	Pike	Stormwater	17 feet of roadside erosion on Creamery Road
63	Greene	Pike	Stormwater	260 feet of erosion along Kuhn Road found during initial visit. Some culverts and catch basins had been instialled by August 2006 but more work needs to be done
64	Greene	Pike	Stormwater	24 feet of erosion along Kuhn Hill Road upslope of culvert crossing road.

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
65	Greene	Pike	Stormwater	18 feet of erosion along Old School House Road
66	Greene	Pike	Stormwater	95 feet of erosion along Bartleson Road near intersection of Beaver Dam Road
67	Greene	Pike	Stormwater	100+ feet of eroded ditch that crosses Bartleson Road
68	Dreher	Wayne	Stormwater	115 feet of erosion along Osborn Road
69	Greene	Pike	Stormwater	25 feet of erosion along a steep portion of Pine Grove Road was observed during initial visit. The area was well vegetated and rocklined by August 2006
70	Dreher	Wayne	Stormwater	750 feet of roadside erosion along Route 191 just upslope of Wallenpaupack Creek
71	Greene	Pike	Stormwater	390 feet of erosion along Route 447
72	Dreher	Wayne	Stormwater	27 feet of erosion along Route 191 was observed during initial visit was stabilized during August 2006 visit
73	Dreher	Wayne	Stormwater	12 feet of erosion at culvert inlet along Route 191
74	Dreher	Wayne	Stormwater	10 feet of erosion along Huckleberry Hill
75	Dreher	Wayne	Streambank	Streambank erosion at Route 196 bridge crossing on Wallenpaupack Creek
76	Greene	Pike	Stormwater	92 feet of erosion along Creamery Road that directs sediment directly to Wallenpaupack Creek was observed during initial visit. A new catch basins have been installed and no visible erosion was observed in August 2006
77	Greene	Pike	Stormwater	Erosion seen around a culvert on Carlton Hill Rd during initial site visit; still some minor erosion in 2006
78	Coolbaugh	Monroe	Streambank	Minor roadside erosion at stream crossing-trib to Wallenpaupack Creek-during initial visit; in 2006 erosion very minor
79	Dreher	Wayne	Stormwater	Erosion seen along side of Robinson Rd during initial site visit; well vegetated and road repaired in 2006
80	Dreher	Wayne	Stormwater	150 feet of roadside erosion along Rte 191 seen during initial site visit; road repaired and well vegetated in 2006

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
81	Dreher	Wayne	Stormwater	54 feet of erosion 10-12 feet high along Rte 191 during initial site visit; still severely eroded and in need of stabilization in 2006
82	Sterling	Wayne	Stormwater	225 feet of erosion along Maple Grove Rd seen during initial site visit; rock lined areas and vegetation seen in 2006
83	Sterling	Wayne	Stormwater	60 feet of eroded bank seen along Maple Grove Rd during initial site visit; well vegetated in 2006
84	Sterling	Wayne	Stormwater	20 feet of eroded hillside along Neville Rd. seen during initial site visit; well vegetated during 2006
85	Sterling	Wayne	Stormwater	165 feet of eroded ditch seen along Sepko Rd during initial site visit; well vegetated in 2006
86	Madison	Lackawanna	Stormwater	250 feet of eroded roadside along Rte 690
87	Salem/Sterling	Wayne	Streambank	135 feet of eroded streambank along Wallenpaupack Creek
88	Salem/Sterling	Wayne	Streambank	240 feet of eroded streambank along Wallenpaupack Creek, undercutting occurring
89	Salem/Sterling	Wayne	Streambank	400 feet of eroded streambank along Wallenpaupack Creek, at one point erosion 10 ft high, undercutting
90	Salem/Sterling	Wayne	Streambank	120 feet of eroded streambank along Wallenpaupack Creek
91	Salem	Wayne	Stormwater	16 feet of minor erosion seen along J&J Rd during initial site visit; in 2006 vegetated
92	Salem	Wayne	Stormwater	24 feet of eroded roadside along J&J Rd.
93	Salem	Wayne	Stormwater	198 feet of ditch washed out along Pond Rd. during initial site visit; no problem seen in 2006
94	Jefferson	Lackawanna	Stormwater	250 feet of erosion along Jefferson Rd. seen during initial site visit; in 2006 some minor erosion still apparent
95	Jefferson	Lackawanna	Stormwater	345 feet of roadside washing out on Rte 247, needs catch basin
96	Jefferson	Lackawanna	Stormwater	130 feet of scour and exposed roots at culvert on Rte 247, needs catch basin
97	Jefferson	Lackawanna	Stormwater	450 feet of eroded roadside along Rte 247, washing into stream during initial site visit; in 2006 well vegetated

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
98	Jefferson	Lackawanna	Stormwater	Exposed ditch washing out along Wimmers Rd during initial site visit; in 2006 road repaved, ditches in good shape
99	Jefferson	Lackawanna	Stormwater	Exposed roots and eroded bank along Wimmers Rd during initial site visit; in 2006 road repaved and ditches look good
100	Jefferson	Lackawanna	Stormwater	250 feet of eroded ditches along Hitchcock Rd during initial site visit; in 2006 well vegetated
101	Jefferson	Lackawanna	Stormwater	1000 feet of exposed bank along Cortez Rd after road work during initial site visit; no problem seen in 2006
102	Sterling	Wayne	Stormwater	Minor erosion washing into Wallenpaupack Creek on Forks Bridge Rd.
103	Salem	Wayne	Stormwater	900 ft of steeply sloped ditches along Industrial Park Rd leading to Wallenpaupack Creek, needs rock lining
104	Jefferson	Lackawanna	Stormwater	Roadwork done before initial site visit and left unvegetated; in 2006 new culvert installed, looks good
105	Lake	Wayne	Stormwater	Unfinished ditch eroding along side of Bob Black Rd. near Jones Creek
106	Salem	Wayne	Stormwater	150 feet of erosion seen at intersection of Bidwell Hill Rd and Ledgedale Rd. during initial site visit; in 2006 well vegetated
107	Salem	Wayne	Stormwater	300 feet of eroded ditch during initial site visit, large sediment pile spilling into wetland; in 2006 ditch was vegetated
108	Salem	Wayne	Stormwater	50 feet of eroded hillside along Ledgedale Rd.
109	Lake	Wayne	Stormwater	900 feet of eroding ditch, side of Avoy Rd. breaking up
110	Lake	Wayne	Stormwater	105 feet of eroded ditch from road work seen during initial site visit; in 2006 problem was not seen
111	Paupack	Wayne	Stormwater	90 feet of eroded bank along West Shore Drive near Paupackan Lake
112	Paupack	Wayne	Stormwater	300 feet of unfinished work washing off bank on West Shore Drive near Paupackan Lake during initial site visit; in 2006 problem not seen
113	Pauapck	Wayne	Stormwater	72 feet of eroded hillside at edge of Daniels Rd.
114	Paupack	Wayne	Stormwater	450 feet of eroded bank along Daniels Rd extending 15-20 feet high seen during initial site visit, still eroded during June 2006

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
115	Paupack/Lake	Wayne	Stormwater	Manure pile and eroded ditch at farm on Avoy & Eisenhower Rd during initial site visit; in 2006 manure pile gone and roadside vegetated
116	Salem	Wayne	Stormwater	215 feet of erosion on side of Goosepond Road seen during initial visit, still eroded in June 2006 - needs stabilization
117	Paupack	Wayne	Stormwater	350 feet of minor erosion along edge of Goosepond Rd., sediment washing into wetland
118	Lake	Wayne	Stormwater	420 feet of roadside erosion along Maines Rd. (dirt)
119	Paupack	Wayne	Stormwater	60 feet of eroded roadside along Highland Dr. found during initial visit and still eroded in August 2006. Needs drainage work or catch basin
120	Paupack	Wayne	Stormwater	195 feet of erosion along Rte 590 found during initial visit, apparently fixed by PennDOT August 2006
121	Salem	Wayne	Stormwater	2000 feet of eroded bank after ditch work along Maines Rd. found during initial visit, revegetated as of August 2006
122	Paupack	Wayne	Shoreline	Erosion and exposed roots along shoreline of Lake Wallenpaupack
123	Palmyra	Pike	Shoreline	Exposed mulch that could erode easily into Lake Wallenpaupack
124	Palmyra	Pike	Shoreline	Erosion and exposed roots along shoreline of Lake Wallenpaupack
125	Paupack	Wayne	Shoreline	Erosion and exposed roots along shoreline of Lake Wallenpaupack
126	Palmyra	Pike	Shoreline	Erosion and exposed roots along shoreline of Lake Wallenpaupack
127	Palmyra	Pike	Shoreline	10 feet of erosion with exposed roots along Lake Wallenpaupack approximately 2 feet high
128	Palmyra	Pike	Shoreline	50 feet of erosion along Lake Wallenpaupack approximately 1 foot high
129	Palmyra	Pike	Shoreline	200 feet of erosion and exposed treet foots along shoreline of Lake Wallenpaupack approximately 5 feet high
130	Palmyra	Pike	Shoreline	150 feet of erosion and exposed tree roots along shoreline of Lake Wallenpaupack approximately 10 feet high
131	Palmyra	Pike	Shoreline	Erosion and exposed roots along shoreline of Lake Wallenpaupack
132	Palmyra	Pike	Shoreline	15 feet of erosion along shoreline of Lake Wallenpaupack approximately 8-15 feet high

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
133	Palmyra	Pike	Shoreline	10 feet of erosion and exposed tree roots along shoreline of Lake Wallenpaupack approximately 10-15 feet high
134	Palmyra	Pike	Shoreline	10 feet of erosion and exposed tree roots along shoreline of Lake Wallenpaupack approximatley 3-5 feet high
135	Salem	Wayne	Shoreline	15 feet of erosion and exposed tree roots along shoreline of Lake Wallenpaupack approximately 5-8 feet high
136	Salem	Wayne	Shoreline	20 feet of erosion along shoreline of Lake Wallenpaupack approximately 3-5 feet high
137	Salem	Wayne	Shoreline	Erosion and exposed dirt along bank and under bridge
138	Salem	Wayne	Shoreline	Exposed treet roots along eastern bank of Five Mile Point on Lake Wallenpaupack
139	Salem	Wayne	Shoreline	15 feet of erosion and exposed tree roots along western bank of Five Mile Point approximately 15 feet high.
140	Paupack	Wayne	Shoreline	150 feet of erosion along Lake Wallenpaupack across from dam, approximately 50 feet high
141	Paupack	Wayne	Shoreline	75 feet of shoreline erosion on bank above existing rock retaining wall (4 feet high)
142	Paupack	Wayne	Shoreline	50 feet of shoreline erosion along Lake Wallenpaupack (3-4 feet high)
142	Salem	Wayne	Shoreline	150 feet of moderate shoreline erosion along Lake Wallenpaupack near inlet swale (2-5 feet high)
144	Palmyra	Pike	Shoreline	200 feet of moderate erosion near docking area at point where stream enter Lake Wallenpaupack
145	Salem	Wayne	Shoreline	75 feet of eroded shoreline near Ledgedale
146	Palmyra	Pike	Shoreline	Eroded shoreline near Ledgedale
147	Palmyra	Pike	Shoreline	100 feet of erosion near beach and dock area approximately 15-30 feet wide.
148	Palmyra	Pike	Shoreline	150 feet of eroded shoreline along Lake Wallenpaupack near Ironwood Point approximately 2-4 feet high

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
149	Palmyra	Pike	Shoreline	200 feet of erosion along inlet channels into Lake Wallenpaupack from culverts crossing Route 507
150	Palmyra	Pike	Shoreline	300 feet of erosion along Lake Wallenpaupack near Palmyra Beach
151	Paupack	Wayne	Shoreline	100 feet of erosion along Lake Wallenpaupack near boat launch across from dam
152	Dreher	Wayne	Stormwater	200 feet of erosion along Nevin Road near corner of Nevin and Mill Creek
153	Dreher	Wayne	Streambank	200 feet of severe erosion along banks of Mill Creek
154	Palmyra	Pike	Stormwater	25 feet of erosion along an unnamed tributary of Lake Paupack
155	Coolbaugh	Monroe	Stormwater	Some erosion on side of road. State needs to stabilize bank
156	Lake	Wayne	Stormwater	Approximately 100 yards of eroded stormwater swale
157	Lake	Wayne	Stormwater	Eroding swales throughout Paupack Glen
158	Palmyra	Pike	Stormwater	800 to 1000 feet of eroding roadsideat Site 2 in Penn Wood, approx 15 feet high
159	Palmyra	Pike	Stormwater	200 yards of eroding roadways in Penn Wood Community, approximately 2-3 feet high.
160	Greene	Pike	Stormwater	50 feet of hillside erosing towards road and lake on Laurel Lane, approximately 4-5 feet high
161	Lake	Wayne	Stormwater	800 feet of eroded roadside on Avoy Road acrsss from Craft Pond, approximately 8 feet high.
162	Palmyra	Pike	Stormwater	Paupack Heights Community-wide stormwater problems. The Community Association is currently planning to install a retention basin.
163	Palmyra	Pike	Stormwater	Roadside erosion along unnamed Road off Route 507 near mailboxes 1108 and 1111
164	Palmyra	Pike	Stormwater	Eroding swales along Leonard Road off of Ainsley Road
165	Palmyra	Pike	Stormwater	300 feet of eroding swales along lake access road
166	Palmyra	Pike	Stormwater	Eroding swales along Pellett Road
167	Palmyra	Pike	Stormwater	Stormwater and culvert problems on Simons Point neart Chipmunk Drive and Nyack Drive

Lake Wallenpaupack Watershed – Watershed Investigations Nonpoint Source Pollution Problem Areas				
Site Number	**Township**	**County**	**Problem Type**	**Problem Area Description**
168	Lake	Wayne	Stormwater	Stormwater runoff onto lake from property
169	Lake	Wayne	Stormwater	100 yards of eroding swales in Oakview
170	Lake	Wayne	Stormwater	300 yards of eroding swales in Oakview along Lake Drive and Knollwood Road
171	Lake	Wayne	Agricultural	Shaffer Farm on Route 590 near Hamlin Diner - Needs heavy use are protection, water diversions and larger area for ag waste management
172	Salem	Wayne	Agricultural	Mayeski Farm ag waste problems. Needs larger ag waste facility and heavy use area protection. Cows crossing over stream needs stream crossing and stabilization of barnyard
173	Palmyra	Pike	Shoreline	Eroding area from stormwater runoff draining directly into lake off of Pellett Road
174	Salem	Wayne	Streambank	25 feet of streambank erosion and junction of East and West Branch Wallenpaupack Creek
175	Salem	Wayne	Streambank	20 feet of erosion along West Branch Wallenpaupack Creek which is eroding pylings of Interstate 84 Bridge
176	Sterling	Wayne	Agricultural	Curtis farm - cows in stream - need stream crossing, heavy use area protection near barnyard
177	Greene	Pike	Agricultural	Whermann Farm – agricultural waste problems

Appendix C

Map 1 – Nonpoint Source Pollution Problem Areas And BMPs Installed in the Lake Wallenpaupack Watershed

Appendix D

BMPs Installed in the Lake Wallenpaupack Watershed

BMPs Implemented in the Lake Wallenpaupack Watershed				
Project Name	**Project Type**	**Project Cost**	**Township**	**Project Description**
Cove Point Development	Stormwater	$28,888	Paupack	Rock-lined channel and guardrails.
Sandy Shore	Stormwater	$20,000	Paupack	Catch basin, rip-rap swale, road repair
Karl Eisenhauer Farm	Agricultural	$49,973	Paupack	Manure storage facility, strip cropping, water diversions, critical area planting, vegetative cover establishment
Robert Sibello Farm	Agricultural	$43,500	Salem/ Paupack	Agricultural waste facility
Robert Sibello Farm	Agricultural	$11,703	Salem	Water diversion, three water control structures, and a grassed waterway
Phil Pruss Farm	Agricultural	$20,888	Salem	Manure storage facility
Lewellyn Courtright Farm	Agricultural	$36,684	Salem	Earthen manure storage facility with tile drainage
Clare Madden Farm	Agricultural	$31,969	Salem	Covered manure storage facility, filter strips
Andrew Keating Farm	Agricultural	$36,742	Jefferson	Earthen manure storage facility, fencing, diversions
Joy Simons Property	Streambank	$9,862	Sterling	Streambanks stabilized with rock and mud sills (log structure) to improve fisheries habitat
The Escape POA	Stormwater	$46,365	Palmyra	Rock-lined channel discharging to detention basin
Hemlock Grove POA	Stormwater	$16,666	Palmyra	Stormwater drainage and erosion control
Bob Coutts Farm	Agricultural	$14,250	Palmyra	Water control diversions
Penn Wood Assn.	Stormwater	$11,238	Palmyra	Rock-lined channels and rock basins
Big Wood Development	Stormwater	$22,500	Palmyra	Rock-lined channels
Dominic Mastri Farm	Agricultural	$6,932	Greene	Rock-lined channels and inlet/outlet structures, diversion terraces, and grassed waterways
George Uhl Farm	Agricultural	$50,205	Greene	Manure storage facility and water diversion structures
Karen Leckner Property	Streambank	$25,944	Greene	Streambank stabilization with rock
Velma Krager Farm	Agricultural	$13,878	Paupack	Water control sturctures
John Powloski Farm	Agricultural	$3,342	Lake	Winter cover crop, diversion terraces and grassed waterways
William Heberling Farm	Agricultural	$873	Greene	Winter Cover Crop
Frank Spudeno Farm	Agricultural	$5,365	Salem	Spring development and permanent vegetative cover
George Stone Farm	Agricultural	$983	Greene	Permanent vegetative cover

BMPs Implemented in the Lake Wallenpaupack Watershed				
Project Name	**Project Type**	**Project Cost**	**Township**	**Project Description**
Bruce Ortwine Farm	Agricultural	$2,303	Salem	Diversion terraces and seeding
Frank Padula Farm	Agricultural	$25,240	Salem	Manure storage facility, grassed waterways, water control structures, and permanent vegetative cover
John Czubowicz Farm	Agricultural	$2,391	Lake	Critical area seeding
Carrol Krautter Farm	Agricultural	$1,497	Greene	No-till seeding and permanent vegetative practices
John Yarmosh Farm	Agricultural	$3,877	Greene	Fields were revitalized and revegetated
Richard Gadomski Farm	Agricultural	$4,200	Salem	Hedgerow removal and installation of stripcropping
Edward Blasko Farm	Agricultural	$3,860	Sterling	Improvements to existing hayfield, including top dressing with lime and fertilizer and reseeding
Marlyn Shaffer Farm	Agricultural	$4,379	Salem	Improved vegetation, strip cropping, and tile drainage
Joseph Krompasky Farm	Agricultural	$7,917	Salem	Water inlet control structure with tile drainage, strip cropping, and no-till seeding
Wallenpaupack Lake Est	Stormwater	$40,980	Paupack	Rock lined channels, catch basins, N-12 culverts, and rip-rap aprons
Woodland Hills Assn.	Stormwater	$14,160	Paupack	Rock-lined channels draining to rock basin
John Urash Farm	Agricultural	$3,398	Salem	Fields were limed and fertilized to establish permanent vegetative cover
Glen Stevens Farm	Agricultural	$45,148	Jefferson	Solid manure storage facility
Briar Hill North Assn.	Stormwater	$36,800	Paupack	Rock-lined channels with rock-lined dissipator and flow spreader
Dennis Held Farm	Agricultural	$32,439	Jefferson	Solid manure storage facility
Nick Simyan Farm	Agricultural	$30,826	Jefferson	Solid manure storage facility
Kingston Property	Shoreline	$5,950	Palmyra	Rip-rap bank toe stabilization, grading, and seeding of eroded shoreline, stabilized boat access
Circle Green	Stormwater	$6,661	Palmyra	Grading and hydroseeding of eroded roadside bank
Hemlock Grove Development	Stormwater	$14,855	Palmyra	Rock lined channels, catch basins, N-12 culverts, and rip-rap aprons
Beechwood Cove Development	Stormwater	$26,227	Palmyra	Rock lined channels, catch basins, N-12 culverts, waterbars, and rip-rap aprons

BMPs Implemented in the Lake Wallenpaupack Watershed				
Project Name	**Project Type**	**Project Cost**	**Township**	**Project Description**
Bartleson Road	Stormwater	$3,345	Palmyra	Rock lined channels, N-12 culverts, and French drains
Lakecrest/ Beitleman Property	Shoreline	$8,593	Palmyra	Rip-rap bank toe stabilization, grading, and seeding of eroded shoreline
Lacawac Sanctuary	Stormwater	$16,454	Salem	Rock lined channels, N-12 culverts, waterbars, and rip-rap aprons
Scartelli Property	Streambank	$14,995	Salem	Gabion basket structure streambank stabilization, seeding
Mill Brook	Streambank	$32,000	Palmyra	Rip-rap bank toe stabilization, grading, and seeding of eroded streambank
Dorothy Fazio	Streambank	$3,995	Palmyra	Large native stone used to stabilize eroding streambank.
Clare Madden Farm	Agricultural	$10,500	Salem	Agricultural waste facility (cost share)
Beechwood Cove	Stormwater	$19,109	Palmyra	Water control, rock-lined channels, roadside stabilization
Killam Park Association	Stormwater	$800	Palmyra	Rip-rap stabilization of drainage ditch
Lakecrest	Shoreline	$1,000	Palmyra	Lakeshore stabilization using vegetation
Bakker Marine	Stormwater	$45,681	Paupack	Stormwater constructed wetland
East Branch Wallenpaupack Creek	Streambank	$56,102	Greene	Stabilized streambank using rock and vegetation
Mill Brook	Streambank	$3,687	Palmyra	Provided additional plantings for Mill Brook Streambank Stabilization Project
Hermans Woods	Stormwater	$67,010	Greene	Repaired eroded land near Wallenpaupack Creek. Filled in area, installed rock-lined ditch and vegetation
William Heberling Farm	Agricultural	$20,635	Greene	Heavy use area protection, stabilized with stones
Lew Courtright Farm	Agricultural	$74,859	Salem	Agricultural waste facility, heavy use area protection
Wallenpaupack Lake Estates	Stormwater	$73,212	Paupack	Rip rap on roadsides, sluice pipe installed to control water
Carroll Krautter Farm	Agricultural	$80,792	Greene	Agricultural waste facility, heavy use area protection
Bob Lesniak Farm	Agricultural	$93,142	Lake	Agricultural waste facility, filter field, livestock exclusion fencing around pond
Pawloski Farm	Agricultural	$85,631	Lake	Water diversion using sluice pipes, heavy use area protection

BMPs Implemented in the Lake Wallenpaupack Watershed				
Project Name	**Project Type**	**Project Cost**	**Township**	**Project Description**
Will Keating Farm	Agricultural	$114,681	Jefferson	Concrete barnyard, water controls
Emil Swingle Farm	Agricultural	$97,851	Lake	Concrete heavy use area protection, agricultural waste facility
Jim Keating Farm	Agricultural	$58,977	Jefferson	Agricultural waste facility, roof (two projects)
Mangan Cove	Shoreline	$74,621	Paupack	Lakeshore stabilization using rock and vegetation, soil amendment
Greene Township	Stormwater	$650	Greene	Rip rap erosion control on sides of township roads – Creamery Rd. and Russell Lake Rd.
Paupack Township	Stormwater	$650	Paupack	Rip rap erosion control on sides on township road – Wangam Falls Rd.